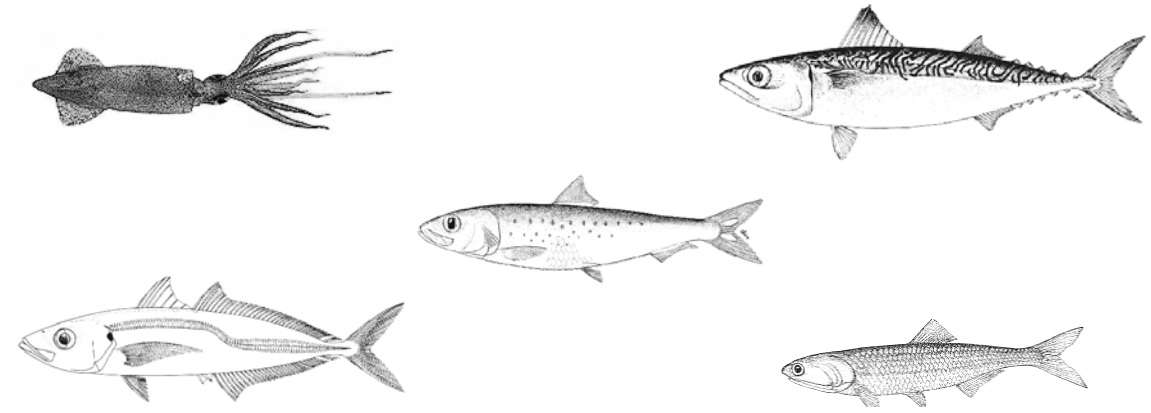
STATUS OF THE PACIFIC COAST COASTAL PELAGIC SPECIES FISHERY AND RECOMMENDED ACCEPTABLE BIOLOGICAL CATCHES

STOCK ASSESSMENT AND FISHERY EVALUATION 2014



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Appendix A: 2014 SAFE Tables
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LIST OF ACRONYMS AND ABBREVIATIONS

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

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

1.0 INTRODUCTION

The purpose of this report is to briefly summarize aspects of the coastal pelagic species (CPS) Fishery Management Plan (FMP) and to describe the history of the fishery and its management. The guidelines for FMPs published by the National Marine Fisheries Service (NMFS) require that a stock assessment and fishery evaluation (SAFE) report be prepared and reviewed annually for each species managed under this FMP: Pacific sardine (*Sardinops sagax*), Pacific mackerel (*Scomber japonicus*), northern anchovy (*Engraulis mordax*), jack mackerel (*Trachurus symmetricus*), market squid (*Doryteuthis opalescens*), and krill (*euphausiid spp.)*. Pacific herring (*Clupea pallasi*) and jacksmelt (*Atherinopsis californiensis*) were added as Ecosystem Component species, concurrent with Council approval of Amendment 13 to the CPS FMP. The SAFE report for Pacific Coast CPS fisheries was developed by the Council's Coastal Pelagic Species Management Team (CPSMT) from information contributed by scientists at NMFS, the Southwest and Northwest Fisheries Science Centers (SWFSC, NWFSC), California Department of Fish and Wildlife (CDFW), Oregon Department of Fish and Wildlife (ODFW), and Washington Department of Fish and Wildlife (WDFW). Included in this report are descriptions of landings, fishing patterns, estimates of the status of stocks, and acceptable biological catches (ABCs). Stock assessments for Pacific sardine and Pacific mackerel are typically published in briefing book materials in April and June, respectively. In addition, they may be included as appendices to the SAFE report, when there is a new full or updated assessment, or a projection estimate available. The ABC recommendations, together with social and economic factors, are considered by the Council in determining annual harvest guidelines and other measures for actively managed fisheries (i.e., Pacific mackerel and Pacific sardine).

2.0 THE CPS FISHERY

2.1 Management History

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

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

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

2.2 Recent Management

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

2.2.1 Amendment 8

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

In June 1999, NMFS partially approved the CPS FMP. Approved FMP elements included: (1) the management unit species; (2) CPS fishery management areas, consisting of a limited entry (LE) zone and two subareas; (3) a procedure for setting annual specifications including harvest guidelines (HG), quotas, and allocations; (4) provisions for closing directed fisheries when the

directed portion of a HG or quota is taken; (5) fishing seasons for Pacific sardine and Pacific mackerel; (6) catch restrictions in the LE zone and, when the directed fishery for a CPS is closed, limited harvest of that species to an incidental limit; (7) a LE program; (8) authorization for NMFS to issue exempted fishing permits for the harvest of CPS that otherwise would be prohibited; and (9) a framework process to make management decisions without amending the FMP.

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

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

2.2.2 Amendment 9 – Bycatch Provisions; Treaty Indian Fishing Rights

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

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

2.2.3 Amendment 10 – Limited Entry Capacity Goal; Permit Transfers; Market OY/MSY

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

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

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

2.2.4 Sardine Allocation Regulatory Amendment

In September 2002, a majority of the Coastal Pelagic Species Advisory Subpanel (CPSAS) recommended the Council initiate a regulatory or FMP amendment and direct the CPSMT to prepare management alternatives for revising the sardine allocation framework. The Council directed the CPSMT to review CPSAS recommendations for revising the allocation framework. At the March 2003 Council meeting, the SSC and CPSAS reviewed analyses of the proposed management alternatives for sardine allocation. Based on the advisory body recommendations and public comment, the Council adopted five allocation management alternatives for public review. In April 2003, the Council took final action on the regulatory amendment. This change was implemented by NMFS on September 4, 2003 (68*FR*52523).

The new allocation system: (1) changed the definition of Subarea A and Subarea B by moving the geographic boundary between the two areas from 35°40' N latitude (Point Piedras Blancas, California) to 39° N latitude (Point Arena, California); (2) moved the date when Pacific sardine that remains unharvested is reallocated to Subarea A and Subarea B from October 1 to September 1; (3) changed the percentage of the unharvested sardine that is reallocated to Subarea A and Subarea B from 50% to both subareas, to 20% to Subarea A and 80% to Subarea B; and (4) provided for coastwide reallocation of all unharvested sardine that remains on December 1. This revised allocation framework was in place for the 2003 and 2004 fishing seasons. It was also used in 2005 because the 2005 HG was at least 90% of the 2003 harvest guideline.

2.2.5 Amendment 11 - Allocation

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

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

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

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

- Analyze each alternative in a consistent manner.
- Review differential impacts on northern and southern sectors for each alternative.

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

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

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

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

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

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

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

The Council also heeded the advice of the CPSAS, CPSMT, and SSC regarding the dynamic nature of the Pacific sardine resource and uncertainties inherent in long-term projections, and scheduled a formal review of the allocation formula in 2008. The review was intended to provide a comparison of the performance of the fishery to the projections used to evaluate the adopted allocation scheme and will include any new information from Pacific sardine research. The review was postponed and has not been re-scheduled.

2.2.6 Amendment 12 – Krill Fishing Prohibition

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

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

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

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

Amendment 12 was approved by the Secretary and in 2009, NMFS published the implementing regulations in a final rule (74*FR33372*).

2.2.7 Amendment 13 – Annual Catch Limits

The Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006 (MSRA) established several new fishery management provisions pertaining to National Standard 1 (NS1) of the MSA. The MSA sought to end overfishing and required rebuilding plans for those stocks considered to be overfished. It also introduced new fishery management concepts including overfishing levels (OFLs), annual catch limits (ACLs), annual catch targets (ACTs), and accountability measures (AMs) that are designed to better account for scientific and management uncertainty. Council action on Amendment 13 also included a recommendation to add Pacific herring and jacksmelt to the FMP, as Ecosystem Component Species.

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

2.2.8 Sardine Start Date Change

At its June 2013 meeting, the Council adopted an annual start date of July 1 for the Pacific sardine fishery. The previous start date was January 1 each year. The change to a different start date was made to allow more time for spring and summer sampling results to be analyzed and organized, and subsequently to become available to the Stock Assessment Team. The new schedule would allow for more confidence in the spring/summer sampling results because there is more time available for analysis, interpretation, and organization. The period allocations were not changed with the new start date. However, with the fishing year ending June 30, there will be no rollover of unused quota into the July 1-September 14 fishing period.

2.2.9 Amendments in Development

2.2.9.1 Amendment 14 – Northern Anchovy MSY

In November 2013, in response to a lawsuit by the conservation group Oceana, the Council took final action to establish an MSY value for the northern subpopulation of northern anchovy (NSNA). At its November 2010 meeting, the Council considered two options that were analyzed by the CPSMT, but ended up not adopting either one. One of those analyzed values was an MSY reference point of Fmsy = 0.30, which was formally adopted by the Council in November 2013. Incorporating this reference point into management will require an FMP amendment, tentatively planned as CPS FMP Amendment 14.

2.2.9.2 Amendment 15 – Unmanaged Forage Fish

In 2014, the Council adopted a range of alternatives to provide additional protections to a suite of unfished and unmanaged forage fish. The likely scenario would be to incorporate these as Ecosystem Component species, with language added to each of the existing Council FMPs that describes the species and the process that the Council would take in order to establish a fishery for them. These fish would not be CPS stocks that are already actively managed or in monitored status in the CPS FMP.

2.3 CPS Fisheries – History and Description

During the 1940s and 1950s, approximately 200 vessels participated in the Pacific sardine fishery. In California, some present-day CPS vessels are remnants of that fleet. CPS finfish landed by the roundhaul fleet (fishing primarily with purse seine or lampara nets) are sold around the world in several product forms. For example, Pacific mackerel are typically sold to Asian and European, middle Eastern and Baltic markets for human consumption. Sardines are exported largely for canning for human consumption, high value table consumption products, and long-line bait. Although the percent of CPS sold for tuna feed or bait fluctuates based on demand, product availability, etc, the percent sold in higher value categories is generally growing (Steele, pers comm, 2014). In addition to fishing for CPS finfish, many of these vessels fish for market squid, Pacific bonito, bluefin and yellowfin tuna (which are fished primarily in California); and Pacific herring (fished primarily in Oregon/Washington but not in California).

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

2.3.1 Federal Limited Entry Fishery

The CPS LE fleet currently consists of 65 permits and 56 vessels (Table 2-3), operating under a Federal permit program. The LE vessels range in age from 4 to 70 years, with an average age of 34 years (Table 2-4). The capacity goal and transferability provisions established under Amendment 10 are based on calculated gross tonnage (GT) of individual vessels. Calculated GT serves as a proxy for each vessel's physical capacity and is used to track total fleet capacity. Calculated GT incorporates a vessel's length, breadth, and depth, which are consistent measures across vessel registration and U.S. Coast Guard documentation lists. As described at 46 CFR § 69.209, GT is defined as:

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

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

GT values for the current fleet range from 23.8 GT to 206.9 GT, with an average of 88 GT (Tables 2-3 and 2-4). The fleet capacity goal established through Amendment 10 is 5,650.9 GT, and the trigger for restricting transferability is 5,933.5 GT (Goal + 5%). The current LE fleet is 4,753 GT, well within the bounds of the capacity goal.

2.3.2 California Federal Limited Entry Sardine Fishery

California's sardine fishery began in the 1860s as a supplier of fresh whole fish. The fishery shifted to canning from 1889 to the 1920s in response to a growing demand for food during World War I. Peaking in 1936-37, sardine landings in the three west coast states plus British Columbia reached a record 717,896 mt. In the 1930s and 1940s Pacific sardine supported the largest commercial fishery in the western hemisphere, with sardines accounting for nearly 25 percent of all the fish landed in the United States by weight. In the 1940s, the fishing fleet consisted of 376 vessels and more than 100 canneries and reduction plants which employed thousands from San Francisco to San Diego, California.

The fishery declined and collapsed in the late 1940s due to overfishing and changes in environmental conditions, and remained at low levels for nearly 40 years. The fishery declined southward, with landings ceasing in Canadian waters during the 1947-1948 season, in Oregon and Washington in the 1948-1949 season, and in the San Francisco Bay in the 1951-1952 season. The California Cooperative Fisheries Investigations (CalCOFI), a consortium of state and federal scientists, emerged to investigate the causes of the sardine decline. Analyses of fish scale deposits in deep ocean sediments off southern California found layers of sardine and anchovy scales, with nine major sardine recoveries and subsequent declines over a 1700-year period (Baumgartner et al. 1992). Sardines and anchovies both vary in abundance over periods of about 60 years. Cold-water oceanic cycles favor anchovies and warm-water cycles favor sardines. The decline of the

sardine fishery became a classic example of a 'boom and bust' cycle, a known characteristic of clupeoid stocks.

In 1967, the California Department of Fish and Game implemented a moratorium that lasted nearly 20 years. The remaining vessels diversified into other coastal pelagic "wetfish" fisheries. Sardines began to return to abundance in the late 1970s, when the Pacific Decadal Oscillation shifted to a warm cycle again, but this time fishery managers adopted a highly precautionary management framework. California's sardine fishery reopened in 1986 with a 1,000 short ton quota, authorized by the Legislature when the biomass exceeded 20,000 mt. The sardine resource grew exponentially in the 1980s and early 1990s, with recruitment estimated at 30 percent or greater each year. In 1998, the sardine resource was declared "recovered," with a biomass estimated at slightly more than 1 million mt. The quota set by CDFG had increased to 43,545 mt, and it was virtually completely utilized.

In 1999, the new coastwide harvest guideline (HG) jumped to 186,791 mt, based on a 1999 biomass estimate of 1.58 million mt. In 2000, California harvested 57,935 mt. About 71 percent of the catch was exported, valued at $23.3 million, and approximately 17 percent of the catch went to canneries. However, the last cannery in southern California was sold in December, leaving only one cannery remaining in Monterey, in a fishery that had employed more than 100 canneries and reduction plants statewide during the fishery's heyday in the 1930s and 1940s.

The sardine recovery appeared to level off during 1999-2002. By August 2002, the Northern area sardine fishery attained its allocation and was forced to close early. Northwest sardine interests lobbied the Council for an emergency reopening and revision to the allocation framework because thousands of tons of sardine were available and going unharvested in the Southern fishery.

In the early 2000s the California fishery encountered an abundance of small sardines on traditional fishing grounds, for which markets were very limited. The larger fish appeared to move offshore in their northern migration, out of the range of California seiners who made most of their catches inside the 3-mile state boundary. The lack of canning-size sardines caused the last cannery in Monterey to sell its canning equipment. Still, sardines ranked among the top fisheries in California in volume and sixth in value with ex-vessel ranging $4.5 to more than $5 million. With a main focus now on export markets, California shipped sardines to as many as 22 countries worldwide, and annual export values exceeding $20 million.

From 1998-2006, California sardine landings averaged 46,793 mt. In 2005, Oregon landings surpassed California for the first time since the fishery reopened. California caught nearly 81,000 mt of the 152,564 mt HG in 2007 – the highest landings since the 1960s. Ex-vessel value exceeded $8 million, and 66,896 tons of sardine were exported to 37 countries, with an export value of $40.4 million.

In 2008, the HG declined 42 percent, to 89,093 mt, and the sardine fishery closed early in all three allocation periods, with California catching 57,803 mt of the total. Beginning in 2008, California's sardine fishery was closed more than it was open, and it was closed early, during the peak fall season in all years but 2012 and 2013. In 2009, the annual HG was attained in 77 fishing days. California landings totaled 37,578 mt, with two-thirds of the catch in Monterey. California exported 33,909 mt to 35 countries. In 2010, California landings fell to 33,658 mt of the 72,039 mt quota, and 83 percent of the catch was landed in San Pedro. The summer period closed July 22, the fishery reopened on September 15, and closed for the year September 24. The 2011 sardine fishery experienced another 30 percent reduction in HG, with only 50,526 mt allowed to be

harvested of a 537,173 mt age 1+ biomass. California caught 27,714 mt in 83 total days of fishing opportunity.

In 2012, although the biomass and HG increased substantially (988,385 mt biomass and 109,409 mt HG), California landings continued declining, to only 23,037 mt. Fishermen couldn't find sardines early in the year, then focused on a banner squid season during the summer. There was further evidence of a natural sardine decline in 2013 as sardines disappeared from Canadian waters. The 2013 HG decreased 69 percent to 66,495 mt, and California harvested only 7,074 mt. Pacific mackerel landings surpassed sardine for the first time since 1993. In place of sardine, a decadal squid population explosion has occupied the California purse seine fleet in recent years. Since federal management began in 2000, the sardine biomass has declined more than 70 percent since the 2006 high of 1.3 million mt, and harvest limits have fallen from a high of an HG of 186,971 mt in 2000 to an ACT of 23,293 mt in 2014.

2.3.3 Oregon State Limited Entry Sardine Fishery

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

ODFW began work with the Developmental Fisheries Board and the industry to develop alternatives for the fishery. In December 2005, the Oregon Fish and Wildlife Commission (OFWC) moved the Pacific sardine fishery from a developing fishery into a state-run LE fishery system. Twenty Oregon permits were initially established and made available to qualifying participants for the 2006 fishery. The OFWC amended a LE permit eligibility rule in August 2006, which resulted in an immediate addition of six permits for a total of 26 LE sardine fishery permits. The Oregon Limited Entry fleet does not have capacity restrictions.

In April 2009 the OFWC enacted a number of rule changes for the Pacific sardine fishery. First, the OFWC modified the requirement for minimum landings of sardines into Oregon to qualify for permit renewal that was enacted in 2006. These minimum landing requirements for permit renewal were effective only when the federal coastwide maximum HG for the fishing year exceeded 100,000 mt. The minimum landing requirements themselves, either a minimum of ten landings of at least five mt each or landings totaling at least $40,000 ex-vessel price, were not changed. Next, the OFWC eliminated a rule that became effective in 2008, which specified that permit holders must either own or operate a vessel that is permitted. The OFWC also established a lottery system for sardine permits. If the number of permits issued falls below 24 a lottery may be held the following year, but the total number issued shall not exceed 26 LE permits. A new rule defined catching vessels and limited catch sharing to catching vessels with state LE sardine permits. In 2012, the OFWC eliminated the landings requirements for permit renewal.

The Pacific sardine fishery in Oregon operates as a day fishery with vessels based primarily in Astoria where processing plants for sardine operate. Many vessels utilize aircraft to assist in locating schools of sardine and setting their nets when weather permits. Weather and tides are

major factors in fishing operations and timing of vessels transiting in and out of the Columbia River.

2011

Twenty-five state limited entry vessels were permitted in Oregon in the 2011. Sixteen of those vessels (64%) participated in the sardine fishery. Table 2-5(a) contains information for vessels that participated in the 2011 fishery. Note that seven vessels landing sardine in Oregon (44%) also held federal and/or Washington state LE permits. Oregon landings totaled 8,321 mt or 20% of the initial 41,326 mt federal directed sardine fishery harvest allocation. Oregon landings in 2011 were the lowest since 2000. Only 1999, the first year of the renewed Oregon sardine fishery, after its more than 50 year hiatus, had lower total landings. Sardines were landed in only two of the three allocation periods with 81.8% landed in the 2nd period and 18.2% landed in the 3rd period. Landings ranged from less than 10 mt to over 100 mt with the most being between 40 mt and 70 mt. As in the previous three years, all three allocation periods were closed to directed fishing before the end of the period because the allocation was reached. These early closures have resulted in a change in the timing of greatest harvest from August and September when sardine typically have their greatest oil content in the Pacific Northwest to July. The ex-vessel value of sardine landed in the directed fishery in Oregon totaled $2.4 million with a modal price of $300/mt in 2011 and averaged $288/mt.

2012

The number of permitted vessels remained at twenty-five state limited entry vessels in Oregon. Twenty-one of those vessels (84%) participated in the sardine fishery. Table 2-5(b) contains information for vessels that participated in the 2012 fishery. Note that eight vessels landing sardine in Oregon (38%) also held federal and/or Washington state LE permits. Oregon landings totaled 39,935.8 mt or 42% of the initial 94,409 mt federal directed sardine fishery harvest allocation. Oregon landings in 2012 were the third highest in volume and by far the highest in ex-vessel revenue since the fishery resumed in 1999. Sardines were landed during all three allocation periods with 7.2% landed in the 1st period, 68.1% landed in the 2nd period and 24.7% landed in the 3rd period. Landings ranged from less than 10 mt to 110 mt with the most being between 40 and 90 mt. Directed fishing closed before the end of the second period because the allocation was reached. Unlike recent years, directed fishing remained open for the full duration of the first and third periods. The ex-vessel value of sardine landed in the directed fishery in Oregon totaled $ 8.4 million. Price was more variable than in 2011 and averaged $210/mt overall.

2013

As in recent years, twenty-five state limited entry vessels were permitted in Oregon in 2013. Fourteen of those vessels (56%) participated in the sardine fishery. Table 2-5(c) contains information for vessels that participated in the 2013 fishery. Note that three vessels landing sardine in Oregon (21%) also held federal and/or Washington state LE permits. Oregon landings totaled 24,761.5 mt or 43% of the initial 57,495 mt federal directed sardine fishery harvest allocation. Although its share of the total was equally high in 2013 as in 2012, Oregon landings declined significantly from 2011, in proportion to the reduced directed fishery allocation coastwide. Sardines were landed in all three allocation periods with 0.6% landed during the 1st period, 80.1% landed in the 2nd period and 19.3% landed in the 3rd period. As in most years, landings ranged from less than 10 mt to nearly 100 mt with the most being between 40 and 70 mt. As

in 2012, only directed fishing during the second allocation period closed before the end of the period because the allocation was reached. The ex-vessel value of sardine landed in the directed fishery in Oregon totaled $6.0 million with an overall average price of $241/mt in 2013.

2.3.4 Oregon Anchovy Fishery

State developmental fishery permits for harvesting anchovy were issued from 1995 to 2009. All developmental fisheries in Oregon have a limited number of permits available and landing requirements for permit renewal, but the number of permits and landing requirements differed by target species. In 2009 Oregon issued four of the 15 developmental fishery permits available for the anchovy fishery. In December 2009, all developmental fisheries programmatic activities including permitting were suspended due to lack of funding. The OFWC moved the anchovy fishery to a Category C developmental fishery, those that are managed under a state or federal FMP which has established permit and/or gear limitations. Because the federal CPS FMP does not have permit restrictions for vessels operating north of 39°N latitude, the ocean fishery for northern anchovy is now an open access fishery off Oregon limited to legal gear under the CPS FMP and state regulations. In recent years, northern anchovy were infrequently targeted during open periods for the sardine fishery.

<u>2011-2013</u>
During 2011, purse seine landings totaled 21.2 mt, all taken while the sardine fishery was open. A groundfish trawl vessel landed a trace amount of anchovy (<0.01mt). During 2012, no anchovy were landed in Oregon. During 2013, 12.7mt of northern anchovy were landed in the purse seine fishery and an additional 0.1 mt were landed incidentally by the whiting fishery.

2.3.5 Washington State Limited Entry Sardine Fishery

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

The Pacific Northwest sardine fishery saw a rapid expansion of catch between the years 1999 to 2002 when landings increased from 771 mt to 15,820 mt. In response to this situation, WDFW engaged in an extensive public process to address management needs in the fishery. In 2003, following this public process, a formal Sardine Advisory Board (Board) was created, and the WDFW Director, in collaboration with the Board, advanced the sardine fishery designation from trial to experimental as provided for under the ECFA. The number of experimental fishery permits was capped at 25. The experimental fishery program continued through June 2009. Besides

limiting participation, WDFW also restricted the amount of sardines sold for reduction to a 15 percent season cumulative total by weight by individual vessel.

During the 2009 Washington State legislative session, WDFW proposed legislation to establish a commercial license limitation program specifically for the harvest and delivery of Pacific sardines into the state. The legislation was passed into rule in July 2009. The new rules established 16 licenses to be issued to holders of a 2008 sardine experimental fishery permit only, with an exception for past participants of the experimental fishery that became ineligible because of loss of their vessel at sea. These newly created sardine licenses can be sold. In addition, the new rule provides criteria for the issuance of temporary annual permits at the discretion of the WDFW Director. In combination, the number of permanent and temporary annual licenses cannot exceed 25. There are no vessel capacity restrictions in the Washington limited entry fleet.

In 2009, 16 experimental fishery permits were issued to those who met the renewal criteria, which required that they previously held such a permit and also held a minimum of 50 percent ownership in the vessel designated on the sardine permit. After the creation of the sardine license in July 2009, licenses could be transferred (sold). To maintain a sardine license, annual renewal is required; through 2013 the number of licenses remained at 16. In 2010 and 2012 a single temporary annual license was also issued. The number of actively fished Washington sardine licenses was seven in 2011, 11 in 2012 and 12 in 2013. Table 2-6 lists the vessels designated on Washington sardine fishery licenses/permits in 2013.

The Washington sardine fishery opens annually by rule on April 1. However, fishing opportunity is typically limited until late spring or early summer. In some years the first period allocation is attained before April 1, in others, sardine abundance offshore is not sufficient to support commercial activity until early or mid-June. In 2011 the sardine harvest guideline was attained March 5 and the first opportunity for fishing off Washington was at the beginning of the second allocation period on July 1. But in 2012 and 2013 the harvest guidelines from the first period were not attained and sardine abundance was such that fishermen were able to begin fishing mid-June, and continue into the second period without interruption.

A total of 8,009 mt, 34,655 mt, and 29, 381 mt of sardines were landed into Washington in 2011, 2012, and 2013 respectively. In 2012 and 2013 there were 591 and 446 landings respectively which are up considerably compared to the 127 landings in 2011. The number of landings increased in 2012 and 2013 due to high abundance of sardines off the Washington and Oregon coasts and because sardine catch was low in California due to a shift in focus to squid, which allowed for greater opportunity to harvest and market sardine in Washington.

Beginning in 2008, July has consistently been the most productive month for sardines. In 2011, 77% of landings were in July and 23% were in September. In 2012, 10% of landings were in June, 39% in July, 25% in August, 19% in September, and 7% in October. In 2013, 5% of landings were in June, 45% in July, 29% in August, 12% in September, and 9% in October. The average landing in 2011 was 63 mt, in 2012, 59 mt and in 2013, 66 mt.

All landings in 2011, 2012, and 2013 were made into Westport or Ilwaco. As documented in logbooks, the majority (75% - 100%) of the catch occurs in waters adjacent to Washington. In

2012, a total of 749 sets were made and 723 (97%) were successful and in 2013, 572 sets were made with 545 (95%) of them successful. This is up from the 2011 landings in which 160 sets were made with 94% of them successful. The average catch per successful set is typically between 53 mt and 58 mt. Total ex-vessel value for 2011, 2012 and 2013 was $2.1 million, $7.7 million and $6.6 million respectively.

Pacific sardines are the targeted catch in the Washington fishery, but anchovy, mackerel, and squid may be retained and landed. In 2011, 2012 and 2013 mackerel was the only other coastal pelagic species landed, fluctuating from 0.42 mt in 2011 to 636 mt in 2012 to 196 mt in 2013.

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

2.3.6 Washington State Anchovy Fisheries

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

Except for herring which is under a license limitation program, participation in baitfish fisheries is not limited. Other regulations include seasonal closures of Grays Harbor and Willapa Bay to protect out-migrating salmon. Harvest guidelines are not set, but in 2010 the WDFW adopted permanent rules restricting northern anchovy catch and disposition. The new rules limit the catch, possession or landing of anchovy to 5 mt daily and to 10 mt weekly. In addition, the rules limit the amount of anchovy taken for reduction (or the conversion of fish to products such as fish meal or fertilizer) to 15% of a landing by weight. These rules were intended to discourage the development of high-volume fisheries for anchovy and yet still accommodate traditional bait fishing activity. In 2011, Washington anchovy landings totaled 191 mt, rose to 218.1 mt in 2012, and then fell to 115.7 mt in 2013.

2.3.7 California's Market Squid Fishery

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

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

Under the restricted access program in the MSFMP, a permit is needed to participate in the fishery. Qualification for different types of permits and transferability options was based on historical participation in the fishery. In 2013, 75 vessel permits, 34 light boat permits, 44 brail (netted scoop) permits, and zero experimental permits were issued. Of the 75 vessel permits issued, 67 vessels made commercial landings in 2013. Forty-three vessels made 90 percent of the landings (by tonnage) in 2013. Market squid vessel permits allow a vessel to attract squid with lights and use large purse seine nets to capture squid. Brail permits allow a vessel to attract squid with lights and use brail gear to capture squid. Light boat permits only allow a vessel to attract squid with lights (30,000 watts, maximum). Experimental nontransferable market squid permits allow vessels to fish in areas not historically targeted by the market squid fishery (north of San Francisco). In 2014, revised regulations went into effect clarifying the take of squid incidentally after a closure of the directed market squid fishery. These regulations require incidental landings of squid to contain 10 percent or less of squid and 2 tons or less of squid, when landed with another targeted species.

2.3.8 Treaty Tribe Fisheries

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

The Makah Tribe sent a letter to NMFS expressing their intent to attain an allocation and to enter the Pacific sardine fishery in 2006. However, no formal request was subsequently submitted.

In fall 2011 and 2012, the Quinault Indian Nation sent a letter to the NMFS SWR Regional Administrator requesting up to 9,000 mt as a Tribal sardine allocation for the 2012 and 2013 fishing years, respectively. The Quinault Nation submitted similar requests each season since, including a request for 1,000 mt for the six month season of January 1, 2014 – June 30, 2014; and 4,000 mt for the July 1, 2014 – June 30, 2015 sardine fishing year. The Council accounted for the requests when it set harvest specifications and management measures at its November 2011, 2012, 2013, and April 2014 meetings. The final tonnage amount is subsequently agreed to between NMFS and the Quinault Nation.

Quinault Indian Nation fishers harvested 1294 mt in 2012 and 586 mt in 2013. Agreements were reached with NMFS to give unharvested fish to the coast-wide fishery both of these fishery years and also in the six month season January 1, 2014 – June 30, 2014.

2.3.9 California Live Bait Fishery

Through much of the 20th century, CDFW monitored the harvest of CPS finfish in the California live bait fisheries by requiring live bait logs. Northern anchovy and Pacific sardine are the main species in this fishery, with a variety of other nearshore or CPS taken incidentally. An estimated 20% of this harvest is sold to private fishing vessels, with the remainder to the CPFV fleet, where payment to the bait haulers is on a percentage basis of the CPFV revenues (Thomson *et al.* 1994). An example of the first Live Bait Log from 1939, termed a "Daily Bait Record" as printed for the State of California, Department of Natural Resources, and Division of Fish and Game can be found in Alpin (1942). The nature of the data collected were self-reported daily estimates of the number of "scoops" taken and sold by the fishermen, by species. Although this variety of data does not lend itself readily to rigorous scientific analysis, there are at least 74 years of data available, collected in a reasonably uniform manner that can serve as an index to this low volume, high value fishery.

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

2.3.9.1 Legislative History

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

Live bait logs have been at different times mandated by state law or submitted to the CDFW on a voluntary basis. In the early 1990s sardine became more prevalent in the bait fishery, and quotas were imposed on their annual take pursuant to management efforts to recover the sardine population off California. In 1995, CDFW lifted quotas restricting the quantity of sardines that the live bait industry could harvest. The sardine population along the California Coast was

increasing toward a “recovered” level, as anchovy showed a decline, and sardines became the preferred live bait over anchovy. With the sardine quota lifted, the level of scrutiny on the harvest of the live bait industry lessened.

2.3.9.2 Species Composition

The ratio of anchovy to sardine in the southern California live bait harvests shifts significantly as the populations of these two fish expand and contract over periods of years or decades. Much of the early reported harvest consisted of anchovy, following the collapse of the sardine fishery in the 1940s. Through the years 1994 to 2006 the proportion of anchovy in the total reported harvest ranged from a high of 58 percent in 1994 to a new low in 2004 of five percent. The proportion of sardine ranged from a low of 42 percent in 1994, to a high of 95 percent in 2004 (Table 4-13).

A new market squid live bait fishery has expanded in southern California in recent years. However, the amount of market squid harvested and the value of the fishery is largely unknown, as there are no permitting and reporting requirements. The live bait fishery is likely a low-volume, high-value endeavor, as recreational anglers targeting mainly white seabass are willing to pay up to $85 for a “scoop” of live squid, approximately 12 pounds.

2.3.9.3 Logbook Information

The CDFW Live Bait Log (Title 14, Section 158, California Code of Regulations: DFG 158, October 1989) requires only the estimated scoops taken daily of either anchovy or sardine be reported, and a check mark be made if certain other species are taken, with space for comments related to fishing. Other species noted, but not consistently enumerated in the live bait harvest, include white croaker (*Genyonemus lineatus*), queenfish (*Seriphus politus*), Pacific and jack mackerels, and various small fishes collectively known as "brown bait" that can include juvenile barracuda (*Sphyraena argentea*), Osmerids, Atherinids, and market squid (Table 4-11). Estimates of ancillary catch data has been documented in earlier reports, and in CPS FMP Amendment 9.

The CDFW Coastal Pelagic Species / Highly Migratory Species Project presently archives the CDFW live bait logs. Preliminary estimates of the reported total live bait harvest in California through 2008 have been appended to previously reported estimates from Thomson *et al.* (1991, 1992, 1994) (Table 4-12). The CDFW is in an ongoing effort to evaluate the current logbook structure, reporting requirements, and the information obtained in order to correct the data problems identified above, increase reporting compliance rates, and to better estimate the economics of the fishery.

2.3.10 Oregon Live Bait Fishery

Historically commercial capture of CPS for live bait has primarily occurred in the Umpqua River estuary where Pacific sardine, northern anchovy, and a number of other species not under Federal management may be taken by beach seine and sold as bait, some of which is sold as live bait. In 2009 the Oregon Fish and Wildlife Commission implemented rules to allow capture of northern anchovy in a limited number of Oregon estuaries. All other species must be released unharmed. This harvest of anchovy is limited to commercial vessels that use the anchovy as live bait in commercial fishing operations on the catching vessel. The gear used to capture anchovy is restricted to purse seines with a maximum length of 50 fathoms (300 ft), lampara nets, and hook

and line. This live bait fishery is open from July 1 to October 31. Fishers intending to fish for anchovy in this manner must notify Oregon State Police with the vessel name, fishing location and estimated time of the activity 12 hours prior to fishing activity. Information on live bait catch must be recorded in logbooks provided by ODFW.

2011

In 2011, there was no record of live bait capture of northern anchovy in Oregon estuaries under these new rules. One baitnet landing of Pacific herring, an ecosystem component species in the CPS FMP, was reported on fish tickets in 2011. A small amount of Pacific herring was landed with a small amount of Pacific sardine in Winchester Bay and both were likely used as live bait.

2012

As in 2011, there was no record of live bait capture of northern anchovy in Oregon estuaries. Four baitnet landings of Pacific herring by two vessels were reported on fish tickets in 2012. As in 2011, these were small amounts landed in Winchester Bay and most likely used as bait. No other species were reported in these landings.

2013

There were no landings of northern anchovy or Pacific herring reported for use as live bait, either in fish tickets or logbooks.

2.3.11 Washington Live Bait Fishery

The majority of Washington's anchovy catch is harvested as live bait for use in recreational and commercial fisheries. Although all Washington anchovy landings are reported on fish tickets, no distinction is made between anchovy destined for packaged product versus anchovy destined for use as live bait. The live bait fishery occurs inside three miles on the southern Washington coast, inside Grays Harbor, Willapa Bay, and the lower Columbia River.

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

2.3.12 References

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Title 14, California Code of Regulations. Title 14, Section 158, California Code of Regulations: DFG 158, October 1989.

3.0 REFERENCE POINTS AND MANAGEMENT FRAMEWORK

3.1 Optimum Yield

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

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

OY for a CPS stock is defined to be the level of harvest which is less than or equal to ABC estimated using an ABC control rule, consistent with the goals and objectives of this FMP, and used by the Council to manage the stock. In practice, OY is determined with reference to ABC. As necessary additional OY considerations (economic, social, and ecological) will be used to set ACLs, ACTs, and/or HGs on an annual or multi-year basis. In particular, OY will be set less than OFL/ABC to the degree required to prevent overfishing.

3.2 Definition of Overfishing Limits, MSY, and OFL and ABC Control Rules

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

3.3 Definition of Overfishing

Overfishing occurs whenever a stock or stock complex is subjected to a level of fishing mortality or annual total catch that jeopardizes the capacity of a stock or stock complex to produce MSY on a continuing basis. The definition of overfishing is in terms of a fishing mortality or exploitation rate. In general, overfishing criteria for CPS are based on MSY or MSY proxy harvest rates applied to the best available estimate of biomass. In cases where biomass estimates or stock distributions include portions of the population in foreign waters, a DISTRIBUTION term will be used to estimate the percentage of the population in U.S. EEZ.

Overfishing in the CPS fishery is "approached" whenever projections indicate overfishing will occur within two years. Depending on the exploitation rate, overfishing can occur when CPS stocks are at either high or low abundance levels. The Council must take action to eliminate overfishing when it occurs and to avoid overfishing when exploitation rates approach the overfishing level.

In operational terms, overfishing occurs in the CPS fishery whenever catch exceeds the overfishing limit (OFL); an annual amount of catch. This annual amount of catch corresponds to the estimate of MSY fishing mortality on an annual basis.

3.4 Definition of an Overfished Stock

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

3.5 Rebuilding Programs

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

Rebuilding programs for CPS are an integral part of general control rule for actively managed stocks but may be developed or refined further in the event that biomass of a CPS stock reaches the overfished level.

3.6 Harvest Control Rules

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

The use of harvest control rules for actively managed stocks is 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 harvest control rules, a definition of overfishing and a definition of an overfished stock.

Along with preventing overfishing, the main use of control rules for the monitored stocks is to help gauge the need for active management. Harvest control rules and harvest policies for monitored CPS stocks may be more generic and simple than those for actively managed stocks with significant fisheries. Any stock supporting catches approaching the ABC levels should be actively managed unless there is too little information available or other practical problems.

In 2011, Amendment 13 to the CPS FMP was adopted to ensure the FMP was consistent with new aspects of the advisory guidelines published at 50 CFR 600.310 with respect to a process for setting ACLs and accountability measures (AMs). Amendment 13 modified management measures to include the specification of new reference points such as ACLs. This included the process for annually setting ACLs and associated AMs, as well as other provisions for preventing overfishing, such as the potential of setting ACTs.

The formulas established by Amendment 13 for actively managed species such as Pacific sardine and Pacific mackerel are shown below.

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

The OFL is an annual catch amount that corresponds to the estimate of (annual) MSY fishing mortality. The OFL is expressed in terms of numbers or weight of fish; overfishing occurs if catch exceeds the OFL. For Pacific sardine the OFL is based on a MSY proxy harvest rate, determined by the best available scientific information, applied to the best available estimate of biomass. Additionally, because a portion of the sardine population is in foreign waters, the OFL is adjusted using a DISTRIBUTION to estimate the percentage of the population in the U.S. EEZ.

The ABC is a harvest specification set below the OFL and is a threshold that incorporates a scientific uncertainty buffer against overfishing (i.e., exceeding the OFL). The ABC is decided by the Council based on its preferred level of overfishing risk aversion. The ABC incorporates a percentage reduction of the OFL selected according to an SSC determination on scientific uncertainty and a risk policy determined by the Council. In cases where scientific uncertainty (σ) associated with estimating an OFL is quantified by the SSC, the percentage reduction that defines the scientific uncertainty buffer and the ABC can be determined by translating the estimated σ to a range of probability of overfishing (Pstar) values. After the Council decides on its level of preferred risk (Pstar) that value is matched to its corresponding BUFFER fraction. The BUFFER fraction then is applied to the OFL according to the ABC control rule.

An ACL is the level of annual catch of a population or population complex that is set to help prevent overfishing from occurring and, if met or exceeded, that triggers accountability measures such as a closure of the fishery or a review the management strategy of the fishery. The Pacific sardine fishery is managed to keep total catch from all sources below the ACL. ACLs are set no higher than ABC, and the HG cannot exceed the ACL or ABC. In cases where the result of the HG formula exceeds the ABC value, the Council will set a lower ACL, HG, or ACT in response. Along with optimum yield (OY) considerations, an HG or ACT may be utilized below an ACL or sector-specific ACL to account for management uncertainty, discard or bycatch mortality and

research take. These provisions will be considered on an annual basis in response to changing resource status and fishery dynamics.

Along with the setting of HGs or ACTs below the ACL, accountability measures (AMs) are in place, such as inseason management controls and post-season review processes, to prevent ACLs from being exceeded and to correct or mitigate overages of the ACL if they occur.

To some extent, the previously existing HG control rules for actively managed species also merge scientific uncertainty and OY considerations thereby providing additional reductions from OFL levels. Therefore, HG control rules are considered in conjunction with ABC control rules to prevent overfishing (see Section 4.6).

For monitored stocks, Amendment 13 maintained the previously existing harvest control rules but modified them so as to specify the new necessary management reference points. Amendment 13 stated that for the monitored finfish stocks (Northern anchovy [northern and central subpopulations] and jack mackerel) the OFL would be based on existing species-specific MSYs, if previously specified, or other MSY proxies. The existing 75 percent reduction buffer in the ABC control rule (ABC equals 25 percent of MSY) would remain in use until recommended for modification by the Council's Scientific and Statistical Committee (SSC) based on best available science and approved by the Council (below). ABCs are further reduced based on estimated resident stock size in U.S. waters. ACLs would be specified for multiple years until such time as the species becomes actively managed or new scientific information becomes available.

Default control rules for CPS Finfish Monitored Stocks:

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

Reference points for monitored CPS stocks are difficult to determine due to limited data to estimate biomass and productivity, however current landings of CPS finfish monitored stocks are extremely low. While landings remain low, the stock remains in the monitored category, ACLs are specified for multiple years, and stock status is assessed infrequently; any stock supporting catches approaching or exceeding the ACL levels will be reviewed to see if they should be moved to active management.

The default control rules and overfishing specifications are generally used for these monitored stocks. Stock specific MSY proxies, ABC, and ACLs can be revised based on the best available science as recommended by the SSC and as adopted through the annual harvest specification process, and will be reported in the CPS SAFE.

3.6.1 General Harvest Guideline/Harvest Control Rule for Actively Managed Species

The general form of the harvest control rule used for actively managed CPS fisheries was designed to continuously reduce the exploitation rate as biomass declines. The general formula used is:

HG = (BIOMASS-CUTOFF) x FRACTION

where HG is the harvest target level, CUTOFF is the lowest level of estimated biomass at which directed harvest is allowed, and FRACTION is the fraction of the biomass above CUTOFF that can be taken by the fishery. The BIOMASS is generally the estimated biomass of fish age 1+ at the beginning of the fishing season. The purpose of CUTOFF is to protect the stock when biomass is low. The purpose of FRACTION is to specify how much of the stock is available to the fishery when BIOMASS exceeds CUTOFF. It may be useful to define any of the parameters in this general harvest control rule, so they depend on environmental conditions or stock biomass. Thus, the harvest control rule could depend explicitly on the condition of the stock or environment.

The formula generally uses the estimated biomass for the whole stock in one year (BIOMASS) to set harvest for the entire stock in the following year (HG), although projections or estimates of BIOMASS, index of abundance values, or other data may be relied upon as well. The BIOMASS represents an estimate and thus is subject to some amount of uncertainty. For example, recent CPS stock assessments resulted in coefficients of variation associated with terminal biomass estimates of roughly 30%. It is important to note that scientific uncertainty around biomass estimates (stock assessment error) was accounted for in the current Pacific sardine harvest guideline rule.

The general harvest control rule for CPS (depending on parameter values) is compatible with the MSA and useful for related species that are important as forage. If the CUTOFF is greater than zero, then the harvest rate (HG/BIOMASS) declines as biomass declines. By the time BIOMASS falls as low as CUTOFF, the harvest rate is reduced to zero. The CUTOFF provides a buffer of spawning stock that is protected from fishing and available for use in rebuilding if a stock becomes overfished. The combination of a spawning biomass buffer equal to CUTOFF and reduced harvest rates at low biomass levels means that a rebuilding program for overfished stocks may be defined implicitly. Moreover, the harvest rate never increases above the FRACTION. If the FRACTION is approximately equal to F_{MSY}, then the harvest control rule harvest rate will not exceed F_{MSY}. In addition to the CUTOFF and FRACTION parameters, a maximum harvest level parameter (MAXCAT) was established so that total harvest specified by the general formula never exceeds the 200,000 mt. The MAXCAT is used to protect against extremely high catch levels due to errors in estimating biomass, to reduce year-to-year variation in catch levels, and to avoid overcapitalization during short periods of high biomass and high harvest. Also, the MAXCAT distributes the catch from strong year classes across a wider range of fishing seasons.

Other general types of control rules may be useful for CPS and this FMP does not preclude their use as long as they are compatible with National Standards and the MSFCMA.

3.6.2 Harvest Guideline Control Rule for Pacific Sardine

The harvest control rule for Pacific sardine sets an HG for the U.S. fishery based on an estimate of biomass for the whole sardine stock, a minimum biomass threshold (CUTOFF) equal to 150,000 mt, a harvest FRACTION between 5% and 15% (depending on oceanographic conditions as described below), and maximum allowable catch (MAXCAT) of 200,000 mt (PFMC 1998). The

U.S. HG is calculated from the target harvest for the whole stock by prorating the total HG based on 87% DISTRIBUTION of total biomass in U.S. waters, e.g.:

HG= (BIOMASS – CUTOFF) • FRACTION • DISTRIBUTION

Harvest FRACTION depends on recent ocean temperatures, because sardine stock productivity is typically higher under ocean conditions associated with warm water temperatures. An estimate of the relationship between F_{MSY} for sardine and ocean temperatures is:

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

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

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

In February 2013, the Council and the NOAA Southwest Fisheries Science Center convened a workshop of experts to re-visit parameters of Pacific sardine harvest control rule. The workshop participants found that the California Cooperative Oceanic Fisheries Investigations (CalCOFI) temperature series provides a better relationship to sardine productivity than the SIO temperature series. Subsequently, the council initiated a process to use the CalCOFI temperature index in sardine management. The Council was able to use the new temperature series and revised Fmsy relationship to determine the OFL ad ABC at the April 2014 meeting. However, using the new temperature and temperature relationship in the HG control rule required a different process, under the framework of the CPS FMP. Council and NMFS staff, along with the CPSMT, developed a draft environmental assessment, with final Council action scheduled for the November 2014 meeting. That would allow the Council to use the revised HG control rule when it sets annual sardine management measures at its April 2015 meeting. The revised Fmsy relationship under consideration at the September and November 2014 Council meetings is:

$$F_{MSY} = -18.46452 + 3.25209\ (T) - 0.19723(T^2) + 0.0041863(T^3)$$

The Council also considered adjusting the harvest FRACTION range to something other than 5%-15%, in order to provide the same harvest policy approach toward Pacific sardine that has been employed under the CPS FMP. Alternative FRACTION ranges considered included 0%-20%, 5%-20%, and 10%-20%. The Council took final action in November 2014, and adopted a harvest FRACTION range of 5%-20%.

3.6.3 Harvest Control Rule (Harvest Guideline (HG) rule) for Pacific Mackerel

The HG control rule for Pacific mackerel sets the CUTOFF and the definition of an overfished stock at 18,200 mt and the FRACTION at 30%. Overfishing is defined as any fishing in excess of the OFL calculated using the OFL control rule. No MAXCAT is defined, given the U.S. fishery appears to be limited by markets and resource availability to about 40,000 mt per year; however,

in the event landings increase substantially, then the need for such a cap should be revisited. The target harvest level is defined for the entire stock in Mexico, Canada, and U.S. waters (i.e., not just the U.S. portion), and the U.S. target harvest level is prorated based on 70% relative abundance in U.S. waters.

3.6.4 Default CPS Control rule and Monitored Stocks

Northern anchovy (northern and central subpopulations), jack mackerel and market squid are currently classified under monitored status in CPS FMP. The Council may use the default harvest control rule (ABC = OFL*0.25) for setting ABC for Monitored species unless a better species-specific rule is available, as is the case for market squid. The default harvest control rule can be modified under framework management procedures.

3.3.5.1 Northern Anchovy-Central Subpopulation

The central subpopulation of northern anchovy ranges from approximately San Francisco, California, to Punta Baja, Mexico. The OFL or ABC is prorated by the DISTRIBUTION of the stock in U.S. waters to arrive at ABC in U.S. waters. In November 2010, the Council adopted an ABC and ACL both equal to 25,000 mt.

3.3.5.2 Northern Anchovy-Northern Subpopulation

The northern subpopulation of northern anchovy ranges from San Francisco north to British Columbia, with a major spawning center off Oregon and Washington that is associated with the Columbia River plume. The northern subpopulation supports small but locally important bait and human consumption fisheries. Northern anchovy is an important source of forage to local predators, including depleted and endangered salmonid stocks.

Additionally the portion of the northern subpopulation of northern anchovy resident in U.S. waters is unknown. It is likely that some biomass occurs in Canadian waters off British Columbia. In November 2010, the Council adopted an ABC and ACL both equal to 9,750 mt.

3.3.5.3 Jack Mackerel

The MSY level for jack mackerel is calculated by age/area from mid-range potential yield values. OFL or ABC in U.S. waters is prorated according to the DISTRIBUTION of the stock in U.S. waters (65 percent). In November 2010, the Council established an ABC and an ACL both equal to 31,000 mt.

3.3.5.4 Market Squid

The MSY Control Rule for market squid is founded generally on conventional spawning biomass "per recruit" model theory. Specifically, the MSY Control Rule for market squid is based on evaluating (throughout a fishing season) levels of egg escapement associated with the exploited population. The estimates of egg escapement are evaluated in the context of a "threshold" that is believed to represent a minimum level that is considered necessary to allow the population to maintain its level of abundance into the future (i.e., allow for "sustainable" reproduction year after year). In practical terms, the Egg Escapement approach can be used to evaluate the effects of

fishing mortality (F) on the spawning potential of the stock, and in particular, to examine the relation between the stock's reproductive output and candidate proxies for the fishing mortality that results in MSY (F_{MSY}).

The fishing mortality (F_{MSY}) that results in a threshold level of egg escapement of at least 30 percent is used as a proxy for MSY. However, it is important to note that the level of egg escapement is reviewed periodically, as new information becomes available concerning the dynamics of the stock and fishery, to ensure that the threshold meets its objective as a long-term, sustainable biological reference point for this marine resource. This is not a trivial exercise, given the need for ongoing research regarding the biology of this species, which may result in revised recommendations in the future. Current studies include developing an aging program, sampling reproductive status of squid landed in the fishery, and a collaboration with industry to develop a long-term index of paralarval abundance. The market squid fishery operates within the constraints of currently adopted regulations of the MSFMP (e.g., annual landings cap, weekend closures, closed areas, limited entry), and also monitored by NMFS, as long as egg escapement is equal to, or greater than, the threshold value. In the event that egg escapement is determined to be below the 30 percent threshold for two successive years, then a point-of-concern would be triggered under the FMP's management framework, and the Council could consider moving market squid from Monitored to Active management status. Current state regulations for squid are not anticipated to change in the near future, however, should existing laws limiting effort or harvest be rescinded, further management actions by the Council could also be considered. In November 2010, the Council adopted an ABC proxy of Fmsy resulting in egg escapement ≥ 30%. Recent research has provided new information regarding squid egg escapement (see Dorval et al 2013).

3.7 Annual Specifications and Announcement of Harvest Levels

Each year, the Secretary will publish in the *Federal Register* the final specifications for all CPS Actively managed by the Council. The total U.S. harvest will be allocated to the various fisheries as ACLs, HGs or ACTs, or as quotas.

In calculating ACLs, ACTs, HGs and quotas for each species, an estimate of the incidental catch of each species caught while fishermen are targeting other species will be taken into account. Therefore, the total HG will consist of an incidental catch portion and a directed fishery portion. In general, HGs or ACTs will be used to describe direct and incidental commercial fishery take, will be set in accordance with harvest control rules, and may be below the ACL to take into account management uncertainty and additional known sources of mortality such as recreational harvest, discards, bycatch, research take, and live bait fisheries. This will be done to minimize the chances of exceeding the target harvest levels and the ACL.

If the HG, ACL, or ACT for the directed fishery is reached the directed fishery will be closed by an automatic action and incidental catch will continue to be allowed under the incidental catch allowance, which is expressed in an amount of fish or a percentage of a load (Section 5.1). If the estimated incidental catch portion of the HG, ACL, or ACT has been set too high, resulting in the probability of not attaining the target harvest level by the end of the fishing season, the remaining incidental catch portion may be allocated to the directed fishery through the "routine" management procedures. This reallocation of the remaining incidental catch portion of the HG to the directed

fishery is not likely to be necessary unless substantial errors are discovered in calculations or estimates.

3.7.1 General Procedure for Setting Annual Specifications

The intent of the management approach under the FMP is to reassess the status of each Actively managed species at frequent intervals and preferably every year (although a full analytic stock assessment may not be necessary or possible in some cases). The general procedure for making the annual specifications for CPS is as follows:

1. The CPSMT will produce a SAFE report that documents the current estimates of biomass for each CPS assessed and status of the fishery. In the report, the CPSMT will include the most recent harvest specifications and the stock assessment used to inform harvest specifications.

2. The Council will review all information compiled for the annual specifications, consider recommendations of the SSC, CPSMT, CPSAS; and will hear public comments. The Council also will review any important social and economic information at that time, then make a recommendation to the NMFS Regional Administrator on the final specifications, including OFL, ABC, OY levels, ACLs, ACTs, HGs, quotas, allocations, and other management measures for the fishing season.

3. Following the Council meeting, the NMFS Regional Administrator will make a determination of the final specifications. This determination will be published in the *Federal Register* with a request for additional public comment.

4. Alternate Procedure: If assessment and season schedules warrant, the NMFS Regional Administrator may make preliminary harvest specifications quickly (without prior discussion at a Council meeting) to allow fishing to begin without delay. As soon as practicable, the Council will review all background documents contributing to the determination of the biomass estimates and make a final recommendation for the resulting target harvest level, HGs and quotas. Following the meeting of the Council, the NMFS Regional Administrator will consider all comments and make a determination of whether any changes in the final specifications are necessary. If such changes are warranted, they will be published in the *Federal Register*.

   The intention of the proposed regulations is to have public review of and a Council recommendation on the estimated biomass and HGs before the fishing season begins; however, the NMFS Regional Administrator is not precluded from announcing the HGs in the *Federal Register* before the process is completed so that fishermen can plan their activities and begin harvesting when the fishing season begins.

   If assembling the data and producing a report would require enough time that permitting a complete public review before the beginning of the fishing season could reduce the season, then this alternate procedure should be used.

5. NMFS and the west coast states will monitor the fishery throughout the year, tracking incidental catch, ACTs, and HGs and quotas. If an HG or quota for any species is or is likely

to be reached prematurely, a "point of concern" may occur, triggering a possible review of the status of the stock. If the directed harvest portion of an ACT or ACL, HG, or quota is reached, then directed fishing will be prohibited and the pre-specified incidental trip limit will be imposed as an automatic action through publication of a notice in the *Federal Register*.

3.8 Section References:

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

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

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

4.0 Bycatch and Discard Mortality

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

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

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

CPS vessels fish with roundhaul gear (purse seine or lampara nets). These are encircling type nets, which are deployed around a school of fish or part of a school. When the school is surrounded, the bottom of the net may be closed, then the net drawn next to the boat. The area including the free-swimming fish is diminished by bringing one end of the net aboard the vessel. When the fish are crowded near the fishing vessel, pumps are lowered into the water to pump fish and water into the ship's hold. Another technique is to lift the fish out of the net with netted scoops (e.g., stocking brails). Roundhaul fishing results in little unintentionally caught fish, primarily because the fishermen target specific schools, which usually consists of one species. CPS typically school with similarly sized fish. The most common incidental catch in the CPS fishery is another coastal pelagic species (e.g., Pacific mackerel incidental to the Pacific sardine fishery). If larger fish are in the net, they can be released alive before pumping or brailing by lowering a section of the cork-line or by using a dip-net. The load is pumped out of the hold at the dock, where the catch is weighed and incidentally-caught fish can be observed and sorted. Because pumping at sea is so common, any incidental catch of small fish would not be sorted at sea. Grates can be used to sort larger non-CPS from the catch. Grates are mandatory in Oregon to sort larger non-CPS from the catch. At-sea observers have recorded discard at one time or another since the year 2000 off the states of Oregon, Washington, and California. Incidental harvest of non-prohibited larger fish are often taken home for personal use or processed.

Historically, market squid have been fished at night with the use of powerful lights, which cause squid to aggregate, allowing fishermen to pump squid directly from the sea or to encircle them with a net. California actively manages the market squid fishery in waters off California and has developed an FMP for the state-managed fishery. Management measures pertinent to bycatch include

Establishing a prohibition on use of lights in Gulf of the Farallones National Marine Sanctuary to eliminate the potential of future negative interactions with seabirds.

Additionally, several circumstances in the fishery tend to reduce bycatch:

1. Most of what would be called bycatch under the MSA is caught when roundhaul nets fish in shallow water over rocky bottom. Fishermen try to avoid these areas to protect their gear. Also, they may be specifically prohibited to fish these areas because of closures.
2. South of Pt. Buchon, California, many areas are closed to roundhaul nets under California law and the FMP, which reduces the chance for bycatch.

3. In California, a portion of the sardine caught incidentally by squid or anchovy harvesters can be sold.
4. A provision in the CPS FMP allowing landings of less than five tons without a LE permit should reduce an regulatory discard, because those fish can be landed without penalty.
5. From 1996 to 2003, bycatch from the live bait logs was reported with an incidence of 10%. The primary species taken as incidental catch was barracuda. Virtually all fish caught incidentally in this fishery are either used for bait, for personal use, or released alive. (See Table 4-11).
6. CDFW's logbook program for the squid fishery collects data including bycatch.

4.1 Federal Protection Measures

The National Marine Fisheries Service regularly conducts Endangered Species Act (ESA) section 7 consultations to ensure that federally threatened or endangered species are not adversely affected by federally managed fisheries. Since 1999, the NMFS Sustainable Fisheries Division (SFD) Southwest Region/West Coast Region has conducted numerous formal and informal consultations with Federal agencies, including the NMFS Protected Resource Division (PRD) and U.S. Fish and Wildlife Service (USFWS) regarding CPS fisheries. In all informal consultations the PRD concurred with the SFD, that the CPS fishery is not likely to adversely affect protected resources. In all formal consultations on the Pacific sardine fishery specifically, no jeopardy determinations were made.

Most recently, the NMFS SWR Sustainable Fisheries Division initiated a formal Section 7 consultation with NMFS SWR Protected Resources Division (PRD) on the continued management and prosecution of the Pacific sardine fishery. PRD completed a formal Section 7 consultation on this action and in a biological opinion (BO) dated December 21, 2010, determined that fishing activities conducted under the CPS FMP and its implementing regulations are not likely to jeopardize the continued existence of any endangered or threatened species under the jurisdiction of NMFS or result in the destruction or adverse modification of critical habitat of any such species. Specifically, the current status of the Lower Columbia River Chinook, Snake River Fall Chinook, Upper Willamette Chinook, Puget Sound Chinook, Lower Columbia River coho and Oregon coast coho, were deemed not likely to be jeopardized by the Pacific sardine fishery. Additionally, NMFS determined that the potential for direct incidental take of other ESA-listed salmon, marine mammals, sea turtles, green sturgeon, abalone, or steelhead, through the harvest of sardines in the purse seine fishery was discountable, and the potential indirect adverse effects of sardine harvest on ESA-listed species were insignificant.

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

reporting requirements and conservation measures were implemented within the CPS FMP to provide further protection for southern sea otters.

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

1. CPS fishing boat operators and crew are prohibited from deploying their nets if a southern sea otter is observed within the area that would be encircled by the purse seine.
2. If a southern sea otter is entangled in a net, regardless of whether the animal is injured or killed, such an occurrence must be reported within 24 hours to the Regional Administrator, NMFS West Coast Region.
3. While fishing for CPS, vessel operators must record all observations of otter interactions (defined as otters within encircled nets or coming into contact with nets or vessels, including but not limited to entanglement) with their purse seine net(s) or vessel(s). With the exception of an entanglement, which will be initially reported as described in #2 above, all other observations must be reported within 20 days to the Regional Administrator.

4.1.1 California Coastal Pelagic Species Pilot Observer Program

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

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

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

Potential future needs of any CPS observer program include: standardization of data fields, development of a fishery-specific Observer Field Manual, construction of a relational database for

the observer data, and creation of a statistically reliable sampling plan. A review of the protocol and catch data by NMFS Southwest Science Center staff, the CPS Management team and other CPS interested parties is planned in the future to help address some of these needs.

4.2 Fishery South of Pigeon Point

Information from at-sea observations by the CDFW and conversations with CPS fishermen suggest that bycatch south of Pigeon Point is not significant in these fisheries. However, some individuals have expressed concern that game fish and salmon might constitute significant bycatch in this fishery. This is a reasonable concern, because anchovy and sardine can be forage for these predators, but there are no data to confirm significant bycatch of these species. CDFW port samples indicate minimal incidental catch in the California fishery (Tables 4-5). The behavior of predators, which tend to dart through a school of prey rather than linger in it, and can more easily avoid encirclement with a purse seine, may help to minimize bycatch.

CDFW port samplers collect information from CPS landings in Moss Landing and ports to the south. Biological samples are taken to monitor the fish stocks, and port samplers report incidentally caught fish. Reports of incidental catch by CDFW port samplers confirm small and insignificant landings of bycatch at California off-loading sites (Tables 4-5). These data are likely representatives of actual bycatch, because (as noted) fish are pumped from the sea directly into fish holds aboard the vessel. Fishermen do not sort catch at sea or what passes through the pump. Unloading of fish also occurs with pumps. The fish are either pumped into ice bins and trucked to processing facilities in another location, or to a conveyor belt in a processing facility, where fish are sorted, boxed, and frozen.

From 1985 through 1999, there were 5,306 CDFW port samples taken from the sardine and mackerel landings. From 1992 to 1999, incidental catch was reported on only 179 occasions, representing a 3.4 percent occurrence. Up to 1999 reports of incidental catch were sparse, and prior to 1992 none were reported. Earlier incidents of bycatch may not have been noted, because the harvest of anchovy and sardine was small, and only since 1995 did the harvest of sardine increased substantially (see Table 8-1). The incidental catch reported are primarily marketable species that do not meet the definition of bycatch in the MSA. During this period, unless an incidental species represented a significant portion of the load (at least a whole percentage point) the amount of the incidental catch was not recorded. Of the incidental catch reported from 1992 to 1999, the two most prevalent species were market squid at 79 percent, and northern anchovy at 12 percent incidence within samples (not by load composition). CDFW port samples provide useful information for determining the significance of bycatch in the CPS fishery off California (south of Pigeon Point).

In 2001, California wetfish port samplers began tallying undocumented incidental catch observed during landings in greater detail, and listed the occurrence of species in each sampled landing. The port sampling program records bycatch observed (i.e., presence or absence evaluations), but actual amounts of incidental catch have not been quantified to date. In 2011, bycatch data was recorded by estimates of pounds observed in an offload at northern California ports. Offloading facilities in northern California allow observations and estimates of bycatch amounts compared to southern California ports. These observations are summarized in Table 4-5 for the 5 years between 2009 and 2013. The dynamic of the 2008 sardine fishery changed due to a decrease in the annual harvest guideline. Since then, fishing activity no longer takes place year around, but has been truncated

within each allocation period. This may have affected the types and frequencies of organisms observed during the offloading process of sardine. The most commonly occurring flora and fauna in wetfish landings during 2013 were jack mackerel, market squid, kelp, Pacific sanddab, hornyhead turbot, kelp bass, unspecified octopus, Pacific bonito, and California scorpionfish. Fifty-six incidental species were observed in total.

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

4.2.1 Incidental Catch Associated with the Market Squid Fishery

Because market squid frequently school with CPS finfish, mixed landings of market squid and incidentally caught CPS finfish occur intermittently. In 2013, less than one percent of round haul market squid landings (by tonnage) included reported incidental catch of CPS (Table 4-6).

Although non-target catch in market squid landings is considered minimal, the presence of incidental catch (species that are landed along with market squid that are not recorded through landing receipt processes [i.e., not sold] as is typically done for incidentally-caught species) has been documented through CDFW's port sampling program. During 2013, incidental catch consisted of 58 species (Table 4-7). Similar to previous years, most of this catch was other pelagic species, including Pacific sardine and mackerel. However, kelp and jellyfish were also observed frequently.

The extent that market squid egg beds and bottom substrate are damaged by purse seine operations, which may contribute to mortality of early life stages, is not known at this time. One way to determine if nets are disturbing egg beds is to look for egg cases in market squid landings. When market squid egg cases are observed at offloading sites, there are two potential reasons that egg cases may be in the net: 1) market squid released eggs in the net after being captured, or 2) egg cases were taken from the ocean floor during fishing activity. In 2013, market squid egg cases were identified in 6.7 percent of observed landings. Since market squid exude egg cases while in a purse seine net, the observed egg cases need to be collected and aged. If egg cases are more than one day old, then egg cases were likely to have been taken from the bottom. Based on market squid embryo development and the condition of the outside of the egg capsule, determining if the egg case was laid in the net or collected from the bottom is possible.

4.3 Fishery North of Point Arena

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

4.3.1 Oregon

CPS vessels landing in Oregon primarily target Pacific sardine. Oregon's LE sardine permit rules stipulate that an at sea observer be accommodated aboard vessels when requested by ODFW.

ODFW does not have personnel dedicated to observe and document bycatch of non- target species on sardine vessels and available state personnel were unable to conduct onboard observations of any CPS fishery vessels during 2011 through 2013. Also, no federal observers were placed on the vessels. To reduce bycatch, the state requires the use of a grate over the intake of the hold to sort out larger species of fish, such as salmon or mackerel. The grate size spacing can be no larger than 2-3/8 inches between bars. Oregon rules require seine gear logbooks that record incidental catch including salmonids and other species.

In 2010, the Council designated Pacific herring, which occur in waters off all three states, and jacksmelt, which typically occur only in waters off California, as "ecosystem component species" defined in the National Standard 1 guidelines when Amendment 13 to the CPS FMP was adopted (see section 2.2 for more on the status of Amendment 13). The Council also required that incidental catch of these two species continue to be reported in the SAFE document.

2011

Based on logbook records, bycatch of salmonids by the Oregon fleet remained low in 2011 and 49% of the 72 salmon caught were released live. Thus, the incidental catch rate was 0.009 salmon per mt of sardines landed (Table 4-8). Both logbook data (Table 4-9) and fish ticket data (Table 4-10) indicate that other non-target species catch in the sardine fishery remained low and in 2011 was composed entirely of Pacific mackerel. Non-target species catch in the sardine fishery included only 5.2 mt of Pacific mackerel (Table 4-10) with the 8,321 mt of sardines landed. Thus, non- target species accounted for 0.06% of total landings in the 2011 sardine fishery.

In July 2011, one vessel targeted northern anchovy and landed only Pacific sardine as incidental catch, and the quantity of sardine landed was 2.6 mt or 0.03% of targeted sardine catch. For the sardine fishery, no ecosystem component species were landed as incidental catch or recorded in logbooks in 2011 (Tables 4-9 and 4-10).

2012

The bycatch of salmonids reported in logbooks by the Oregon fleet remained at the low levels of recent years. Half (49%) of the 125 salmon reportedly caught were released live. The incidental catch rate was 0.003 salmon per mt of sardines landed (Table 4-8). Large amounts of Pacific mackerel (1,585.8 mt) were landed during the course of the sardine fishery in 2012. Some landings were comprised of 100% Pacific mackerel and likely represented opportunistic targeting when sardines may not have been as readily accessible. Other than Pacific and jack mackerels, both logbook data (Table 4-9) and fish ticket data (Table 4-10) indicate that the catch of other non-target species in the sardine fishery was comprised of Pacific herring (0.35 mt) and a trace amount of shad with the 39,936 mt of sardines landed. Non-target species, including mackerels, accounted for 4% of the sardine fishery landings in 2012.

For ecosystem component species during 2012, a small amount of Pacific herring (0.35 mt) was reported in fish ticket landing records for the sardine fishery. As in 2011, there were no reports of jacksmelt being taken in 2012, based on both fish ticket and logbook records.

2013

As in 2012, the bycatch of salmonids by the Oregon fleet was similar to levels of recent years, according to logbook records (Tables 4-8 and 4-9). Of the 198 salmon reportedly caught, 59% were released live. The incidental catch rate was 0.008 salmon per mt of sardines landed. Both logbook data (Table 4-9) and fish ticket data (Table 4-10) indicate that with the exception of mackerel, other non-target species catch in the sardine fishery remained low. Non-target species catch in the sardine fishery included 435.6 mt of Pacific mackerel, 60.1 mt of jack mackerel, and trace amounts of shad and sablefish (Table 4-10) with the 24,762 mt of sardines landed. Thus, non-target species accounted for 2.0% of total landings in the 2013 sardine fishery.

4.3.2 Washington

From 2000 through 2004, WDFW required fishers to carry at-sea observers, and to provide financial support for this observer effort. Bycatch information was collected in terms of species, amount, and condition; observers noted whether the fish were released or landed, and whether alive, dead, or in poor condition. During the five-year period of the program, overall observer coverage averaged over 25 percent of both total landed catch and number of landings made. Based on observer data, the bycatch of non-targeted species in the Washington sardine fishery was relatively low. Due to low bycatch levels, as well as a WDFW commitment to industry that the observer fee would only be assessed until bycatch in the sardine fishery could be characterized, the mandatory observer program was suspended at the conclusion of the 2004 season. A comparison of logbook and observer data from 2000 to 2004 indicated that logbook data, in general, tended to under report bycatch by 20 to 80 percent (Culver and Henry, 2006). For this reason, salmon bycatch in the Washington sardine fishery for years subsequent to the observer program is calculated by multiplying total sardine catch and the observed five-year average bycatch rates. Bycatch and mortality estimates of incidentally captured salmon by year and species are shown in Table 4-8. The estimated bycatch was 488 fish: 242 Chinook and 246 coho in 2011; 2,116 fish: 1,050 Chinook and 1,067 coho in 2012; and 1,794 fish: 890 Chinook and 904 coho in 2013.

Incidental species caught and reported on Washington fish tickets are shown in Table 4-14. Mackerel, both Pacific and jack, comprise the majority of non-target catch in the sardine fishery. Until recent years incidental catch, other than mackerel, was minimal. In 2011, mackerel was the only non-target catch (0.43 mt). However, in 2012 and 2013 other non-target species were landed and reported on fish tickets. Seven species other than mackerel were recorded in 2012 and consisted of American shad, Chinook, chum, coho, Pacific herring, pink salmon, and spiny dogfish. The non-target catch landed was less than 0.01 mt each, with the exception of Chinook (0.03 mt) and coho (0.29 mt). In 2013, eight non-target species were landed; of these the largest amount, other than mackerel, was Chinook (0.12 mt).

4.4 Section References

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

5.0 SAFETY AT SEA CONSIDERATIONS

The safety of fishing activities is an important management concern. Roundhaul fisheries operating off the Pacific Coast are often limited by environmental conditions, most notably inclement weather. Given that the average age of permitted CPS vessels in the LE fishery is 34 years and many older vessels are constructed of wood, concern has been raised regarding their safety and seaworthiness. Implementing time/area closures or restricting transferability could impact safety by making more difficult to replace an older vessel with a newer, safer vessel; or by promoting fishing during hazardous weather conditions. This concern in part is addressed by Amendment 10 to the CPS FMP (January 2003), which allows LE permits to be transferred to another vessel and/or individual.

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

From 2008 through 2013, the directed Pacific sardine fishery experienced seasonal closures because the period allocation was (in most cases) met prior to the end of that fishing period. The declining trend in HGs, beginning in 2008 have led to a "derby style" fishery where vessels compete for a share of the seasonal harvest guideline over a short period of time. Such derby fisheries can create unsafe conditions, as season duration is compressed and competition increases.

The 2014-2015 ACT (set equal to the ACL of 23,293 mt) is the lowest in more than 10 years, and may contribute to another derby style fishery. In 2012 and 2013, the fishery did not close during the January 1-June 30 and the September 15-December 31 fishing periods, but the July 1-September 14 fishery did close. This may be more likely to occur during the July 1-September 14 fishing period than the January 1-June 30 fishing period, due to the fact that fishing is typically happening coastwide during the summer period, and early inclement weather may restrict the northwest fishery in the fall.

6.0 ECONOMIC STATUS OF WASHINGTON, OREGON, AND CALIFORNIA CPS FISHERIES IN 2011

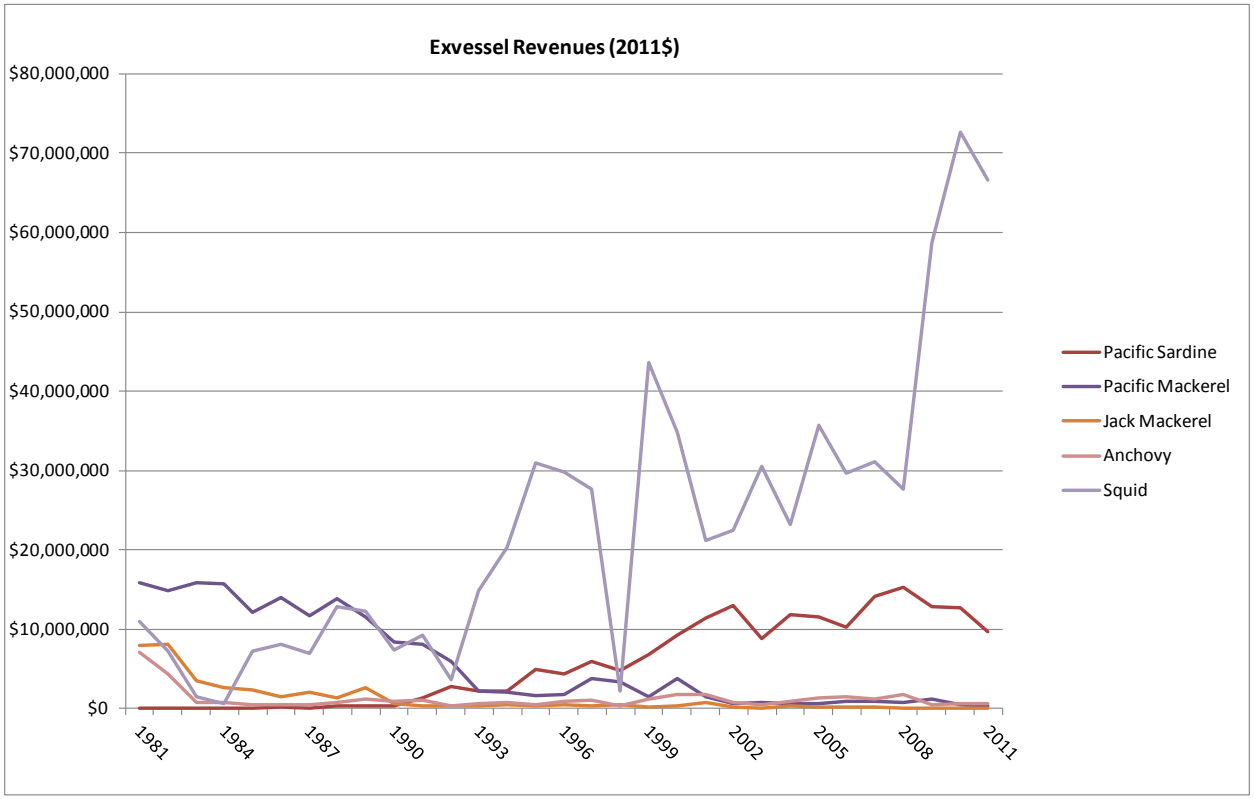
NOTE: This section, including text and figures, will be updated to reflect current data and information relevant to the economic status of CPS fisheries.

This section summarizes economic data presented in Tables 6-1 through 6-5 (Appendix A) and Figures 6-1 through 6-10 (at the end of this section). The tables have been updated, through 2013. However, the narrative in this section is pending. It reflects information through 2011 only. For more up to date information, please refer to Tables 6-1 through 6-5.

Preliminary data shows Washington, Oregon and California landings of CPS totaled 172,580 mt in 2011, a 14 percent decrease from 2010. Market squid landings, all in California, totaled 121,555 mt in 2011, down 7 percent from 2010. Pacific sardine landings of 46,746 mt in 2011 fell 30 percent from 2010 (66,892 mt). The ex-vessel revenue from all CPS landings was $77.3 million in 2011, down 11 percent from 2010 (2010 converted to 2011 dollars).

Market squid accounted for 70 percent and Pacific sardine 27 percent of total west coast, CPS landings in 2011. Landings of Pacific mackerel decreased 35 percent, and landings of northern anchovy rose 119 percent from 2010 to 2011. Real ex-vessel market squid revenues (2011$) decreased 8 percent from 2010. The decrease in market squid landings was accompanied by a 1 percent decrease in ex-vessel price from $555 to $548 per mt (2011$). There was a 28 percent decrease in aggregate CPS finfish landings from 2010; ex-vessel revenue decreased by 22 percent. In 2011, market squid accounted for slightly more than 11 percent of total west coast ex-vessel revenues, and CPS finfish accounted for almost 2 percent. Washington, Oregon and California shares of total west coast CPS landings in 2011 were 5 percent, 6 percent and 89 percent respectively.

California sardine landings were 27,714 mt in 2011 down 18 percent from 2010, 33,659 mt. Market squid again ranked first in ex-vessel revenue generated by California commercial fisheries in 2011, with ex-vessel revenue of $66.6 million, $17.2 million greater than that for Dungeness crab in second place. Landings of Pacific sardine ranked seventh highest in California ex-vessel revenues in 2011 at $4.4 million. California Pacific mackerel landings were 1,357 mt in 2011, down 34 percent from 2010. California landings of Northern anchovy were 2,601 mt in 2011, up 93 percent from 2010.



Oregon's landings of Pacific sardine decreased 47 percent in 2011, from 20,852 mt to 11,023 mt. Sardine generated $3.2 million in ex-vessel revenue for Oregon in 2011, 2 percent of the state's total ex-vessel revenues, ranking it eighth behind Dungeness crab in total ex-vessel revenues. Washington landings of Pacific sardine decreased 35 percent from 12,381 mt in 2010 to 8,009 mt in 2011. With ex-vessel revenue less than 1 percent of the Washington total in 2011, sardine ranked 15th behind Dungeness crab in ex-vessel value.

Oregon landings of Pacific mackerel decreased from 49 mt in 2010 to 7 mt in 2011, and anchovy landings fell from 138 mt to 21 mt. In Washington there were no landings of Pacific mackerel in 2010 and anchovy landings rose from 120 mt to 188 mt.

In 2011, there were 148 vessels with west coast landings of CPS finfish, unchanged from 2010. With no change in the number of vessels and a decrease in total CPS finfish landings, finfish landings per vessel, 345 mt in 2011, decreased 27 percent from 2010. Of the vessels landing CPS finfish in 2011, 17 percent depended on CPS finfish for the greatest share of their 2011 ex-vessel revenues. From 2010 to 2011, the number of vessels with west coast landings of market squid increased from 159 to 167, with 60 percent of these vessels dependent on market squid for the largest share of their total 2011 exvessel revenue. Market squid landings were 727 mt per vessel in 2011, down 11 percent from 2010. Market squid total exvessel revenue shares for vessels that depend mainly on market squid, and finfish total ex-vessel revenue shares for vessels that depend mainly on CPS finfish have averaged about 80 percent and 77 percent respectively per vessel since 2000. Roundhaul gear accounted by far for the largest share of total CPS landings and ex-vessel revenue by gear type in 2011, dip net gear was a far distant second.

The major west coast processors and buyers of CPS finfish are concentrated in the Los Angeles, Santa Barbara-Ventura, Monterey and the Columbia River port areas of Oregon and Washington. The ex-vessel markets for market squid are mainly in the Los Angeles, Santa Barbara-Ventura and Monterey port areas.

In 2011, 130,064 mt of market squid were exported through west coast customs districts with an export value of $178.5 million; a 10 percent increase in quantity, and a 23 percent increase in value of west coast market squid exports from 2010. Exports exceeded domestic landings by 8,509 mt in 2011 indicating that they included inventories from previous years. The primary country of export was China, 58 percent of the total, which received 75,659 mt, down 11 percent from the quantity exported to China in 2010. Over 80 percent of market squid exports went to China and five additional countries: Philippines (11,133 mt), Spain (7,170 mt), Viet Nam (5,458 mt), Japan (5,539 mt), and Hong Kong (3,245 mt). Domestic sales were generally made to restaurants, Asian fresh fish markets or for use as bait.

In 2011, 40,693 mt of sardines were exported through west coast customs districts down 30 percent from 2010. Sardine exports were valued at $34.8 million in 2011, down 21 percent from 2010. Japan was the primary export market in 2011, receiving 4,212 mt, a 49 percent decrease in its imports from 2010, and representing 23 percent of total west coast sardine exports in 2011. Thailand was second with 6,877 mt, 17 percent of the total a 56 percent decrease from 2010, followed by China, Australia and Russia. Together these five countries accounted for over 60 percent of total west coast sardine exports in 2011.

Figure 9-1. Annual west coast landings and real exvessel revenues (2011$) for all CPS species, 1981-2011.

Figure 9-2. Percentage contribution of west coast CPS finfish and market squid landings to the total exvessel value of all west coast landings, 1981-2011.

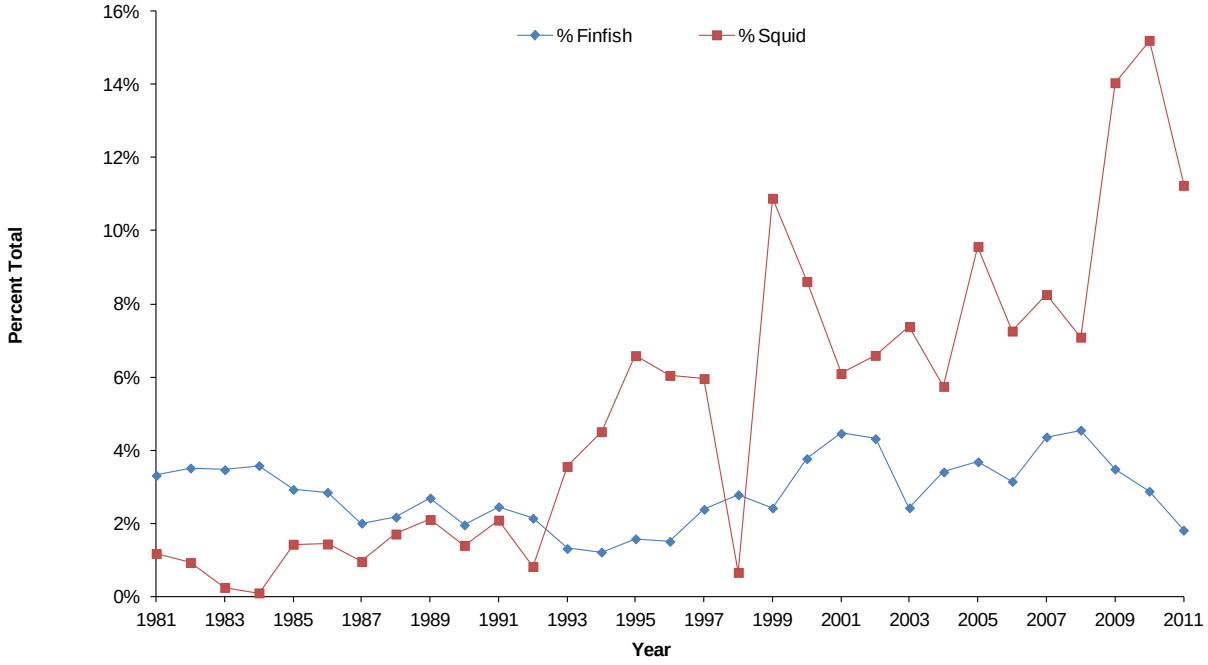


Figure 9-3. West coast CPS finfish landings and real exvessel price ($/lb, 2011$), 1981-2011.

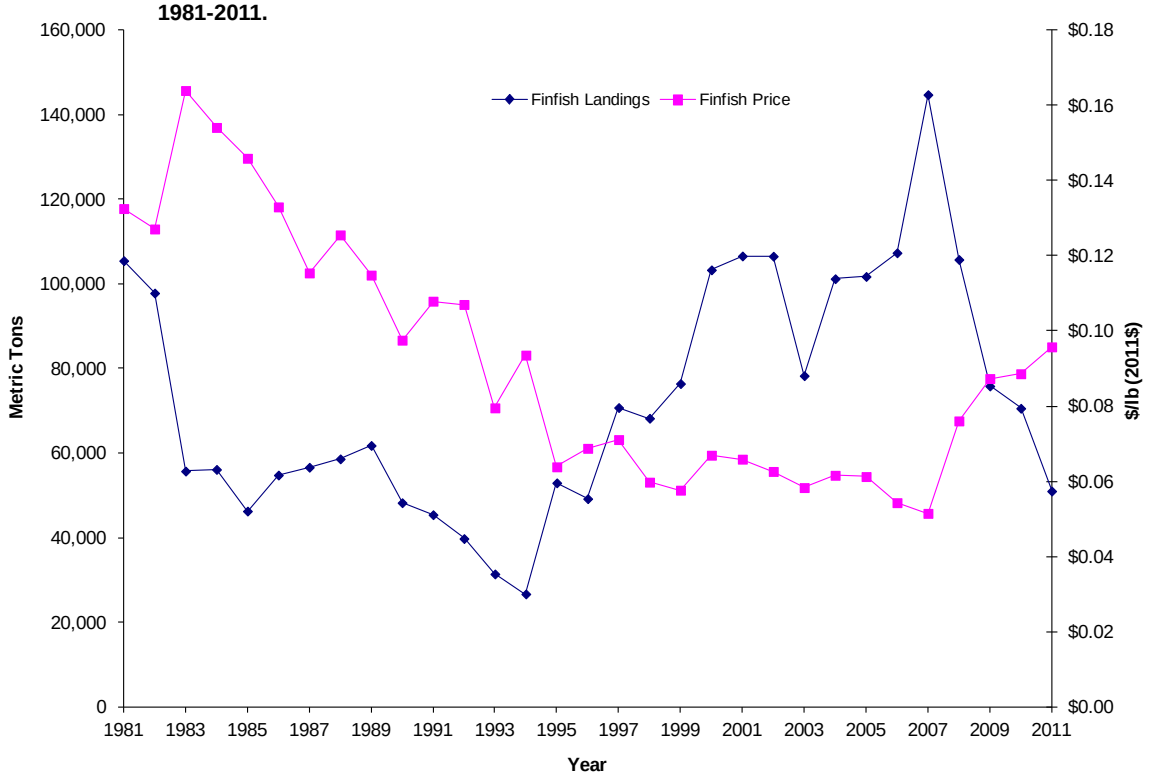


Figure 9-4. West coast market squid landings and real exvessel price ($/lb, 2011$), 1981-2011.

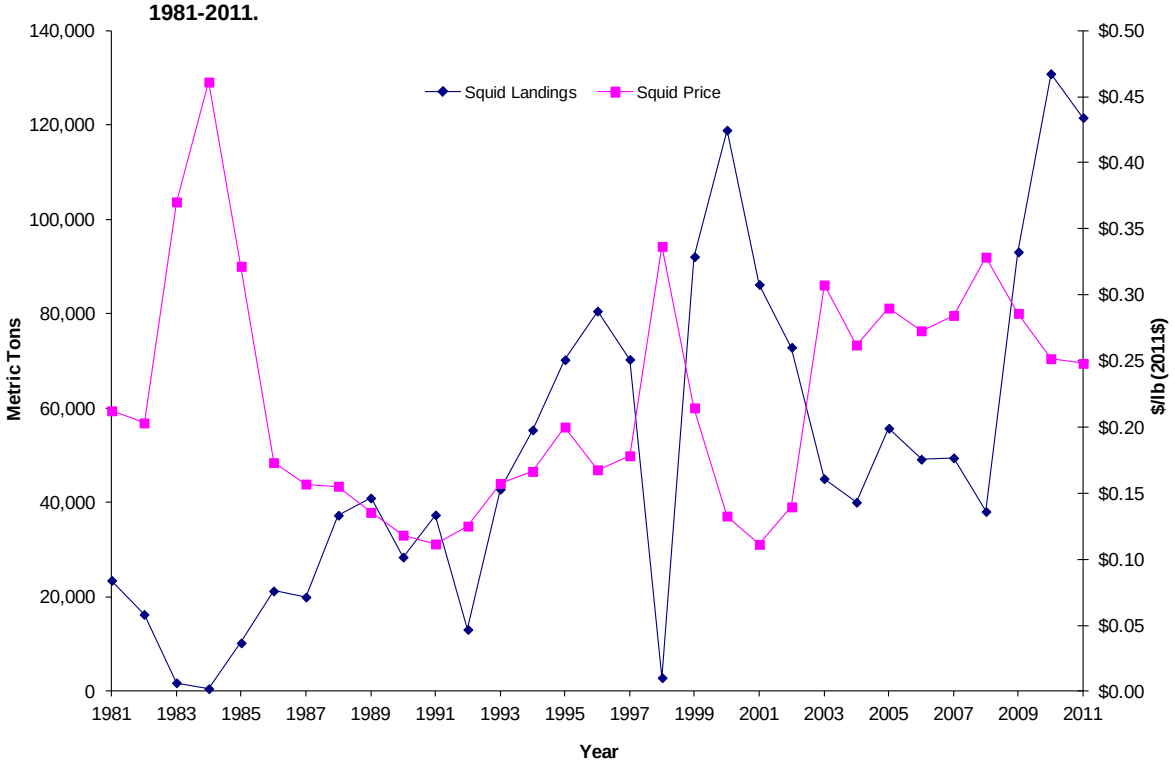
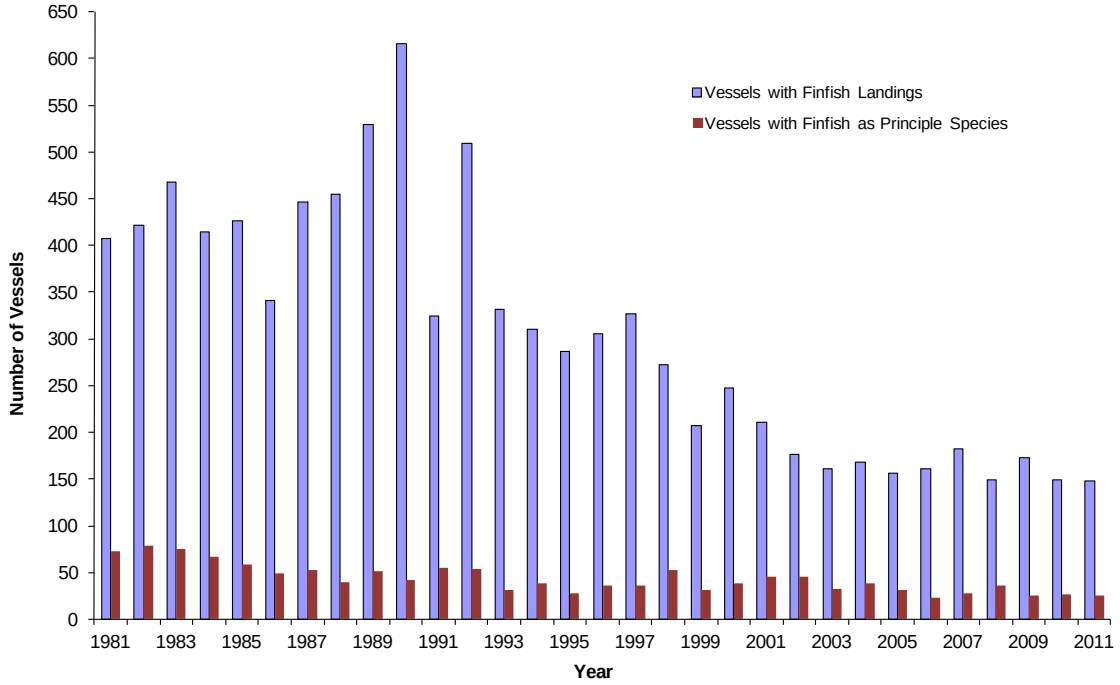
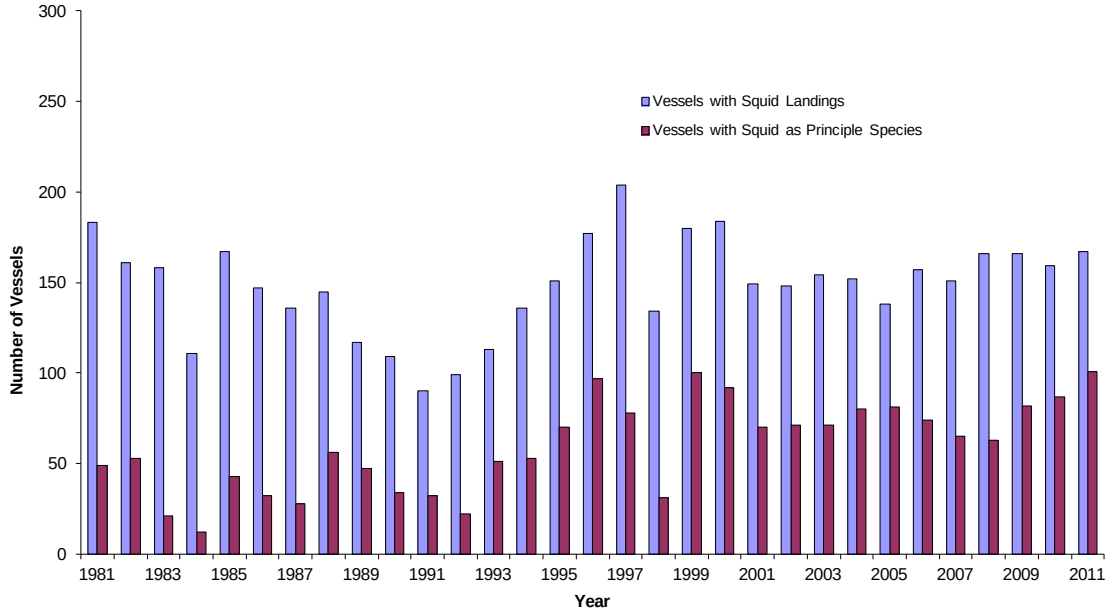


Figure 9-5. Number of vessels with west coast landings of CPS finfish, and number for which CPS finfish was the principle species, 1981-2011.



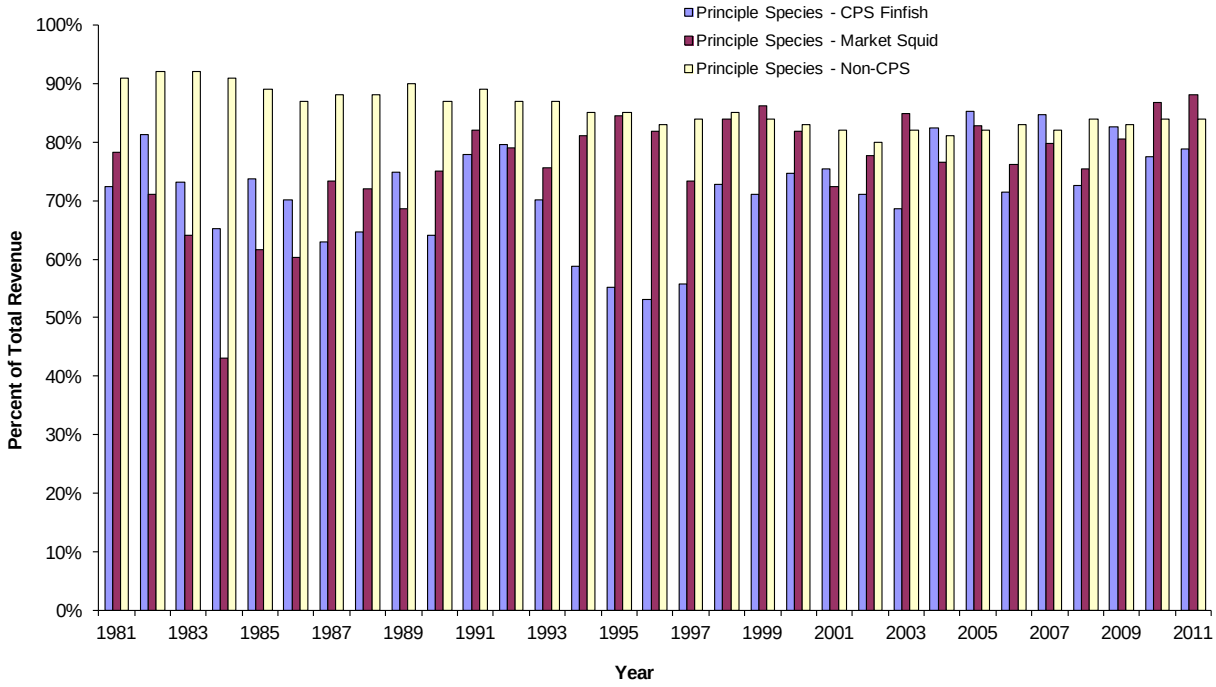
Note: The principle species accounts for the largest share of the vessel's annual exvessel revenue.

Figure 9-6. Number of vessels with west coast landings of market squid, and number for which market squid was the principle species, 1981-2011.



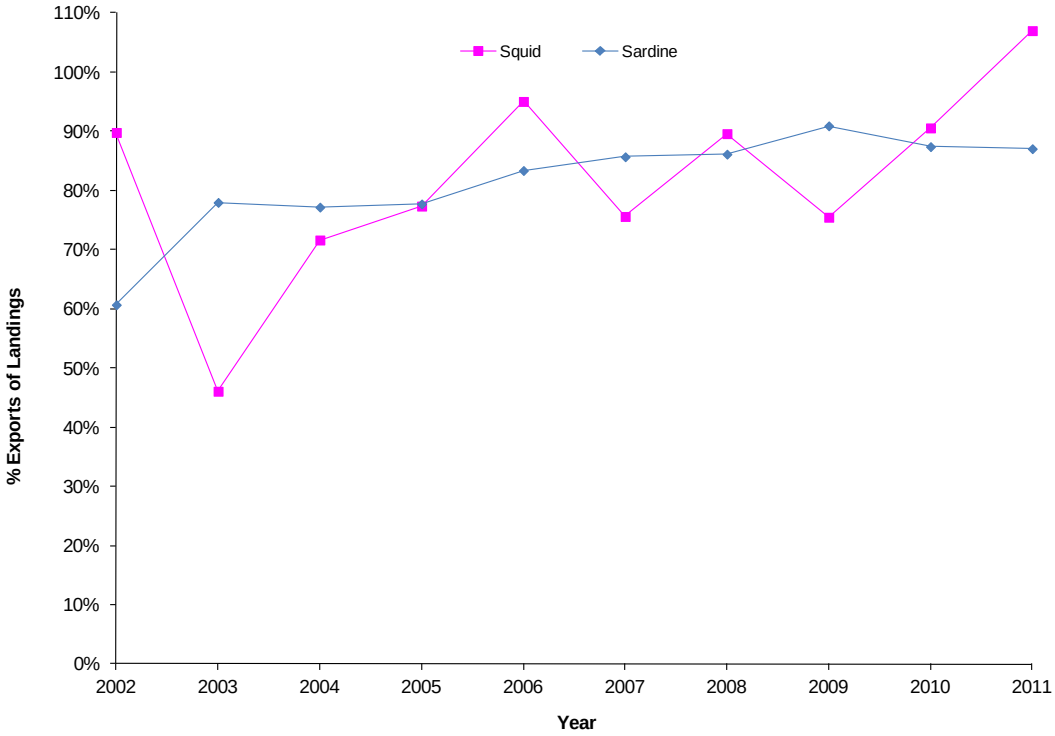
Note: The principle species accounts for the largest share of the vessel's annual exvessel revenue.

Figure 9-7. Average share of principle species revenues of total revenues for vessels whose principle species was CPS finfish, market squid or non-CPS, 1981-2011.



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

Figure 9-8. West coast sardine and squid exports as a share of landings, 2002-2011



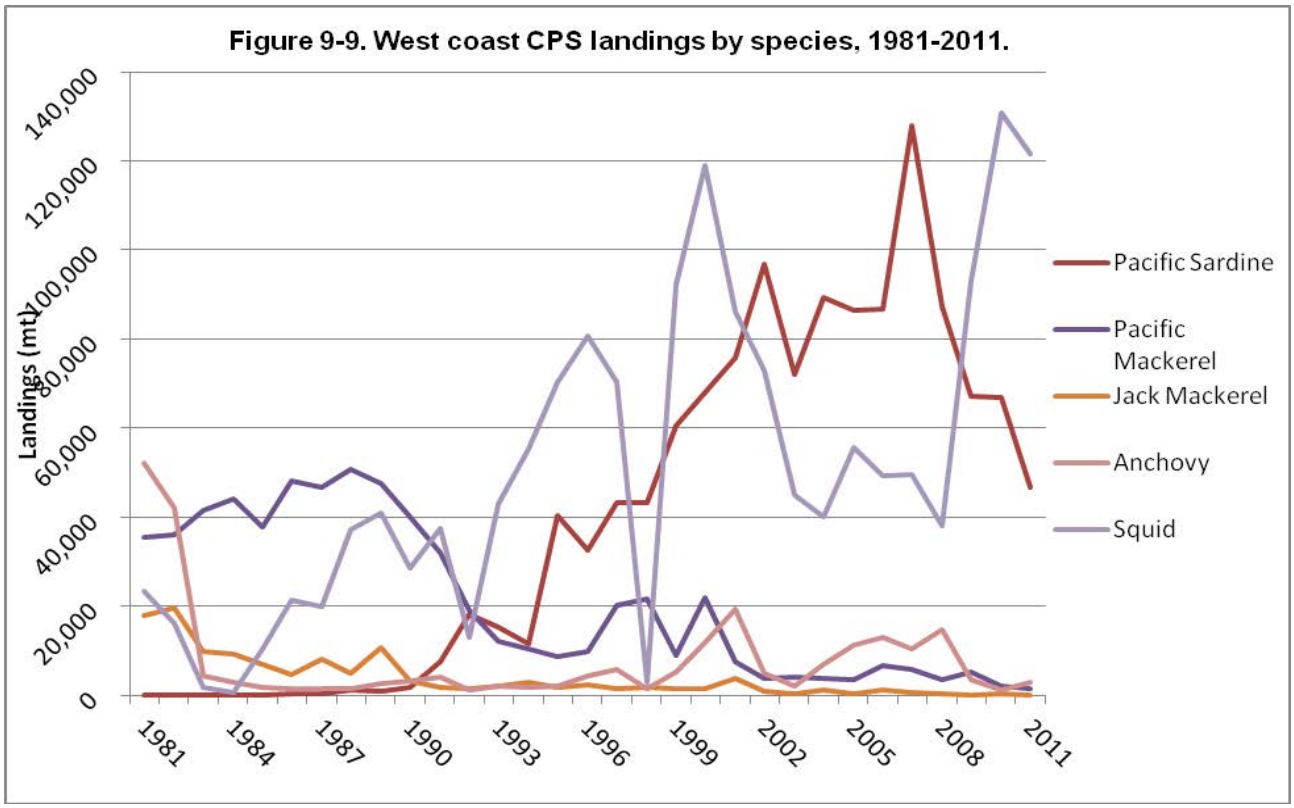


Figure 9-9. West coast CPS landings by species, 1981-2011.
Landings (mt)
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
1981
1984
1987
1990
1993
1996
1999
2002
2005
2008
2011
Pacific Sardine
Pacific Mackerel
Jack Mackerel
Anchovy
Squid

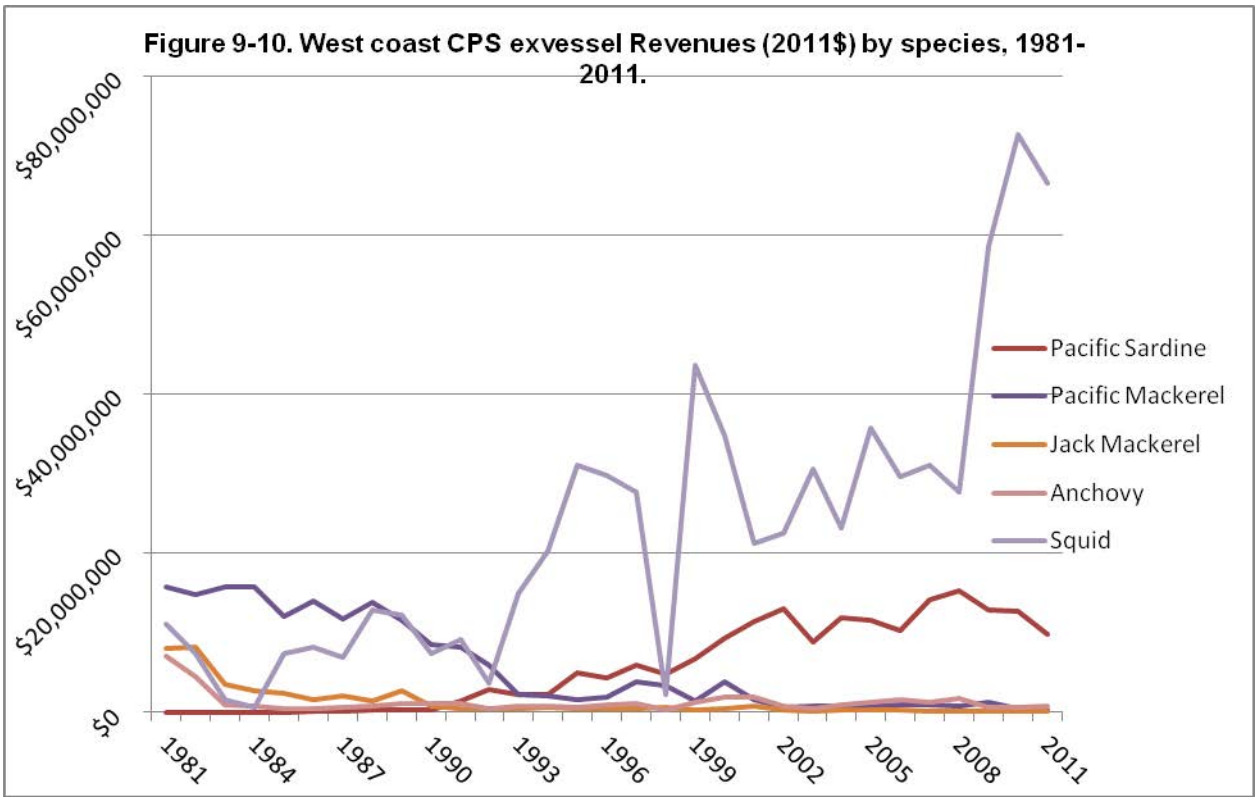


Figure 9-10. West coast CPS exvessel Revenues (2011$) by species, 1981-2011.
$80,000,000
$60,000,000
$40,000,000
$20,000,000
$0
1981
1984
1987
1990
1993
1996
1999
2002
2005
2008
2011
Pacific Sardine
Pacific Mackerel
Jack Mackerel
Anchovy
Squid

7.0 ECOSYSTEM CONSIDERATIONS

7.1 INTRODUCTION

There is a growing national interest in augmenting existing single-species fisheries management approaches with ecosystem-based fishery management principles that could place fishery management decisions and actions in a the context of a broader scope. NOAA/NMFS Science Centers around the country are working to improve the science behind ecosystem-based fishery management including status monitoring and reporting on ecosystem health (Levin et al. 2009). In March 2014, the NWFSC and SWFC presented an "Annual State of the California Current Report" to the PFMC (PFMC 2014). Some of the ecosystem information in that report is also presented here. This section provides a summary of ecosystem trends and indicators being tracked by NOAA and other scientists that are related CPS. Additionally, Appendix A of Amendment 8 to the CPS FMP provides a review of the life-cycles, distributions, and population dynamics of CPS and discusses their roles as forage and can be found on the Council's web site. Appendix D provided a description of CPS essential fish habitat that is closely related to ecosystem health and fluctuation. Research efforts into ecosystem functions and trophic interactions will improve our knowledge base and improved CPS management decisions.

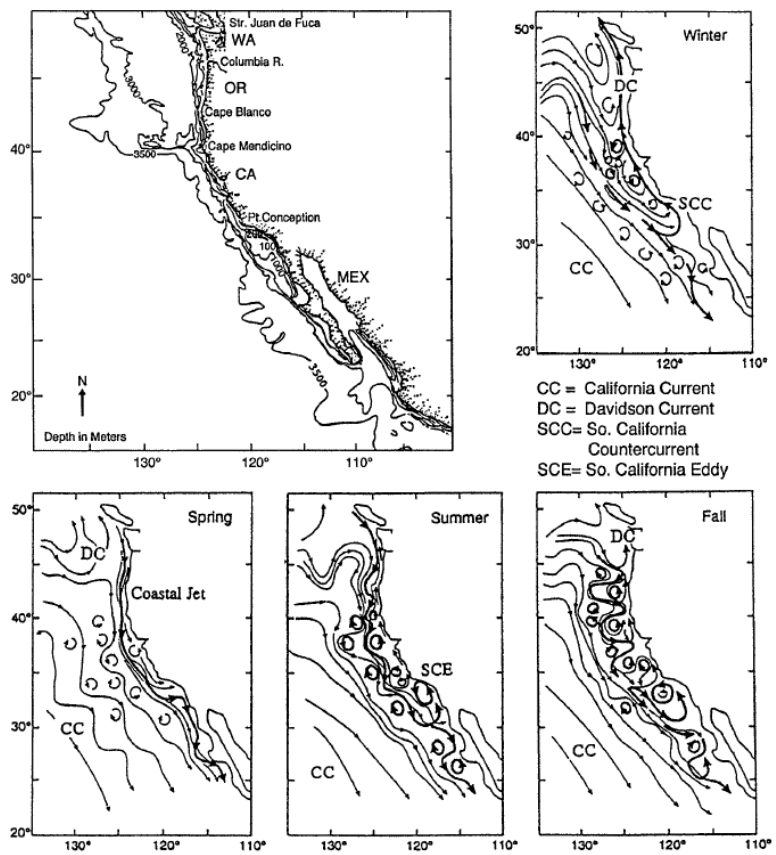


Figure 1. Seasonal variation of large-scale currents along the West Coast with bathymetry illustrating the dynamic conditions in the CCLME. The CC flows southward year round offshore from the shelf break to several hundred kilometers. Along the shelf break, several other currents are found, including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

7.2 Description of the California Current Large Marine Ecosystem

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

Davidson Current and California Undercurrent, the Southern California Countercurrent, as well as many eddies and smaller shelf currents.

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

The CCLME is characterized as often having very high biological productivity (>250 mg C/m^2/day) that is stimulated by the addition of nutrients that is either upwelled along the shelf break or advected in surface currents from the Gulf of Alaska into the northern region or beginning of the California Current (Ware and Thomson 2005, Hickey and Banas 2008). The biological productivity is reflected in the extensive nearshore kelp beds, large schools of CPS (e.g., sardine, anchovy, squid, etc.) and groundfish (Pacific hake) that, in turn, support large populations of marine mammals, sea birds and highly migratory species (e.g., tuna, sharks, billfish).

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

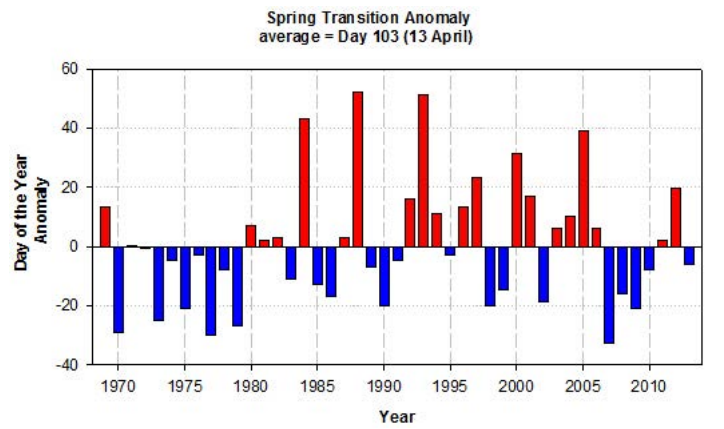


Figure 2. Anomaly of the date of the spring transition. William

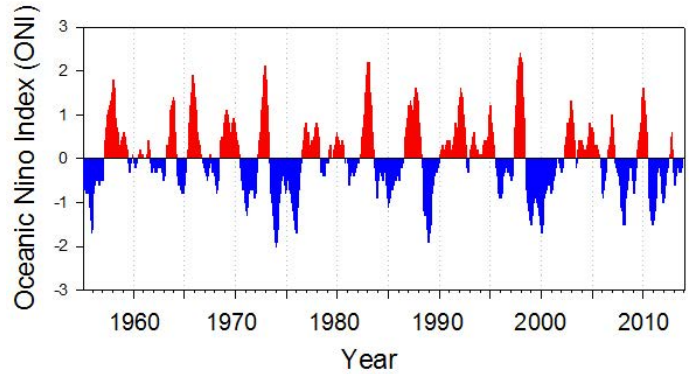


Figure 3. Oceanic Nino Index anomalies. Red indicates warm or El Nino conditions and blue cool La Nina conditions.

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

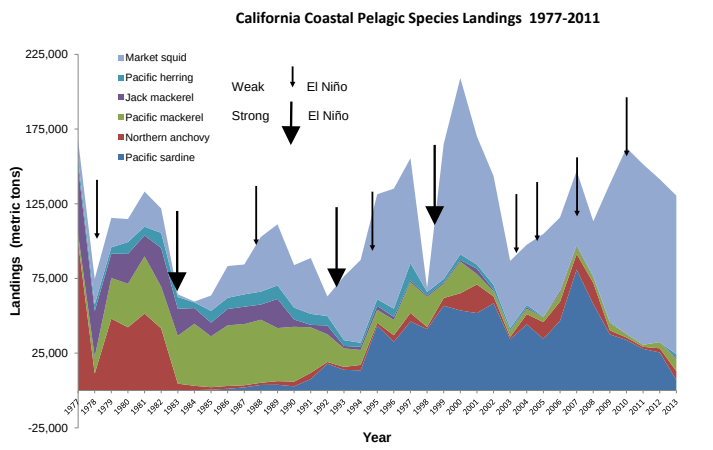


Figure 4. El Nino events and California CPS landings.

On an interannual time scale of 3-7 years, the CCLME and the entire Pacific Ocean is affected by the El Niño/La Niña conditions that are captured by the Oceanic Niño Index (Figure 3). During El Niños, upwelling is generally ineffective and warm salty surface waters move up from the south which reduces primary productivity. During La Niñas the productivity of the California Current is usually enhanced by the addition of cool, nutrient rich waters from the north, and increased effective upwelling. During El Niños, CPS landings in CA often fluctuate widely, with decreased catches of market squid, anchovy and Pacific herring, while the landings for sardine and mackerel often remain relatively constant (Figure 4, CDFW).

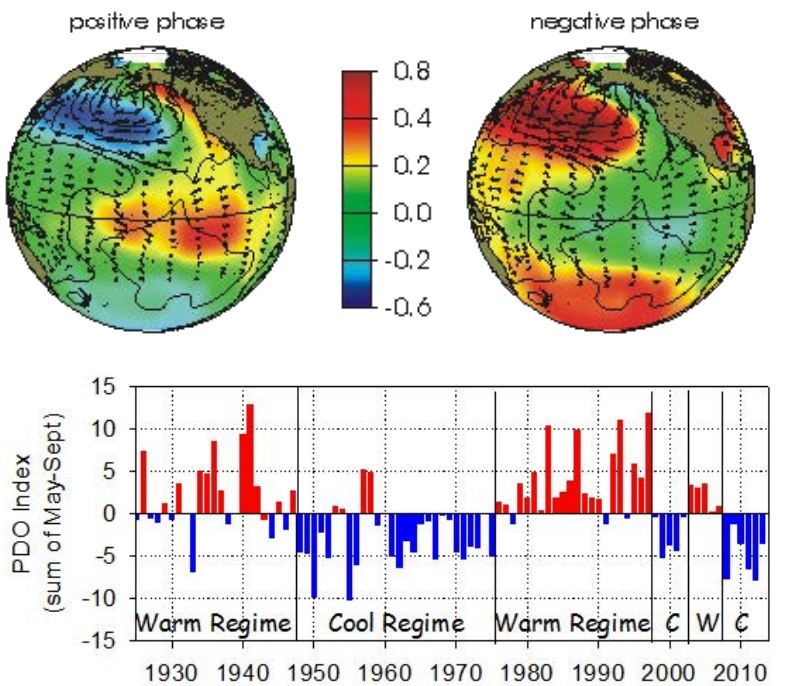


Figure 5. Time series of shifts in sign of the Pacific Decadal Oscillation (PDO,) 1925 to 2011. Values are averaged over the months of May through September. Red bars indicate positive (warm) years; blue bars negative (cool) years. Note that 2011 was the most negative since 2008. http://www.nwfsc.noaa.gov/research/divisions/fed/oeip/ca-pdo.cfm

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

positive from 1977-1998. Since 1998 the PDO has fluctuated positive and negative, perhaps indicating an unusual climatic period for the CCLME.

The effects of the PDO on fisheries are mixed. In general, the warm phase of the PDO is associated with warm ocean temperatures off the West Coast and reduced landings of coho and Chinook salmon while the cool phase is associated with higher salmon landings (Mantua et. 1997). For sardine, positive PDO indices seem to correlate with high landings along the CCLME, while anchovy landings are reduced under positive PDO (Figure 6) (Takasura et al. 2008). Recent work by Zwolinski and Demer (2013) indicate that sardine recruitment is strongly linked to adult condition and the PDO prior to spawning. Others have found that environmental conditions during spawning, such as sea surface temperatures (Lindegren and Checkley 2013) and curl-driven upwelling (Rykaczewski and Checkley 2008) are important for sardine larval survival and recruitment. Until a good understanding of the oceanographic/ecological mechanisms that affect the productivity of sardine and anchovy stocks is achieved, this correlation, which is essentially based on one cycle of the PDO, must be viewed with caution. A recent paper by Zwoliski and Demer (2012) highlighted the similarity between present oceanographic conditions and past condition (1930's) when the CCLME sardine population crashed after a change in the PDO. However, MacCall et al. (2012) noted that management/harvest rates were much different in the 1930's.

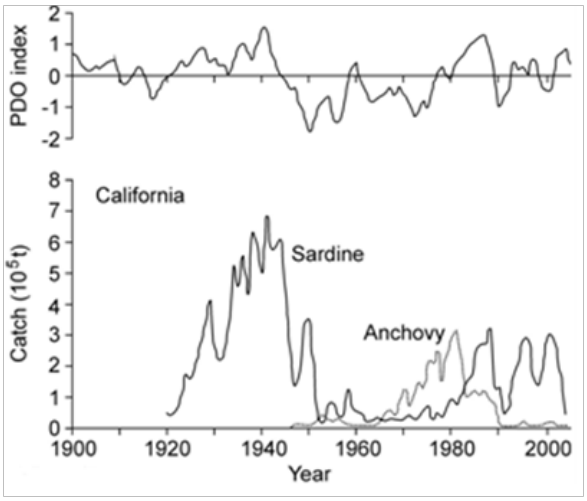


Figure 6. The relationships between sardine and anchovy landings in California and the PDO. From Takasura et al. 2008.

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

Finally, climate change is a significant threat to the CCLME. While ocean temperatures have been relatively cool the last few years, these are expected to rise in the future. Furthermore, ocean acidification appears to already be having an effect on CCLME plankton and perhaps forage fish feeding and recruitment. Recent work by Bednarsek et al. (2014) revealed that ocean acidification

in some areas of the CCLME is now great enough to dissolve the shells of the pelagic snail (*Limacina helicina*), and important prey for forage fish and other pelagic species.

7.3 Current Climate and Oceanographic Conditions

7.3.1 Spring Transition

In 2013, the Spring Transition (Figure 2) was average (7 April 2014), and once upwelling began the Northwest winds (which cause upwelling) remained relatively weak through much of the spring and summer. Most upwelling occurred in July. Upwelling was limited in September and October resulting in an average year of upwelling. The North Pacific Ocean remained in a La Niña condition all of 2013. As such, sea surface temperatures were anomalously cold most months, but chlorophyll *a*, was not very high most months, as is typical during a La Niña. These oceanographic conditions may have been good for anchovy, herring, and smelt recruitment, but they were probably not good for sardine. However, since an coast wide index of recruitment (i.e., 0-age survey) is unavailable for these fishes, we will have to wait until the 2013 age class enters the fishery before we know if ocean conditions in 2013 were conducive for some CPS spawning and recruitment.

7.3.2 El Niño/Southern Oscillation

The Oceanic Niño Index for the Pacific Ocean reflects a mostly La Niña neutral condition for all of 2013. Cold water dominated the CCLME during most of the year (Figure 3). Based on model forecasts, an El Niño is may be forming and arrive by late spring or summer 2014.

7.3.3 Pacific Decadal Oscillation

The PDO was negative for most of the entire year in 2013 (Figure 7). A negative PDO is considered unfavorable for sardine and favorable for anchovy (Chavez et al. 2003). Effects of a negative PDO on other CPS, such as market squid, appears to also be positive. The continued negative PDO is good for Pacific salmon and anchovy populations.

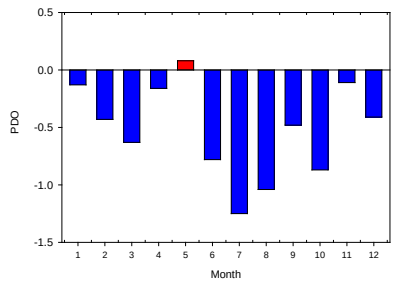


Figure 7. Monthly Pacific Decadal Oscillation index values in 2013. http://jisao.washington.edu/pdo/

7.3.4 Columbia River Flows

The Columbia River provides the largest source of freshwater entering the California. As such, it has a large effect on the oceanography and biological resources on the region (Hickey et al. 2009; Litz et al. 2013). The mouth of the Columbia River is often the center of the sardine fishing off the Pacific Northwest, not only because it is close to processing plants, but because sardines and other CPS actively congregate feed in the biological rich plume habitat (Peterson and Peterson. 2009). In July 2013(the beginning of the sardine commercial opening) relative high flows (Figure 8) and associated low salinities may have forced sardines to stay away from the mouth of the Columbia River but not as much as 2011 and 2012 (Emmett et al. 2012).

7.4 Trends in Ecosystem Indicators

7.4.1 Sea Surface Temperatures

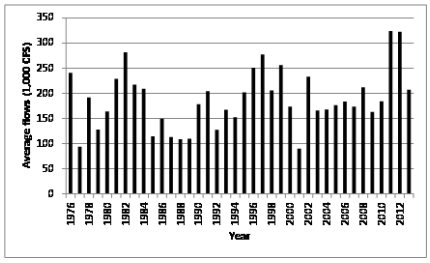


Figure 8. Average Columbia River July flows

Sea surface temperatures appear to affect the abundance/productivity of sardine, anchovy and other CPS species abundance (Chavez et al. 2003; Jacobson et al. 2001, 2005). In 2013 coastal ocean temperatures were anomalously cold in January through May but extremely warm in September and October before being cold again in November and December (Figure 9),. These cold ocean temperatures reflected the continued La Niña and negative PDO conditions that began in late 2008.

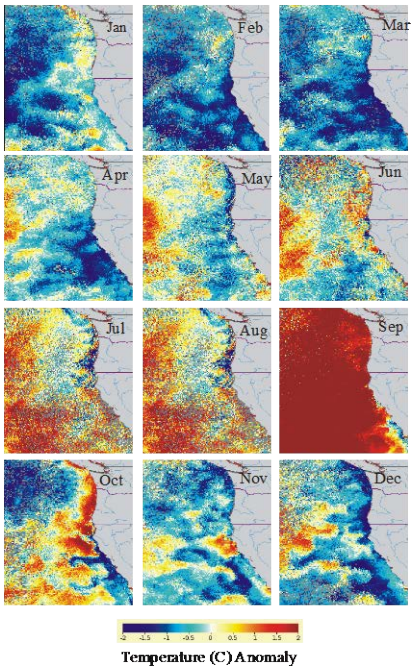


Figure 9. Monthly sea surface temperature anomalies in 2013. http://coastwatch.pfel.noaa.gov/

7.4.2 Ocean Productivity

Chlorophyll *a* is a phytoplankton pigment that can be measured at the surface by satellites. In 2013 coastal chlorophyll *a* was below normal from March-May. During the rest of the year Chlorophyll levels average.

7.4.3 Copepods

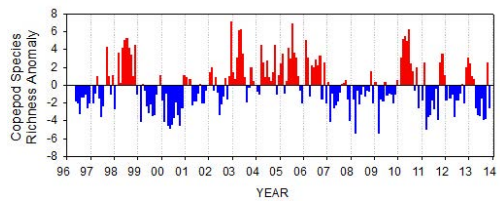


Figure 10. Monthly anomaly of copepod diversity found off Newport, OR: William Peterson, NOAA, NMFS, Newport, OR.

Copepod species richness is surveyed by the NMFS, NWFSC off Newport, OR and is highly correlated to the PDO. (http://www.nwfsc.noaa.gov/research /divisions/fed/oeip/ea-copepod-biodiversity.cfm). In 2013 (Figure 10) the copepod community was composed of a few, primarily subarctic species, species typical of highly productive ocean conditions. This indicates the physical ocean remained in a La Niña and the biological environment did also. The presence of subarctic species is favorable for coho salmon returns to the Columbia River, but they have not been correlated to CPS abundance in the CCLRM, although preliminary information indicates that when these cold-water copepods are abundant, Pacific herring and anchovy often recruit. However, sardines appear to recruit better during warm ocean conditions and when a subtropical copepod community is present (Emmett 2012).

7.4.4 Forage fishes and invertebrates

Night time pelagic forage fish surveys off the Columbia River by NMFS/NWFSC were discontinued in 2012. At this time, only day time pelagic survey data are available. Since daytime surveys typically underestimate forage fish abundance, they are not presented here (Krutzikowsky and Emmett 2005).

Surveys for juvenile fish and krill have been conducted by the NMFS/SWFSC off the Central California in the May-June time period since 1983 (Figure 11). In 2010, juvenile sardine numbers dropped far below their long-term average and they have remained low through 2013. Juvenile anchovy abundance also remains low, although slightly more than 2012. Market squid encounters were above average, while juvenile rockfish densities were the highest ever observed. Krill densities also continued to be above average, but only slightly.

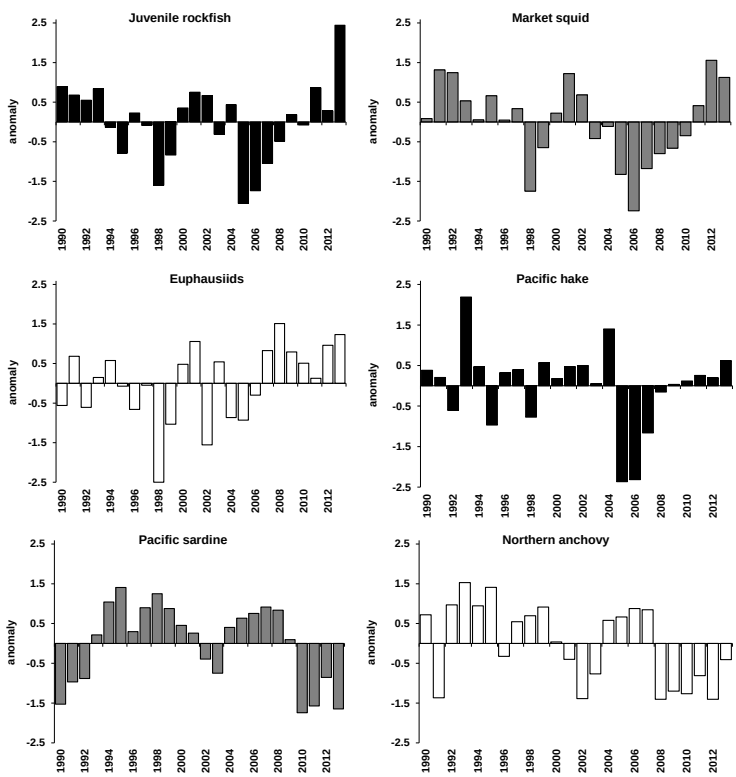


Figure 11. Long-term standardized anomalies of six pelagic forage species off central California. John Field, NOAA, NMFS, SWFSC.

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Climate Indicators:

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

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

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

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

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

8.0 Stock Assessment Models, Stock Status, and Management Recommendations

The CPS FMP distinguishes between "actively managed," "monitored," "ecosystem component, and "prohibited harvest" species management categories. Actively managed species (Pacific sardine and Pacific mackerel) are formally assessed through Council proceedings annually or biennially. Over the years, seasonal closures and allocations, harvest guidelines, incidental landing allowances, and other management controls have been used for these stocks. Other CPS species (northern anchovy, jack mackerel, and market squid) are monitored to ensure their stocks are stable, but annual stock assessments and Federal fishery controls are not used on an annual basis. Ecosystem component species Pacific herring and jacksmelt) are not considered part of the CPS fishery, but can be discretionarily categorized in the FMP as EC species. EC species do not require specification of reference points, but incidental catch of EC species should be monitored for indications of change in status of their vulnerability to the fishery. Krill (consisting primarily of two species of euphausiids) are listed under the prohibited harvest category, and there is no directed take allowed.

While this document focuses on U.S. fisheries, many CPS stocks are distributed coastwide, hence, catch information from Mexican fisheries is of interest. See Table 8-1 for information on commercial harvest of CPS finfish landed into Ensenada, Mexico (1978-2013).

On a systematic basis, the CPSMT makes recommendations to the Council and related agencies regarding appropriate management categories for each stock, both short- and long-term. Changes to the appropriate management category for each species can be made annually by the Council, based on all available data, including ABC levels and MSY control rules, and goals as outlined in the CPS FMP (PFMC 2010).

Finally, while this document focuses on U.S. fisheries, many CPS stocks are characterized by expansive ranges depending on oceanographic conditions and thus, catch information from both Mexico and Canada are of critical interest. See Table 8-4 for CPS harvest statistics from commercial fisheries operating in the U.S., Mexico, and Canada (2000-2013).

In June 2013, the CPSMT recommended moving Pacific mackerel from actively managed to monitored status starting in the 2014-2015 season, based on very low catches, limited additional sample information, and indications that the population's sustainability is not presently being compromised by fishing pressure. At the June 2013 meeting, the Council chose to keep Pacific mackerel as an actively-managed species.

Based on biomass estimates, landings, conservation, socio-economics, and other information, the CPSMT recommends that Pacific sardine and Pacific mackerel remain as an actively managed species, while jack mackerel, northern anchovy, and market squid remain as Monitored stocks.

8.1 Actively Managed Species

8.1.1 Pacific sardine

Hill *et al.* (2014) summarized the status of the Pacific sardine resource off the U.S. Pacific Coast, British Columbia, and northern Baja California, Mexico. Pacific sardine landings for these areas

totaled 111,935 mt in calendar year 2013 (Table 8-4). Total international harvest of sardine was 170,085 mt in 2012 and 137,801 mt in 2011. During 2013, landings in California (7,114 mt) decreased from the previous year (23,044 mt in 2012) (Table 8-3). Combined Oregon-Washington landings for 2013 (54,532 mt) were lower than in 2012 (78,059 mt) (Table 8-3). U.S. landings totaled 61,646 mt in 2013.

The U.S. sardine fishery is regulated using a quota-based HG management approach (see Section 8.1.1.1). From 2000 to 2007, landings by the U.S.-based fisheries were typically lower than the recommended HGs (Table 8-3). Due to a series of lower quotas, the U.S. fishery has been subjected to in-season closures during 2008 to 2011 and 2013. The 2013 HG (66,495 mt) was about 40% lower than the 2012 HG, and was almost entirely captured. The Council established a U.S. ACL/ACT of 23,293 mt for the 2014-15 management year beginning July 1, 2014 (see section 8.1.1.1 below).

Harvest of Pacific sardine by the Ensenada (Mexico) fishery is not yet regulated by a quota system, but there is a minimum legal size requirement of 150 mm standard length and measures are in place to control fleet capacity. The Ensenada fishery landed 50,289 mt in 2013, similar to catch from the previous year (Table 8-4). Canadian sardine landings increased substantially after 2007 (1,524 mt), peaking at 22,223 mt in 2010. However, the Canadian fishery found no sardine in 2013 (Table 8-4).

The stock assessment update conducted in 2014 (Hill *et al.* 2014) provided a stock biomass (age 1+) estimate of 369,506 mt in July 2014 (Table 8-2). Recent biomass and recruitment estimates (2000-14) from Hill *et al.* (2014) are provided in Table 8-2. In all past Pacific sardine stock assessments, it was assumed that all U.S. catches were of the northern subpopulation. However, it is now generally agreed that during warm months, some of the catch in the Southern California area include southern subpopulation fish. The 2014 stock assessment used satellite oceanography data to partition catch data from Ensenada and Southern California ports, in order to exclude landings and biological compositions attributed to the southern subpopulation.

8.1.1.1 Pacific Sardine Harvest Control Rules for 2014-2015

In April 2014 the Council adopted the most recent sardine stock assessment (Hill et al. 2014) to set harvest specifications for the 2014-15 management year beginning July 1, 2014. Stock biomass from that assessment (369,069 mt, Hill *et al.* 2014) was used to calculate all harvest control rules below.

In March 2014 the PFMC adopted the use of CalCOFI SST data for specifying environmentally-dependent E_{MSY} each year, beginning July 2014. Based on this recent decision, the OFL and ABC was based on an $E_{\mathrm{MSY}} = 0.12197$, which corresponds to the three-year running average of CalCOFI SST for 2011-13 (15.3353 °C). In April 2014, the Council chose to establish an ACL and ACT for 2014-15 using a harvest fraction equal to 0.12197 based on the CalCOFI data. Harvest control rule formulas for the 2014-15 management year were calculated as follows:

$$\mathrm{OFL} = \mathrm{BIOMASS} * E_{\mathrm{MSY}} * \mathrm{DISTRIBUTION},$$

$$\mathrm{ABC} = \mathrm{BIOMASS} * \mathrm{BUFFER}_{P\text{-}star} * E_{\mathrm{MSY}} * \mathrm{DISTRIBUTION},$$

$$\mathrm{ACL/ACT} = (\mathrm{BIOMASS} - \mathrm{CUTOFF}) * \mathrm{FRACTION} * \mathrm{DISTRIBUTION},$$

Where: BIOMASS = 369,069 mt; E_{MSY} and FRACTION= 0.12197; DISTRIBUTION = 0.87; $BUFFER_{P\text{-}star\ 0.4}$ = 0.9128; and CUTOFF = 150,000 mt.

Using these control rules, the Council approved an OFL of 39,210 mt and an ABC of 35,792 mt. The Council set the ACL and ACT equal to 23,293 mt, and adopted a 500 mt incidental set aside for each of the three fishing periods. Accounting for a Quinault Indian Nation allotment of 4,000 mt and a total of 1,500 mt incidental set-aside, the period allocations were established as follows: Period 1 (July 1-September 14, 2014) = 7,218 mt; Period 2 (September 15-December 31, 2014) = 4,323 mt; and Period 3 (January 1-June 30, 2015) = 6,252 mt. Any uncaught allocation from Periods 1 and 2 will be rolled into the subsequent period. Any uncaught allocation from Period 3 will not be rolled into the subsequent period. The Council also adopted a mixed load allowance of up to 45 percent sardines caught in other coastal pelagic species fisheries, after directed fishing is closed.

2014-2015 Pacific Sardine Harvest Specifications				
ACL/ACT = 23,293 mt; Tribal set-aside = 4,000 mt; Adjusted ACL/ACT = 19,293 mt				
	Jul. 1 – Sep. 14	Sep. 15 – Dec. 31	Jan. 1 – Jun. 30	Total
Seasonal Allocation	7,718 (40%)	4,823 (25%)	6,752 (35%)	19,293
Incidental Set-Aside	500	500	500	1,500
Adjusted (Directed) Allocation	7,218	4,323	6,252	17,793

8.1.2 Pacific Mackerel

Total biomass (age-1+ biomass, *B*) steadily declined from the mid-1980s to the early 2000s, at which time the population began to increase moderately in size. However, in historical terms, the population remains at a relatively low abundance level, due primarily to oceanographic conditions, given limited fishing pressure over the last decade has likely not compromised this species' biology (i.e., their role in the larger CPS assemblage off the Pacific coast). Finally, recent estimates of stock size are necessarily related to assumptions regarding the dynamics of the fish (biology) and fishery (operations) over the last several years, which generally confound long-term (abundance) forecasts for this species (see Crone *et al.* 2011). It is important to note that exploitation of this stock has changed considerably over the last two decades, i.e., during the 1990s, the directed fisheries off California had average annual landings of roughly 18,000 mt, whereas since 2002, average yearly landings have decreased substantially. This pattern of declining yields in recent years generally characterized all of the fisheries, including U.S. commercial and recreational sectors, as well as the commercial fishery of Mexico. California landings in the 2013-14 fishing year were 10,629 mt, almost double as compared with the previous fishing year, but still below the ACT and well below the ABC.

The last full assessment in 2011, with no assessment conducted in 2012, and catch-only projection estimates done in 2013 and 2014. In June 2013, the Council amended the assessment and

management schedule for Pacific mackerel, such that a full stock assessment will be conducted every four years, starting in 2015, with catch-only projections every alternating four years, in off-science years. Annual harvest specifications and management measures will be set for two years at a time, starting with the 2015-16 and 2016-17 fishing years.

8.1.2.1 Harvest Guideline for 2014-15

At its June 2014 meeting, the Council adopted a catch-only biomass projection estimate of 157,106 mt and an OFL of 32,992 mt. Based on the biomass estimate and a P* of 0.45, the Council set the ABC and ACL both equal to 30,138 mt, a HG of 29,170 mt, an ACT of 24,170, and an incidental set aside of 5,000 mt.

Should the directed fishery realize the ACT of 24,170 mt, the directed fishery will close, and will shift to an incidental-only fishery, with a 45 percent mixed load allowance when Pacific mackerel are landed with other CPS, with the exception that up to 1 mt of Pacific mackerel could be landed without landing any other CPS. The Council also adopted a check-in provision to consider re-allocating a portion of the set-aside to the directed fishery, should the directed fishery attain the ACT.

The Council will consider a full mackerel assessment at its June 2015 meeting, and will set annual specifications for two consecutive years.

8.2 Monitored Species

The monitored species category of the CPS FMP includes the northern subpopulation of northern anchovy, the central subpopulation of northern anchovy, jack mackerel, and market squid. This management category is intended for those species or stocks that do not require intensive harvest management and where monitoring of landings and available abundance indices are considered sufficient to manage the stock. The default control rules and overfishing specifications are used for Monitored stocks unless otherwise specific. Stock-specific MSY proxies, ABC, and ACLs can be revised based on the best available science as recommended by the SSC and as adopted through the annual harvest specification process, and will be reported in the CPS SAFE.

Under the default harvest control rule, the ABC is set to 25% of the OFL until the SSC recommends an alternate value based on best available science. ACLs are set for multiple years until new information becomes available, or until the stock is moved to active management. Stocks may be moved between active and monitored categories on short notice, under the point-of-concern framework.

8.2.1 Northern Anchovy

The most recent complete assessment for northern anchovy was described in Jacobson *et al.* (1995). California landings of northern anchovy began to increase in 1964, peaking in 1975 at 143,799 mt. After 1975, landings declined. From 1983 to 1999, landings did not exceed 6,000 mt per year. There were no reported landings of northern anchovy in Oregon from 1981 through 1999. Washington landings of anchovy were rarely reported before 1967. Landings peaked in the 1970's

at 286 mt in 1975 and thereafter declined, not exceeding 100 mt until 1995. From 2000 to 2013, northern anchovy landings averaged 203 mt for Washington and 51 mt for Oregon for years with reported landings, and 7,881 mt for California. The greatest northern anchovy landings in California occurred in 2001 (19,277 mt). In Washington, the peak occurred in 2009 (810 mt). In Oregon, the peak in northern anchovy landings occurred in 2008 and 2010. Anchovy landings in other years were less than 70 mt.

Anchovy (mt)	**WA**	**OR**	**CA**
2000	79	<1	11,753
2001	68	0	19,277
2002	229	3	4,650
2003	214	39	1,676
2004	213	13	6,793
2005	164	68	11,182
2006	161	9	12,790
2007	153	5	12,390
2008	109	260	14,285
2009	810	39	2,668
2010	108	138	1,847
2011	191	21	2,601
2012	218	0	2,488
2013	116	13	5,933

Through the 1970s and early 1980s, Mexican landings increased, peaking at 258,745 mt in 1981 (Table 8-1). Mexican landings decreased to less than 2,324 mt per year during the early 1990s, with a spike of 17,772 mt in 1995, primarily during the months of September through November. Catches in Ensenada decreased to 4,168 mt in 1996; and remained at less than 5,000 mt through 2013.

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

Stock	OFL	ABC	ACL	ACT

Northern anchovy, northern subpopulation	39,000 mt	9,750 mt	Equal to ABC	1,500 mt
Northern anchovy, central subpopulation	100,000 mt	25,000 mt	Equal to ABC	N/A

8.2.2 Jack Mackerel

Jack mackerel have not been significantly targeted on the West Coast regular stock assessments or efforts to collect biological information on jack mackerel have not been a priority. The SWFSC Acoustic-Trawl survey, which began in 2006 could potentially be used to provide abundance estimates in the future, but may need a methodology review prior to use in a stock assessment. Management efforts to collect fishery-dependent age composition data, such as the CDFW Port Sampling Program, are in place for the two actively managed CPS (Pacific sardine and Pacific mackerel), but not for jack mackerel, aside from samples taken prior to 1995.

Landings of jack mackerel in the California pelagic wetfish fishery through the decade of the 1990s reached a maximum of 5,878 mt in 1992, and averaged under 1,900 mt over 1990-2000. During the previous decade, California landings ranged from a high of 25,984 mt in 1982 to a low of 9,210 mt in 1985. Currently, most landings of jack mackerel are incidental to Pacific sardine and Pacific mackerel in California; however, pure landings do occur sporadically. From 2000 to 2013, jack mackerel landings averaged 13 mt for Washington for years with reported landings, 67 mt for Oregon, and 779 mt for California. In California and Oregon, jack mackerel landings occurred each year; however, in Washington, jack mackerel were landed in 2002, 2003, 2010, 2012, and 2013.

Jack mackerel (mt)	**WA**	**WA (unspecified mixed mackerel)**	**OR**	**CA**
2000	-		161	1,269
2001	-	371	196	3,624
2002	12	238	8	1,006
2003	2	54	74	156
2004	-	22	126	1,027
2005	-	24	70	213
2006	-	41	5	1,167
2007	-	36	14	631

2008	-	6	46	274
2009	-	4	2	119
2010	<1	2	3	306
2011	-	<1	14	80
2012	14	553	96	133
2013	24	123	123	894

Mason (2001) concluded that spawning biomass estimates of the past were inadequate.

Anecdotal evidence suggests that the spawning biomass may be large in California waters, but test fishing found the adult fish too scattered for economical harvest, since portions of the contemporary catch are sometimes found in small aggregations of young fish along rocky shores.

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

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

Coastwide landings 2010-2013 were as follows:

Jack Mackerel	ACL (mt)	Landings (mt)
2010	31,000	310
2011	31,000	80
2012	31,000	145
2013	31,000	892

8.2.3 Market Squid

The CDFW manages the market squid fishery through a state-based management plan including an annual landings cap and various spatial/temporal constraints, such as weekend closures, area and time closures to address seabird issues, and harvest replenishment areas within MPAs (CDFG 2005). In addition, the Egg Escapement Method has been used as an assessment tool, to evaluate population dynamics and biological reference points (MSY related) regarding this species (Section 4.3.4 and Dorval et al. 2008). The fishery control rules currently in place under the California

MSFMP, are thought to preclude the need for active Federal management. However, if fishery operations change substantially in the future (for example, spatially expands, harvest high amounts of immature squid), additional management measures could be considered.

In 2010, the Council approved benchmarks for market squid, which remain in place until changed by the Council:

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

8.2.3.1 California's Market Squid Fishery

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

In 2013, the market squid fishery was California's largest fishery, with landings estimated at 104,404 mt. This is a 7 percent increase from 2012 (97,732 mt). The total ex-vessel value increased from $63.9 million in 2012 to $73.7 million in 2013. The median ex-vessel price per ton of market squid in 2013 was $640. The fishing permit season for market squid extends from April 1 through March 31 of the following year. During the 2012-2013 season (as opposed to the 2013 calendar year) 96,239 mt were landed, a decrease from the 2011-2012 season (122,390 mt). In addition, the California market squid fishery closed early for the third consecutive season, due to projected attainment of the harvest guideline of 118,000 st.

8.3 Prohibited Species

Amendment 12 to the CPS FMP was approved by the Secretary of Commerce in 2009. Amendment 12 prohibits the directed harvest of krill species. The Amendment described EFH for krill, and set an ACL equal to zero.

8.4 Ecosystem Component Species

In June 2010, the Council added Pacific herring (*Clupea pallassi*) and jacksmelt (*Atherinopsis californiensis*), two species not under Federal management, to the Ecosystem Component category of the CPS FMP. Several criteria should be met for a species to be included in the EC category (MSA Section 660.310(d)(5)(i)). These are 1) be a non-target stock/species; 2) not be subject to overfishing, approaching overfished, or overfished and not likely to become subject to overfishing or overfished in the absence of conservation and management measures; and 3) not generally retained for sale or personal use within the CPS fishery, although "occasional" retention is not by itself a reason for excluding a species from the EC category. There is no directed California commercial herring fishery. Identifying and including EC species in an FMP is not mandatory but

may be done for a variety of purposes, including data collection, for ecosystem considerations related to specification of OY for the associated fishery, as considerations in the development of conservation and management measures for the associated fishery, and/or to address other ecosystem issues.

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

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9.0 Emerging Issues

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

9.1 Pacific Sardine

9.1.2 Exempted Fishing Permits and Aerial Survey

From 2009 through 2013, the Northwest Aerial Sardine Survey, LLC (NWSS) conducted an aerial stock survey to provide a biomass estimate for use in the sardine stock assessment. In 2009-2010 the survey was a coordinated effort covering the entire coast from Mexico to Canada, but from 2011-2013 it covered only portions of the Oregon and Washington coasts. The survey utilized up to 3,000 mt of the total allowable harvest, with any un-used set-aside returned to the subsequent period's directed fishery. Table 9.1 shows the Oregon/Washington EFP landings from 2009-2013, and Table 9.2 shows the California EFP landings in 2009-2010.

The survey involved a two-stage sampling design. First, aircraft flew at a specified elevation over a set of transects that extend approximately 38 miles off the coast. Photos were taken of sardine schools, to estimate surface area and biomass. Then spotter planes worked in tandem with purse seine vessels to capture sardine schools of varying sizes, to establish a relationship between surface area and biomass. The survey also collected biological samples from captured point sets. The

survey generally followed the same protocols and design each year, with relatively minor adjustments.

The survey encountered challenges from poor weather, cloud cover, and funding. The summer 2013 survey was only partially completed, and was subsequently not included as an index in the 2014 sardine stock assessment. Citing these challenges, as well as relatively low allowable harvest for the 2014-15 fishing year, the NWSS did not request an EFP for 2014. However, the NWSS also expressed interest in conducting the survey again in the future.

In November 2013, CDFW proposed a methodology review of a Southern California aerial survey, in cooperation with CWPA. That methodology review was recommended by the Council, but postponed until the survey proponents had a chance to collect more field data and refine their methods.

9.1.3 Harvest Control Rule/Management Strategy Evaluation

The current Pacific sardine harvest control rule includes stock-recruit and temperature-recruit relationships that play roles in determining the harvestable fraction of the stock. The temperature index used in the harvest control rules has been the Scripps Institution of Oceanography (SIO) Pier. However, a November 2010 publication by McClatchie et al. (Can. J. Fish. Aquat. Sci. 67: 1782–1790, November 2010) identified a divergence of temperatures between the SIO Pier and sea surface temperatures (SST) in the Southern California Bight. The SST readings from the California Cooperative Oceanic Fisheries Investigations (CalCOFI) showed declines that were not seen in the SIO temperatures. The publication also called into question the sardine productivity assumptions inherent in the sardine harvest control rules.

In February 2013, the Council and the Southwest Fisheries Science Center co-sponsored a workshop to explore the temperature-recruitment parameters and other issues relative to sardine harvest management. The workshop took place February 5-8, 2013, at the Scripps Institution of Oceanography in La Jolla, California, with advanced distribution of key documents. These included a workshop Terms of Reference with a purposed statement and four objectives related to Pacific sardine management: 1) mathematical specifications for an initial risk assessment framework to evaluate the performance of alternative Overfishing Limit and HG control rules, 2) a new formulation of the temperature-recruit relationship, 3) consideration of potential changes to the Distribution term used in the HCR, and 4) preliminary plans for a full management strategy evaluation.

Invited workshop participants included experts in the fields of fisheries oceanography, stock assessment modeling, and ecosystem modeling. These participants included the original authors of Amendment 8, attendees from Canada and Mexico, CPSAS representatives, the CPSMT, and many others who have participated in the science and management of Pacific sardine.

At its April 2013 meeting, the Council considered the workshop report, which was included in that meeting's briefing book materials, agreeing with the workshop participants that Objectives #1 and #2 warranted further consideration. The Council set a schedule to implement relevant changes to sardine management. At subsequent meetings (November 2013, March 2014, September 2014, and November 2014) the Council approved incorporation of the new temperature-recruit relationship and use of the CalCOFI temperature index into Pacific sardine management.

9.2 Pacific Mackerel

At its June 2013 meeting, the Council adopted a revised assessment and management schedule, with full assessments occurring every four years, starting in 2015, and catch-only projection estimates occurring every alternating four years. Annual harvest specifications and management measures will be set for two years in a row, starting with the 2015-2016 fishing year. Landings of Pacific mackerel have been well below the ABC, up until the 2013-2014 fishing year, which saw a significant increase in landings.

9.3 Management Issues

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

9.3.1 Implementation of the Magnuson-Stevens Reauthorization Act of 2006

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

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

9.3.2 Ecosystem Based Fishery Management

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

The Council formally established an Ecosystem Plan Development Team (EPDT), which developed an advisory fishery ecosystem plan (FEP). The Council also established an Ecosystem Advisory Subpanel. The two bodies held a joint kick off meeting in February, 2010.

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

In 2014, the Council approved a range of alternatives for additional protections of currently unfished and unmanaged forage fish. Draft FMP amendment language is under consideration,

which would be added to each of the four regulatory FMPs, adding a suite of species to the Ecosystem Component category in each FMP. The proposal also includes requirements that must be met prior to starting a fishery on one or more of the species on the list. Final action is scheduled for March 2015.

9.4 International CPS Fisheries

There has been significant interest in coastwide management for the Pacific sardine fishery, which would entail a more consistent forum for discussion between the U.S., Mexico, and Canada. Continued U.S.-Mexico bilateral meetings indicate Mexico's willingness to continue scientific data exchange and cooperation on research. In June, 2011, the Council and NMFS sponsored the second installment of a workshop aimed at improving stock assessment science for CPS species. Participants shared information about several different survey methods. Participants from British Columbia and Mexico attended, in addition to fisheries scientists, industry representatives, and other stakeholders. The group produced a research plan that lays the groundwork for a coordinated survey designed to compare the various survey methods, and to collect important stock assessment data.

In addition, Mexico has a new research vessel that will be capable of conducting acoustic-trawl surveys from the southern tip of the Baja Peninsula to the U.S. – Mexico border. In conjunction with the U.S. surveys, this will provide a synoptic acoustic-trawl survey from the southern tip of Baja to the northern tip of Vancouver Island, Canada.

The Trinational Sardine Forum (TSF) has been a positive venue for international exchange. The 2013 TSF was held December 5-6, at the Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE), in Ensendad, Mexico.

9.5 Rights-based Management

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

The National Marine Fisheries Service (NMFS) sponsored a Catch Shares Workshop in February 2010 to explore the applicability and utility of catch shares in the sardine fishery. That workshop included representatives of the commercial and recreational fishing industries; Federal and state governments; and NGOs. Workshop proceedings were issued in early 2011, and are available from the NMFS Southwest Region Office.

NMFS hosted a second workshop in April 2012, that explored the pros and cons of rights-based management (i.e., catch shares), and solicited input regarding what elements of a CS program would make sense and which wouldn't, in the context of the west coast sardine fishery. There are no current plans to implement a catch shares approach for CPS fisheries. The 2012 workshop proceedings can be found at http://docs.lib.noaa.gov/noaa_documents/NMFS/CPSII-Proceedings.pdf, and the 2010 workshop proceedings can be obtained by contacting Amber Rhodes in the NMFS Long Beach office, at 562-980-4000.

9.6 Ocean Renewable Energy

9.6.1 Summary

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

9.6.2 Adverse Impacts

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

9.7 Climate Change

9.7.1 Summary

Recent reports by the International Panel on Climate Change (IPCC) have made it clear that the earth's climate is changing, and with it the environmental conditions in the ocean are also changing (http://www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html). The Pacific and other oceans are expected to warm in the future. The California Current is known to historically have large natural fluctuations in its oceanography and CPS abundance. Baumgartner et al. (1992) and Field et al. 2009) looked at deposits of coastal pelagic fish scales and were able to identify historic periods or regimes of anchovy and sardine abundance, probably linked to large scale climate phenomena. For example, during the 1930s-1950ss when the California Current was undergoing a "warm" period as reflected in the Pacific Decadal Oscillation (Mantua et al. 1997) sardines were highly abundant, only to crash as the California Current and the North Pacific entered a cool period. The biological mechanisms causing these abrupt shifts in abundance are still unclear (Checkley et al. 2009), but probably related to decadal changes in wind-stress curl (Rykaczewski and Checkley 2007) and ocean temperatures (Takasuka et al. 2008) linked to productivity and temperature tolerances. Scientists originally thought that anchovy and sardine populations fluctuated out of phase because of "competitive" interactions, but this may not be true (Barange et al. 2009).

9.7.2 Adverse Impacts

Changes in the North Pacific Ocean climate were recently identified as major factors in the decline and subsequent ESA listing of the anadromous smelt eulachon (*Thaleichthys pacificus*) (Eulachon Biological Review Team. 2010). Such changes are also affecting Pacific salmonid populations (Schindler et al. 2009). How climate change will alter the productivity of the California Current

fish stocks, or if it will enhance decadal fluctuations in fish abundance is uncertain, but the future effects on fisheries could be modeled based on current knowledge (Hollowed et al. 2009).

9.8 Aquaculture

NOAA's National Aquaculture Policy seeks to streamline the permitting process as one way to decrease the seafood "trade deficit" (much more seafood is imported than exported) in the United States. Among many competing uses of the U.S. EEZ, aquaculture too requires dedicated space for infrastructure and operations, and in some cases, the proposed site can conflict with traditional fishing areas. In 2014, the Council considered a proposed mussel mariculture facility off Southern California (http://www.pcouncil.org/wp-content/uploads/E1_SUP_OC3_CatalinaSeaRanch_APR2014BB.pdf). The CPSAS commented that the proposed site was located in important CPS fishing areas, and that the proponents had not sufficiently engaged the fishing community.

This type of user group conflict will likely continue, although the implementation of marine planning may eventually serve as a tool to identify, minimize, and successfully resolve conflicts over use of ocean resources.

9.9 References

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10.0 Research and Data Needs

A declining trend in Pacific sardine biomass estimates points to the need for robust assessment procedures and appropriate management responses, in order to meet the requirements of the FMP. These include the recognition of the importance of CPS as forage for many salmon and groundfish stocks that are currently at low abundance levels, the importance of CPS biomass estimates to the Council's annual determination of allowable coastal pelagic harvests, and the need to monitor status of the market squid stock using data-intensive techniques.

In addition to research and data needs presented in this section, refer to the Council's comprehensive research and data needs document last revised in March 2013. The document includes a chapter dedicated to CPS matters and can be obtained by contacting the Council office or by visiting the Council web page. Also, the most recent Pacific sardine and Pacific mackerel assessments and STAR Panel reports include detailed, species-specific, research and data needs.

The 2014 Pacific sardine stock assessment, for the first time, differentiated the northern and southern subpopulations, generating a biomass estimate for only the northern subpopulation. This is a departure from past stock assessments, which assumed that all landings from Ensenada, Mexico, north were of the northern stock.

The highest priority research and data needs for CPS are:

- Develop methods for differentiating southern from northern subpopulation of Pacific sardines, and develop an appropriate management approach.
- Gain more information about the status of CPS resources in the north using egg pumps, trawl and sonar surveys, and spotter planes.
- Develop a coastwide (Mexico to British Columbia) synoptic survey of sardine and Pacific mackerel biomass; i.e., coordinate a coastwide sampling effort (during a specified time period) to reduce "double-counting" caused by migration.

- Develop a formal review process for the harvest control rules for Pacific sardine and Pacific mackerel. Currently this review is not part of the stock assessment process.
- Increase fishery sampling for age structure (Pacific sardine and Pacific mackerel) in the northern and southern end of the range. Establish a program of port sample data exchange with Mexican and Canadian scientists.
- Evaluate the role of CPS resources in the ecosystem, the influence of climatic/oceanographic conditions on CPS, and define predator-prey relationships.
- Routinely, collect detailed cost-earnings data to facilitate analyses for long-term changes to the sardine allocation structure.

10.1 Pacific Sardine

High priority research and data needs for Pacific sardine include:

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

10.2 Pacific Mackerel

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

Fishery-independent survey data for measuring changes in mackerel spawning (or total) biomass are currently lacking. Further, at this time, a single index of relative abundance is used in the assessment, which is developed from a marine recreational fishery (CPFV fleet) that typically does not (directly) target the species, nor report all catches. Future research funds should focus on

improving the current CPFV survey, with a long-term emphasis, which will necessarily rely on cooperative efforts between the industry, research, and management bodies. Finally, further sensitivity analysis related to this index of relative abundance, including issues surrounding catchability (and/or selectivity) and influences regarding time-varying vs. constant parameterization of these fishery time series should be examined.

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

10.3 Market Squid

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

Although some coastwide squid distribution and abundance has been extracted from fishery-independent midwater and bottom trawl surveys aimed at assessing other finfish species, there is no reliable measure of annual recruitment success beyond information obtained from the fishery. Since fishing activity generally occurs only on shallow-water spawning aggregations, it is unclear how fluctuations in landings are related to actual population abundance and/or availability to the fishery itself. That is, the general consensus from the scientific and fishery management communities is that squid do inhabit, to some degree, greater depths than fished by the fleet; however, species' range suppositions are qualitative at this point in time. Better information on the extent and distribution of spawning grounds along the U.S. Pacific Coast is needed, particularly, in deep water and areas north of central California. Additionally, fecundity, egg survival, and paralarvae density estimates are needed from different spawning habitats in nearshore areas and oceanographic conditions associated with the population. Data on mechanisms and patterns of dispersal of adults, as well as paralarvae, along the coast is necessary to clarify how local impacts might be mitigated by recruitment from other areas inhabited by this short-lived species. See Dorval 2008 and Dorval et al 2013 for additional information.

Although some fishery effort information is now being collected with a logbook program in the State of California, the continuation of this program is essential to provide estimates of relative

abundance (e.g., CPUE time series) in the future. Continuation and/or establishment of annual surveys using midwater trawls, bottom trawls, remotely operated vehicles, and satellite and aerial surveys would also provide useful information for developing alternative indices of abundance other than those derived from logbook data.

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

Currently, market squid fecundity estimates, based on the Egg Escapement Method (Dorval et al. 2008 and 2013), are used informally to assess the status of the stock through evaluations of alternative biological reference points related to productivity and MSY. The Egg Escapement Method is based on several assumptions, (1) immature squid are not harvested; (2) potential fecundity and standing stock of eggs are accurately measured; (3) life history parameters are accurately estimated (e.g., natural mortality, egg laying rate); and (4) instantaneous fishing mortality (F) translates into meaningful management units. Given the inherent uncertainty associated with these assumptions, each must receive more scrutiny in the future through continuation of rigorous sampling programs in the field that generate representative data for analysis purposes, as well as further histological evaluations in the laboratory and more detailed assessment-related work. For example, data collected through the CDFW port sampling program will provide information on the age and maturity stages of harvested squid. Further, laboratory work concerning mantle condition, especially the rate of mantle "thinning," will benefit our understanding of squid life history and subsequently help improve the overall assessment of this species. Finally, other poorly-understood biological parameters relate to spawning and senescence (for example, life history strategies concerning spawning frequency, the duration of time spent on spawning grounds, and the period of time from maturation to death).

10.4 Live Bait Fishery

The California live bait fishery supplies product for several recreational fisheries, primarily in southern California, but as far north as Eureka. Live bait catch is generally comprised of both Pacific sardine and northern anchovy. Sardine typically represents a larger portion of the live bait catch, ranging from about 50% to 95% between 1994 and 2010. Total live bait landings in those years vary between about 2500 mt and 5000 mt, with effort increasing in summer months. However, these estimates are based only on logbooks provided by a limited number of bait haulers, and estimates provided by the CPFV industry. Since the sale of live bait in California is not permitted in a manner similar to that used for the commercial sale of CPS, estimates of tonnage and value are imprecise. Therefore, no estimates of volume or value for the sale of market squid for live bait are available at this time. However, the CDFW will reexamine reporting requirements and data needs to better estimate landings and value.

Although tonnage of CPS and market squid taken in the live bait fishery is minimal compared with volume taken in the commercial fishery, the price per pound is significantly greater. Live bait

haulers report that sardines sold as live bait average approximately $4 per pound, based on a 10-pound scoop and scoop price of about $40. (Buck Everingham, pers. comm.)

10.5 Socioeconomic Data

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

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

10.5.1 Commercial Fisheries

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

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

10.5.2 Non-market Values

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

10.6 Observer Program

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

10.7 References

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11.0 ESSENTIAL FISH HABITAT

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

> *"Waters include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; substrate includes sediment, hard bottom, structures underlying the waters, and associated biological communities;*

necessary means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle."

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

Process for five-year Review of CPS EFH

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

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

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

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

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

Description of Existing EFH

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

- Pacific sardine (*Sardinops sagax*)

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

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

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

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

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

This description is as follows:

> *The east-west geographic boundary of EFH for each individual CPS finfish and market squid is defined to be all marine and estuarine waters from the shoreline along the coasts of California, Oregon, and Washington offshore to the limits of*

the exclusive economic zone (EEZ) and above the thermocline where sea surface temperatures range between 10^0C to 26^0C. The southern boundary of the geographic range of all CPS finfish is consistently south of the US-Mexico border, indicating a consistency in SSTs below 26^0C, the upper thermal tolerance of CPS finfish. Therefore, the southern extent of EFH for CPS finfish is the US-Mexico maritime boundary. The northern boundary of the range of CPS finfish is more dynamic and variable due to the seasonal cooling of the SST. The northern EFH boundary is, therefore, the position of the 10^0C isotherm which varies both seasonally and annually.

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

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

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

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

New Information

Existing EFH descriptions for CPS are based largely on presence/absence data and upon a thermal range within the broader geographic area in which CPS stocks occur. The 1998 EFH identification and descriptions also base EFH on historical presence or "where environmental conditions do not preclude colonization by the CPS" (PFMC 1998). Although temperature associations among individual species and life stages within the CPS complex exhibit some variation, the temperature range that describes existing EFH is sufficiently representative of habitat associations. This temperature range is between 10°-26° C, although CPS can be found at temperatures outside that

range. The CPSMT considered information contained in several recent publications relevant to CPS. The new information continues to support the strong linkage between CPS distribution and sea surface temperature, which varies spatially and temporally, and thus does not present any significant change in existing documented habitat associations. All the new information considered during this process is included in the References section below.

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

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

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

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

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

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

Habitat Areas of Particular Concern (HAPCs)

The implementing regulations for the EFH provisions of the MSA (50 CFR part 600) encourage the FMCs to identify specific types or areas of habitat within EFH as “habitat areas of particular

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

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

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

Fishing Gear Effects

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

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

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

One notable change in fishing activities since 1998 has been a spatial shift in west coast CPS landings. In 1998, the Pacific Northwest sector harvested approximately 1-2% (by weight) of the total west coast CPS landings. More recently, the Pacific Northwest was responsible for harvesting

approximately 28% of total CPS landings in 2009 (PFMC 2010). It is important to note that the increase in Pacific Northwest landings represents a shift in where landings are occurring, and not necessarily an overall increase in landings along the west coast. There is no reason to conclude any increase in effects, because methods and gear are essentially the same between California and the Pacific Northwest industry sectors.

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

Emerging Threats

Climate Change

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

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

The "source water" for the California Current appears to fluctuate depending on the status of the PDO and ENSO (DFO. 2010). This has significant effects on CPS and other species in the CC. In 2008, the North Pacific Current was very strong, as was the amount of water that split south from this current to become the CC. When the southern split is strong, much nutrient rich North Pacific waters enter the CC and appear to enhance primary and secondary productivity (DFO 2010;

http://www.pac.dfo-mpo.gc.ca/science/oceans-eng.htm). In 2009 and spring 2010 North Pacific flows to the CC were reduced, which decreased overall productivity.

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

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

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

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

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

Ocean Energy Development

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

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

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

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

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

Conclusions

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

- New information still supports the strong linkage between CPS habitat utilization and sea surface temperature, which along with other oceanographic conditions like upwelling and primary productivity, is both spatially and temporally variable. Therefore, although this information is likely to help inform EFH consultations, and provides additional background on CPS habitat, it does not warrant changes to the existing description of CPS EFH.
- The fishing impacts and non-fishing impacts sections of Appendix D to Amendment 8 sufficiently describe those adverse impacts as well as conservation measures to mitigate those impacts.
- New information on climate change and ocean energy development should be added to body of information on potential impacts to CPS EFH. This should be published in the 2011 SAFE[1] document, to remain available for use in EFH consultations and for future EFH reviews.
- The timing of the periodic review of krill EFH should be synchronized with the future reviews of CPS EFH.

[1] The Federal EFH regulations call for publishing the results of periodic EFH reviews in the SAFE report.

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APPENDIX A:
SAFE TABLES

TABLE 2-1. HISTORY OF COUNCIL ACTIONS

- The Council initiated development of the FMP for northern anchovy in January of 1977. The FMP was submitted to the Secretary in June of 1978. Regulations implementing the FMP were published in the *Federal Register* on September 13, 1978 (43*FR*40868).

- The first amendment changed the method of specifying the domestic annual harvest for Northern anchovy and added a requirement for an estimate of domestic processing capacity and expected annual level of domestic processing. Approval for this amendment was published in the *Federal Register on July 18, 197*9 (44*FR*41806).

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

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

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

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

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

- The Council began developing the seventh amendment as a new FMP for CPS on a motion from NMFS and California in 1990. A complete draft was available in November of 1993, but the Council suspended further work, because NMFS withdrew support due to budget constraints. In July of 1994, the Council decided to proceed with the plan through the public comment period. NMFS agreed with the decision on the condition that the Council also consider the options of

dropping or amending the anchovy FMP. Thus, four principal options were considered for managing CPS (1) drop the anchovy FMP (no Federal or Council involvement in CPS); (2) continue with the existing FMP for anchovy (status quo); (3) amend the FMP for northern anchovy; and (4) implement an FMP for the entire CPS fishery. In March of 1995, the Council decided to proceed with the FMP for CPS. Final action was postponed until June 1995 when the Council adopted a draft plan that had been revised to address comments provided by NMFS and the SSC. Amendment 7 was submitted to the Secretary, but rejected by NMFS, SWR, as being inconsistent with National Standard 7. NMFS announced its intention to drop the FMP for northern anchovy (in addition to FMP's other species) in the *Federal Register* on March 26, 1996 (61*FR*13148), but the action was never completed.

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

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

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

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

- In April 2001, the Council adopted the capacity goal and transferability provisions recommended by the CPSMT for inclusion in Amendment 10. The Council directed the CPSMT to develop an amendment to the CPS FMP that included the capacity goal, provisions for permit transferability,

a process for monitoring fleet capacity relative to the goal, and a framework for modifying transferability provisions as warranted by increases or decreases in fleet capacity. The amendment also addressed determination of OY and MSY for market squid.

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

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

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

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

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

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

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

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

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

- At the April 2003 Council meeting, the CPSAS reviewed the five management alternatives and developed recommendations for the Council. The Council took final action on the regulatory amendment. The proposed action adopted by the Council would (1) change the definition of subarea A and subarea B by moving the geographic boundary between the two areas from 35° 40' N latitude to 39° N latitude, (2) move the date when Pacific sardine that remains unharvested is reallocated to Subarea A and Subarea B from October 1 to September 1, (3) change the percentage of the unharvested sardine that is reallocated to Subarea A and Subarea B from 50 percent to both

subareas to 20 percent to Subarea A and 80 percent to Subarea B, and (4) reallocate all unharvested sardine that remains on December 1 coastwide. The Council's intent is for this interim revision to the allocation framework be in effect for the 2003 and 2004 seasons. The allocation regime could be extended to 2005 if the 2005 HG were at least 90 percent of the 2003 HG.

- The regulatory amendment for allocation of the Pacific sardine HG was approved on August 29, 2003. The final rule implementing the regulatory amendment was published September 4, 2003 (68*FR*52523).

- At the November 2003 Council meeting, the Council adopted a HG of 122,747 metric tons (mt) for the 2004 Pacific sardine fishery, within an incidental catch allowance of up to 45 percent. This HG was based on a biomass estimate of 1,090,587 mt. Per the revised allocation framework, on January 1, the HG was allocated 33 percent to the northern subarea and 66 percent to the southern subarea, with a subarea dividing line at Point Arena, CA. The final rule implementing the HG was published December 3, 2003 (68*FR*67638).

- At the June 2004 Council meeting, the Council adopted the following management measures for the July 2004-June 2005 Pacific mackerel fishery: 1) total fishery HG of 13,268 mt; 2) directed fishery guideline of 9,100 mt; and 3) set-aside for incidental catches of 4,168 mt and an incidental catch rate limit of 40 percent when mackerel are landed with other CPS species, except that up to one mt of Pacific mackerel could be landed without landing any other CPS. The Council also requested NMFS track utilization of the directed fishery guideline and advise the Council at the March 2005 meeting if additional action (e.g., a mop-up fishery) was warranted. Additionally, the Council initiated an amendment to the CPS FMP with the primary purpose of allocating the coastwide Pacific sardine HG. The Council discussed a schedule that included final Council action on the FMP amendment by June 2005, which would enable implementation by January 2006. To facilitate development of the amendment, the Council directed the CPSAS to draft a range of alternative sardine allocation scenarios. The Council also directed the CPSMT to formally review the CPS FMP issues raised by NMFS to identify issues that could be addressed through amendment to the CPS FMP and if they could be addressed in the short-term or would require more extensive time to complete.

- At the September 2004 Council meeting, the Council adopted STAR Panel reports for Pacific mackerel and Pacific sardine. New assessment methodologies were used for management of the 2005 sardine fishery and the 2005-2006 Pacific mackerel fishery. Relative to the CPS FMP amendment process, the Council requested the CPSAS to narrow the current broad range of Pacific Sardine allocation alternatives for Council consideration at the November 2004 meeting. The Council received information from the CPSMT about their consideration of several FMP-related issues raised by NMFS, and directed Council staff to communicate to NMFS the Council plans for further review of CPS EFH.

- At the November 2004 Council meeting, the Council adopted a HG of 136,179 mt for the 2005 Pacific sardine fishery. This HG was based on a biomass estimate of 1.2 million mt. Per the FMP allocation framework, on January 1 the HG was allocated 33 percent to the northern subarea and 66 percent to the southern subarea with a subarea dividing line at Point Arena, California. Additionally, the Council directed the CPSMT and staff to begin development of Amendment 11

to the CPS FMP to include alternatives for sardine allocation, as recommended by the CPSAS as well as two additional alternatives. The Council reviewed the draft analyses and considering formal adoption of allocation alternatives at the April 2005 Council meeting.

- At the March 2005 Council meeting, the Council reviewed a progress update from NMFS SWR on a proposed course of action for management of krill in the West Coast EEZ and National Marine Sanctuaries under the auspices of the CPS FMP. The Council approved a draft outline for an alternatives analysis.

- At the April 2005 Council meeting, the Council approved a range of alternatives for the allocation of Pacific sardine for further analysis and public review. After reviewing preliminary results on the range of alternatives approved for analysis in November 2004 and reports of the CPS advisory bodies, the Council eliminated two alternatives (Alternatives 2 and 5) from further consideration. The Council recommended that the CPSMT follow the advice of the SSC as they complete the analysis of allocation alternatives for public review.

- At the June 2005 Council meeting, the Council addressed three CPS matters, pacific mackerel HG and management measures, long-term Pacific sardine allocation, and CPS EFH.

  Regarding Pacific mackerel, the Council adopted the new assessment and the following management measures for the July 2005-June 2006 Pacific mackerel fishery: 1) total fishery HG of 17,419 mt; 2) directed fishery guideline of 13,419 mt; and 3) set-aside for incidental catches of 4,000 mt and an incidental catch rate limit of 40 percent, when mackerel are landed with other CPS, except that up to one mt of Pacific mackerel could be landed without landing any other CPS. The Council requested NMFS track utilization of the directed fishery guideline and advise the Council at the March 2006 meeting if release of the incidental set-aside was warranted.

  Regarding Pacific sardine allocation, the Council took final action on a long-term allocation of the annual Pacific sardine HG. The Council approved a modified version of Alternative 3, which provided the following allocation formula for the non-tribal share of the HG:

  1. A seasonal allocation structure with 35 percent of the HG to be allocated coastwide on January 1.
  2. 40 percent of the HG, plus any portion not harvested from the initial allocation, to be reallocated coastwide on July 1.
  3. On September 15 the remaining 25 percent of the HG, plus any portion not harvested from earlier allocations, to be reallocated coastwide.

  The Council also recommended a review of the allocation formula in 2008.

  The Council adopted the 2005 SAFE document as drafted by the CPSMT including the required review of CPS EFH. The Council recommended no changes to the existing definition of EFH because the CPSMT review identified no new information on which to base EFH modifications. The Council agreed with the research needs identified by the CPSMT in the 2005 SAFE and stressed the importance of coastwide sardine research and harvest policy review.

- At the November 2005 Council meeting, the Council adopted a Pacific sardine HG of 118,937 mt for the 2006 season to be managed under the terms of the allocation arrangements under Amendment 11.

  The Council also approved a range of krill fishing alternatives for public review and additional analysis, including a preliminary preferred alternative to identify krill as a prohibited species in the EEZ. The proposed krill management measures were implemented as Amendment 12 to the CPS FMP. At the June 2005 Council meeting, the Council addressed three CPS matters, pacific mackerel HG and management measures, long-term Pacific sardine allocation, and CPS EFH.

- At the March 2006 Council meeting, the Council took final action adopting CPS FMP Amendment 12 to prohibit harvest of all species of krill in the U.S. EEZ. Additionally, the Council adopted an EFH designation for all species of krill that extends the length of the West Coast from the shoreline to the 1,000 fm isobath and to a depth of 400 meters. No habitat areas of particular concern were identified.

- At the June 2006 meeting, the Council adopted the new assessment model and the following management measures for the July 2006-June 2007 Pacific mackerel fishery: a total fishery HG of 19,845 mt, a directed fishery guideline of 13,845 mt; and a set-aside for incidental catches of 6,000 mt and an incidental catch rate limit of 40 percent when mackerel are landed with other CPS, except that up to one mt of Pacific mackerel could be landed without landing any other CPS.

- At the November 2006 meeting, the Council adopted a HG of 152,654 mt for the 2007 Pacific sardine fishery. This HG was based on a biomass estimate of 1.32 million mt. Per the FMP allocation framework adopted under Amendment 11, the Pacific sardine HG was allocated seasonally with 35 percent of the HG allocated coastwide January 1, 40 percent of the HG, plus any portion not harvested from the initial allocation reallocated coastwide July 1; and the remaining 25 percent of the HG, plus any portion not harvested from earlier allocations, to be reallocated coastwide September 15. The Council also recommended a 45 percent incidental catch rate be allowed for other CPS fisheries in the event that a seasonal allocation be taken before the end of an allocation period or the HG was taken before the end of the year.

  Additionally, the Council reviewed the draft Terms of Reference for the CPS stock assessment process scheduled for 2007 and directed Council staff to revise the document as recommended by the CPSAS, the CPSMT, and the SSC and distribute it for public review. The Council approved a final document in March 2007 for use during the review of full assessments for Pacific mackerel and Pacific sardine in May and September, respectively.

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

- At the June 2007 Council meeting, he Council adopted the new assessment model and the following management measures for the July 2007-June 2008 Pacific mackerel fishery: an acceptable biological catch (ABC) for U.S. fisheries of 71,629 mt, a directed fishery HG of 40,000

mt, and in the event the directed fishery reaches 40,000 mt, the directed fishery will revert to an incidental-catch-only fishery with a 45 percent incidental catch allowance when Pacific mackerel are landed with other CPS, except that up to 1 mt of Pacific mackerel could be landed without landing any other CPS. The Council and NMFS will track the 2007-08 Pacific mackerel fishery and will recommend an in-season review of the mackerel season for the March 2008 Council meeting, if needed, with the possibility of re-opening the directed fishery as a routine action. Additionally, the Council directed Council staff to send a letter to the U.S. State Department requesting increased coordination with Mexico on the exchange of data for the improvement of international management of CPS.

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

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

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

- In June 2008, the Council adopted an updated Pacific mackerel assessment and the following management measures for the July 2008-June 2009 Pacific mackerel fishery: 1) Establish a harvest guideline for the directed fishery at 40,000 mt, providing an 11,772 mt set-aside for incidental landings in other fisheries. 2) Close the directed fishery and revert to an incidental-catch-only fishery with a 45 percent incidental landing allowance when Pacific mackerel are landed with other coastal pelagic species (CPS), except that up to 1 mt of Pacific mackerel could be landed without landing any other CPS. If needed, conduct an in-season review of the 2008-2009 Pacific mackerel fishery at the nearest feasible Council meeting, with the possibility of either releasing a portion of the incidental set-aside to the directed fishery or further constraining incidental landings to ensure total harvest remains below the ABC.

- In November 2008, the Council adopted a harvest guideline (HG) of 66,932 mt for the 2009 Pacific sardine fishery. This HG was based on a biomass estimate of 662,886 mt and the harvest control

rule in the CPS FMP. The Council recommended that 1,200 mt of the HG be set-aside prior to allocation for dedicated Pacific sardine research activities in period 2. The Council recommended an adjusted allocation of 59,232 mt as the HG for the directed fishery to be allocated seasonally per the Amendment 11 framework. To allow for incidental landings of Pacific sardines in other CPS fisheries and to help to ensure the fishery does not exceed the total HG, the Council adopted a set aside of 6,500 mt allocated across seasonal periods as follows:

HG = 66,932 mt; Research set aside = 1,200 mt; Adjusted HG = 65,732 mt				
	Period 1	Period 2	Period 3	
	Jan 1- Jun 30	Jul 1- Sep 14	Sep 15 – Dec 31	Total
Seasonal Allocation (mt)	23,006	26,293	16,433	65,732
Incidental Set Aside (mt)	1,000	1,000	4,500	6,500
Adjusted Allocation (mt)	22,006	25,293	11,933	59,232

If a seasonal allocation to the directed fishery is reached or exceeded in any period NMFS would close the directed sardine fishery and the fishery would revert to an incidental fishery with an incidental landing allowance of no more that 20 percent Pacific sardine by weight.

Under this proposal, the Council recommends NMFS take the following inseason automatic actions:

- Any unused seasonal allocation to the directed fishery from Period 1 or Period 2 rolls into the next period's directed fishery.

- Any overage of a seasonal allocation to the directed fishery from Period 1 or Period 2 is deducted from the next Period's directed fishery.

- Any unused Seasonal Incidental Set-Aside from Period 1 or Period 2 rolls into the next period's directed fishery.

- If both the seasonal allocation to the directed fishery and the Seasonal Incidental Set-Aside are reached or exceeded in any period, the retention of Pacific sardine will be prohibited and the overage will be deducted from the next period's directed fishery.

- Any of the research set-aside that is not used in Period 2 rolls into the third seasonal period's directed fishery HG.

- In November 2008, the Council also adopted a public review draft of the Terms of Reference document for the 2009 STAR Panel process. The Council also tasked Council staff with scheduling two STAR Panels for 2009; one in May 2009 focused on a full Pacific mackerel assessment and Pacific sardine assessment methodology, and a second in September 2009 that focuses on the review of a full Pacific sardine assessment.

- At the March 2009 meeting, the Council adopted a final Terms of Reference as a guide for the 2009 coastal pelagic species STAR process. The Council approved minor changes to the document as recommended by the Scientific and Statistical Committee (SSC). A final document will be posted to the Council website in the near future. The Council also scheduled two STAR Panels, both to be held at the Southwest Fisheries Science Center in La Jolla, California. The first occurred May 4-8, 2009 and will review a full assessment of Pacific mackerel as well as the survey design for a proposed Pacific sardine survey. The second occurred September 21-25, 2009 to review a full assessment of Pacific sardine.

  The Council also approved for public review two EFP proposals for an industry-sponsored Pacific sardine research survey in 2009. The Council requested that Pacific sardine industry representatives work to provide a detailed single proposal that addresses the recommendations of the SSC and the Coastal Pelagic Species Management Team (CPSMT). The Council asked the proposal be submitted for publication on the Council website as soon as feasible, but no later than April 15, 2009 to allow for adequate review in advance of the May 4-8, 2009 STAR Panel meeting where survey methodology is scheduled for thorough evaluation. The Council also recommended National Marine Fisheries Service (NMFS) adjust the research set-aside for this effort from 1200 metric ton (mt) to 2400 mt.

  The Council also reviewed the final NMFS guidelines for implementing National Standard 1 and held an initial scoping session on amending the coastal pelagic species FMP in accordance. In general, issues identified for further consideration include: updating the definition and implementation of the harvest control rules to comply with new management mechanisms such as ACLs, acceptable biological catch (ABC), and overfishing levels (OFLs), developing these mechanisms for monitored and prohibited harvest species, a listing of potential species to be categorized as ecosystem species, and revising measures for more efficient inseason monitoring and enhanced preseason and postseason accounting. Specifically, the Council was interested in advancing concepts brought forward by the SSC, CPSMT, CPS Advisory Subpanel, and public testimony. The Council reviewed initial analysis of potential alternatives at its November 2009 meeting in Costa Mesa, California, as the second stage of a four Council meeting process.

- In June 2009, the Council adopted the full Pacific mackerel assessment and the following harvest specifications and management measures for the July 2009-June 2010 Pacific mackerel fishery:
  1. Establish an acceptable biological catch of 55,408 metric ton (mt) and a harvest guideline for the directed fishery of 10,000 mt, which includes an incidental set-aside of 2,000 mt for incidental catch in non-divested fisheries.
  2. Should the directed fishery attain landings of 8,000 mt, the Council recommends that National Marine Fisheries Service (NMFS) close the directed fishery and revert to an incidental-catch-only fishery with a 45 percent incidental landing allowance when Pacific mackerel are landed with other coastal pelagic species (CPS), except that up to 1 mt of Pacific mackerel could be landed without landing any other CPS.

  Additionally, to provide time to address research and data needs associated with the Pacific mackerel assessment, the Council recommended no assessment in 2010 and a full assessment in 2011.

- At the November 2009 meeting, the Council expressed support for further development and analyses of the alternatives proposed pursuant to National Standard 1 (NS1) of the Magnuson Act. The Council supported analysis of sector specific annual catch limits, but not for the live bait fishery and requested an analysis of annual catch targets to address management uncertainty and to buffer against overfishing. Additionally, the Council supports the proposed meetings between the CPS Management Team and the Scientific and Statistical Committee CPS Subcommittee to further review the CPS harvest control rules and their adequacy for addressing uncertainty and preventing overfishing. The Council put a lower priority on including additional forage species in the CPS FMP and on development of mechanisms to streamline inseason management. The Council recommended work on these issues with a focus on meeting time-sensitive requirements of the MSA and guidelines for meeting National Standard 1.

  The Council also adopted a harvest guideline (HG) of 72,039 metric tons (mt) for the 2010 Pacific sardine fishery. This HG is based on a biomass estimate of 702,024 mt and the harvest control rule in the Coastal Pelagic Species (CPS) Fishery Management Plan. The Council recommends that 5,000 mt of the HG be set-aside prior to allocation for dedicated Pacific sardine research activities in 2010. The Council recommends an adjusted allocation of 67,039 mt as the HG for the directed fishery to be allocated seasonally per the Amendment 11 framework. To allow for incidental landings of Pacific sardines in other CPS fisheries and to help to ensure the fishery does not exceed the total HG, the Council adopted a set aside of 7,000 mt allocated across seasonal periods as follows:

HG = 72,039 mt Research set aside = 5,000 mt Adjusted HG = 67,039 mt				
	Jan 1- Jun 30	Jul 1- Sep 14	Sep 15 – Dec 31	Total
Seasonal Allocation (mt)	23,463	26,816	16,760	67,039
Incidental Set Aside (mt)	1,000	1,000	1,000	3,000
Management Uncertainty			4,000	4,000
Adjusted Allocation (mt)	22,463	25,816	11,760	60,039

- At the March, 2010 meeting, the Council considered a proposed EFP for the industry-sponsored aerial sardine survey. This would be the third year of the aerial survey, which was reviewed by a STAR panel in May 2009. The proposed research survey would utilize the 5,000 mt EFP set-aside that the Council approved at the November 2009 meeting. 2,100 mt each would be allocated to the northwest and the southwest, respectively, with an additional 800 mt set aside for a fall pilot LIDAR survey in the Southern California Bight.

  Also at the March meeting, the Council considered and adopted Amendment 13 preliminary preferred alternatives for public review. These included:
  - All actively managed and monitored CPS species remain in the fishery, and krill are moved to a new Ecosystem Component species category.

- Maintain existing Status Determination Criteria (SDC) for CPS FMP stocks, and develop MSY proxy for the northern subpopulation of northern Anchovy.
- No preferred alternative for overfishing levels (OFLs), acceptable biological catches (ABCs0 and annual catch limits (ACLs), pending additional analyses.
- Maintain the default harvest control rule for monitored stocks.
- Further analyze the use of accountability measures such as ACTs, set-asides, and management uncertainty buffers to address research, live bait, management uncertainty, and incidental fishery mortality.
- Maintain all current species in the current CPS FMP and transfer no species to state management.

- At the April 2010 meeting, the Council approved the EFP proposal, as modified in response to SSC and CPSMT suggestions. The Council voted to transmit a letter to NMFS Southwest Region, recommending approval of the EFP. The EFP was ultimately approved and issued by NMFS.

- At the June 2010 meeting, the Council adopted management measures for Pacific mackerel, for the fishing season beginning July 1, 2010 through June 30, 2011. Because there was no new assessment for 2010, the Council based management measures on the previous year's assessment. The following measures were adopted:
  - Establish an acceptable biological catch of 55,408 metric ton (mt) and a harvest guideline for the directed fishery of 11,000 mt, which includes an incidental set-aside of 3,000 mt for incidental catch in non-directed CPS fisheries.
  - Should the directed fishery attain landings of 8,000 mt, the Council recommends that National Marine Fisheries Service (NMFS) close the directed fishery and revert to an incidental-catch-only fishery with a 45 percent incidental landing allowance when Pacific mackerel are landed with other coastal pelagic species (CPS), except that up to 1 mt of Pacific mackerel could be landed without landing any other CPS.

  Also in June 2010, the Council took final action on Amendment 13 to the CPS FMP, Annual Catch Limits and Accountability Measures. In adopting the final FMP amendment, the Council selected the following alternatives:
  - All actively managed, monitored species, and prohibited harvest species (krill) in the FMP are to be categorized as "in the fishery."
  - Jacksmelt and Pacific herring are to be added to the FMP as ecosystem component (EC) species and monitor incidental catch in CPS fisheries.
  - Modify the existing harvest control rules for actively managed species to include a buffer or reduction in acceptable biological catch (ABC) relative to overfishing limit (OFL) to account for scientific uncertainty. This buffer will be determined though the annual management cycle through a combination of scientific advice from the SSC and a policy determination of the Council.

  Control Rules for Actively Managed Species:

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

OFL = overfishing limit
ABC = acceptable biological catch
FMSY = fishing mortality rate that maximizes catch biomass in the long term.
ACL = annual catch limit
HG = harvest guideline
ACT = annual catch target

- Maintain the default harvest control rules for monitored stocks 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. The value of 0.25 in the ABC control rule (a 75 % buffer) will remain in use until recommended for modification by the Scientific and Statistical Committee and approved by the Council.

Control Rules for Monitored Species:

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

- Add sector-specific ACLs, ACTs, and AMs, to the CPS FMP management framework for use in the annual harvest and management specification process.
- Add language to specify that the Council will include ecological considerations when reviewing and/or adopting SDCs, OFLs, ABCs, and ACLs.

While not a change to the FMP, the Council confirmed that status determination criteria for CPS FMP are to remain as currently specified with the exception of the Northern subpopulation of Northern anchovy (for which no criteria existed at the time). The Council anticipated adopting a maximum sustained yield (MSY) proxy for this subpopulation through the annual management cycle at its November 2010 meeting.

- At the November 2010 meeting, the Council approved the sardine stock assessment and adopted management measures for the 2011 sardine fishery. Management measures were based on a biomass estimate of 537,173 metric tons (mt). The Council adopted an Overfishing Limit (OFL) of 92,767 mt, a P* value of 0.40, and a corresponding Acceptable Biological Catch (ABC) of 84,681 mt. The Council set an Annual Catch Limit (ACL) equal to the ABC of 84,681 mt. The Council adopted a harvest guideline (HG) of 50,526 mt, with a 4,200 mt set-aside for dedicated Pacific sardine research activities in 2011. (*Only 2,700 mt was subsequently proposed for EFP research, thereby adding 1,500 mt to the 2011 third period directed fishery*). The Council also adopted a set aside of 5,000 mt allocated across seasonal periods as in the following table. Incidental catch limits during closed periods and rollover provisions for quota overages and underages remain the same as prior years.

HG = 50,526 mt; EFP set aside = 4,200 mt; Adjusted HG = 46,326 mt				
	Jan 1- Jun 30	Jul 1- Sep 14	Sep 15 – Dec 31	Total
Seasonal Allocation (mt)	16,214	18,530	11,582	46,326

Incidental Set Aside (mt)	1,000	1,000	1,000	3,000
Management Uncertainty (mt)			2,000	2,000
Adjusted Allocation	15,214	17,530	8,582	41,326

The Council also adopted catch limits for monitored CPS stocks, under the Amendment 13 provisions approved at the June 2010 meeting:

Stock	**OFL**	**ABC**	**ACL**	**ACT**
Jack mackerel	126,000 mt	31,000 mt	Equal to ABC	
Northern anchovy, Northern subpop	39,000 mt	9,750 mt	Equal to ABC	1,500 mt
Northern anchovy, central subpop	100,000 mt	25,000 mt	Equal to ABC	
Market squid	F_{msy} proxy resulting in Egg Esc $\geq$ 30%	F_{msy} proxy resulting in Egg Esc $\geq$ 30%	Exempt	

The Council approved new Terms of Reference (TOR) documents for the CPS STAR panel process and a Methodology Review process. The methodology review process TOR was developed as a way to provide independent review of new stock survey and assessment methods for use in CPS fisheries management. As of November 2010, the egg production and aerial survey methods were used in the sardine stock assessment. At the November meeting, the Council considered three other methods to be reviewed for potential use in the sardine stock assessment. These were the SWFSC's Acoustic-Trawl survey, LIDAR imagery, and satellite imagery. (*Note: subsequently, only the Acoustic-Trawl method was reviewed – and approved – for use in CPS stock assessments. The proponents of the other two methods withdrew from consideration prior to panel review*).

- At the March 2011 meeting, the Council considered a preliminary proposal to conduct stock survey research under a NMFS-issued Exempted Fishing Permit (EFP). Unlike the previous two years, the only proposal was aimed at conducting industry-sponsored aerial survey research off the Pacific Northwest. Northwest Sardine Survey (NWSS), LLC submitted the preliminary proposal. The California Wetfish Producers Association (CWPA) participated in the aerial survey during 2009 and 2010, but did not choose to pursue the research again in 2011. The NWSS proposal identified 2,100 mt to utilize for the aerial survey, representing half of the EFP set-aside from the November Council meeting. However, because the CWPA did not propose to use any of the EFP set-aside, the Northwest and California industry members agreed that it would be reasonable for the NWSS to increase its request, to 2,700 mt. The Council approved the proposal for public review, offering several suggestions, including adopting most of the CPSMT's requests in its supplemental report

- At the April 2011 meeting, the Council considered the revised EFP proposal, and voted to recommend that NMFS approve the EFP, subject to minor revisions. The Council Executive Director subsequently transmitted a letter of support to the NMFS Southwest Region, expressing support for the EFP proposal.

  Also at the April 2011 meeting, the Council considered a report of the CPS Methodology Review Panel, which provided guidance on potential for use of acoustic-trawl surveys in stock assessments for CPS fisheries. Acknowledging that there are concerns about whether the methodology should be used to develop absolute abundance estimates for Pacific sardine, the Council approved the methodology for potential contributory use in future stock assessments for Pacific Coast CPS fisheries.

- At the June 2011 meeting, the Council approved Pacific mackerel stock assessment and management measures for the 2011-2012 fishery, beginning July 1, 2011 and ending June 30, 2012. Because Amendment 13 was not yet in place, the Council adopted management benchmarks that would apply under both a pre- and post-Amendment 13 fishery. Therefore, management measures included OFL, ABC, HG, ACL, and ACT:

Biomass	211,126 mt
Overfishing Limit (OFL)	44,336 mt
P* (risk of overfishing)	0.45
Acceptable Biological Catch (ABC)	42, 375 mt
Annual Catch Limit (ACL)	40,514 mt
Harvest Guideline (HG)	40,514 mt
Annual Catch Target (ACT)	30,386 mt

  The ACT of 30,336 mt is 75% of the HG/ACL, and reflects a defacto incidental set-aside of 10,128 mt. After attaining the ACT, the fishery will revert to management similar to recent past years: Other CPS fisheries harvest may include up to 45% Pacific mackerel by weight, and directed harvest of Pacific mackerel up to 1 mt would be allowed). Upon attainment of the ACL (40,514 mt), no retention of Pacific mackerel would be allowed in CPS fisheries. The Council also adopted a provision to consider in April 2012 the possibility of re-allocating the incidental set-aside to the directed fishery. This provision was included in case mackerel become available and in demand. The set aside is relatively large compared with prior years. Therefore, the Council agreed that near the end of the fishing year (spring/summer 2012), if there is a large amount of set aside remaining, it has the option to allocate some of the set aside for directed harvest.

- At the November 2011 meeting, the Council approved the full stock assessment for Pacific sardine, which produced a biomass estimate of 988,385 mt. The Council considered the Quinault Tribal Nation's intention to harvest up to 9,000 mt, and a 3,000 mt EFP set aside, and adopted an allocation plan as indicated in the table below. The Council also approved a recommendation to conduct a methodology review for the Canadian DFO trawl survey off Vancouver Island, which was subsequently scheduled for the spring of 2012.

Harvest Specifications for the 2012 Pacific sardine fishery. ACT = 109,409 mt; Tribal Set Aside = 9,000 mt; EFP set aside = 3,000 mt; Adjusted ACT = 97,409 mt				
	Jan 1- Jun 30	Jul 1- Sep 14	Sep 15 – Dec 31	Total
Seasonal Allocation (mt)	34,093 (35%)	38,964 (40%)	24,352 (25%)	97,409
Incidental Set Aside (mt)	1,000	1,000	1,000	3,000
Adjusted Allocation (mt)	33,093	37,964	23,352	94,409

- At the March 2012 meeting, the Council recommended that the National Marine Fisheries Service approve and issue the EFP proposed by the Northwest Aerial Sardine Survey. Any of the 3000 mt set-aside that not utilized was to be re-allocated to the third period directed fishery. The Council also asked the CPSMT to explore ways to streamline the CPS EFP process, and report back at the June Council meeting.

- The Council adopted management measures and harvest specifications for the upcoming fishing year, including an Annual Catch Limit of 40,514 metric tons (mt), an Annual Catch Target of 30,386 mt, and incidental set-aside of 10,128 mt. The Council also adopted a provision to consider in April 2013 the possibility of re-allocating the incidental set-aside to the directed fishery. These measures were based on the 2011 Pacific mackerel stock assessment, which was approved at the June 2011 Council meeting.

- At the November 2012 meeting, the Council approved COP 23, which describes an EFP process for CPS fisheries. The Council also approved a workshop designed to review Pacific sardine harvest parameters, to be held in spring, 2013, and directed staff to develop a terms of reference and begin plans to implement the workshop.

  The Council also approved the stock assessment update, and established harvest specifications and management measures in the table below. In setting harvest for the 2013 fishing year, the Council recognized the Quinault Tribe's intent to harvest up to 9,000 mt, and an EFP set aside of 3,000 mt.

2013 Pacific sardine harvest specifications and allocation plan HG = 66,495 mt; Tribal set-aside = 9,000 mt; potential EFP set-aside = 3,000 mt Adjusted HG = 54,495 mt				
	Jan 1- Jun 30	Jul 1- Sep 14	Sep 15 – Dec 31	Total
Seasonal Allocation (mt)	19,073 (35%)	21,798 (40%)	13,624 (25%)	54,495
Incidental Set-Aside (mt)	1,000	1,000	1,000	3,000
Adjusted (Directed) Allocation (mt)	18,073	20,798	12,624	51,495

- At the March 2013 meeting, the Council recommended that NMFS approve the 3,000 mt EFP research set-aside, as requested by the Northwest Aerial Sardine Survey, LLC.

- At its April 2013 meeting, the Council considered a report on the sardine harvest parameters workshop, and scheduled potential action for the June 2013 meeting. (That was subsequently shifted to final action at the November 2013 meeting0. The Council also indicated support for changing the sardine fishery start date from January 1 to July 1, and scheduled final action for the June 2013 meeting.

- At the June 2013 meeting, the Council adopted Pacific mackerel management measures and harvest specifications for the 2013-2014 fishing year. These included an overfishing limit of 57,316 mt, a P* choice of 0.45, acceptable biological catch and annual catch limit (ACL) set equal to 52,358 mt, and an annual catch target (ACT) equal to 39,268 mt. The 13,089 mt difference between the ACL and ACT is an incidental catch buffer. The Council also approved a "check in" at the subsequent April meeting, to consider re-allocating some of the incidental catch to the directed fishery, in the case that landings are significantly up, and approaching the initial directed allocation.

  The Council also voted to amend the management and assessment schedule for Pacific mackerel. The new schedule calls for full stock assessments every four years starting in 2015, alternating with catch-only projection estimates every four years, in off-science years. Biennial harvest specifications will be made for two years at a time.

  Also at the June meeting, the Council voted to change the fishery start date for Pacific sardine to July 1, starting in 2014. A biomass projection estimate was to be used to set harvest specifications for the January 1-June 30 period during the 2014 transition year, and the Council anticipated a full stock assessment would be available to inform annual harvest specifications for the fishing year beginning July 1, 2014.

- At the November 2013 meeting, the Council adopted Pacific sardine management measures for the six-month period January 1-June 30, 2014. This includes approving a biomass estimate of 378,120 metric tons (mt) and an Overfishing Limit of 59,214 mt. Based on a P* choice of 0.4, the

Acceptable Biological Catch and Annual Catch Limit were set at 54,052 mt. The annual Harvest Guideline was set at 29,770 mt, with an Annual Catch Target set at 19,846 mt. Accounting for a 1,000 mt Tribal allocation and a 500 mt incidental set-aside, the January 1-June 30 allocation was set at 5,446 mt. Other management measures were to be consistent with the 2012 fishery, with the exception of (1) the incidental landing allowance that was set at 45 percent for mixed loads, after the directed fishery closes, and (2) there would be no rollover of uncaught fish from the first six-month period into the following fishing period.

The Council considered a letter of intent from the Northwest Aerial Sardine Survey, LLC to conduct survey research during summer 2014. The Council adopted the request for public review and scheduled a final determination, including the final tonnage amount, at the April 2014 Council meeting. (The request for an EFP set-aside was subsequently withdrawn).

The Council established a Maximum Sustainable Yield (MSY) reference point for the northern subpopulation of northern anchovy. Based on information that northern anchovy are subject to large population fluctuations and have relatively high productivity, the Council selected annual fishing rate: Fmsy = 0.3 as the appropriate MSY reference point.

The Council also endorsed methodology reviews of the California Department of Fish and Wildlife/California Wetfish Producers Association aerial survey methodology for the Southern California Bight, of the Northwest Aerial Sardine Survey, and the NMFS acoustic sardine survey. The methodology review was to be coordinated with the Southwest Fisheries Science Center to optimize logistical and financial contingencies. The Council also tasked the Coastal Pelagic Species (CPS) Management Team and CPS Advisory Subpanel with reviewing the draft Council Operating Procedure for a CPS methodology review process and with providing their recommendations at a future Council meeting.

- At the March 2014 meeting, the Council adopted the technical change of using the CalCOFI temperature index, rather than the Scripps Pier temperature recordings, in calculating the annual overfishing limit (OFL) for Pacific Sardine. The new temperature index and new temperature-productivity relationship was to be used for establishing the OFL starting with the April 2014 meeting, when the Council established annual harvest specifications and management measures for the fishing year beginning July 1, 2014. The Council directed the CPSMT and NMFS to further evaluate alternatives for applying the new temperature index and Fmsy relationship to annual harvest specifications, and to report back to the Council at the September 2014 meeting.

- At the April 2014 meeting, the Council adopted harvest specifications and management measures for Pacific sardine, for the fishing year running July 1, 2014 through June 30, 2015. This included an OFL of 39,210 mt and an ABC of 35,792 mt, based on a P* value of 0.40. The Council set the ACL and the ACT both to 23,293 mt, and adopted a 500 mt incidental set aside for each of the three fishing periods. Accounting for a Quinault Indian Nation allotment of 4,000 mt and a total of 1,500 met incidental set aside, the period allocations were set to 7,218 mt in Period 1 (July 1 – September 14), 4,323 mt for Period 2 (September 15 – December 31), and 6,252 mt for Period 3 (January 1 – June 30, 2015). The Council approved rollovers from Periods 1 and 2 into the subsequent Period, with no rollover from Period 3 into the next fishing year. The Council also

adopted a mixed load allowance of up to 45 percent sardines caught in other CPS fisheries, after directed Pacific sardine fishing closes.

- At the June 2014 meeting, the Council adopted harvest specifications and management measures for Pacific mackerel. Based on a catch-only projection estimate of 157,106 mt, the Council adopted an OFL of 32,992 mt, an ABC and ACL both equal to 30,138 mt, an HG of 29,170 mt, and an ACT of 24,170 mt. The difference between the HG and the ACT is a 5,000 mt incidental set aside. Should the directed fishery realize the ACT (24,170 mt), the directed fishery will close, and shift to an incidental only fishery, with a 45 percent incidental landing allowance when Pacific mackerel are landed with other CPS, with the exception that up to 1 (one) mt of Pacific mackerel may be landed without landing any other CPS. The Council also adopted a check in provision, to consider reallocating a portion of the set aside to the directed fishery, should the directed fishery attain the ACT.

- At the November 2014 meeting, the Council adopted the technical change of using the CalCOFI temperature index, rather than the Scripps Pier temperature recordings, in calculating annual harvest specifications for Pacific Sardine; and adopted an accompanying harvest FRACTION term ranging between five and 20 percent. This replaces the current range of five and fifteen percent.

TABLE 2-2. REGULATORY ACTIONS

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

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

November 1, 2000. NMFS announced the closure of the directed fishery for Pacific mackerel in the EEZ off the Pacific coast on October 27, 2000. The FMP and its implementing regulations require NMFS to set an annual HG for Pacific mackerel based on a formula in the FMP and to close the fishery when the HG is reached. The HG of 20,740 mt was reached before the end of the fishing season on June 30, 2001, which required closing the directed fishery and setting an incidental harvest limit for Pacific mackerel so that the harvest of other CPS would be further restricted. The intended effect of this action was to ensure conservation of the Pacific mackerel resource. For the reasons stated here and in accordance with the FMP and its implementing regulations at 50 CFR 660.509, the directed fishery for Pacific mackerel was closed October 27, 2000, after which time no more than 20 percent by weight of any landing of Pacific sardine could be Pacific mackerel. (65*FR*65272)

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

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

February 22, 2001. NMFS announced changes to the restriction on landings of Pacific mackerel for individuals participating in the CPS fishery and for individuals involved in other fisheries who harvest small amounts of Pacific mackerel. The incidental limit on landings of 20 percent by weight of Pacific mackerel in landings of Pacific sardine, northern anchovy, jack mackerel, and market squid remained in effect; however, CPS fishermen could land up to one mt of Pacific mackerel even if they landed no other species from the trip. Non CPS fisherman could land no more than one mt of Pacific mackerel per trip. After the

HG of 20,740 mt was reached, all landings of Pacific mackerel would be restricted to one mt per trip. This action was authorized by the FMP and was intended to ensure that the fishery achieved, but did not exceed, the HG while minimizing the economic impact on small businesses. For the reasons stated here, no fishing vessel could land more than one mt of Pacific mackerel per fishing trip, except that fishing vessels with other CPS on board could land more than one mt of Pacific mackerel in a fishing trip if the total amount of Pacific mackerel on board the vessel did not exceed 20 percent by weight of the combined weight of all CPS on board the vessel. (66*FR*11119)

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

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

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

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

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

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

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

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

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

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

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

December 31, 2002. NMFS issued a regulation to implement the annual HG for Pacific sardine in the U.S. EEZ off the Pacific coast for the fishing season January 1, 2003, through December 31, 2003. This HG was calculated according to the CPS FMP and established allowable harvest levels for Pacific sardine off the Pacific coast. Based on the estimated biomass of 999,871 mt and the formula in the FMP, a HG of 110,908 mt was determined for the fishery beginning January 1, 2003. The HG was allocated one third for Subarea A, which was north of 35° 40' N latitude (Point Piedras Blancas, California) to the Canadian border,

and two thirds for Subarea B, which was south of 35° 40' North latitude to Mexican border. The northern allocation was 36,969 mt; the southern allocation was 73,939 mt. If an allocation or the HG was reached, up to 45 percent by weight of Pacific sardine could be landed in any landing of Pacific mackerel, jack mackerel, northern anchovy, or market squid. (67*FR*79889).

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

June 26, 2003. NMFS proposed a regulatory amendment to the CPS FMP. This amendment was submitted by the Council for review and approval by the Secretary. The proposed amendment would change the management subareas and the allocation process for Pacific sardine. The purpose of this proposed amendment was to establish a more effective and efficient allocation process for Pacific sardine and increase the possibility of achieving OY. (68*FR*37995)

July 29, 2003. NMFS proposed a regulation to implement the annual HG for Pacific mackerel in the EEZ off the Pacific coast. The CPS FMP and its implementing regulations require NMFS to set an annual HG for Pacific mackerel based on the formula in the FMP. (68*FR*44518)

September 4, 2003. NMFS issued a final rule to implement a regulatory amendment to the CPS FMP that changed the management subareas and the allocation process for Pacific sardine. The purpose of this final rule was to establish a more effective and efficient allocation process for Pacific sardine and increase the possibility of achieving OY. (68*FR*52523)

September 9, 2003. NMFS announced the reallocation of the remaining Pacific sardine HG in the EEZ off the Pacific coast. On September 1, 2003, 59,508 mt of the 110,908 mt HG was expected to remain unharvested. The CPS FMP required that a review of the fishery be conducted and any uncaught portion of the HG remaining unharvested in Subarea A (north of Pt. Arena, California) and Subarea B (south of Pt. Arena, California) be added together and reallocated, with 20 percent allocated to Subarea A and 80 percent to Subarea B; therefore, 11,902 mt was allocated to Subarea A and 47,600 mt was allocated to Subarea B. The intended effect of this action was to ensure that a sufficient amount of the resource was available to all harvesters on the Pacific coast and to achieve OY. (68*FR*53053)

October 3, 2003. NMFS issued a final rule to implement the annual HG for the July 1, 2003 - June 30, 2004 Pacific mackerel fishery in the EEZ off the Pacific coast. The CPS FMP and its implementing regulations require NMFS to set an annual HG for Pacific mackerel based on the formula in the FMP. Based on this approach, the biomass for July 1, 2003, was 68,924 mt. Applying the formula in the FMP results in a HG of 10,652 mt, which was lower than last year but similar to low HGs of recent years. (68*FR*57379)

October 28, 2003. NMFS announced the closure of the fishery for Pacific sardine in the EEZ off the Pacific coast north of Pt. Arena, California (39° N latitude) at 12:01 a.m. local time on October 17, 2003. The purpose of this action was to comply with the allocation procedures mandated by the CPS FMP. (68*FR*61373)

December 3, 2003. NMFS proposed a regulation to implement the annual HG for Pacific sardine in the U.S. EEZ off the Pacific coast for the fishing season January 1, 2004 through December 31, 2004. This HG was calculated according to the regulations implementing the CPS FMP and established allowable harvest levels for Pacific sardine off the Pacific coast. (68*FR*67638)

February 25, 2004. NMFS issued a regulation to implement the annual HG for Pacific sardine in the U.S. EEZ off the Pacific coast for the fishing season January 1, 2004 through December 31, 2004. This action adopted a HG and initial subarea allocations for Pacific sardine off the Pacific coast that were calculated according to the regulations implementing the CPS FMP. Based on a biomass estimate of 1,090,587 mt (in U.S. and Mexican waters), using the FMP formula, the HG for Pacific sardine in U.S. waters for January 1, 2004 through December 31, 2004 was 122,747 mt. The biomass estimate was slightly higher than last year's estimate; however, the difference between this year's biomass was not statistically significant from the biomass estimates of recent years. Under the FMP, the HG was allocated one third for Subarea A, which was north of 39° N latitude (Pt. Arena, California) to the Canadian border, and two thirds for Subarea B, which was south of 39° N latitude to the Mexican border. Under this final rule, the northern allocation for 2004 would be 40,916 mt and the southern allocation would be 81,831 mt. (69*FR*8572). July 20, 2004. NMFS proposed a regulation to implement the annual HG for Pacific mackerel in the EEZ off the Pacific coast for the fishing season July 1, 2004 through June 30, 2005. The CPS FMP and its implementing regulations required NMFS to set an annual HG for Pacific mackerel based on the formula in the FMP. This action proposed allowable harvest levels for Pacific mackerel off the Pacific coast. (69 *FR* 43383)

September 14, 2004. Information memorandum. NMFS announced the reallocation of the remaining Pacific sardine HG in the U.S. EEZ off the Pacific coast. A regulatory amendment (69 *FR* 8572, February 25, 2003) required that NMFS conduct a review of the fishery 10 months after the beginning of the fishing season on January 1, and reallocate any unharvested portion of the HG, with 20 percent allocated north of Point Area, California, and 80 percent allocated south of Point Arena, California. (69 *FR* 55360)

October 21, 2004. NMFS issued a final rule to implement the annual HG for the July 1, 2004 - June 30, 2005 Pacific mackerel fishery in the EEZ off the Pacific coast. The CPS FMP and its implementing regulations required NMFS to set an annual HG for Pacific mackerel based on the formula in the FMP. Based on this approach, the biomass for July 1, 2003, was 81,383 mt. Applying the formula in the FMP resulted in a HG of 13,268 mt. (69 *FR* 61768)

December 8, 2004. NMFS proposed a regulation to implement the annual HG for Pacific sardine in the U.S. EEZ off the Pacific coast for the fishing season January 1, 2005 through December 31, 2005. This HG was calculated according to the regulations implementing the CPS FMP and established allowable harvest levels for Pacific sardine off the Pacific coast. (69 *FR* 70973)

June 22, 2005. NMFS issued a regulation to implement the annual HG for Pacific sardine in the U.S. EEZ off the Pacific coast for the fishing season January 1, 2005 through December 31, 2005. This HG was calculated according to the regulations implementing the CPS FMP and established allowable harvest levels for Pacific sardine off the Pacific coast. Based on a biomass estimate of 1,193,515 mt (in U.S. and Mexican waters) and using the FMP formula, NMFS calculated a HG of 136,179 mt for Pacific sardine in U.S. waters. Under the FMP, the HG was allocated one-third for Subarea A, which was north of 39°00' N. lat. (Pt. Arena, California) to the Canadian border, and two-thirds for Subarea B, which was south of 39° 00' N. lat. to the Mexican border. Under this final rule, the northern allocation for 2005 would be 45,393 mt, and the southern allocation would be 90,786 mt. (70 *FR* 36053)

August 29, 2005. NMFS proposed a regulation to implement the annual HG for Pacific mackerel in the U.S. EEZ off the Pacific coast. For specific regulations, see final rule language from October 21, 2005 below. (70 *FR* 51005)

October 21, 2005. NMFS issued a final rule to implement the annual HG for Pacific mackerel in the U.S. EEZ off the Pacific coast. The biomass estimate for July 1, 2005, was 101,147 mt. Applying the formula in the FMP resulted in a HG of 17,419 mt, which was 32 percent greater than last year but similar to low HGs of recent years. For the last three years, the fishing industry has recommended dividing the HG into a directed fishery and an incidental fishery, reserving a portion of the HG for incidental harvest in the Pacific sardine fishery so that the Pacific sardine fishery was not hindered by a prohibition on the harvest of Pacific mackerel. At its meeting on June 15, 2005, the CPSAS recommended for the 2005–2006 fishing

season that a directed fishery of 13,419 mt and an incidental fishery of 4,000 mt be implemented. An incidental allowance of 40 percent of Pacific mackerel in landings of any CPS would become effective if the 13,419 mt of the directed fishery was harvested. The CPSAS also recommended allowing up to 1 mt of Pacific mackerel to be landed during the incidental fishery without the requirement to land any other CPS. (70 *FR 61235*)

October 28, 2005. NMFS announced that the Council submitted Amendment 11 to the CPS FMP for Secretarial review. Amendment 11 would change the framework for the annual apportionment of the Pacific sardine HG along the U.S. Pacific coast. The purpose of Amendment 11 was to achieve optimal utilization of the Pacific sardine resource and equitable allocation of the harvest opportunity for Pacific sardine. The public comment period on Amendment 11 was open through December 27, 2005. (70 *FR* 62087)

January 17, 2006. NMFS proposed a regulation to implement the annual HG for Pacific sardine in the U.S. EEZ off the Pacific coast for the fishing season of January 1, 2006 through December 31, 2006. This HG was calculated according to the regulations implementing the CPS FMP and established allowable harvest levels for Pacific sardine off the Pacific coast. (71 *FR* 2510)

June 29, 2006. NMFS issued the final rule to implement Amendment 11 to the CPS FMP, which changed the framework for the annual apportionment of the Pacific sardine HG along the U.S. Pacific coast. The purpose of this final rule was to achieve optimal utilization of the Pacific sardine resource and equitable allocation of the harvest opportunity for Pacific sardine. (71 *FR* 36999)

July 5, 2006. NMFS issued a final rule to implement the annual HG for Pacific sardine in the U.S. EEZ off the Pacific coast for the fishing season of January 1, 2006, through December 31, 2006. This HG was calculated according to the regulations implementing the CPS FMP and established allowable harvest levels for Pacific sardine off the Pacific coast. Based on the estimated biomass of 1,061,391 mt and the formula in the FMP, a HG of 118,937 mt was determined for the fishery beginning January 1, 2006. (71 *FR* 38111)

August 21, 2006. This notice retracted the Notice of Intent (NOI) to prepare an Environmental Impact Statementto analyze a range of alternatives for the annual allocation of the Pacific sardine HG proposed action published on July 19, 2004. Further scoping subsequent to the publication of the NOI revealed additional information indicating that it was unlikely the proposed action would result in significant environmental impacts. An EA was completed and a subsequent Finding of No Significant Impact was signed. (71 *FR* 48537)

October 20, 2006. NMFS proposed a regulation to implement the annual HG for Pacific mackerel in the U.S. EEZ off the Pacific coast. (71 *FR* 61944).

December 7, 2006. NMFS proposed a regulation to implement new reporting and conservation measures under the CPS FMP. These reporting requirements and prohibitive measures would require CPS fishermen/vessel operators to employ avoidance measures when southern sea otters are present in the area they are fishing and to report any interactions that may occur between their vessel and/or fishing gear and sea otters. The purpose of this proposed rule was to comply with the terms and conditions of an incidental take statement from a biological opinion issued by the U.S. Fish and Wildlife Service regarding the implementation of Amendment 11 to the CPS FMP. (71 *FR* 70941).

January 31, 2007. NMFS issued a final rule to implement the annual HG and management measure for the 2006-2007 Pacific Mackerel fishery. Based on the estimated biomass of 112,700 mt and the formula in the FMP, a HG of 19,845 mt was in effect for the fishery which began on July 1, 2006. This HG applied to Pacific mackerel harvested in the U.S. EEZ off the Pacific coast from July 1, 2006 through June 30, 2007, unless the HG was attained and the fishery was closed before June 30, 2007. All landings made after July 1, 2006, will be counted toward the 2006–2007 HG of 19,845 mt. There was a directed fishery of 13,845 mt, followed by an incidental fishery of 6,000 mt. An incidental allowance of 40 percent of Pacific mackerel in landings of any CPS would become effective after the date when 13,845 mt of Pacific mackerel

was estimated to have been harvested. A landing of one mt of Pacific mackerel per trip was permitted during the incidental fishery for trips in which no other CPS is landed. (72 *FR* 4464).

May 30, 2007. This action implemented new reporting and conservation measures under the CPS FMP. The purpose of this action was to prevent interactions between CPS fisherman and southern sea otters, as well as establish methods for fishermen to report these occurrences. These reporting requirements and conservation measures require CPS fishermen/vessel operators to employ avoidance measures when southern sea otters are present in the area they are fishing and to report any interactions that may occur between their vessel and/or fishing gear and sea otters. (72 *FR* 29891).

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

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

January 31, 2008 NMFS issued the final rule to implement the annual HG for Pacific mackerel for the fishing season of July 1, 2007 through June 30, 2008. The HG for the 2007–2008 fishing season is 40,000 mt. If this total was reached, Pacific mackerel fishing would be closed to directed harvest and only incidental harvest would be allowed at a 45 percent by weight incidental catch rate when landed with other CPS, except that up to one mt of Pacific mackerel could be landed without landing any other CPS. (73 *FR* 5760).

August 20, 2008 NMFS proposed a regulation to implement the annual HG for Pacific mackerel in the EEZ off the Pacific coast for the fishing season of July 1, 2008 through June 30, 2009. (73 *FR* 49156).

August 20, 2008 NMFS issued a final rule that noticed effectiveness of reporting requirements of interactions that may occur between a CPS vessel and/or fishing gear and sea otters originally published on May 30, 2007 (see above). The May 30th final rule contained information collection requirements that at the time of publication had not yet been approved by OMB. The final rule stated that NMFS would publish a subsequent Federal Register notice announcing the effectiveness of those requirements. Therefore NMFS announces that OMB approved the collection of information requirements contained in the May 30, 2007, final rule under Control Number 0648-0566 with an expiration date of August 31, 2010. (73 *FR* 60191).

October 10, 2008 NMFS issued a final rule that notices effectiveness of reporting requirements of interactions that may occur between a CPS vessel and/or fishing gear and sea otters originally published on May 30, 2007 (see above). The May 30th final rule contained information collection requirements that at the time of publication had not yet been approved by OMB. The final rule stated that NMFS would publish a subsequent Federal Register notice announcing the effectiveness of those requirements. Therefore NMFS announces that OMB approved the collection of information requirements contained in the May 30, 2007, final rule under Control Number 0648-0566 with an expiration date of August 31, 2010. (73 *FR* 60191).

November 18, 2008 NMFS issued a final rule to implement the annual HG for Pacific mackerel in the EEZ off the Pacific coast for the fishing season of July 1, 2008, through June 30, 2009. The HG for the 2008–2009 fishing season is 40,000 mt. If this total is reached, Pacific mackerel fishing will be closed to directed harvest and only incidental harvest will be allowed at a 45 percent by weight incidental catch rate when landed with other CPS, except that up to one mt of Pacific mackerel can be landed without landing any other CPS. (73 *FR* 68362).

January 5, 2009. NMFS proposed a regulation to implement the annual harvest guideline (HG) for Pacific sardine in the U.S. exclusive economic zone (EEZ) off the Pacific coast for the fishing season of January 1, 2009, through December 31, 2009. This HG was proposed according to the regulations implementing the Coastal Pelagic Species (CPS) Fishery Management Plan (FMP) and established allowable harvest levels for Pacific sardine off the Pacific coast. The proposed initial HG for the 2009 fishing year was 65,732 mt and was proposed to be divided across the seasonal allocation periods in the following way: January 1-June 30, 22,006 mt was allocated for directed harvest with an incidental set-aside of 1,000 mt; July 1-September 14, 25,293 mt was allocated for directed harvest with an incidental set-aside of 1,000 mt; September 15-December 31, 11,933 mt was to be allocated for directed harvest with an incidental set-aside of 4,500 mt. If during any of the seasonal allocation periods the applicable adjusted directed harvest allocation was projected to be taken, fishing would be closed to directed harvest and only incidental harvest would be allowed. (74 FR 252).

May 6, 2009. NMFS proposed a regulation to adjust the harvest specifications for Pacific sardine in the U.S. exclusive economic zone (EEZ) off the Pacific coast for the fishing season of January 1, 2009, through December 31, 2009. The proposed action increased the tonnage of Pacific sardine allocated for industry conducted research from 1200 metric tons (mt) to 2400 mt and decreases the second and third period directed harvest allocations by 750 mt and 450 mt, respectively. (74 FR 20897).

June 30, 2009. NMFS issued a final rule to adjust the harvest specifications for Pacific sardine in the U.S. exclusive economic zone (EEZ) off the Pacific coast for the fishing season of January 1, 2009, through December 31, 2009. This final rule increased the tonnage of Pacific sardine allocated for industry-conducted research from 1200 metric tons (mt) to 2400 mt and decreases the second and third period directed harvest allocations by 750 mt and 450 mt, respectively. (74 FR 31199).

July 13, 2009. NMFS issued a final rule to implement Amendment 12 to the Coastal Pelagic Species (CPS) Fishery Management Plan (FMP) which would provide protection for all species of krill off the West Coast (i.e., California, Oregon and Washington). This rule would prohibit the harvest of all species of krill by any fishing vessel operating in the Exclusive Economic Zone (EEZ) off the West Coast, and would also deny the use of exempted fishing permits to allow krill fishing (74 FR 33372).

July 17, 2009. NMFS prohibited directed fishing for Pacific sardine off the coast of Washington, Oregon and California. This action was necessary because the directed harvest allocation total for the second seasonal period (July 1– September 14) was projected to be reached by the effective date of the rule. From the effective date of the rule until September 15, 2009, Pacific sardine could only be harvested as part of the live bait fishery or incidental to other fisheries; the incidental harvest of Pacific sardine is limited to 20–percent by weight of all fish per trip. Fishing vessels had to be at shore and in the process of offloading at 12:01 am Pacific Daylight Time on date of closure. (74 FR 34700).

September 23, 2009. NMFS issued a temporary rule prohibiting directed fishing for Pacific sardine off the coasts of Washington, Oregon and California. This action was necessary because the directed harvest allocation total for the third seasonal period (September 15–December 31) was projected to be reached by the effective date of the rule. From the effective date of this rule until December 31, 2009, Pacific sardine could only be harvested as part of the live bait fishery or incidental to other fisheries; the incidental harvest

of Pacific sardine was limited to 20–percent by weight of all fish per trip. Fishing vessels had to be at shore and in the process of offloading at 12:01 am Pacific Daylight Time on date of closure. (74 FR 48421)

September 29, 2009. NMFS issued a proposed regulation to implement the annual harvest guideline (HG) for Pacific mackerel in the U.S. exclusive economic zone (EEZ) off the Pacific coast. This HG is proposed according to the regulations implementing the Coastal Pelagic Species (CPS) Fishery Management Plan (FMP) and establishes allowable harvest levels for Pacific mackerel off the Pacific coast. The proposed total HG for the 2009–2010 fishing year was 10,000 metric tons (mt) and was proposed to be divided into a directed fishery HG of 8,000 mt and an incidental fishery of 2,000 mt. (74 FR 49845).

December 22, 2009. NMFS issued a temporary rule prohibiting the incidental harvest of Pacific sardine off the coasts of Washington, Oregon and California. This action was necessary because the incidental set aside for the third allocation period of the 2009 Pacific sardine season was reached. From the effective date of this rule until January 1, 2010, Pacific sardine can only be harvested as part of the live bait fishery. (FR 74 67986).

January 13, 2010. NMFS issued a proposed rule to implement annual harvest specifications for the 2010 sardine fishery off the U.S. West Coast. NMFS proposed a regulation to implement the annual harvest guideline (HG) and seasonal allocations for Pacific sardine in the U.S. exclusive economic zone (EEZ) off the Pacific coast for the fishing season of January 1, 2010, through December 31, 2010. This rule is proposed according to the Coastal Pelagic Species (CPS) Fishery
Management Plan (FMP). The proposed 2010 acceptable biological catch (ABC) or maximum HG is 72,039 mt. 5,000 mt of this 72,039 mt would initially be set aside for use under an Exempted Fishing Permit (EFP), if issued, leaving the remaining 65,732 mt as the initial commercial fishing HG. That HG would be divided across the seasonal allocation periods in the following way: January 1–June 30, 22,463 mt would be allocated for directed harvest with an incidental set-aside of 1,000 mt; July 1–September 14, 25,861 mt would be allocated for directed harvest with an incidental set-aside of 1,000 mt; September 15–December 31, 11,760 mt would be allocated for directed harvest with an incidental set-aside of 1,000 mt with an additional 4,000 mt set aside to buffer against reaching the ABC. (75 FR 1744).

March 10, 2010. NMFS issued the sardine Final Rule to implement the annual harvest specifications for the 2010 sardine fishery off the U.S. West Coast. The proposed allocation of the overall HG over three fishing periods, were identical to those proposed on January 13, 2010 (above). (75 FR 11068).

June 15, 2010. NMFS issued a temporary rule announcing the closure of the first period sardine fishery, effective at 12:01am Pacific Daylight Time June 12. From 12:01 am on the date of closure through June 30, 2010, Pacific sardine may be harvested only as part of the live bait fishery or incidental to other fisheries, with the incidental harvest of Pacific sardine limited to 30 percent by weight of all fish caught during a trip. (75 FR 33733).

July 22, 2010. NMFS issued a temporary rule announcing the closure of the second period sardine fishery, effective at 12:01am Pacific Daylight Time July 22. From 12:01 am on the date of closure through September 14, 2010, Pacific sardine may be harvested only as part of the live bait fishery or incidental to other fisheries, with the incidental harvest of Pacific sardine limited to 30 percent by weight of all fish caught during a trip. (75 FR 42610).

September 27, 2010. NMFS issued a temporary rule announcing the closure of the third period sardine fishery, effective at 12:01am Pacific Daylight Time September 24. From 12:01 am on the date of closure through December 31, 2010, Pacific sardine may be harvested only as part of the live bait fishery or incidental to other fisheries, with the incidental harvest of Pacific sardine limited to 30 percent by weight of all fish caught during a trip. (75 FR 59156).

January 27, 2011. NMFS issued a proposed rule on annual specifications and management measures for Pacific sardine, under the CPS FMP. The proposed 2011 maximum HG for Pacific sardine was 50,526 metric tons (mt), of which 4,200 mt was initially set aside for potential use under an Exempted Fishing Permit (EFP). The remaining 46,326 mt, constituting the initial commercial fishing HG, would be divided across the seasonal allocation periods in the following way: January 1–June 30: 16,214 mt would be allocated for directed harvest with an incidental set-aside of 1,000 mt; July 1–September 14: 18,530 mt would be allocated for directed harvest with an incidental set-aside of 1,000 mt; September 15– December 31: 11,582 mt would be allocated for directed harvest with an incidental set-aside of 1,000 mt, plus an additional 2,000 mt set aside to buffer against reaching the total HG. (76 FR 4854).

March 4, 2011. NMFS issued a temporary emergency rule to close first period directed sardine fishery, anticipating that the first period allocation of 15,214 metric tons would have been harvested by then. Under this rule, Pacific sardine could have been harvested only as part of the live bait fishery or incidental to other fisheries; and the incidental harvest of Pacific sardine was limited to 30-percent by weight of all fish caught per trip. The effective date was12:01 a.m. March 5, 2011. (76 FR 11969).

May 25, 2011. The Final Rule implementing the closure of the first period directed sardine fishery (see above) was issued. (76 FR 30276).

June 28, 2011. NMFS issued a Proposed Rule to implement parts of proposed Amendment 13 to the CPS FMP, which is intended to ensure the FMP is consistent with advisory guidelines published in Federal regulations. NMFS also issued a request for comments, which were due by July 28, 2011. Amendment 13 revises the framework process that was in place to set and adjust fishery specifications and management measures and modifies this framework to include the specification new reference points such as annual catch limit (ACL).

November 14, 2011. NMFS issued a final rule to implement parts of Amendment 13 to the CPS FMP, which is intended to ensure the FMP is consistent with advisory guidelines published in Federal regulations. Amendment 13 revised the framework process that was in place to set and adjust fishery specifications and management measures and modified this framework to include the specification new reference points such as annual catch limit (ACL). (76 FR 70362).

April 3, 2012. NMFS issued a proposed rule on annual specifications and management measures for Pacific sardine, under the CPS FMP. The proposed 2012 maximum HG for Pacific sardine was 109,409 metric tons (mt), of which 3,000 mt was initially set aside for potential use under an Exempted Fishing Permit (EFP) and 9,000 mt for potential harvest by the Quinault Indian Nation. The remaining 97,409 mt, constituting the initial commercial fishing HG, would be divided across the seasonal allocation periods in the following way: January 1–June 30: 34,093 mt would be allocated for directed harvest with an incidental set-aside of 1,000 mt; July 1–September 14: 38,964 mt would be allocated for directed harvest with an incidental set-aside of 1,000 mt; September 15– December 31: 24,352 mt would be allocated for directed harvest with an incidental set-aside of 1,000 mt. (77 FR 19991).

April 12, 2012. NMFS issued a proposed rule on annual specifications and management measures for Pacific mackerel, under the CPS FMP. The proposed 2011-2012 maximum HG for Pacific mackerel was 40,514 metric tons (mt), and the ACT was 30,386 mt. If the ACT was attained, the directed fishery would close, and the difference between the ACL and the ACT (10,128 mt) would be reserved as a set aside for incidental landings in other CPS fisheries and other sources of mortalities. (77 FR 21958).

August 8, 2012. NMFS issued a final rule on annual specifications and management measures for Pacific sardine, under the CPS FMP. The final 2012 maximum HG for Pacific sardine was 109,409 metric tons

(mt), of which 3,000 mt was initially set aside for potential use under an Exempted Fishing Permit (EFP) and 9,000 mt for potential harvest by the Quinault Indian Nation. The remaining 97,409 mt, constituting the initial commercial fishing HG, would be divided across the seasonal allocation periods in the following way: January 1–June 30: 34,093 mt would be allocated for directed harvest with an incidental set-aside of 1,000 mt; July 1–September 14: 38,964 mt would be allocated for directed harvest with an incidental set-aside of 1,000 mt; September 15– December 31: 24,352 mt would be allocated for directed harvest with an incidental set-aside of 1,000 mt. (77 FR 47318).

June 18, 2012. NMFS issued a final rule on annual specifications and management measures for Pacific mackerel, under the CPS FMP. The final 2011-2012 maximum HG for Pacific mackerel was 40,514 metric tons (mt), and the ACT was 30,386 mt. If the ACT is attained, the directed fishery would close, and the difference between the ACL and the ACT (10,128 mt) would be reserved as a set aside for incidental landings in other CPS fisheries and other sources of mortalities. (77 FR 36192).

August 23, 2012. NMFS issued a temporary rule announcing the closure of the second period sardine fishery, effective at 12:01am Pacific Daylight Time August 23. From 12:01 am on the date of closure through September 14, 2012, Pacific sardine may be harvested only as part of the live bait fishery or incidental to other fisheries, with the incidental harvest of Pacific sardine limited to 30 percent by weight of all fish caught during a trip. (77 FR 50952).

December 7, 2012. NMFS issued a proposed rule on annual specifications and management measures for Pacific mackerel, under the CPS FMP. The proposed 2012-2013 maximum HG for Pacific mackerel was 40,514 metric tons (mt), and the ACT was 30,386 mt. If the ACT was attained, the directed fishery would close, and the difference between the ACL and the ACT (10,128 mt) would be reserved as a set aside for incidental landings in other CPS fisheries and other sources of mortalities. (77 FR 73005).

January 31, 2013. NMFS issued a proposed rule on annual specifications and management measures for Pacific sardine, under the CPS FMP. The proposed 2013 maximum HG for Pacific sardine was 66,495metric tons (mt), of which 3,000 mt was initially set aside for potential use under an Exempted Fishing Permit (EFP) and 6,000 mt for potential harvest by the Quinault Indian Nation. The remaining 57,495 mt, constituting the initial commercial fishing HG, would be divided across the seasonal allocation periods in the following way: January 1–June 30: 19,123 mt would be allocated for directed harvest with an incidental set-aside of 1,000 mt; July 1–September 14: 22,998 mt would be allocated for directed harvest with an incidental set-aside of 1,000 mt; September 15– December 31: 12,374 mt would be allocated for directed harvest with an incidental set-aside of 1,000 mt. (78 FR 6794).

March 26, 2013. NMFS issued a final rule on annual specifications and management measures for Pacific mackerel, under the CPS FMP. The final 2012-2013 maximum HG for Pacific mackerel was 40,514 metric tons (mt), and the ACT was 30,386 mt. If the ACT was attained, the directed fishery would close, and the difference between the ACL and the ACT (10,128 mt) would be reserved as a set aside for incidental landings in other CPS fisheries and other sources of mortalities. (78 FR 18249).

June 17, 2013. NMFS issued a final rule on annual specifications and management measures for Pacific sardine, under the CPS FMP. The final 2013 maximum HG for Pacific sardine was 66,495metric tons (mt), of which 3,000 mt was initially set aside for potential use under an Exempted Fishing Permit (EFP) and 6,000 mt for potential harvest by the Quinault Indian Nation. The remaining 57,495 mt, constituting the initial commercial fishing HG, would be divided across the seasonal allocation periods in the following way: January 1–June 30: 19,123 mt would be allocated for directed harvest with an incidental set-aside of 1,000 mt; July 1–September 14: 22,998 mt would be allocated for directed harvest with an incidental set-aside of 1,000 mt; September 15– December 31: 12,374 mt would be allocated for directed harvest with an incidental set-aside of 1,000 mt. (78 FR 36117).

August 20, 2012. NMFS issued a temporary rule announcing the closure of the second period sardine fishery, effective at 12:01am Pacific Daylight Time August 22. From 12:01 am on the date of closure through September 14, 2012, Pacific sardine may be harvested only as part of the live bait fishery or incidental to other fisheries, with the incidental harvest of Pacific sardine limited to 40 percent by weight of all fish caught during a trip. (78 FR 51097).

December 23, 2013. NMFS issued a proposed rule to change the starting date of the annual Pacific sardine fishery from January 1 to July 1. This would change the fishing season from one based on the calendar year to one based on a July 1 through the following June 30th schedule. No other changes to the annual allocation structure are proposed and the existing seasonal allocation percentages would remain as specified in the FMP; as would the current quota roll-over provisions. (78 FR 77413).

February 28, 2014. NMFS issued a final rule to change the starting date of the annual Pacific sardine fishery from January 1 to July 1. This changed the fishing season from one based on the calendar year to one based on a July 1 through the following June 30th schedule. No other changes to the annual allocation structure were made and the existing seasonal allocation percentages remain as specified in the FMP; as do the current quota roll-over provisions. (78 FR 11343).

TABLE 2-3. Coastal pelagic species 2013 limited entry permit vessel listing[/4] with calculated gross tonnage (GT) values for each vessel. (Page 1 of 2)

Vessel Name	Permit No.	Coast Guard Number/ Vessel ID	Calculated Vessel GT[/1]	Permit GT Endorsement	Permit Transfer Allowance[/2]
PROVIDER	1	572344	63.8	63.8	70.2
UNASSOCIATED	2	----	---	43.5	47.9
SEA VENTURE	3	WN4232NW	98.4	98.4	108.2
BARBARA H	4	643518	121.1	121.1	133.2
KAREN MARIE	5	593871	82.0	82.0	90.2
CACHALOT	6	654091	98.1	98.1	107.9
SAN PEDRO PRIDE	7	549506	160.7	160.7	176.8
FERRIGNO BOY	8	602455	139.3	139.3	153.2
KING PHILIP	9	1061827	156.9	156.9	172.6
SEA WAVE	10	951443	206.9	206.9	227.6
UNASSOCIATED	11	---	---	56.2	61.8
ANGELETTE	12	608579	114.8	114.8	126.3
PIONEER	13	246212	141.9	141.9	156.1
TRITON	14	CF7218UH	89.3	89.3	98.2
SAINT JOSEPH	15	633570	84.4	84.4	92.8
-----	16	---	---	137.5	151.3
RISING SPIRIT	17	WN0416RK	61.9	61.9	68.1
ATLANTIS	18	649333	63.8	63.8	70.2
SEA PEARL	19	CF7336UH	124.6	124.6	137.1
UNASSOCIATED	20	---	---	111.9	123.1
SPERANZA MARIE	21	643138	77.0	77.0	84.7
OCEAN ANGEL IV	22	OR868ADK	63.5	63.5	69.9
PACIFIC PREDATOR	23	OR018ADR	97.7	97.7	107.5
OCEAN ANGEL I	24	584336	63.8	63.8	70.2
SEA DIAMOND	25	509632	68.1	68.1	74.9
MANANA	26	253321	23.8	23.8	26.2
NEW QUEEN	27	OR588ADB	55.5	55.5	61.1
MINEO BROS.[/3]	28	CF0163TF	73.4	73.4	80.7
UNASSOCIATED	29	---	---	42.0	46.2
MINEO BROS.[/3]	30	CF0163TF	40.8	40.8	44.9
SHELLFISH	31	506989	340.2	340.2	374.2
ELDORADO	32	690849	54.9	54.9	60.4
KELSEY NICOLE	33	1210115	194.0	194.0	213.4
CAROL N ROSE	34	1211776	125.6	125.6	138.2
ENDURANCE	35	613302	42.0	42.0	46.2
NEW SUNBEAM	36	284470	27.0	27.0	29.7
CALOGERA A	37	984694	85.3	85.3	93.8
EILEEN	38	252749	119.9	119.9	131.9
PAMELA ROSE	39	693271	61.9	61.9	68.1
NEW STELLA	40	598813	71.8	71.8	79.0
TRAVELER	41	661936	44.0	44.0	48.4
LUCKY STAR	42	295673	41.5	41.5	45.7
OCEAN ANGEL II	43	622522	149.5	149.5	164.5
CRYSTAL SEA	44	1061917	137.0	137.0	151.8
TRIONFO	45	625449	79.2	79.2	87.1
RELENTLESS	46	CF2009TK	85.0	85.0	93.5
HEAVY DUTY	47	655523	84.4	84.4	92.8
ALIOTTI BROS	48	685870	107.2	107.2	117.9
LADY J	49	647528	40.7	40.7	44.8
INVINCIBLE	50	1225596	50.2	50.2	55.2
ENDEAVOR	51	971540	72.3	72.3	79.5

TABLE 2-3. Coastal pelagic species 2013 limited entry permit vessel listing/4 with calculated gross tonnage (GT) values for each vessel. (Page 2 of 2)

Vessel Name	Permit No.	Coast Guard Number/ Vessel ID	Calculated Vessel GT/1	Permit GT Endorsement	Permit Transfer Allowance2
ANTOINETTE W	52	606156	37.0	37.0	40.7
CAPE BLANCO	53	648720	158.2	158.2	174.0
OCEAN ANGEL III	54	OR108ADL	82	126.5	139.2
UNASSOCIATED	55	---	---	40.4	44.4
KATHY JEANNE	56	507798	86.3	86.3	94.4
MERVA W	57	532023	54.4	54.4	59.8
SANTA MARIA	58	236806	91.1	91.1	100.2
STELLAR	59	1190501	73.3	74.5	82.0
PACIFIC KNIGHT	60	OR155ABZ	63.4	63.4	69.7
ALEUTIAN SPIRIT	61	621542	59.9	59.9	65.9
SEABOUND	62	AK9671AF	67.8	39.7	43.7
EMERALD SEA	63	626289	86.3	86.3	94.9
LUCKY MARIE	64	602150	35.1	54.5	60.0
BOUNTY	65	629721	26.4	26.4	29.0

/1 Vessel Gross Tonnage GT=0.67(Length*Breadth*Depth)/100. See 46 CFR 69.209.
/2 Maximum transfer allowance is based on permit GT + 10%.
/3 Vessel Mineo Bros is associated with permits 28 and 30
/4 Several CPS permit transfers occurred in 2013. The above list includes vessels with permits at the end of December 2013 that received renewal permit applications. Vessels that had permits earlier in the year but transferred their permit to other vessels were not included

TABLE 2-4. Vessel age and calculated gross tonnage (GT) for the initial and current Federal limited entry fleet.

	Initial Fleet	Current Fleet
Number of Vessels	65	56
Average Vessel Age	35 years	34 years
Range of Ages	12 to 66 years	4 to 70 years
Average GT	71.3	88
Range of GT	12.8 to 206.9	23.4 to 206.9
Sum of Fleet GT	4,635.9	4,753
Capacity Goal (GT)1/	---	5,650.9
Transferability Trigger	---	5,933.5

1/ Established in Amendment 10 to the CPS FMP.

TABLE 2-5 (a). Oregon state limited entry sardine permit vessels landing sardine in 2011.

Vessel Name	Coast Guard Number	Year Built	Length	Breadth	Depth	Calculated Vessel GT[2/]	Federal Limited Entry	WA Limited Entry
ANTHONY G	605599	1979	58	24	8	74.6		
CAROL N ROSE	1211776	2008	68	23	11	115.3	X	
CRYSTAL SEA	1061917	1997	66	26	12	138	X	
DELTA DAWN	647246	1982	49.6	19	10.1	63.8		X
EVERMORE	248555	1944	76.3	22.2	11.4	129.4		
HARBOR GEM	974306	1982	58	19.5	10	75.8		
LAUREN L KAPP	OR072ACX	----	72	---	---	---		
OCEAN ANGEL II	622522	1980	74.5	28	10.7	149.5	X	
OCEAN DREAM	621541	1980	58	19	10.2	75.3		
PACIFIC JOURNEY	OR661ZK	1996	71	22	10	104.7	X	
PACIFIC KNIGHT	OR155ABZ	1978	62	19.6	7.6	61.9	X	
PACIFIC PURSUIT	OR873ABY	1993	63	---	---	---		
PACIFIC RAIDER	972638	1991	57.7	22.7	11	96.5		X
ST. ZITA	648115	1982	49.6	21.5	10.5	75		
SUNRISE	238918	1939	80.2	22.2	10.2	121.7		
WESTERN WARRIOR	625471	1980	36.3	15	8.8	32.1		

1/ Vessel dimension information was obtained from NOAA at www.st.nmfs.noaa.gov/st1/CoastGuard/VesselByName.html.
2/ Vessel Gross Tonnage GT=0.67(Length*Breadth*Depth)/100 (The CPSMT is working on discrepancies between Tables 2-3 through 2-6.).

TABLE 2-5(b). Oregon state limited entry sardine permit vessels landing sardine in 2012.

Vessel Name	Coast Guard Number	Year Built	Length	Breadth	Depth	Calculated Vessel GT[2/]	Federal Limited Entry	WA Limited Entry
ANTHONY G	605599	1979	58	24	8	74.6		
CRYSTAL SEA	1061917	1997	66	26	12	138	X	
D C COLE	556145	1975	49.6	19	10.1	63.8		
DELTA DAWN	647246	1982	49.6	19	10.1	63.8		X
EMERALD SEA	626289	1980	62.7	26	7.9	86.3	X	X
EVERMORE	248555	1944	76.3	22.2	11.4	129.4		
HARBOR GEM	974306	1982	58	19.5	10	75.8		
LADY LAW	1131965	2002	74.7	25	13.3	166.4		
LAUREN L KAPP	OR072ACX	----	72	---	---	---		
OCEAN ANGEL II	622522	1980	74.5	28	10.7	149.5	X	
OCEAN DREAM	621541	1980	58	19	10.2	75.3		
PACIFIC JOURNEY	OR661ZK	1996	71	22	10	104.7	X	
PACIFIC PREDATOR	OR018ADR	---	57	20	---	---	X	
PACIFIC PURSUIT	OR873ABY	1993	63	---	---	---		
PACIFIC RAIDER	972638	1991	57.7	22.7	11	96.5		X
ROYAL PACIFIC	OR873ABY	---	73	---	---	---		
SEA VENTURE	WN4232NW	---	66	---	---	---	X	
SEQUEL	1240646	2012	57.8	22.7	11.5	101.1		
SHELTER COVE	1239174	2012	58	25	11	106.9		
SUNRISE	238918	1939	80.2	22.2	10.2	121.7		

WESTWIND	246530	1944	72.5	20.2	8.4	82.4		

1/ Vessel dimension information was obtained from NOAA at www.st.nmfs.noaa.gov/st1/CoastGuard/VesselByName.html.
2/ Vessel Gross Tonnage GT=0.67(Length*Breadth*Depth)/100

TABLE 2-5 (c). Oregon state limited entry sardine permit vessels landing sardine in 2013.

Vessel Name	Coast Guard Number	Year Built	Length	Breadth	Depth	Calculated Vessel GT[2/]	Federal Limited Entry	WA Limited Entry
ANTHONY G	605599	1979	58	24	8	74.6		
ARCTIC FOX	1187928	2006	57.3	26	12.6	125.8		X
DELTA DAWN	647246	1982	49.6	19	10.1	63.8		X
JOHNNY A	625595	1980	49.6	22	9.7	70.9		
LAUREN L KAPP	OR072ACX	----	72	---	---	---		
MISS ROXANNE	976542	1991	58	19.5	10	75.8		
OCEAN DREAM	621541	1980	58	19	10.2	75.3		
PACIFIC JOURNEY	OR661ZK	1996	71	22	10	104.7		
PACIFIC PURSUIT	OR873ABY	1993	63	---	---	---		
PACIFIC RAIDER	972638	1991	57.7	22.7	11	96.5		X
PACIFIC VENTURE	WN7995RP	---	59	19	---	45[3]		
SEQUEL	1240646	2012	57.8	22.7	11.5	101.1		
ST. TERESA	623983	1980	49	18.5	8.5	51.6		
WESTWIND	246530	1944	72.5	20.2	8.4	82.4		

1/ Vessel dimension information was obtained from NOAA at www.st.nmfs.noaa.gov/st1/CoastGuard/VesselByName.html.
2/ Vessel Gross Tonnage GT=0.67(Length*Breadth*Depth)/100
3/ Vessel Gross Tonnage provided by WDFW.
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TABLE 2-6. Washington limited entry sardine licenses in 2010.

Vessel Name	Coast Guard Number	Year Built	Registered Measurements (ft)1/			Calculated Vessel GT 2/	Other Permits/Licenses	
			Length	Breadth	Depth		Federal Limited Entry	Oregon Limited Entry
ATLANTIS	649333	1982	49.6	19.0	10.1	63.8	x	
BAINBRIDGE	236505	1937	78.6	22.7	9.6	114.8	x	
CAPE CAUTION	606699	1979	49.6	19.0	10.1	63.8		
DELTA DAWN	647246	1982	49.6	19.0	10.1	63.8		x
HEAVY DUTY	655523	1983	58.0	21.3	10.2	84.4	x	
HUSTLER	943301	1989	55.0	17.0	8.2	51.4		
JUNO	260614	1950	131.3	30.1	12	317.8		
LISA MARIE	1038717	1996	78.0	25.3	13	171.9		
MARAUDER	975597	1991	58.0	22.8	10.5	93.0		
	OR761ABL	2004	25.7			0.0		
PACIFIC JOURNEY	OR661ZK	2001	64.3	22.0	10.3	97.7	x	x
PACIFIC LEADER	643138	1981	59.5	21.0	9.2	77.0	x	x
PACIFIC RAIDER	972638	1991	57.7	22.7	11.0	96.5		x
	OR108ADL	1980	68.0					
SPARTAN	607367	1979	58.0	19.0	10.1	74.6		x
ST. TERESA	623983	1980	49.0	18.5	8.5	51.6		x

VOYAGER	248217	1945	66.7	20.2	9.3	84.0		

1/Vessel dimension information was obtained from NOAA at www.st.nmfs.noaa.gov/st1/CoastGuard/VesselByName.html.
2/ Vessel Gross Tonnage GT=0.67(Length*Breadth*Depth)/100 (The CPSMT is working on discrepancies between Tables 2-3 through 2-6).

TABLE 4-1 (continued). Preliminary catch summary for vessels targeting Pacific sardine from NMFS-SWR coastal pelagic species pilot observer program, 2004-2008. (Page 2 of 2).

Target species - Pacific sardine					
Species	**Target Catch**	**Incidental Catch**	**Bycatch Returned**		
			Alive	**Dead**	**Unknown**
Unid. Smelt		2			
Unid. Surf Perch		1			
Unid. Turbot				60	
White Croaker		31 lbs	50 lbs		
Yellowfin Croaker		10 lbs			
CA Sea Lion			49		
Harbor Seal			1		
Unid. Gull			3	2	4

TABLE 4-2. Preliminary catch summary for vessels targeting market squid from NMFS-SWR coastal pelagic species pilot observer program, 2004-2008.

Target species - Squid					
Species	**Target Catch**	**Incidental Catch**	**Bycatch Returned**		
			Alive	**Dead**	**Unknown**
Squid	1274 mt		28 mt	350 lbs	2 mt
Anchovy		100 lbs	120 lbs		
Jack Mackerel		2 mt	18 lbs	2 lbs	
Pacific Mackerel		20 mt	20 mt	180 lbs	1 lb
Sardine		12 mt	13 mt	1077 lbs	3 lbs
Spanish Mackerel		20 lbs			
Bat Ray			53		1
Bat Star			1		
Blue Shark			2		
Common Mola			1		
Pelagic Stingray			60		
Pacific Butterfish		19			1
Sunstar		30	4		
Squid Eggs					505 lbs
Lobster			3		
Brittle Star				3000	
Unid. Batfish				2 lbs	
Unid. Crab		1	1		93
Unid. Croaker		3	2	16 lbs	
Unid. Flatfish		1	1	6	2
Unid. Jellyfish		4			
Unid. Mackerel		2 lbs	102 lbs		
Unid. Octopus		1			
Unid. Rockfish		1	1	4	
Unid. Ray			4		1

Unid. Sanddab		4	3		4
Unid. Seastar		1			
Unid. Seaslug					21
Unid. Scorpionfish		1			
Unid. Surfperch				3	
Unid. Skate		3		1	
Unid. Smelt		49			
Unid. Stingray		9	17		
Unid. Shark					1
Thresher Shark		1			
CA Sea Lion			98		
Harbor Seal			3		
Common Dolphin				1	
Unid. Gull			16	1	

TABLE 4-3. Preliminary catch summary for vessels targeting Pacific mackerel from NMFS-SWR coastal pelagic species pilot observer program, 2004-2008.

Target species - Pacific mackerel					
Species	**Target Catch**	**Incidental Catch**	**Bycatch Returned**		
			Alive	**Dead**	**Unknown**
Pacific Mackerel	40 mt				
Bat Ray			2		
CA Yellowtail			1		
Midshipman			1		
Sardine		16 mt			
Sea Cucumber		5			
Unid. Crab		1			
Unid. Flatfish			3		
Unid. Jellyfish			3		
Unid. Shark			1		

TABLE 6-4. Preliminary catch summary for vessels targeting northern anchovy and northern anchovy/Pacific sardine from NMFS-SWR coastal pelagic species pilot observer program, 2004-2008.

Target species - Anchovy and Anchovy/Sardine					
Species	**Target Catch**	**Incidental Catch**	**Bycatch Returned**		
			Alive	**Dead**	**Unknown**
Anchovy	373 mt		2 mt	1 mt	
Sardine		21 mt	2 mt		
Bat Ray			4		
CA Lizardfish			4		
Kelp Bass		1			
Midshipman					5

Pacific Bonito			20 lbs		
Pacific Mackerel		2			
Queenfish		50 lbs	11 lbs		
Round Stingray			1		
Sculpin		2			
Spiny Dogfish			1		
Unid. Croaker		20	45		
Unid. Flatfish		10			
Unid. Hake		4			
Unid. Seastar			1		
Unid. Smelt		2			
Unid. Turbot			1	1	20
White Croaker		50 lbs	35 lbs		
Yellowfin Croaker		50 lbs	10 lbs		
CA Sea Lion			5		
Sea Otter			1		

Table 4-5. Percent frequency of incidental catch in observed Pacific sardine and mackerel landings, by port, 2009-2013. (Page 1 of 5).

	All Ports Combined						Monterey/Moss Landing						Ventura/Port Hueneme/ Terminal Island/ San Pedro				
Common Name	**2009**	**2010**	**2011**	**2012**	**2013**		**2009**	**2010**	**2011**	**2012**	**2013**		**2009**	**2010**	**2011**	**2012**	**2013**
Finfish																	
Anchovy, northern	7.8	3.4	7.4	1.9	0.9		8.3	3.5	8.9	4.0	3.6		6.5	3.2	3.0	0.5	0.4
Barracuda, California	0.8	0.2	0.5	0.4			0.8		0.3	0.4			0.9	0.4	1.0	0.5	
Bass, barred sand		0.2	0.2	0.7	0.3									0.4	1.0	1.2	0.4
Bass, kelp	0.6	0.4		1.3	4.4								1.9	0.7		2.2	5.3
Bass, striped				0.3						0.4						0.2	
Blacksmith					0.3												0.4
Bonito, Pacific	1.4	0.6		0.1	3.8								4.6	1.1		0.2	4.6
Butterfish	0.8	3.4	4.4	1.8	1.5		0.4	3.5	4.3	3.6	3.6		1.9	3.2	5.0	0.5	1.1
Cabezon				0.1						0.4							
Combfish, longspine		0.2	0.2	0.1					0.3					0.4		0.2	
Corbina, California				0.1												0.2	
Croaker, unspecified	0.3				0.3								0.9				0.4
Croaker, white	4.7	5.0	5.7	3.1	0.9		6.7	7.8	6.2	6.9	5.4			2.5	4.0	0.5	
Croaker, yellowfin	0.3			0.3						0.7			0.9				
Cusk eel, basketweave		0.7	0.5	0.1										1.4	2.0	0.2	
Cusk-eel, spotted																	
Eel, unspecified																	
Eel, wolf (wolf-eel)			0.2	0.3					0.3							0.5	
Eel, yellow snake																	
Fish, unspecified	0.6	0.4					0.8							0.7			
Flatfish, unspecified	1.1	0.9	1.0	1.9	0.6		0.4		0.3	0.7			2.8	1.8	3.0	2.7	0.7
Flounder, starry	0.8	0.7	1.2	0.9			1.2	1.6	1.6	2.2							
Flounder, unspecified																	
Flyingfish	0.6	0.2	0.2	0.3	0.3								1.9	0.4	1.0	0.5	0.4
Greenling, kelp		0.2	0.2					0.4	0.3								
Grunion, California																	
Hagfish																	
Halfmoon																	
Halibut, California	2.8	2.1	2.5	1.0	1.8		2.8	1.2	2.3	1.4	1.8		2.8	2.9	3.0	0.7	1.8
Herring, Pacific	0.8	2.2	0.7	1.2			1.2	4.7	1.0	2.9							
Jacksmelt	3.9	3.0	2.0	2.8	0.9		5.6	6.2	2.0	6.1	5.4				2.0	0.5	
Kelpfish, giant		0.2		0.3	0.6									0.4		0.5	0.7
Lingcod	0.3		2.2	0.1			0.4		3.0							0.2	
Lizardfish, California	0.3	0.7	0.5	1.2	1.2					0.7	5.4		0.9	1.4	2.0	1.5	0.4
Mackerel, jack	4.7	3.4	1.0	5.7	13.5		2.4		0.3				10.2	6.5	3.0	9.7	16.1
Midshipman, plainfin	0.3	0.7	3.2	0.1	0.6			0.8	3.9				0.9	0.7	1.0	0.2	0.7
Midshipman, specklefin		0.6		0.7	1.8									1.1		1.2	2.1
Midshipman, unspec																	
Opaleye																	
Perch-like, unspecified				0.3						0.7							
Pipefish, bay																	
Pipefish, kelp		0.2		0.1										0.4		0.2	
Poacher, unspecified																	
Queenfish	0.6	0.2	0.2	0.1									1.9	0.4	1.0	0.2	
Rockfish, chilipepper																	
Rockfish, unspecified	0.6	0.2		0.6									1.9	0.4		1.0	
Salema	0.6												1.9				

Salmon, Chinook				0.6						1.1						0.2	
Sanddab, longfin																	
Sanddab, Pacific	6.1	3.4	5.2	2.2	5.0		8.7	6.2	6.6	4.3	7.1			0.7	1.0	0.7	4.6
Sanddab, speckled		0.2		0.7	0.3						1.8			0.4		1.2	
Sanddab, unspecified		1.5	0.2	1.9				1.2		1.4				1.8	1.0	2.2	
Scorpionfish, California	2.2	3.0	2.0	1.3	2.6								7.4	5.7	7.9	2.2	3.2
Sculpin, pithead																	
Sculpin, roughback				0.3												0.5	
Sculpin, staghorn	1.7	2.1	1.7	1.0	0.6		2.4	3.1	2.3	2.5	3.6			1.1			
Sculpin, undentiified	0.3			0.3									0.9			0.5	
Sculpin, yellowchin	0.3												0.9				
Seabass, giant (black)																	
Shad, American	0.3			1.5			0.4			3.6							
Sheephead, California																	
Silversides	0.3		0.2										0.9		1.0		
Smelt, surf		0.7						1.6									
Smelt, true	0.3												0.9				
Snapper, Mexican																	
Sole, C-O					0.9												1.1
Sole, English	1.7	1.1	1.2	0.4			2.4	2.3	1.6	1.1							
Sole, fantail		0.4		1.0	1.8					0.4				0.7		1.5	2.1
Sole, petrale					0.3												0.4
Sole, rock																	
Sole, sand	2.5	2.8	3.7	1.5	1.5		3.6	5.8	4.9	2.9	8.9					0.5	
Sole, slender																	
Sole, unspecified																	
Sunfish, ocean																	
Surfperch, barred																	
Surfperch, black		0.2		0.1	0.6					0.4				0.4			0.7
Surfperch, kelp																	
Surfperch, pink		0.2		0.3										0.4		0.5	
Surfperch, rainbow			0.2						0.3								
Surfperch, rubberlip	0.3		0.2		0.3		0.4		0.3								0.4
Surfperch, shiner		0.4		0.6	0.9					1.1				0.7		0.2	1.1
Surfperch, unspecified				0.1	0.6											0.2	0.7
Surfperch, walleye																	
Tonguefish		0.9	0.2											1.8	1.0		
Topsmelt	0.6	0.7	0.5	0.1									1.9	1.4	2.0	0.2	
Turbot, curlfin	0.3		0.7	1.5	0.3		0.4		1.0	0.4	1.8					2.2	
Turbot, diamond		0.6	0.5	0.6										1.1	2.0	1.0	
Turbot, hornyhead	0.8	0.7	0.7	2.2	4.4		0.4	0.4	0.3	0.4	1.8		1.9	1.1	2.0	3.5	4.9
Turbot, spotted		0.2		0.1	0.6									0.4		0.2	0.7
Turbot, unspecified		0.4	0.5		0.6									0.7	2.0		0.7
Whiting, Pacific																	
Total % Freq. Incidents	51.9	49.3	52.2	47.0	54.5		49.6	50.2	52.5	50.5	50.0		57.4	48.4	51.5	44.5	55.4
Elasmobranchs																	
Guitarfish, shovelnose		0.6	0.2						0.3					1.1			
Ratfish, spotted		0.2						0.4									
Ray, bat	2.2	5.2	2.7	3.1	1.2		1.2	3.1	2.0	3.2	1.8		4.6	7.2	5.0	3.0	1.1
Ray, California butterfly		0.2		0.1	0.3					0.4				0.4			0.4
Ray, Pacific electric	3.1	1.5	3.9	0.6	1.5		3.6	1.9	4.6	0.7	3.6		1.9	1.1	2.0	0.5	1.1
Ray, unspecified	0.6			1.0			0.4			0.4			0.9			1.5	
Shark, brown smoothhound		0.7						1.2						0.4			

Shark, gray smoothhound																	
Shark, horn	0.3	0.2		0.7	0.3								0.9	0.4		1.2	0.4
Shark, leopard		0.6		0.3				0.4						0.7		0.5	
Shark, Pacific angel		0.2		1.6	1.5									0.4		2.7	1.8
Shark, pelagic thresher																	
Shark, smooth hammerhead																	
Shark, spiny dogfish		1.1						1.6						0.7			
Shark, unspecified		0.2		0.1				0.4								0.2	
Skate, big		0.7	1.2	1.0	0.3			1.6	1.6	2.5	1.8						
Skate, California	0.3		0.2	0.3	0.9					0.4			0.9		1.0	0.2	1.1
Skate, long-nosed				0.1						0.4							
Skate, thornback	2.2	2.8	1.2	1.5	2.1		1.6	1.6	0.3	1.8	5.4		3.7	3.9	4.0	1.2	1.4
Skate, unspecified				0.1												0.2	
Stingray, round	0.3	0.7		0.6									0.9	1.4		1.0	
Total % Freq. Incidents	8.9	14.9	9.6	11.3	7.9		6.7	12.1	8.9	9.7	7.0		13.9	17.6	11.9	12.4	7.0
Invertebrates & Plants																	
Algae, marine	0.8	0.2		0.6												1.0	
Bryozoan			0.2												1.0		
Crab shells				0.3	0.6		1.2			0.7	1.8			0.4			0.4
Crab, box																	
Crab, decorator				0.4						0.4						0.5	
Crab, Dungeness	4.7	3.9	3.4	1.8	1.2			8.2	4.6	4.3	7.1						
Crab, globe		0.4	0.2	1.0	0.6										1.0	1.7	0.7
Crab, rock unspecified	0.3	0.2		0.9	0.3		6.7				1.8		0.9			1.5	
Crab, sheep		0.6		0.4	2.3					0.4				0.7		0.5	2.8
Crab, slender														0.4			
Crab, spider	0.3	0.2		0.7									0.9	1.1		1.2	
Crab, swimming	0.3	1.3	0.5	0.6	1.2								0.9		2.0	1.0	1.4
Crab, unspecified	0.3	0.2	0.7	1.3	0.9					0.4			0.9	0.4	3.0	2.0	1.1
Eelgrass		0.6	0.5	1.5						1.1				2.5	2.0	1.7	
Gorgonians (sea fans)														0.4			
Invertebrate, unspecified				0.1										1.1		0.2	
Jellyfish	6.7	0.9	4.9	1.2	0.6			1.9	6.6	2.9	3.6						
Kelp	10.0	7.8	8.9	11.0	11.4			5.1	8.2	10.1	5.4		14.8		10.9	11.7	12.6
Kelp, feather boa	1.1	1.5	0.2	3.8			9.5			1.4			1.9		1.0	5.5	
Lobster, California spiny	0.3	0.6		1.5	1.2		7.9						0.9	10.4		2.5	1.4
Nudibranch							0.8							2.9			
Octopus, unspecified	0.3	0.7	1.2	2.4	3.8			0.4	1.3	2.9	8.9			1.1	1.0	2.0	2.8
Pleurobranch																	
Prawn, ridgeback		1.1					0.4	1.9						1.1			
Prawn, spot	0.3	0.9		0.1												0.2	
Salps			0.5	0.1										0.4	2.0	0.2	
Sea cucumber	0.3	0.2	0.2	0.9	0.6		0.4			0.4			0.9	1.8	1.0	1.2	0.7
Sea pansy																	
Sea stars	4.4	2.8	3.0	1.6	1.2			4.3	3.6	3.6	3.6		0.9	0.4	1.0	0.2	0.7
Shrimp, black-spotted bay	2.8	1.9	2.7	0.9				2.7	3.3	2.2					1.0		
Shrimp, unspecified		1.3	0.5	0.3	0.3		6.0	0.4						1.4	2.0	0.5	0.4
Snail, top							4.0							1.1			
Snail, unspecified														2.2			
Sponge, unspecified			0.2						0.3								
Squid, jumbo																	
Squid, market	5.6	8.6	10.1	7.8	11.4			12.8	10.8	8.3	5.4		5.6		7.9	7.5	12.6
Squid, market (Egg Cases)																	

Surfgrass							5.6							4.7			
Tunicates							1.2										
Turkish Towel	0.8			0.3						0.7							
Total % Freq. Incidents	39.2	35.8	38.2	41.7	37.5		43.7	37.7	38.7	39.7	37.5		28.7	34.1	36.6	43.0	37.5
Total All Incidents	364	536	406	679	56		252	257	305	277	285		112	279	101	402	341
Total Observed Landings	166	159	89	186	7		42	50	33	34	110		55	109	56	146	118

Table 4-6. Incidental catch reported on landing receipts with greater than fifty percent market squid (by tonnage per landing) from 2008 – 2013 for round haul gear.

	2008		2009		2010		2011		2012		2013	
Common Name	Number of Landings	Metric Tons	Number of Landings	Metric Tons	Number of Landings	Number of Landings	Metric Tons	Metric Tons	Number of Landings	Metric Tons	Number of Landings	Metric Tons
Anchovy, northern	22	34	11	10	8	2	2	6	2	1	4	5
Bonito, Pacific	7	2	1	1	0	0	0	0	0	0	0	0
Mackerel, jack	53	46	54	73	66	11	16	74	51	70	23	19
Mackerel, Pacific	119	199	209	240	239	29	79	330	114	128	52	92
Sardine, Pacific	257	497	303	328	206	41	94	279	150	190	55	113

TABLE 4-7. Percent frequency of bycatch in observed loads of California market squid by port, 2009-2013.

	Total All Ports						**San Pedro/Terminal Island**						**Ventura/Port Hueneme**						**Monterey/Moss Landing**				
CommonName	**2009**	**2010**	**2011**	**2012**	**2013**		**2009**	**2010**	**2011**	**2012**	**2013**		**2009**	**2010**	**2011**	**2012**	**2013**		**2009**	**2010**	**2011**	**2012**	**2013**
Finfish																							
Anchovy, northern	1.4	4.2	2.8	3.6	3.5		1.1		1.7	17.6	2.9			10.0	1.3	3.0	4.3		11.1	5.3	3.6	2.8	2.7
Barracuda, California			0.6	1.1	0.4				0.9						2.7	2.0	0.8						
Bass, kelp		0.4			0.3			1.8			1.0						0.3						
Blacksmith					0.1												0.3						
Bonito, Pacific					0.1						1.0												
Butterfish (Pacific pompano)		3.0	3.8	10.1	10.0			1.8	1.7	8.8	10.7			10.0	4.0	11.4	11.6			2.9	4.6	8.5	7.7
Combfish, longspine			0.4		0.1										1.3		0.3				0.3		
Croaker, white (kingfish)		0.8	1.6	1.5	1.0										1.3	0.3	0.5			1.2	2.3	3.2	2.0
Eel, wolf (wolf-eel)			0.2	0.5	0.5											0.3					0.3	0.9	1.3
Fish, unspecified	0.5			0.1									4.5									0.3	
Flatfish, unspecified	0.5	2.1	0.6		0.3		0.6	1.8	2.6		1.0			20.0						1.2			0.3
Flounder, starry		0.4		1.3	0.1															0.6		3.2	0.3
Flyingfish	1.4	0.4		0.5	0.6		1.7	1.8			1.0					1.0	1.1						

Halibut, California			0.2		0.1				0.9		1.0												
Herring, Pacific		0.4	0.2	1.1	1.3															0.6	0.3	2.5	3.4
Jacksmelt		3.4	1.4	2.2	2.5						1.0					1.5	0.3			4.7	2.3	3.2	5.7
Lizardfish, California		0.4	0.4	0.8	2.8			1.8	0.9	5.9	3.9				1.3	1.0	3.0						2.3
Mackerel, jack	5.3	1.7	2.8	2.8	2.6		4.5	7.1	11.1	8.8	2.9		13.6		1.3	3.8	3.0					0.9	2.0
Mackerel, Pacific	17.7	6.3	14.5	2.8	4.3		17.4	23.2	17.9	2.9	3.9		22.7	10.0	13.3	4.6	5.4		11.1	0.6	13.4	0.6	3.0
Mackerel, unspecified				0.3																		0.6	
Midshipman, plainfin	0.5	0.8	0.6	1.2	1.7		0.6		0.9		1.0				1.3	2.3	1.9			1.2	0.3		1.7
Midshipman, specklefin		0.4	0.2	0.1	0.8			1.8			2.9				1.3	0.3	0.8						
Midshipman, unspecified	0.5		0.4				0.6		1.7														
Poacher, unspecified																							
Rockfish, Blue		0.4			0.6															0.6			1.7
Rockfish, chilipepper					0.9																		2.3
Rockfish, unspecified				0.1	0.5						1.0											0.3	1.0
Salmon, Chinook			0.4	0.9	0.5																0.7	2.2	1.3
Sanddab, longfin			0.4	0.3	0.1				0.9		1.0				1.3							0.6	
Sanddab, Pacific		4.6	8.2	3.0	2.7						5.8				16.0					6.4	9.5	7.0	5.0
Sanddab, speckled			0.6	0.1	0.9				1.7												0.3	0.3	2.3
Sanddab, unspecified		0.8		6.3	5.6			3.6		2.9						10.2	11.3					1.9	0.3
Sardine, Pacific	27.3	12.7	10.6	6.7	5.3		27.5	19.6	20.5	14.7	1.9		36.4	30.0	8.0	6.1	4.0			9.4	7.5	6.6	8.1
Scorpionfish, California	1.4		1.4	0.1	0.6		1.7		4.3	2.9	2.9				2.7		0.5						
Sculpin, pithead																							
Sculpin, staghorn		0.8	2.0	1.2	0.5										1.3	0.3	0.5			1.2	2.9	2.5	0.7
Sculpin, undentiified				0.4	0.3											0.3	0.3					0.6	0.3
Silversides	0.5																		11.1				
Sunfish, ocean			0.4	0.3	0.1											0.3	0.3				0.7	0.3	
Surfperch, shiner			0.2	0.9	1.2						1.9					1.8	1.9				0.3		

Topsmelt	0.5			0.1	0.4		0.6										0.8					0.3	
Turbot, hornyhead		0.4	3.2	1.7	3.4						4.9				2.7	2.5	3.5			0.6	4.6	0.9	2.7
Turbot, spotted																							
Turbot, unspecified	0.5	0.4		0.4	0.4		0.6	1.8									0.8					0.9	
Whiting, Pacific					0.4																		1.0
Total % Freq. Incidents	57.9	45.1	58.2	52.8	57.6		56.7	66.1	67.5	64.7	53.4		77.3	80.0	61.3	52.8	57.3		33.3	36.3	53.9	51.6	59.4
Elasmobranchs																							
Ray, bat	1.0	1.7	1.4	4.6	3.8		1.1	5.4	3.4	11.8	10.7				4.0	6.6	4.0			0.6		1.3	1.0
Ray, Pacific electric	0.5	2.1	2.0	1.3	1.9		0.6								1.3	1.0	0.8			2.9	2.9	1.9	4.0
Shark, horn				0.1	0.1											0.3	0.3						
Shark, unspecified																							
Skate, long-nosed				0.1																		0.3	
Skate, unspecified				0.3																		0.6	
Stingray, round	0.5						0.6																
Total % Freq. Incidents	1.9	3.8	3.4	6.5	5.8		2.2	5.4	3.4	11.8	10.7		0.0	0.0	5.3	7.9	5.1		0.0	3.5	2.9	4.1	5.0
Invertebrates & Plants																							
Algae, marine	0.5		0.2		0.3				0.9										11.1				0.7
Cnidaria (Sea Anemones)			0.4	0.1					1.7	2.9													
Crab, box				0.3												0.5							
Crab, Dungeness	0.5	5.1	4.0	3.4	0.9														11.1	7.0	6.5	7.9	2.3
Crab, rock unspecified	0.5		0.4	0.4	0.3		0.6		0.9	5.9					1.3	0.3	0.3						0.3
Crab, sheep				0.3	0.1						1.0											0.6	
Crab, Shore																							
Crab, swimming			0.4						0.9						1.3								
Crab, unspecified	0.5		0.2		0.1		0.6		0.9		1.0												
Eelgrass	2.9	0.4		1.5	3.2		3.4	1.8		2.9	1.0					1.8	0.8					0.9	7.0
Gorgonians (sea fans)		0.4																		0.6			
Grass, Turtle	0.5						0.6																

Jellyfish	1.0	16.0	7.4	4.8	1.9									10.0		0.5	0.3		22.2	21.6	12.1	10.8	4.7
Kelp	17.2	15.6	15.5	12.0	12.8		18.0	19.6	13.7	11.8	13.6		13.6		17.3	13.7	14.0		11.1	15.2	15.7	9.8	11.1
Kelp, feather boa	1.4	0.8	0.4	0.9	1.2		1.7		1.7											1.2		2.2	3.0
Lobster, California spiny	0.5				0.1		0.6				1.0												
Salps				4.4	4.4											8.4	9.1						
Sea cucumber			1.2		0.4				0.9						2.7		0.8				1.0		
Sea Cucumber, warty																							
Sea Hare	0.5			2.3	0.5		0.6									4.3	1.1						
Sea Slug																							
Sea stars	1.4	3.4	2.6	3.1	2.5		1.1		0.9						1.3	1.5	3.5		11.1	4.7	3.6	5.4	2.0
Squid, jumbo			0.2	0.4					0.9													0.9	
Squid, market (Egg Cases)	12.9	8.4	5.2	3.5	6.7		14.0	7.1	5.1		18.4		9.1	10.0	9.3	4.8	6.7			8.8	4.2	2.2	2.7
Surfgrass		0.4		3.2	1.0											3.3	1.1			0.6		3.5	1.3
Tunicates		0.4	0.2		0.1				0.9											0.6			0.3
Urchin, Purple				0.1												0.3							
Total % Freq. Incidents	40.2	51.1	38.4	40.7	36.6		41.0	28.6	29.1	23.5	35.9		22.7	20.0	33.3	39.3	37.6		66.7	60.2	43.1	44.3	35.6
Total All Incidents	209	237	498	744	773		178	56	117	316	103		22	10	75	394	372		9	171	306	316	298
Total Observed Landings	130	130	143	196	196		104	72	77	39	92		22	11	14	74	64		4	50	52	39	40

TABLE 4-8. Expanded salmonid bycatch in Pacific sardine fisheries in Oregon and Washington, 2000-2013.

	Chinook (live)	Chinook (dead)	Coho (live)	Coho (dead)	Pink (live)	Unid (live)	Unid (dead)	Total (live)	Total (dead)	Grand Total
2013										
Oregon[2/]								117	81	198
Washington[3/]	207	683	125	779				332	1,462	1,794
2012										
Oregon[2/]								61	64	125
Washington[3/]	244	806	148	919				392	1724	2116
2011										
Oregon[2/]								35	37	72
Washington[3/]	56	186	34	212				90	398	488

2010										
Oregon[2/]								110	76	186
Washington[3/]	87	288	53	328				140	616	756
2009										
Oregon[2/]								126	115	241
Washington[3/]	56	186	34	212						488
2008										
Oregon[2/]								123	75	198
Washington[3/]	45	149	27	170						391
2007										
Oregon[2/]								349	170	519
Washington[3/]	33	108	20	124				53	232	285
2006										
Oregon[2/]								164	93	257
Washington[3/]	31	101	19	116				50	217	267
2005										
Oregon[2/]								411	176	587
Washington[3/]	47	156	29	178				76	334	410
2004										
Oregon[2/]								518	305	823
Washington	35	225	19	105	0	39	0	93	330	423
2003										
Oregon[2/]								315	185	500
Washington	92	262	81	231	0	173	0	346	493	839
2002										
Oregon[2/]								199	81	280
Washington	150	356	61	765	0	200	0	411	1211	1532
2001										
Oregon[1/]	45	45	201	134	22	45	0	313	179	492
Washington	449	170	571	504	0	80	0	1100	674	1774
2000										
Oregon[1/]	43	72	159	43	0	303	43	505	158	663
Washington	38	3	276	116	0	7	0	321	119	440

1/ Oregon salmon bycatch data 2000-2001 are expanded from a bycatch rate of salmon/trip based on vessel observation program.
2/ Oregon salmon bycatch data 2002-2013 are from logbooks.
3/ Washington totals calculated from observed 2000-2004 observed bycatch rates.

TABLE 4-9. Reported logbook and observed catches of non-target species caught in Oregon sardine fishery, 2007-2013.

Species	2007 Logbook Data	2008 Logbook Data	2009 Logbook Data	2010 Logbook Data	2011 Logbook Data	2012 Logbook Data	2013 Logbook Data
Blue Shark	0	1	0	0	0	0	0
Thresher Shark	3 (2 released alive)	0	0	0	0	0	0
Unknown Shark	5	0	0	0	0	0	0
Salmonids	519 67% alive; 33% dead	198 62% alive; 38% dead	248 53% alive; 47% dead	186 59% alive; 41% dead	72 49% alive; 51% dead	125 49% alive; 51% dead	198 59% alive; 41% dead
Mackerel	473,441 lbs	59,205 lbs	30,872 lbs	15,280 lbs	20 lbs	947,200 lbs	569,650 lbs
Anchovy	500 lbs	8,300 lbs	12,045 lbs	20,450 lbs	0	0	15,000 lbs
Pacific Herring	0	52,200 lbs	2,000 lbs	0	0	6,000 lbs	3,000 lbs
Pacific Hake	0	525 lbs	0	0	0	0	0
Squid	0	225 lbs	0	30 lbs	0	0	0
Jellyfish	0	0	0	0	0	0	0
Spiny Dogfish	-	-	200 lbs	0	0	0	0
Shad	0	0	0	0	0	0	2 lbs

TABLE 4-10. Recorded incidental catch (mt) in Oregon sardine fishery, 2001-2013 (from fish ticket data). Excludes species landed under an Exempted Fishery Permit.

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Pacific mackerel	52.8	126.3	158.3	161.5	316.1	665	699.7	56.8	49.5	39.2	5.2	1,585.8	435.6
Jack mackerel	1.2	0.3	3.2	24.1	3.6	1.4	8	1.6	2.0	<0.01	-	70.9	60.1
Pacific herring	-	3.3	-	10.3	0.1	1.2	-	55.8	-	-	-	0.35	-
Northern anchovy	-	0.2	-	1.0	68.4	8.6	<0.001	2.4	<0.001	1.2	-	-	12.5
Jacksmelt										-	-	-	-
American shad	-	0.3	-	1.2	-	0.44	-	0.3	0.003	-	-	0.005	0.02
Pacific hake	-	-	0.1	-	-	0.002	-	0.005	<0.001	-	-	-	-
Pacific sanddab	-	-	-	-	-	<0.001	0.002	-	-	-	-	-	-
Dover sole	-	-	-	-	-	-	0.002	-	-	-	-	-	-
Sablefish	-	-	-	-	-	0.01	-	-	-	-	-	-	0.01

Sharks	-	-	0.3	0.3	0.4	0.16	0.14	0.01	1.1	-	-	-	-
Squid	-	-	-	13.9	-	-	-	-	0.003	-	-	-	-
Jellyfish	-	-	-	5.5	-	-	-	-	<0.001	-	-	-	-

Table 4-11. Species noted as encountered on CDFW Live Bait Logs, 1996-2012.

Year	Days Fished	Jack Mackerel	Pacific Mackerel	Barracuda	Herring	Grunion	Smelts (Atherinids)	Shiner Surfperch	White Croaker	Queenfish	Market Squid	Pacific Bonito
2013	210	4	51	6			2				8	
2012	865	2	26								39	
2011	909	4	18				1				31	
2010	632	1	47								11	1
2009	848	2	77	6						1		1
2008	891	2	92	7							2	6
2007	970	2	245	22				2	1	1	7	12
2006	940	7	169	3								2
2005	1,045	49	188	27							1	6
2004	1,059	87	214	13						1	1	8
2003	1,123	18	140	23							2	
2002	1,105	9	147	1						1		
2001	1,052	11	176	56		1						
2000	488	25	87	34		1						
1999	449	16	77	7	1		1					
1998	809	8	189	69	1			1				
1997	773	46	190	104				3				
1996	522	10	45	27	3		5					

TABLE 4-12. Estimates of Pacific sardine and Northern anchovy live bait harvest in California. Data for 1939-1992 from Thomson et al. (1994), and 1993-2013 from CDFW live bait logs. Values are in metric tons with the assumption that 1 scoop =12.5 lbs.

Year	Anchovy	Sardine	Year	Anchovy	Sardine
1939	1,364	0	1977	6,410	0
1940	1,820	0	1978	6,013	107
1941	1,435	0	1979	5,364	0
1942	234	0	1980	4,921	12
1943	WII	WII	1981	4,698	6
1944	WII	WII	1982	6,978	38
1945	WII	WII	1983	4,187	193
1946	2,493	0	1984	4,397	53
1947	2,589	0	1985	3,775	11
1948	3,379	0	1986	3,956	17
1949	2,542	0	1987	3,572	216
1950	3,469	0	1988	4,189	50
1951	4,665	0	1989	4,594	100
1952	6,178	0	1990	4,842	543
1953	5,798	0	1991	5,039	272
1954	6,066	0	1992	2,572	1,807
1955	5,557	0	1993	669	176
1956	5,744	0	1994	2,076	1,506
1957	3,729	0	1995	1,278	2,055
1958	3,843	0	1996	703	1,801
1959	4,297	0	1997	1,077	2,344
1960	4,225	0	1998	304	2,037
1961	5,364	0	1999	453	2,411
1962	5,595	0	2000	834	1,270
1963	4,030	0	2001	1,347	1,226
1964	4,709	0	2002	1,010	1,759
1965	5,645	0	2003	978	3,124
1966	6,144	0	2004	192	3,900
1967	4,898	0	2005	1,464	2,817
1968	6,644	0	2006	476	3,601
1969	4,891	0	2007	699	3,352
1970	5,543	0	2008	719	2,968
1971	5,794	0	2009	774	2,702
1972	5,307	0	2010	504	1,860
1973	5,639	0	2011	1,053	2,073

1974	5,126	0	2012	356	2,594
1975	5,577	0	2013	739	1,847
1976	6,202	0			

TABLE 4-13. Ratio of anchovy to sardine in reported live bait catch in California, 1994-20013. Values are in metric tons with the assumption that 1 scoop =12.5 lbs.

Year	Anchovy	Sardine	Total	Proportion Anchovy	Proportion Sardine
2013	739	1,847	2,586	0.29	0.71
2012	356	2,594	2,950	0.12	0.88
2011	1,053	2,073	3,126	0.34	0.66
2010	504	1,860	2,364	0.21	0.79
2009	774	2,702	3,476	0.22	0.78
2008	719	2,968	3,687	0.20	0.80
2007	699	3,352	4,051	0.17	0.83
2006	476	3,601	4,077	0.12	0.88
2005	1,464	2,817	4,281	0.34	0.66
2004	192	3,900	4,092	0.05	0.95
2003	978	3,124	4,102	0.24	0.76
2002	1,010	1,759	2,769	0.36	0.64
2001	1,347	1,226	2,573	0.52	0.48
2000	834	1,270	2,104	0.4	0.6
1999	453	2,411	2,864	0.16	0.84
1998	304	2,037	2,341	0.13	0.87
1997	1,077	2,344	3,421	0.31	0.69
1996	703	1,801	2,504	0.28	0.72
1995	1,278	2,055	3,333	0.38	0.62
1994	2,076	1,506	3,582	0.58	0.42

TABLE 4-14. Directed Sardine Fishery By-Catch from Fish Tickets (metric tons) in Washington.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Arrowtooth Flounder														0.02

American Shad			0.18						<0.01				0.01	0.02
Chinook		<0.01		<0.01									0.03	0.12
Chum													<0.01	
Coho	<0.01												0.29	0.08
Mackerel	4.32	272.44	259.32	52.40	22.34	19.04	40.61	35.73	6.32	4.45	2.09	0.43	636.17	195.95
Misc				0.34			1.37			2.34				0.01
Northern Anchovy						1.81					5.44			
Pacific Herring			0.02						4.69				<0.01	<0.01
Pink Salmon													<0.01	<0.01
General Shark	0.10	0.01								0.01				
Sole Rex														<0.01
Spiny Dogfish									<0.01				<0.01	<0.01
Starry Flounder	<0.01													

Table 6-1. West coast landings (mt) and real[1] exvessel revenues (2013 $) for Pacific sardine, Pacific mackerel[2], jack mackerel, anchovy and market squid, 1981-2013.

Year	Pacific Sardine mt	Pacific Sardine Rev	Pacific Mackerel mt	Pacific Mackerel Rev	Jack Mackerel mt	Jack Mackerel Rev	Anchovy mt	Anchovy Rev	Squid mt	Squid Rev
1981	15	$6,605	35,388	$15,935,943	17,778	$7,994,832	52,309	$7,163,053	23,510	$11,111,509
1982	2	$1,110	36,065	$14,981,351	19,617	$8,216,808	42,155	$4,465,021	16,308	$7,374,326
1983	1	$347	41,479	$15,944,100	9,829	$3,556,381	4,430	$828,040	1,824	$1,504,139
1984	1	$1,662	44,086	$15,866,301	9,154	$2,623,518	2,899	$795,422	564	$580,111

1985	6	$2,626	37,772	$12,187,308	6,876	$2,399,189	1,638	$443,029	10,276	$7,361,079
1986	388	$150,475	48,089	$14,165,411	4,777	$1,507,694	1,557	$426,807	21,278	$8,218,789
1987	439	$112,127	46,725	$11,859,703	8,020	$2,121,381	1,467	$549,780	19,984	$7,026,013
1988	1,188	$294,393	50,864	$14,097,272	5,068	$1,365,892	1,518	$715,858	37,316	$12,974,107
1989	837	$322,427	47,713	$11,654,354	10,745	$2,738,041	2,511	$1,152,519	40,974	$12,413,753
1990	1,664	$303,590	40,092	$8,534,640	3,254	$705,193	3,259	$995,961	28,447	$7,534,504
1991	7,587	$1,376,819	32,067	$8,235,190	1,712	$383,392	4,068	$1,004,234	37,389	$9,362,676
1992	18,056	$2,827,043	19,045	$6,040,103	1,526	$360,052	1,166	$337,276	13,112	$3,685,052
1993	15,347	$2,275,402	12,129	$2,219,062	1,950	$405,470	2,003	$703,708	42,830	$15,120,616
1994	11,644	$2,184,654	10,293	$2,071,589	2,906	$549,773	1,859	$793,706	55,383	$20,676,812
1995	40,256	$5,023,211	8,823	$1,624,479	1,877	$412,110	2,016	$520,636	70,252	$31,521,364
1996	32,553	$4,371,327	9,730	$1,826,949	2,437	$423,370	4,505	$971,475	80,561	$30,323,384
1997	43,290	$6,054,951	20,168	$3,792,430	1,533	$337,010	5,779	$1,106,597	70,329	$28,158,094
1998	43,312	$4,884,766	21,561	$3,425,012	1,777	$516,190	1,584	$330,654	2,895	$2,190,229
1999	60,476	$6,899,880	9,094	$1,454,076	1,557	$265,809	5,311	$1,275,891	92,101	$44,416,575
2000	67,982	$9,466,300	22,058	$3,814,435	1,451	$356,513	11,832	$1,879,940	118,903	$35,423,122
2001	75,801	$11,626,831	7,618	$1,532,536	3,839	$772,217	19,345	$1,822,360	86,203	$21,527,003
2002	96,897	$13,278,952	3,744	$657,422	1,026	$260,908	4,882	$780,433	72,895	$22,864,162
2003	71,923	$8,944,181	4,213	$808,712	231	$89,705	1,929	$419,681	45,056	$31,159,519
2004	89,339	$12,036,527	3,708	$686,909	1,160	$319,173	7,019	$978,723	40,068	$23,631,758
2005	86,464	$11,806,383	3,586	$670,594	294	$252,077	11,414	$1,304,661	55,755	$36,432,654
2006	86,608	$10,434,779	6,610	$989,453	1,174	$223,828	12,960	$1,499,325	49,180	$30,279,140
2007	127,789	$14,504,481	5,759	$929,148	646	$158,715	10,548	$1,245,908	49,475	$31,830,888
2008	87,190	$15,648,436	3,597	$748,115	323	$57,558	14,654	$1,778,686	38,101	$28,397,959
2009	67,084	$13,309,783	5,138	$1,175,180	121	$20,481	3,519	$548,396	93,107	$60,562,388
2010	66,892	$12,942,450	2,107	$436,503	314	$65,930	1,284	$591,902	130,864	$74,866,221
2011	46,746	$10,043,691	1,365	$337,501	104	$19,323	2,814	$714,357	121,557	$68,685,124
2012	101,555	$21,474,710	6,070	$1,262,075	272	$39,556	2,705	$461,685	97,734	$64,925,754
2013	63,183	$14,484,115	8,679	$1,638,506	1,097	$210,062	6,061	$1,121,823	104,405	$73,725,321

Source: PacFIN - 2011 data extracted Oct. 22, 2013, and 2012-13 data extracted May 15, 2014.

[1]Real values are current values adjusted to eliminate the effects of inflation. This adjustment has been made by dividing current values by the current year GDP implicit price deflator, with a base year of 2013.

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

Table 6-2. West coast landings (mt) and real[1] exvessel revenues (2013 $) for Pacific sardine, Pacific mackerel[2], jack mackerel, anchovy and market squid by fishery sector, 1981-2013.

	Landings (mt)					**Exvessel Revenues (2013 $)**		

Year	Sardine	P. Mackerel	J. Mackerel	Anchovy	Squid	Sardine	P. Mackerel	J. Mackerel	Anchovy	Squid
	SoCal (San Diego - Ventura/Santa Barbara landing areas)									
1981	14.8	33,971.0	17,558.4	47,269.6	10,684.8	$6,604	$15,417,155	$7,889,232	$6,342,381	$2,579,621
1982	1.8	33,955.5	19,326.3	38,955.4	5,696.4	$1,021	$14,186,871	$8,095,100	$3,861,900	$1,497,835
1983	0.6	37,826.4	7,345.3	3,629.0	858.2	$322	$14,861,861	$2,918,156	$514,678	$652,315
1984	0.9	36,868.2	3,618.7	345.8	73.5	$1,154	$14,316,861	$1,369,217	$242,856	$85,695
1985	3.7	35,001.6	6,647.3	200.4	6,055.8	$1,629	$11,548,921	$2,289,555	$118,605	$3,303,749
1986	304.0	46,086.3	4,586.1	313.0	14,533.7	$115,470	$13,716,504	$1,400,223	$122,821	$5,291,637
1987	391.6	45,751.6	7,810.0	251.3	13,831.2	$102,702	$11,647,220	$2,062,323	$102,991	$4,668,529
1988	1,185.4	50,793.9	4,945.6	252.6	31,526.8	$293,043	$14,053,982	$1,314,043	$115,558	$10,658,498
1989	598.5	47,633.8	10,703.7	733.7	33,317.4	$114,242	$11,616,275	$2,684,160	$562,222	$9,671,039
1990	1,536.8	37,554.2	3,060.4	352.5	20,399.6	$255,731	$8,016,335	$641,009	$184,228	$5,248,976
1991	6,601.4	31,753.3	1,649.0	1,004.1	29,210.1	$1,209,693	$8,143,540	$354,388	$326,793	$6,303,362
1992	14,924.3	18,181.7	1,096.8	347.3	4,526.3	$2,182,546	$5,899,019	$329,507	$115,349	$1,071,080
1993	14,669.6	11,765.8	1,272.1	421.6	32,292.8	$2,146,167	$2,180,621	$264,072	$150,998	$10,546,565
1994	9,348.7	9,902.7	2,512.2	506.0	33,909.1	$1,392,104	$1,997,504	$400,202	$239,726	$11,685,069
1995	34,496.9	8,144.4	1,597.1	682.2	59,780.6	$4,295,420	$1,512,391	$275,017	$270,284	$27,073,235
1996	24,385.0	8,857.7	2,065.2	758.2	61,647.8	$3,076,512	$1,636,859	$383,709	$335,060	$23,063,270
1997	29,893.8	15,178.7	830.0	1,666.7	52,392.3	$3,786,984	$3,167,087	$249,301	$274,318	$20,644,393
1998	32,816.9	19,507.9	1,012.4	579.5	2,405.3	$4,011,467	$3,206,957	$431,036	$158,010	$1,853,920
1999	42,221.5	8,781.4	927.4	3,655.3	80,423.5	$5,072,004	$1,432,747	$246,526	$721,381	$38,902,846
2000	42,195.5	21,877.8	1,218.9	4,832.7	93,621.8	$5,839,887	$3,794,954	$295,165	$702,774	$27,780,688
2001	44,720.4	6,751.8	3,623.9	7,572.0	71,137.2	$6,161,482	$1,366,952	$714,069	$985,332	$17,550,843
2002	44,564.9	3,368.3	1,003.6	1,943.1	40,307.2	$5,658,295	$611,695	$253,325	$358,570	$12,053,387
2003	25,276.6	3,981.6	135.9	847.7	21,608.9	$2,546,089	$769,378	$66,956	$221,659	$15,067,472
2004	28,432.8	3,085.9	1,027.1	2,869.4	26,821.3	$3,243,296	$606,381	$297,037	$532,428	$15,610,512
2005	26,026.2	3,242.7	211.0	4,959.0	45,525.5	$2,934,057	$624,178	$59,873	$802,861	$30,192,006
2006	28,728.8	5,840.8	1,025.8	5,071.5	43,111.9	$3,870,831	$923,130	$189,174	$809,370	$26,616,571
2007	46,147.0	4,891.0	459.8	2,668.6	31,132.3	$5,498,588	$842,710	$116,708	$325,998	$20,277,113
2008	31,013.3	3,249.0	214.7	2,027.3	27,969.3	$3,722,915	$683,124	$45,476	$265,503	$20,734,829
2009	12,485.2	5,028.7	97.7	1,662.9	60,640.2	$1,900,131	$1,164,345	$19,415	$261,121	$40,406,031
2010	28,268.9	2,053.2	295.5	305.6	80,454.5	$3,849,956	$432,788	$65,231	$142,088	$46,441,760
2011	17,628.2	1,341.1	79.8	779.1	77,678.1	$2,477,553	$335,490	$10,612	$338,798	$44,454,935

2012	18,637.3	3,475.1	138.2	214.0	67,834.2	$3,318,492	$894,450	$27,531	$72,178	$45,389,836
2013	6,134.7	8,066.8	892.0	383.6	54,409.8	$1,324,127	$1,519,769	$178,606	$250,851	$38,548,994
	Northern California (North of Ventura/Santa Barbara landing areas)									
1981	<0.1	1,361.2	213.5	4,820.9	12,824.8	$1	$490,124	$100,761	$695,191	$8,531,780
1982	<0.1	2,060.6	281.6	3,003.8	10,611.3	$89	$768,641	$116,340	$509,201	$5,875,424
1983	<0.1	3,465.4	2,458.5	653.0	961.5	$25	$1,005,874	$610,037	$234,546	$846,827
1984	0.3	7,164.9	5,486.2	2,432.9	487.9	$508	$1,521,775	$1,237,598	$482,102	$491,562
1985	2.2	2,719.0	228.1	1,397.0	3,890.1	$997	$611,522	$109,415	$289,973	$3,722,209
1986	84.5	1,999.9	191.1	1,200.9	6,319.8	$35,005	$446,428	$107,359	$258,972	$2,808,450
1987	47.8	963.0	210.2	1,100.7	5,953.8	$9,403	$207,861	$59,058	$325,018	$2,302,592
1988	3.0	65.3	121.9	1,188.6	5,196.9	$1,315	$38,385	$51,778	$527,976	$2,097,169
1989	238.0	69.0	41.6	1,684.0	7,149.5	$207,876	$29,121	$53,813	$484,737	$2,603,683
1990	127.1	2,510.0	194.0	2,845.4	8,047.2	$47,701	$497,238	$64,173	$739,696	$2,285,197
1991	985.9	300.8	43.8	2,985.9	8,175.9	$167,125	$82,631	$25,128	$610,226	$3,057,636
1992	3,127.7	386.9	112.3	773.3	8,559.7	$644,477	$129,798	$29,059	$170,112	$2,606,917
1993	676.1	39.6	400.8	1,529.1	7,057.4	$128,290	$20,782	$137,432	$509,182	$3,489,977
1994	2,295.0	40.4	191.7	1,273.8	15,921.3	$792,550	$27,888	$138,399	$480,643	$7,419,294
1995	5,681.3	461.4	109.4	1,203.7	3,197.7	$715,029	$89,735	$109,826	$141,403	$1,464,519
1996	7,988.2	710.6	91.8	3,659.0	5,004.9	$1,231,448	$133,046	$19,065	$547,455	$2,058,213
1997	13,359.8	3,217.6	329.7	4,050.8	8,490.8	$2,172,781	$594,940	$86,577	$774,433	$4,082,364
1998	10,493.5	1,469.7	39.9	901.6	14.2	$872,160	$200,641	$21,404	$91,014	$20,962
1999	17,475.0	6.5	24.3	1,558.1	306.6	$1,711,073	$15,088	$2,380	$466,333	$108,321
2000	11,367.5	41.1	50.5	6,920.8	7,125.9	$1,260,359	$8,744	$36,042	$1,114,595	$2,494,339
2001	7,102.5	172.8		11,704.9	8,026.6	$1,823,258	$26,159		$748,639	$2,348,962
2002	13,779.2	0.3	1.9	2,706.7	25,953.3	$1,664,720	$690	$530	$331,247	$8,779,646
2003	7,920.9	1.0	19.8	705.7	16,729.1	$826,774	$5,354	$3,072	$100,607	$11,621,521
2004	15,837.5	489.9	<0.1	3,890.8	5,707.0	$1,483,108	$63,181	$18	$347,350	$3,516,338
2005	8,509.3	0.5	0.6	6,192.2	1,916.9	$695,715	$864	$376	$443,468	$1,141,175
2006	17,841.9	31.8	141.0	7,705.0	511.2	$1,855,257	$11,173	$34,216	$638,950	$285,679
2007	34,781.8	123.4	166.8	7,704.4	25.3	$3,492,894	$20,764	$39,659	$879,035	$17,785
2008	26,711.7	206.6	59.5	12,216.0	65.6	$4,401,109	$36,260	$11,637	$1,401,961	$48,238
2009	25,011.9	14.3		978.4	1,183.0	$3,999,202	$2,254		$114,845	$969,853
2010	4,305.5	<0.1	<0.1	717.5	20,137.4	$602,387	$4	$13	$344,670	$11,630,086
2011	10,071.9	14.6		1,822.2	14,487.3	$2,058,335	$1,498		$298,497	$8,200,768
2012	4,241.4	100.3		2,273.5	16,851.3	$958,607	$28,140		$305,841	$11,305,094
2013	895.5	0.1		5,549.2	20,964.2	$177,845	$8		$819,409	$15,015,452
	Pacific Northwest (Oregon and Washington)									

1981		<0.1		1.3			$3		$646	
1982		<0.1		5.1			$85		$19,757	
1983		8.3		2.9			$15,486		$10,665	
1984		3.2		10.1			$1,712		$19,175	
1985		<0.1	<0.1	11.7			$4	$2	$22,039	
1986		<0.1		22.1			$1		$36,078	
1987		1.5		77.6			$925		$104,343	
1988		0.6		40.4			$589		$55,985	
1989		5.0		61.9			$1,933		$89,393	
1990		10.4		50.3			$5,980		$66,581	
1991		0.7	19.3	54.5			$324	$3,739	$57,484	
1992		468.1	316.5	41.7			$4,407	$1,202	$49,698	
1993		310.2	276.6	44.2			$7,388	$3,916	$39,859	
1994		285.6	202.3	70.4			$18,091	$11,165	$69,663	
1995		196.9	148.6	129.8			$6,185	$10,154	$108,861	
1996		126.7	260.5	85.6			$32,898	$11,584	$87,921	
1997		1,766.9	373.7	59.1			$26,765	$1,132	$56,742	
1998	1.0	583.7	724.5	102.5		$1,045	$17,199	$63,749	$81,630	
1999	776.9	305.9	604.5	97.8		$116,417	$6,212	$16,282	$88,169	
2000	14,369.9	138.2	181.1	78.8		$2,356,606	$10,488	$25,304	$62,476	
2001	23,907.6	692.8	215.1	68.0		$3,633,238	$138,964	$58,027	$88,389	
2002	38,543.5	374.9	20.5	231.9		$5,954,584	$44,940	$7,045	$90,616	
2003	37,178.1	213.8	75.4	252.9		$5,414,192	$31,712	$19,676	$84,758	
2004	45,045.4	129.1	132.9	226.5		$7,305,626	$16,216	$22,100	$81,890	
2005	51,831.2	341.4	80.4	232.1	14.5	$8,159,849	$45,326	$190,993	$43,197	$8,557
2006	40,031.1	706.3	7.0	169.7	27.2	$4,706,967	$54,330	$439	$42,239	$17,560
2007	46,808.9	740.5	14.9	158.0	0.6	$5,511,628	$64,439	$1,278	$38,801	$323
2008	29,384.2	66.6	48.4	368.6		$7,517,079	$10,886	$445	$98,700	
2009	29,507.1	57.6		851.2		$7,406,669	$6,623		$153,955	
2010	33,232.9	51.1	4.0	258.1		$8,348,955	$3,684	$12	$105,144	
2011	19,032.0	7.4	24.2	212.3	<0.1	$5,505,384	$497	$8,711	$77,063	$1
2012	78,510.6	2,470.8	126.1	217.5		$17,166,180	$335,319	$10,948	$83,666	
2013	56,036.6	611.8	204.7	128.4		$12,955,832	$118,656	$31,449	$51,547	
	Other									
1981		55.9	6.3	217.1	0.2		$28,662	$4,838	$124,834	$108
1982		48.5	9.5	190.9	0.4		$25,754	$5,368	$74,165	$1,067
1983		179.1	25.5	144.7	3.9		$60,879	$28,188	$68,151	$4,997

1984		49.8	49.3	110.1	2.7		$25,953	$16,702	$51,288	$2,855
1985		51.8	0.2	28.5	330.3		$26,862	$217	$12,412	$335,122
1986		3.0	0.1	21.4	424.1		$2,478	$112	$8,936	$118,702
1987	<0.1	9.0		37.6	199.2	$22	$3,697		$17,429	$54,893
1988	0.1	4.0	<0.1	36.6	592.1	$35	$4,316	$71	$16,340	$218,440
1989	0.2	4.9	0.1	31.7	506.8	$308	$7,026	$67	$16,167	$139,031
1990	0.3	17.3	<0.1	10.5	0.3	$159	$15,087	$11	$5,456	$331
1991		11.8	0.1	23.8	2.6		$8,695	$137	$9,731	$1,678
1992	<0.1	8.1	0.3	3.3	26.5	$20	$6,879	$284	$2,118	$7,055
1993	0.7	13.4	<0.1	7.9	3,479.5	$945	$10,271	$49	$3,668	$1,084,075
1994		64.6	<0.1	9.1	5,552.9		$28,105	$8	$3,674	$1,572,449
1995	77.5	20.2	21.9	0.1	7,273.2	$12,762	$16,167	$17,113	$88	$2,983,611
1996	180.3	35.2	19.6	2.2	13,908.6	$63,366	$24,146	$9,011	$1,040	$5,201,901
1997	36.1	4.8		2.4	9,445.5	$95,186	$3,638		$1,104	$3,431,338
1998	0.9	0.1			475.0	$93	$216			$315,346
1999	3.0	0.2	0.8	0.1	11,370.7	$386	$29	$621	$8	$5,405,408
2000	49.0	0.6	<0.1	<0.1	18,154.9	$9,447	$249	$2	$95	$5,148,094
2001	70.4	0.4	0.1		7,038.8	$8,852	$461	$121		$1,627,198
2002	9.2	<0.1	<0.1		6,634.6	$1,353	$98	$8		$2,031,128
2003	1,547.2	16.8		122.9	6,717.8	$157,126	$2,269		$12,657	$4,470,527
2004	23.1	2.9	<0.1	32.4	7,540.0	$4,497	$1,131	$17	$17,056	$4,504,908
2005	97.4	1.1	1.9	30.7	8,297.7	$16,763	$226	$835	$15,136	$5,090,915
2006	6.3	30.9		14.2	5,530.1	$1,725	$821		$8,767	$3,359,329
2007	51.5	4.0	4.6	16.9	18,317.3	$1,370	$1,235	$1,070	$2,074	$11,535,668
2008	80.6	75.3		41.7	10,065.8	$7,332	$17,845		$12,521	$7,614,891
2009	80.2	37.1	20.9	26.7	31,283.7	$3,780	$1,959	$1,066	$18,475	$19,186,503
2010	1,084.2	3.0	14.2		30,264.8	$141,152	$27	$674		$16,794,376
2011	13.8	1.5			29,392.0	$2,419	$16			$16,029,419
2012	165.2	23.9	7.3		13,048.0	$31,430	$4,166	$1,076		$8,230,824
2013	115.7	0.4	<0.1	<0.1	29,031.0	$26,311	$73	$8	$15	$20,160,875

Source: PacFIN - 2011 data extracted Oct. 22, 2013, and 2012-13 data extracted May 15, 2014.

[1]Real values are current values adjusted to eliminate the effects of inflation. This adjustment has been made by dividing current values by the current year GDP implicit price deflator, with a base year of 2013.

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

Table 6-3. Average annual real[1] exvessel prices (2013 $) for Pacific sardine, Pacific mackerel[2], jack mackerel, anchovy and market squid, 1981-2013.

Year	Pacific Sardine $/lb	Pacific Mackerel $/lb	Jack Mackerel $/lb	Anchovy $/lb	Squid $/lb
1981	$0.20	$0.20	$0.20	$0.06	$0.21
1982	$0.25	$0.19	$0.19	$0.05	$0.20
1983	$0.16	$0.17	$0.16	$0.08	$0.37
1984	$0.75	$0.16	$0.13	$0.12	$0.47
1985	$0.20	$0.15	$0.16	$0.12	$0.32
1986	$0.18	$0.13	$0.14	$0.12	$0.18
1987	$0.12	$0.12	$0.12	$0.17	$0.16
1988	$0.11	$0.13	$0.12	$0.21	$0.16
1989	$0.17	$0.11	$0.12	$0.21	$0.14
1990	$0.08	$0.10	$0.10	$0.14	$0.12
1991	$0.08	$0.12	$0.10	$0.11	$0.11
1992	$0.07	$0.14	$0.11	$0.13	$0.13
1993	$0.07	$0.08	$0.09	$0.16	$0.16
1994	$0.09	$0.09	$0.09	$0.19	$0.17
1995	$0.06	$0.08	$0.10	$0.12	$0.20
1996	$0.06	$0.09	$0.08	$0.10	$0.17
1997	$0.06	$0.09	$0.10	$0.09	$0.18
1998	$0.05	$0.07	$0.13	$0.09	$0.34
1999	$0.05	$0.07	$0.08	$0.11	$0.22
2000	$0.06	$0.08	$0.11	$0.07	$0.14
2001	$0.07	$0.09	$0.09	$0.04	$0.11
2002	$0.06	$0.08	$0.12	$0.07	$0.14
2003	$0.06	$0.09	$0.18	$0.10	$0.31
2004	$0.06	$0.08	$0.12	$0.06	$0.27
2005	$0.06	$0.08	$0.39	$0.05	$0.30
2006	$0.05	$0.07	$0.09	$0.05	$0.28
2007	$0.05	$0.07	$0.11	$0.05	$0.29
2008	$0.08	$0.09	$0.08	$0.06	$0.34
2009	$0.09	$0.10	$0.08	$0.07	$0.29
2010	$0.09	$0.09	$0.10	$0.21	$0.26
2011	$0.10	$0.11	$0.08	$0.12	$0.26
2012	$0.10	$0.09	$0.07	$0.08	$0.30
2013	$0.10	$0.09	$0.09	$0.08	$0.32

Source: PacFIN - 2011 data extracted Oct. 22, 2013, and 2012-13 data extracted May 15, 2014.

[1]Real values are current values adjusted to eliminate the effects of inflation. This adjustment has been made by dividing current values by the current year GDP implicit price deflator, with a base year of 2013.

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

Table 6-4. West coast landings (mt) and real[1] exvessel revenues (2013 $) for Pacific sardine, Pacific mackerel[2], jack mackerel, anchovy and market squid by state, 1981-13.

Year	Pac. Sardine mt	Pac. Sardine Rev	Pac. Mackerel mt	Mack. Rev	Mack. mt	Mack. Rev	Anchovy mt	Anchovy Rev	Squid mt	Squid Rev
	California									
1981	15	$6,605	35,388	$15,935,940	17,778	$7,994,832	52,308	$7,162,406	23,510	$11,111,509
1982	2	$1,110	36,065	$14,981,265	19,617	$8,216,808	42,150	$4,445,265	16,308	$7,374,326
1983	1	$347	41,471	$15,928,614	9,829	$3,556,381	4,427	$817,375	1,824	$1,504,139
1984	1	$1,662	44,083	$15,864,589	9,154	$2,623,518	2,889	$776,246	564	$580,111
1985	6	$2,626	37,772	$12,187,304	6,876	$2,399,187	1,626	$420,990	10,276	$7,361,079
1986	388	$150,475	48,089	$14,165,410	4,777	$1,507,694	1,535	$390,729	21,278	$8,218,789
1987	439	$112,127	46,724	$11,858,778	8,020	$2,121,381	1,390	$445,438	19,984	$7,026,013
1988	1,188	$294,393	50,863	$14,096,682	5,068	$1,365,892	1,478	$659,873	37,316	$12,974,107
1989	837	$322,427	47,708	$11,652,421	10,745	$2,738,041	2,449	$1,063,126	40,974	$12,413,753
1990	1,664	$303,590	40,081	$8,528,645	3,254	$705,193	3,208	$929,381	28,447	$7,534,504
1991	7,587	$1,376,819	32,066	$8,234,866	1,693	$379,653	4,014	$946,750	37,389	$9,362,676
1992	18,052	$2,827,043	18,577	$6,035,696	1,209	$358,848	1,124	$287,578	13,112	$3,685,052
1993	15,346	$2,275,402	11,819	$2,211,674	1,673	$401,554	1,959	$663,849	42,830	$15,120,616
1994	11,644	$2,184,654	10,008	$2,053,497	2,704	$538,609	1,789	$724,043	55,383	$20,676,812
1995	40,256	$5,023,211	8,626	$1,618,294	1,728	$401,957	1,886	$411,775	70,252	$31,521,364
1996	32,553	$4,371,327	9,603	$1,794,051	2,177	$411,786	4,419	$883,555	80,561	$30,323,384
1997	43,290	$6,054,951	18,401	$3,765,665	1,160	$335,878	5,720	$1,049,856	70,329	$28,158,094
1998	43,311	$4,883,720	20,978	$3,407,814	1,052	$452,440	1,481	$249,024	2,895	$2,190,229
1999	59,700	$6,783,463	8,788	$1,447,864	952	$249,527	5,214	$1,187,722	92,101	$44,416,575
2000	53,612	$7,109,694	21,920	$3,803,947	1,269	$331,208	11,753	$1,817,464	118,903	$35,423,122
2001	51,893	$7,993,592	6,925	$1,393,572	3,624	$714,190	19,277	$1,733,971	86,203	$21,527,003
2002	58,353	$7,324,368	3,369	$612,482	1,005	$253,863	4,650	$689,817	72,895	$22,864,162

2003	34,745	$3,529,989	3,999	$777,001	156	$70,028	1,676	$334,923	45,056	$31,159,519
2004	44,293	$4,730,901	3,579	$670,694	1,027	$297,072	6,793	$896,834	40,068	$23,631,758
2005	34,633	$3,646,534	3,244	$625,267	213	$61,084	11,182	$1,261,465	55,740	$36,424,097
2006	46,577	$5,727,812	5,904	$935,124	1,167	$223,390	12,791	$1,457,087	49,153	$30,261,579
2007	80,980	$8,992,852	5,018	$864,709	631	$157,437	10,390	$1,207,108	49,475	$31,830,565
2008	57,806	$8,131,357	3,531	$737,230	274	$57,113	14,285	$1,679,986	38,101	$28,397,959
2009	37,577	$5,903,113	5,080	$1,168,557	119	$20,481	2,668	$394,441	93,107	$60,562,388
2010	33,659	$4,593,495	2,056	$432,819	310	$65,918	1,026	$486,758	130,857	$74,866,221
2011	27,714	$4,538,306	1,357	$337,004	80	$10,612	2,601	$637,295	121,557	$68,685,122
2012	23,044	$4,308,530	3,599	$926,756	145	$28,607	2,488	$378,019	97,733	$64,925,754
2013	7,146	$1,528,283	8,067	$1,519,850	892	$178,614	5,933	$1,070,275	104,405	$73,725,321
	Oregon									
1981			<1	$3						
1982			<1	$85			<1	$206		
1983			8	$15,486						
1984			3	$1,548						
1985			<1	$4	<1	$2	<1	$72		
1986			<1	$1						
1987			1	$925						
1988			1	$589			<1	$2		
1989			5	$1,850			<1	$25		
1990			10	$5,746						
1991			<1	$263	19	$3,739				
1992			462	$233	317	$1,204				
1993			280	$1,263	277	$3,916				
1994			252	$13,853	202	$11,165	1	$288		
1995			189	$5,031	149	$10,154	<1	$685		
1996			61	$5,304	258	$10,634				
1997			1,611	$3,119	373	$1,023				
1998	1	$1,045	538	$11,649	686	$59,013				
1999	776	$114,223	259	$1,341	496	$6,176				
2000	9,528	$1,493,844	119	$7,950	161	$22,410	<1	$390		
2001	12,780	$2,057,742	322	$40,737	183	$51,098				
2002	22,711	$3,529,651	127	$8,095	9	$4,793	3	$2,225		
2003	25,258	$3,609,985	160	$22,875	74	$19,531	39	$3,819		
2004	36,111	$5,818,220	107	$13,434	126	$20,194	13	$5,535		

2005	45,110	$7,175,733	318	$41,175	70	$187,820	68	$1,824	14	$8,557
2006	35,668	$4,203,773	665	$39,166	5	$101	9	$19	27	$17,560
2007	42,144	$4,978,712	702	$54,336	14	$1,083	5	$2,429	1	$323
2008	22,949	$6,080,902	58	$8,383	46	$445	260	$60,832		
2009	21,481	$5,633,744	53	$5,075			39	$9,240		
2010	20,852	$5,525,842	49	$3,022			138	$30,373		
2011	11,023	$3,293,120	7	$383	14	$2,928	21	$6,766	<1	$1
2012	42,619	$9,103,167	1,779	$173,587	95	$5,458				
2013	26,289	$6,299,323	439	$79,831	123	$12,358	13	$4,108		
	Washington									
1981							1	$646		
1982							5	$19,551		
1983							3	$10,665		
1984			<1	$164			10	$19,175		
1985							12	$21,967		
1986							22	$36,078		
1987							78	$104,343		
1988							40	$55,982		
1989			<1	$83			62	$89,368		
1990			<1	$248			50	$66,581		
1991			<1	$61			54	$57,484		
1992			6	$4,174			42	$49,698		
1993			30	$6,125			44	$39,859		
1994			33	$4,238			70	$69,375		
1995			7	$1,154			130	$108,176		
1996			65	$27,593	3	$950	86	$87,921		
1997			156	$23,646	1	$109	59	$56,742		
1998			46	$5,550	39	$4,737	103	$81,630		
1999	1	$2,194	47	$4,871	108	$10,106	98	$88,169		
2000	4,842	$862,762	19	$2,538	20	$2,894	79	$62,086		
2001	11,127	$1,575,496	371	$98,228	32	$6,929	68	$88,389		
2002	15,833	$2,424,933	248	$36,845	12	$2,252	229	$88,391		
2003	11,920	$1,804,207	54	$8,837	2	$146	214	$80,939		
2004	8,934	$1,487,406	22	$2,782	7	$1,907	213	$76,355		
2005	6,721	$984,116	24	$4,152	11	$3,173	164	$41,372		
2006	4,363	$503,194	41	$15,164	2	$338	161	$42,220		

2007	4,665	$532,916	38	$10,103	1	$195	153	$36,372		
2008	6,435	$1,436,177	9	$2,502			109	$37,868		
2009	8,026	$1,772,926	4	$1,548			812	$144,715		
2010	12,381	$2,823,113	2	$662	1	$12	120	$74,771		
2011	8,009	$2,212,264	<1	$114	10	$5,783	191	$70,296		
2012	35,892	$8,063,013	692	$161,732	31	$5,490	217	$83,666		
2013	29,748	$6,656,509	173	$38,824	82	$19,091	116	$47,439		
Source: PacFIN - 2011 data extracted Oct. 22, 2013, and 2012-13 data extracted May 15, 2014.										
[1]Real values are current values adjusted to eliminate the effects of inflation. This adjustment has been made by dividing current										
values by the current year GDP implicit price deflator, with a base year of 2013.										
[2]Pacific mackerel landings and revenues also include landings and revenues of unspecified mackerel.										

Table 6-5. West coast CPS landings (mt) and real[1] exvessel revenues (2013 $) by gear group, 1981-2013.

Year	Roundhaul or Lampara	Dip Net	Pot or Trap	Trawl	Hook and Line	Gillnet	Other or Unknown
	Landings (mt)						
1981	120,578	8,231	<1	11	9	80	
1982	110,254	3,693	1	13	27	82	
1983	56,944	490	<1	8	2	44	40
1984	56,285	64	<1	4	1	189	
1985	55,494	495	1	20	9	430	<1
1986	75,784	88	4	3	<1	135	
1987	75,048	213	1	6	7	1,314	<1
1988	94,190	140	1	39	1	1,395	<1
1989	102,026	248	<1	132	3	100	
1990	76,010	489	1	15	34	72	
1991	81,817	724	37	128	4	63	
1992	47,666	4,322	3	802	15	31	
1993	68,346	5,171	2	592	3	44	
1994	78,350	2,997	59	510	49	11	13
1995	120,940	1,410	1	386	121	9	42
1996	128,354	855	1	401	64	23	
1997	138,534	247	<1	2,157	90	14	
1998	69,660	37	<1	1,334	44	5	

1999	166,933	528	72	961	12	10	
2000	219,844	1,568	45	275	420	4	<1
2001	190,196	1,791	1	621	153	3	
2002	178,656	761	<1	10	10	2	
2003	123,128	133	<1	76	10	<1	<1
2004	140,277	790	<1	110	7	<1	63
2005	154,875	2,504	11	106	9	<1	
2006	154,731	1,582	97	33	84	<1	
2007	193,348	826	<1	15	25	<1	<1
2008	143,364	444		51	3	<1	
2009	167,133	1,831	<1	2	3	<1	
2010	198,085	3,304	31	12	2	2	
2011	168,258	4,301		25	<1	<1	<1
2012	202,889	5,319	<1	47	7	1	<1
2013	179,764	3,217	43	126	273	1	<1
	$/lb (2013 $)						
1981	$0.15	$0.10	N/A	$0.35	$0.53	$0.36	
1982	$0.14	$0.11	$2.00	$0.30	$0.30	$0.28	
1983	$0.17	$0.35	N/A	$0.31	$0.59	$0.27	$0.16
1984	$0.16	$0.47	N/A	$0.42	$0.81	$0.22	
1985	$0.18	$0.53	$0.59	$0.39	$0.36	$0.26	N/A
1986	$0.15	$0.25	$0.21	$0.50	N/A	$0.25	
1987	$0.13	$0.15	$1.57	$0.32	$0.20	$0.15	N/A
1988	$0.14	$0.18	$0.55	$0.58	$0.39	$0.14	N/A
1989	$0.12	$0.13	N/A	$0.17	$0.22	$0.19	
1990	$0.11	$0.07	$0.53	$0.32	$0.61	$0.30	
1991	$0.11	$0.05	$0.13	$0.13	$0.81	$0.21	
1992	$0.12	$0.08	$0.43	$0.01	$0.89	$0.25	
1993	$0.13	$0.10	$0.58	$0.01	$0.80	$0.29	
1994	$0.15	$0.10	$0.19	$0.04	$0.55	$0.33	$0.12
1995	$0.14	$0.16	$0.34	$0.03	$0.28	$0.33	$0.14
1996	$0.13	$0.14	$0.31	$0.06	$0.61	$0.30	
1997	$0.13	$0.21	N/A	$0.01	$0.63	$0.30	
1998	$0.07	$0.41	N/A	$0.04	$0.81	$0.36	
1999	$0.15	$0.21	$0.13	$0.02	$1.28	$0.36	
2000	$0.10	$0.15	$0.13	$0.06	$0.12	$0.29	N/A

2001	$0.09	$0.12	$0.23	$0.12	$0.15	$0.31	
2002	$0.10	$0.14	N/A	$0.31	$1.37	$0.37	
2003	$0.15	$0.31	N/A	$0.12	$1.50	N/A	N/A
2004	$0.12	$0.26	N/A	$0.08	$1.50	N/A	$0.30
2005	$0.14	$0.31	$0.30	$0.86	$0.96	N/A	
2006	$0.12	$0.28	$0.08	$0.24	$0.12	N/A	
2007	$0.11	$0.30	N/A	$0.11	$0.54	N/A	N/A
2008	$0.15	$0.32		$0.02	$1.74	N/A	
2009	$0.20	$0.28	N/A	$0.11	$2.95	N/A	
2010	$0.20	$0.26	$0.26	$0.04	$2.82	$0.25	
2011	$0.21	$0.29		$0.17	N/A	N/A	N/A
2012	$0.19	$0.32	N/A	$0.06	$1.27	$1.58	N/A
2013	$0.22	$0.32	$0.32	$0.07	$0.23	$0.17	N/A
N/A indicates that the corresponding landings (mt) are unknown but assumed to be "<1".							
Source: PacFIN - 2011 data extracted Oct. 22, 2013, and 2012-13 data extracted May 15, 2014.							
[1]Real values are current values adjusted to eliminate the effects of inflation This adjustment has been made							
by dividing current values by the current year GDP implicit price deflator, with a base year of 2013.							

TABLE 8-1. Commercial harvest (metric tons) of CPS finfish in Ensenada, Baja California, Mexico, for calendar years 2000-2013[1/,2/,3/,4/].

Year	Pacific sardine	Northern anchovy	Pacific mackerel	Jack mackerel
2000	67,845	1,562	7,182	0
2001	46,071	76	4,078	0
2002	46,845	0	7,962	0
2003	41,342	1,287	2,678	0
2004	41,897	1,797	1,530	0
2005	55,323	4,873	2,343	0
2006	57,237	1,567	2,318	0
2007	36,847	4,058	3,057	0
2008	66,866	991	180	0
2009	55,911	2,444	8	0
2010	56,821	3,139	85	0
2011	70,336	1,760	2,601	0
2012	49,810	1,809	186	0
2013	50,289	---	---	---

1/ Data for 2000 to 2002 from García and Sánchez (2003).
2/ Data for 2003 provided by Dr. Celia Eva-Cotero, INAPESCA-Ensenada (pers. comm.).
3/ Data for 2004, 2012, and 2013 provided by Dr. Manuel O. Nevarrez, INAPESCA-Guaymas (pers. comm.).
4/ Data for 2005-2011 from CONAPESCA

TABLE 8-2. Pacific sardine population numbers (millions) and biomass (mt) by season for 2000 to 2014 (Hill et al. 2014). Age 1+ biomass as of July 2014 (bold) served as the basis for setting a HG for the U.S. fishery in 2014-15.

		BIOMASS (mt)			POPULATION NUMBERS-AT-AGE (millions)								
Calendar Yr-Sem	Model Yr-Seas	Total (0+)	Age 1+	SSB	0 (R)	1	2	3	4	5	6	7	8+
2000-2	2000-1	1,073,400	1,060,020	---	1,707	948	3,211	3,283	765	314	610	483	564
2001-1	2000-2	971,030	938,722	889,929	1,396	744	2,472	2,580	608	250	485	385	448
2001-2	2001-1	877,893	850,859	---	3,450	1,032	526	1,874	2,037	487	201	392	673
2002-1	2001-2	798,441	733,127	709,131	2,823	812	405	1,464	1,601	383	158	308	529
2002-2	2002-1	696,224	692,564	---	467	1,979	532	295	1,134	1,268	306	127	671
2003-1	2002-2	587,714	578,877	538,750	382	1,512	392	222	858	959	231	96	507
2003-2	2003-1	653,179	489,455	---	20,895	258	939	278	170	677	765	185	484
2004-1	2003-2	783,437	388,039	416,424	17,089	198	691	205	125	498	562	136	355
2004-2	2004-1	922,633	853,213	---	8,860	13,542	155	550	165	101	403	455	397
2005-1	2004-2	1,011,770	844,007	616,788	7,251	10,796	118	401	117	71	280	315	275
2005-2	2005-1	1,179,690	1,053,120	---	16,154	5,800	8,548	95	325	95	58	228	481
2006-1	2005-2	1,313,250	1,007,320	868,822	13,222	4,672	6,637	70	235	68	41	162	342
2006-2	2006-1	1,400,650	1,364,200	---	4,652	10,553	3,688	5,332	57	191	55	33	411
2007-1	2006-2	1,410,470	1,322,380	1,098,180	3,807	8,469	2,896	4,130	44	146	42	25	313
2007-2	2007-1	1,420,150	1,360,980	---	7,551	3,003	6,574	2,306	3,340	36	119	34	277
2008-1	2007-2	1,356,660	1,213,750	1,117,080	6,177	2,335	4,959	1,758	2,554	27	91	26	211
2008-2	2008-1	1,300,960	1,278,360	---	2,884	4,781	1,765	3,895	1,412	2,070	22	74	193
2009-1	2008-2	1,198,010	1,143,420	1,037,970	2,359	3,739	1,345	3,005	1,095	1,603	17	57	149
2009-2	2009-1	1,149,770	1,085,930	---	8,147	1,798	2,765	1,045	2,402	885	1,301	14	168
2010-1	2009-2	1,098,530	944,273	900,161	6,667	1,430	2,149	809	1,854	681	999	11	129
2010-2	2010-1	1,042,180	1,029,270	---	1,648	5,157	1,080	1,686	649	1,500	552	812	114
2011-1	2010-2	942,246	911,047	806,697	1,348	4,125	841	1,292	492	1,130	415	610	85
2011-2	2011-1	861,722	855,648	---	775	1,044	3,118	661	1,038	399	918	338	566
2012-1	2011-2	738,011	723,342	680,004	634	806	2,325	499	788	302	695	256	428
2012-2	2012-1	647,185	643,160	---	514	480	589	1,787	395	630	242	558	550
2013-1	2012-2	501,138	491,408	473,374	421	388	454	1,285	272	426	163	375	369
2013-2	2013-1	465,228	437,821	---	3,498	326	294	356	1,030	220	345	132	603
2014-1	2013-2	403,335	337,081	333,268	---	264	229	263	735	154	242	92	421
2014-2	2014-1	404,433	**369,506**	---	---	2,160	192	176	209	590	124	195	415

TABLE 8-3. Annual U.S. Pacific sardine landings (PacFIN) and harvest guidelines (HG) in metric tons since onset of management under the federal CPS-FMP.

Year	SCA	CCA	CA Total	OR	WA	U.S. Total	HG South	HG North	HG Total
2000	46,835	11,367	58,202	9,529	4,765	72,496	124,527	62,264	186,791
2001	47,662	7,241	54,903	12,780	10,837	78,520	89,825	44,912	134,737
2002	49,366	14,078	63,444	22,711	15,212	101,367	78,961	39,481	118,442
2003	30,289	7,448	37,737	25,258	11,604	74,599	73,939	36,969	110,908
2004	32,393	15,308	47,702	36,112	8,799	92,613	81,831	40,916	122,747
2005	30,253	7,940	38,193	45,008	6,929	90,130	90,786	45,393	136,179
2006	33,286	17,743	51,029	35,648	4,099	90,776	n/a	n/a	118,937
2007	46,199	34,782	80,981	42,052	4,663	127,695	n/a	n/a	152,564
2008	31,089	26,711	57,800	22,940	6,435	87,175	n/a	n/a	89,093
2009	12,561	25,015	37,576	21,482	8,025	67,083	n/a	n/a	66,932
2010	29,352	4,306	33,658	20,852	12,381	66,891	n/a	n/a	72,039
2011	17,642	10,072	27,714	11,023	8,008	46,745	n/a	n/a	50,526
2012	18,802	4,241	23,044	42,618	35,441	101,103	n/a	n/a	109,409
2013	6,291	823	7,114	27,685	26,847	61,646	n/a	n/a	66,495

1/ As of 2003, the 'Southern Subarea' comprises fisheries and landings from Pt. Arena, California (39°N latitude) to the Mexican border.
2/ As of 2006, the U.S. sardine HG was no longer managed by subarea. HG's are now allocated coastwide and released on a seasonal basis.

TABLE 8-4. West Coast Pacific sardine landings (metric tons) by country, 2000-2013.

Year	Ensenada México	United States	B.C. Canada	Total
2000	67,845	72,496	1,721	142,063
2001	46,071	78,520	1,266	125,857
2002	46,845	101,367	739	148,952
2003	41,342	74,599	978	116,919
2004	41,897	92,613	4,438	138,948
2005	55,323	90,130	3,232	148,684
2006	57,237	90,776	1,575	149,588
2007	36,847	127,695	1,522	166,065
2008	66,866	87,175	10,425	164,466
2009	55,911	67,083	15,334	138,328
2010	56,821	66,891	22,223	145,935
2011	70,336	46,745	20,719	137,801
2012	49,810	101,103	19,172	170,085
2013	50,289	61,646	0	111,935

TABLE 8-5. RecFIN estimated recreational harvest of Pacific (chub) mackerel by state (type 'A+B1' estimate in metric tons), 2000-2013. Estimates from 2000-2003 are based on MRFSS sampling. Estimates from 2004-2013 are based on CRFS and ORBS sampling programs, and are not directly comparable to MRFSS.

Year	CA	OR	WA	Total
2000	250.00	0.07	0.00	250.07
2001	561.39	0.05	0.00	561.44
2002	279.11	0.11	0.00	279.22
2003	341.35	0.27	0.00	341.61
2004	546.44	0.10	0.00	546.53
2005	312.06	0.07	0.00	312.13
2006	463.22	0.11	0.00	463.33
2007	239.35	0.91	0.00	240.26
2008	321.54	0.02	0.00	321.56
2009	237.30	0.06	0.00	237.36
2010	235.48	0.00	0.00	235.48
2011	165.54	0.01	0.00	165.55
2012	143.69	0.20	0.00	143.89
2013	109.67	0.27	0.00	109.94

TABLE 8-6. RecFIN estimated recreational harvest of Pacific (chub) mackerel by fishing mode (type 'A+B1' estimate in metric tons), 2000-2013. Estimates from 2000-2003 are based on MRFSS sampling. Estimates from 2004-2013 are based on CRFS and ORBS sampling programs and are not directly comparable to MRFSS.

Year	Shore Modes	Party/ Charter	Private/ Rental	Total
2000	51.30	76.85	121.92	250.07
2001	347.05	52.23	162.17	561.44
2002	92.88	25.74	160.59	279.22
2003	208.40	25.39	107.82	341.61
2004	405.18	21.45	119.91	546.53
2005	223.51	46.98	41.65	312.13
2006	405.84	15.05	42.44	463.33
2007	187.02	19.14	34.10	240.26
2008	275.35	20.89	25.32	321.56
2009	183.89	13.29	40.17	237.36
2010	201.25	9.36	24.87	235.48
2011	124.70	21.21	19.64	165.55
2012	121.05	9.20	13.64	143.89
2013	77.23	18.83	13.88	109.94

TABLE 8-7. Pacific mackerel harvest guidelines and commercial landings (mt) by July-June fishing season since the onset of management under the federal CPS-FMP.

Fishing Season	Harvest Guideline	Landings
1999-00	42,819	6,732
2000-01	20,740	19,510
2001-02	13,837	7,814
2002-03	12,535	2,679
2003-04	10,652	4,452
2004-05	13,268	3,938
2005-06	17,419	3,784
2006-07	19,845	6,890
2007-08	40,000	6,286
2008-09	40,000	4,278
2009-10	10,000	3,010
2010-11	11,000	2,086
2011-12	40,514	1,855
2012-13	40,514	4,753
2013-14[/a]	52,538	8,495

[/a] Landings for the 2013-14 season represent data through March 2014.

Table 9-1. Total landings (mt) of sardines and other species, and number of vessels and processors that participated under Exempted Fishery Permits during 2009-2013. (Source: ODFW and WDFW fish ticket records).

Species	2009	2010	2011	2012	2013	5-Year Total
Sardines	1,178.0	2,013.9	2,699.7	2,914.4	1,526.9	10,333.0
Pacific Mackerel	3.8	9.3	1.2	200.6	13.6	228.4
Jack Mackerel	0.0	0.0	0.0	1.5	0.0	1.5
Jellyfish	2.0	0.0	0.0	0.0	0.0	2.0
Number Vessels	2	3	4	5	2	7
Number Processors	1	1	1	3	1	3

Table 9-2. EFP landings in California. Total landings (mt) of sardines and other species, and number of vessels and processors that participated under Exempted Fishing Permits during 2009-2012. (Sources: Northwest Aerial Sardine Survey, LLC; * NMFS WCR; **CWPA).

Species	2009	2010
Sardines	1685mt*	1,218.2mt
Pacific Mackerel	756.0mt	9.8mt
Jacksmelt	40.00mt	
Kingfish	412.0mt	
Other spp		0.0
Number Vessels **	2	3
Number Processors **	2	2

Appendix B: Pacific Mackerel Stock Assessment

PACIFIC MACKEREL BIOMASS PROJECTION ESTIMATE FOR USA MANAGEMENT (2014-15)

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May 2014

Introduction

Beginning in 2015, the Pacific Fishery Management Council (Council) will begin an assessment/management schedule for Pacific mackerel (*Scomber japonicus*) based on: 1) conducting *full* assessments every four years starting in 2015; 2) conducting catch-only projection estimates every four years starting in 2017; and setting harvest and management guidelines as biennial specifications that serve for two consecutive (fishing) years, starting in 2015. In 2015, a full assessment should be conducted for purposes of providing management advice that serves for two (fishing) years, 2015-16 and 2016-17. In 2017, a catch-only projection estimate should be conducted for informing management for fishing years 2017-18 and 2018-19.

Based on recommendations from the Scientific and Statistical Committee (SSC) and following methods used in last year's Pacific mackerel projection assessment, here we present an extended forecast analysis for providing management advice for the upcoming Pacific mackerel fishing year from July 1, 2014 to June 30, 2015. Sensitivity analysis conducted here was discussed informally with members of the SSC's CPS-Subcommittee prior to preparation of this document.

Methods

Details regarding the assessment model *XA*, which served as the baseline model for developing all annual management guidelines since 2011, are presented in the stock assessment report (Crone et al. 2011; June 2011 Briefing Book, Agenda Item G.2.b, Attachment 1). The projection model used here was parameterized similarly as last year's projection model that provided biomass estimates for management in 2013-14 (Crone 2013, June 2013 Briefing Book, Agenda Item I.2.b, Attachment 2), and assumes a Tier 2 sigma value of 0.72. Important model information follows, including data, parameterizations, and sensitivity analysis:

- Recent Pacific mackerel landings (catch) are presented in Table 1. In the current projection model, forecast catch estimates were included for fishing years 2011-13 (updated catch estimates in 2013).

- No other data or parameterization changes.
- Sensitivity analysis
  - Estimated biomass and derived management quantities were robust to a wide range of alternative catch time series. For example, substantial increases in total landings assumed in the model had little to no effect on estimates of abundance and stock status, given that present catches have remained at very low levels over an extended timeframe.
  - Results were sensitive to alternative assumptions (model scenarios) regarding recent recruitment success and potential impacts on estimates of overall stock (age 1+ fish) biomass used for advising management (Table 2).
    - ✓ In addition to the default projection (forecast recruitment estimates were based on stock-recruitment relationship), three recent recruitment scenarios were evaluated, i.e., assuming forecast recruitment is equal to: 1) the recent average estimated recruitment (2008-10); the historical 3-year (running) low estimated recruitment (1997-00); and the lower bound of the 95% CI associated with the estimated recruitment in the terminal year (2010) of the main period of the default projection model.
    - ✓ Recruitment (age 0-1 yr-old fish) adjustments and subsequent biomass estimation were performed external to the model based on straightforward re-calculations of estimated numbers-at-age from the default projection model, according to the assumed recruitment level and accounting for losses due to natural mortality. That is, recruitment uncertainty was not evaluated internally within the projection model, given inherent constraints in Stock Synthesis regarding changes to recruitment deviations for the forecast vs main periods of the model and subsequently, structural changes to baseline files (catch time series) that would be needed to similarly address the three recruitment scenarios above. Finally, both external and internal recruitment-related adjustments are based on generally similar approaches and expected to produce comparable results.
    - ✓ Estimates of stock (age 1+ fish) biomass generated from the four model scenarios are presented in Figure 1.
- Expectedly, assumptions of depressed recruitment over the last few years resulted in substantial decreases in model estimates of absolute abundance of Pacific mackerel and associated yields to the fisheries. In general, the alternative recruitment success assumptions reflected reductions of roughly one-half to two-thirds of that indicated from the default projection model, depending on the model scenario of interest (Table 2).

Table 1. Pacific mackerel landings (mt) for fishing years 2009 to 2013 (i.e., through June 2014). Recent catch estimates for Ensenada (ENS) in calendar year 2013 are unconfirmed at this time, but not likely to change significantly when final statistics become available. Total commercial and recreational landings were used in the projection model.

Fishing year (July-June)	USA Com.	ENS Com.	Total Com.	Rec.
2009	3,009.7	0.2	3,009.9	268.7
2010	2,085.7	1,604.7	3,690.4	216.6
2011	1,855.4	1,150.8	3,006.1	127.0
2012	4,752.6	116.7	4,869.2	100.2
2013	8,494.7	957.4	9,452.1	109.7

Table 2. Pacific mackerel harvest control rules (HCR) for the 2014-15 fishing year based on alternative assumptions (model scenarios) of recent recruitment success. Default S-R = stock-recruitment (Beverton-Holt) relationship; Avg = average recruitment (2008-10 and 1997-00); and 95% CI = lower 95% CI for 2010 recruitment estimate.

Harvest Control Rule Formulas
OFL = BIOMASS * E_{MSY} * DISTRIBUTION
$ABC_{P\text{-}star}$ = BIOMASS * $BUFFER_{P\text{-}star}$ * E_{MSY} * DISTRIBUTION
HG = (BIOMASS - CUTOFF) * FRACTION * DISTRIBUTION

HCR Parameters	Default S-R Rec	Avg Rec 2008-10	Avg Rec 1997-00	Lower 95% CI Rec
P-star	0.45	0.45	0.45	0.45
ABC Buffer for Tier 2 $Pstar_{0.45}$	0.9135	0.9135	0.9135	0.9135
FRACTION	0.3	0.3	0.3	0.3
CUTOFF (mt)	18,200	18,200	18,200	18,200
DISTRIBUTION (U.S.)	0.7	0.7	0.7	0.7
BIOMASS (ages 1+, mt)	304,184	157,106	122,489	120,625

HCR Values (MT)	Default S-R Rec	Avg Rec 2008-2010	Avg Rec 1997-2000	Lower 95% CI Rec
OFL =	63,879	32,992	25,723	25,331
ABC =	58,353	30,138	23,498	23,140
HG =	60,057	29,170	21,901	21,509

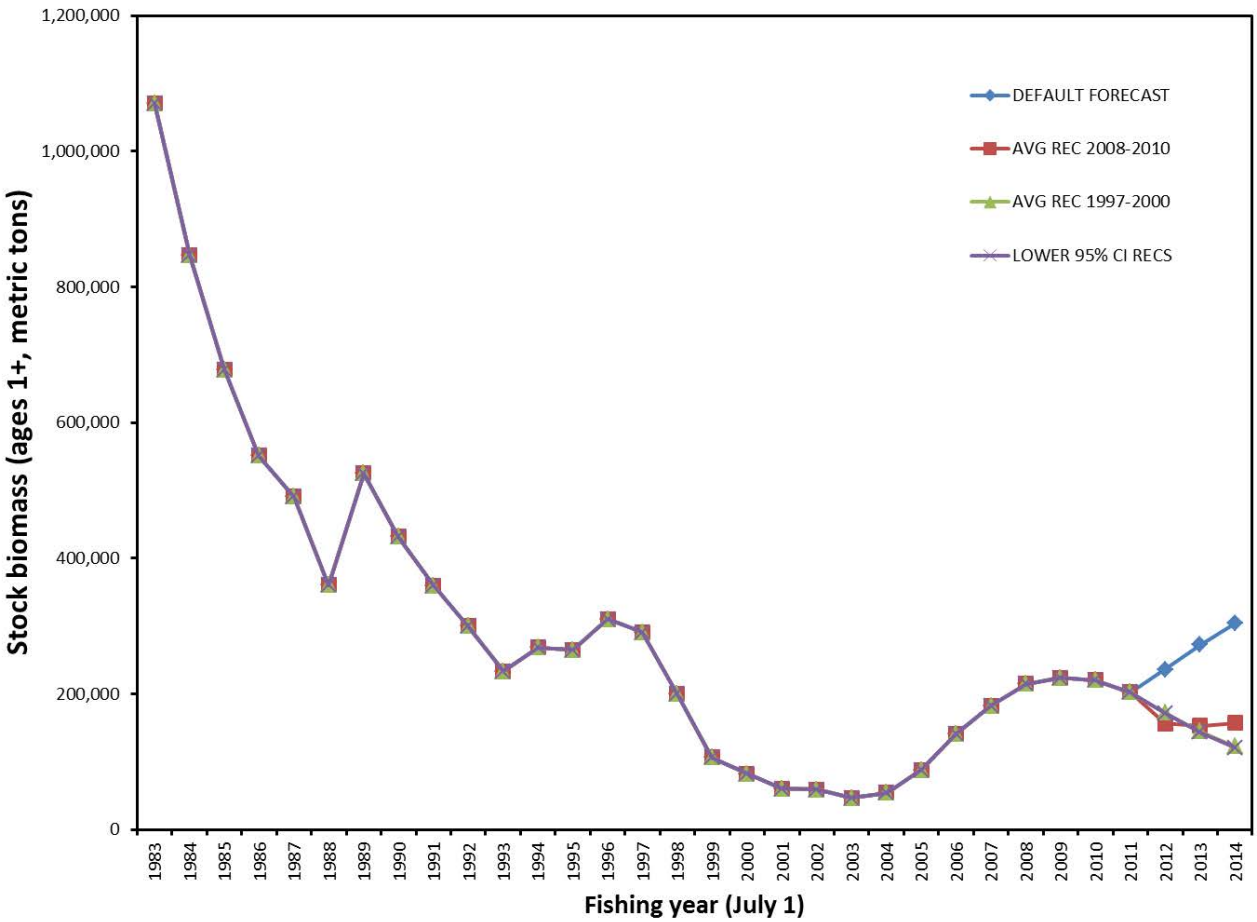

Figure 1. Pacific mackerel stock biomass time series for alternative assumptions (model scenarios) regarding recent recruitment success.

Appendix C: Pacific Sardine Stock Assessment

NOAA Technical Memorandum NMFS

AUGUST 2014

ASSESSMENT OF THE PACIFIC SARDINE RESOURCE IN 2014 FOR U.S.A. MANAGEMENT IN 2014-15

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NOAA-TM-NMFS-SWFSC-531

U. S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Science Center

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AUGUST 2014

ASSESSMENT OF THE PACIFIC SARDINE RESOURCE IN 2014 FOR U.S.A. MANAGEMENT IN 2014-15

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ACRONYMS AND ABBREVIATIONS

ABC	acceptable biological catch
ACT	annual catch target
ATM	Acoustic-trawl method
BC	British Columbia (Canada)
CA	California
CalCOFI	California Cooperative Oceanic Fisheries Investigations
CCA	Central California fishery
CCE	California Current Ecosystem
CDFW	California Department of Fish and Wildlife
CDFO	Canada Department of Fisheries and Oceans
CICIMAR	Centro Interdisciplinario de Ciencias Marinas
CONAPESCA	National Commission of Aquaculture and Fishing (México)
CPS	Coastal Pelagic Species
CPSAS	Coastal Pelagic Species Advisory Subpanel
CPSMT	Coastal Pelagic Species Management Team
CV	coefficient of variation
DEPM	Daily egg production method
ENS	Ensenada (México)
FMP	fishery management plan
HG	harvest guideline
INAPESCA	National Fisheries Institute (México)
Model Year	July 1 (year) to June 30 (year+1)
mt	metric tons
mmt	million metric tons
MexCal	southern fleet based on ENS, SCA, and CCA fishery data
NMFS	National Marine Fisheries Service
NSP	Northern subpopulation of Pacific sardine, as defined by satellite oceanography data
NWSS	Northwest Sardine Survey (aka ‘Aerial Survey’)
NOAA	National Oceanic and Atmospheric Administration
ODFW	Oregon Department of Fish and Wildlife
OFL	overfishing limit
OR	Oregon
PacNW	northern fleet based on OR, WA, and BC fishery data
PFMC	Pacific Fishery Management Council
S1 & S2	Model Season 1 (Jul-Dec) and Season 2 (Jan-Jun)
SAFE	Stock Assessment and Fishery Evaluation
SCA	Southern California fishery
SCB	Southern California Bight (Pt. Conception, CA to northern Baja California)
SS	Stock Synthesis model
SSB	spawning stock biomass
SSC	Scientific and Statistical Committee
SST	sea surface temperature
STAR	Stock Assessment Review
STAT	Stock Assessment Team
SWFSC	Southwest Fisheries Science Center
TEP	Total egg production
VPA	Virtual Population Analysis
WA	Washington
WDFW	Washington Department of Fish and Wildlife

PREFACE

The Pacific sardine resource is assessed each year in support of the Pacific Fishery Management Council (PFMC) process for recommending annual harvest specifications for the U.S. fishery. This sardine assessment report represents a *full assessment* for advising management in fishing year 2014 (newly-established to span July 1, 2014 - June 30, 2015). The last *full assessment* for Pacific sardine was conducted in 2011 (Hill et al. 2011, includes review report), followed by an *update assessment* in 2012 (Hill et al. 2012, includes review report), and *projection assessment* in 2013 (Hill 2013).

This assessment report presents pertinent discussion and results for important model scenarios highlighted in the formal Stock Assessment Review (STAR) held at NOAA's Southwest Fisheries Science Center in La Jolla, CA, March 3-5, 2014. All model scenarios include updated fishery-dependent and -independent time series and reflect different 'states of nature' (model configurations) that include alternative choices for input data (e.g., biological-composition and survey time series) and/or different assumptions or estimators for particular parameterizations of interest (e.g., underlying stock structure and biology, stock-recruitment relationships, data weighting methods for time series, etc.). In this final assessment report, information pertains generally to sensitivity analysis, review (STAR), and STAR panel decisions associated with categories/model scenarios presented in Table 8, particularly, model G (one of two blended, 'preferred' model scenarios initially presented at the STAR) and base model T (final model from STAR meeting). At the onset of the review, both the STAT and STAR panel supported and prioritized model G (length data/length-based selectivity) over blended model H (age data/age-based selectivity) for carrying on more focused evaluations at the meeting. That is, considerable sensitivity analysis was conducted on model G at the meeting to confirm/refute estimates and results from the initial baseline model, as well as further address details of particular data sets/parameterizations/results/diagnostics as identified by the STAR panel during the meeting. Readers should consult both the initial draft assessment report (Hill and Crone 2014) and final review report (STAR 2014) for background information regarding various model scenarios investigated in the initial sensitivity analysis and bases for final choices, assumptions, and parameterizations associated with base model T. Ultimately, model T represented a nearly similar configuration and outcome as model G, with a few key differences based on work conducted at the meeting.

The main objective in this year's assessment development addressed the overriding recommendation from past reviews concerning the importance of survey time series for accurate determination of total abundance of this and other small pelagic fish stocks. Recent estimates of total stock biomass are often the derived quantities most requested by fishery managers for setting harvest guidelines, as is the case for Pacific sardine of the California Current Ecosystem. Attention to direct information regarding abundance from surveys, particularly the more recent acoustic-trawl method (ATM) survey, served as the basis of the overall sensitivity analysis and associated model scenarios presented here. Indirect information regarding stock abundance from related sources of data and parameterizations, particularly pertaining to fitting biological composition time series in the integrated model, was modeled accordingly and in concert with the main goal to produce robust fits to abundance time series and estimates of current total stock abundance for advising management.

EXECUTIVE SUMMARY

The following Pacific sardine assessment was conducted to inform U.S. fishery management for the fishing year that begins July 1, 2014 and ends June 30, 2015. Model T represented the final base model from the formal stock assessment review (STAR) conducted in March 2014 for advising management in 2014-15.

Stock

This annually conducted assessment focuses on the Pacific sardine northern subpopulation (NSP) that ranges from northern Baja California, México to British Columbia, Canada and extends up to 300 nm offshore. In all past assessments, the default approach has been to assume that all catches landed in ports from ENS to BC were from the northern subpopulation. There is now general consensus that catches landed in ENS and SCA likely represent a mixture of southern subpopulation (warm months) and northern subpopulation (cold months) (Felix-Uraga et al. 2004, 2005; Garcia-Morales 2012; Zwolinski et al. 2011; Demer and Zwolinski 2014). Although the ranges of the northern and southern subpopulations can overlap within the Southern California Bight, the adult spawning stocks likely move north and south in synchrony and do not occupy the same space simultaneously to any significant extent (Garcia-Morales 2012). Satellite oceanography data (Demer and Zwolinski 2014) were used to partition catch data from ENS and SCA ports in order to exclude landings and biological compositions attributed to the southern subpopulation.

Catches

The assessment includes sardine landings (metric tons) from six major fishing regions: Ensenada (ENS), southern California (SCA), central California (CCA), Oregon (OR), Washington (WA), and British Columbia (BC). Landings for each port and for the NSP over the past ten years follow:

Calendar Yr-Sem	Model Yr-Seas	ENS Total	ENS NSP	SCA Total	SCA NSP	CCA	OR	WA	BC
2004-1	2003-2	11,212.9	3,922.9	15,232.0	15,232.0	2,145.7	2,203.5	235.3	179.6
2004-2	2004-1	30,684.0	2,373.9	17,161.5	1,512.5	13,162.6	33,908.3	8,564.1	4,258.4
2005-1	2004-2	17,323.0	11,186.6	15,419.0	13,948.1	115.3	691.9	324.0	0.4
2005-2	2005-1	37,999.5	4,396.7	14,833.6	1,508.6	7,824.9	44,316.2	6,605.0	3,231.4
2006-1	2005-2	17,600.9	11,214.6	17,157.7	16,504.9	2,032.6	101.7	0.0	0.0
2006-2	2006-1	39,636.0	0.0	16,128.2	4,909.8	15,710.5	35,546.5	4,099.0	1,575.4
2007-1	2006-2	13,981.4	13,320.0	26,343.6	19,900.7	6,013.3	0.0	0.0	0.0
2007-2	2007-1	22,865.5	11,928.2	19,855.0	5,350.3	28,768.8	42,052.3	4,662.5	1,522.3
2008-1	2007-2	23,487.8	15,618.2	24,127.2	24,114.3	2,515.3	0.0	0.0	0.0
2008-2	2008-1	43,378.3	5,930.0	6,962.1	21.8	24,195.7	22,939.9	6,435.2	10,425.0
2009-1	2008-2	25,783.2	20,244.4	9,250.8	9,221.3	11,079.9	0.0	0.0	0.0
2009-2	2009-1	30,128.0	0.0	3,310.3	29.8	13,935.1	21,481.6	8,025.2	15,334.3
2010-1	2009-2	12,989.1	7,904.2	19,427.7	19,427.7	2,908.8	437.1	510.9	421.7
2010-2	2010-1	43,831.8	9,171.2	9,924.7	562.7	1,397.1	20,414.9	11,869.6	21,801.3
2011-1	2010-2	18,513.8	11,588.5	12,526.4	12,515.4	2,713.3	0.1	0.0	0.0
2011-2	2011-1	51,822.6	17,329.6	5,115.4	11.9	7,358.4	11,023.3	8,008.4	20,718.8
2012-1	2011-2	10,235.0	6,823.3	11,906.2	10,018.8	3,672.7	2,873.9	2,931.7	0.0
2012-2	2012-1	39,575.0	0.0	6,896.1	883.6	568.7	39,744.1	32,509.6	19,172.0
2013-1	2012-2	9,780.0	6,520.0	2,636.0	769.7	84.2	149.3	1,421.4	0.0
2013-2	2013-1	40,509.0	0.0	3,654.8	0.0	739.0	27,535.9	25,425.2	0.0

Data and Assessment

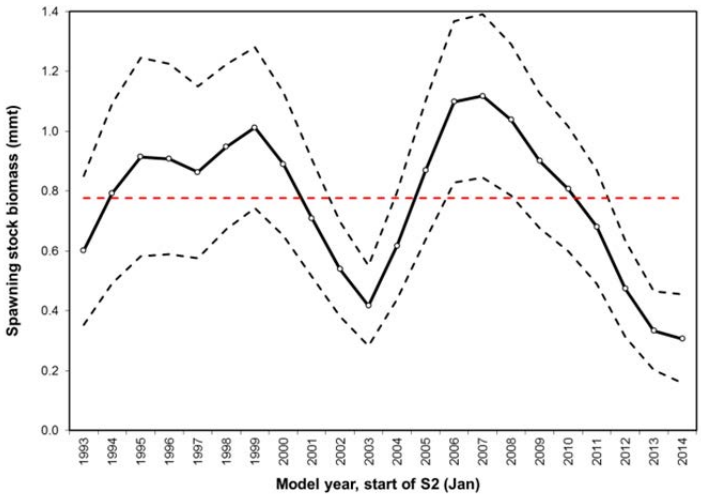
The assessment was conducted using the Stock Synthesis model (SS, version 3.24s), and includes fishery and survey data collected from mid-1993 through 2013. The model is based on a July-June fishing year, with two semester-based seasons per year (S1=Jul-Dec and S2=Jan-Jun). Catches and biological samples for the fisheries off ENS, SCA, and CCA were pooled into a single MexCal fleet (fishery), for which selectivity was modeled separately in each season (S1 and S2). Catches and biological samples from OR, WA, and BC were combined into a single PacNW fleet (fishery) in the model. Three indices of abundance from ongoing surveys were included in the base model: daily and total egg production method (DEPM and TEPM) estimates of spawning stock biomass off CA (1994-2013) and acoustic-trawl method (ATM) estimates of biomass along the west coast (2006-2013). Catchability (*q*) for the ATM surveys (spring and summer) was fixed (1.0) in the final base model T and *q*'s for the egg production surveys were estimated without constraint. The spring and summer ATM time series were modeled with independent, asymptotic selectivities.

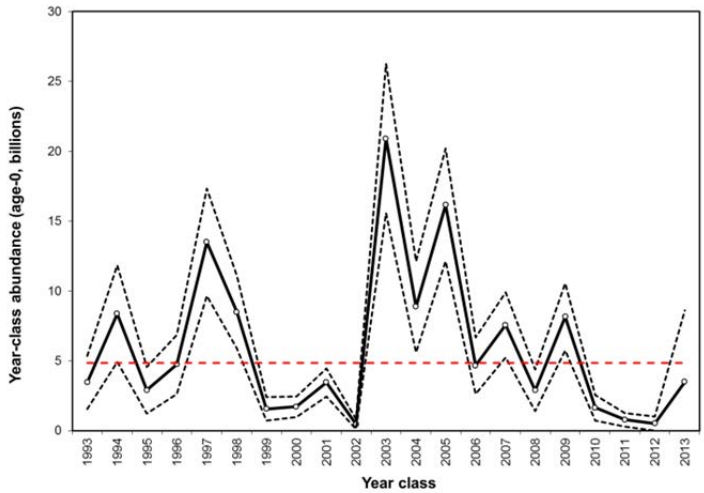
The following data were new to the 2014 assessment:

- Landings for 2012 and 2013 were updated for all fishing regions (ENS to BC), including and projected estimates for the first half of 2014 (2013/semester 2);
- Length compositions from SCA, CCA, OR, WA, and BC fisheries were updated for model year 2012 and the first semester of model year 2013 (July-December 2013 samples). No new length data were available for the ENS fishery;
- Conditional age-at-length data from SCA, CCA, OR, and WA were appended through June 2013;
- DEPM estimate of SSB from the spring 2013 survey off California; and
- ATM-survey estimates of biomass from the spring 2013 survey off California; and the summer 2013 SaKe survey off the U.S. west coast from San Diego to Vancouver Island were added to the model.

Spawning Stock Biomass and Recruitment

Recruitment was modeled using the Beverton-Holt (B-H) stock-recruitment relationship (σ_R=0.75). Steepness estimates typically bounded at 1 for most model scenarios evaluated in sensitivity analysis, with steepness being fixed at 0.8 in the final base model, based on a reasonable range for clupeid stocks indicated from stock-recruitment meta-analysis research. Virgin recruitment (R_0) for the final base model was estimated to be 4.828 billion age-0 fish. The virgin value of the spawning stock biomass (SSB) was estimated to be 0.78 million metric tons (mmt). The SSB increased throughout the 1990s, peaking at 1.01 mmt in 1999 and 1.117 mmt in 2007. Recruitments (age-0 abundance) peaked at 13.5 billion fish in 1997, 20.9 billion in 2003, 16.2 billion in 2005, and 8.1 billion in 2009. The 2010 to 2012 year classes were among the weakest in recent history. The 2013 year class, derived largely from the predicted stock-recruitment curve, was poorly estimated (CV=0.73), but included in calculation of total stock biomass (age 1+ fish, mt) for July 2014.

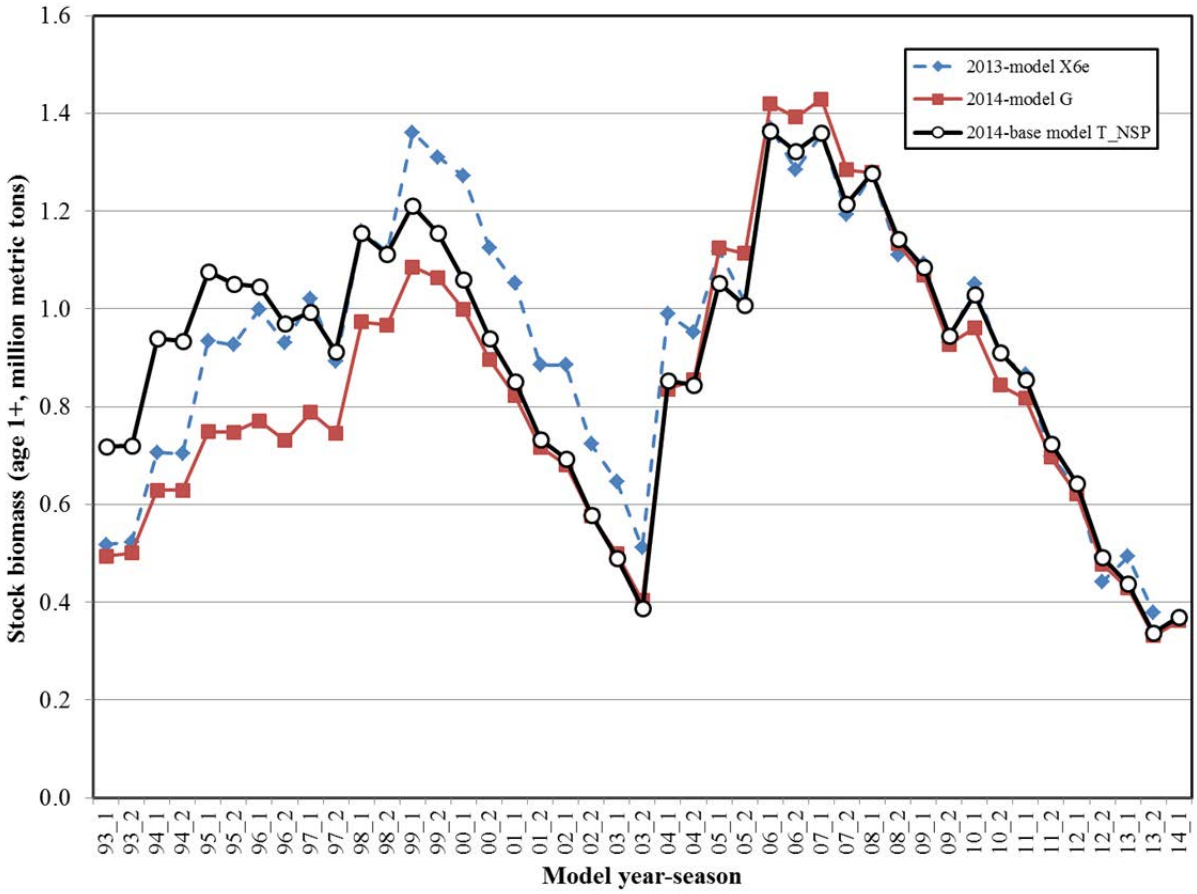




Model year	SSB (mt)	SSB Std Dev	Year class abundance (billions)	Recruits Std Dev
2000	889,929	119,525	1.707	0.368
2001	709,131	97,968	3.450	0.502
2002	538,750	79,127	0.467	0.175
2003	416,424	67,014	20.895	2.673
2004	616,788	89,430	8.860	1.636
2005	868,822	115,871	16.154	2.017
2006	1,098,180	134,709	4.652	1.012
2007	1,117,080	136,349	7.551	1.166
2008	1,037,970	126,448	2.884	0.742
2009	900,161	112,589	8.147	1.207
2010	806,697	104,196	1.648	0.458
2011	680,004	94,716	0.775	0.239
2012	473,374	80,309	0.514	0.251
2013	333,268	65,697	3.498	2.559
2014	306,237	74,121	---	---

Stock Biomass

Stock biomass, used for calculating harvest specifications, is defined as the sum of the biomass for sardine ages one and older (age 1+). Stock biomass increased throughout the 1990s, peaking at 1.27 mmt in 1999 and 1.42 mmt in 2007. Stock biomass is projected to be 369,506 mt as of July 2014.



Exploitation Status

Exploitation rate is defined as the calendar year catch divided by the total mid-year biomass (July-1, ages 0+). Exploitation rate for the U.S. fishery peaked at 14.4% in 2012 and total exploitation peaked at 18.4% that same year. The U.S. and total exploitation rates for the NSP calculated from the final base model are as follows:

Calendar year	USA	Total
2000	6.25%	9.13%
2001	6.47%	8.16%
2002	11.79%	13.84%
2003	9.93%	12.91%
2004	8.34%	9.51%
2005	6.39%	7.98%
2006	5.63%	6.55%
2007	7.52%	9.40%
2008	6.17%	8.62%
2009	5.55%	8.64%
2010	5.52%	9.29%
2011	4.83%	10.59%
2012	14.40%	18.42%
2013	12.06%	13.47%

Harvest Control Rules

Harvest guideline

Based on results from final base model T, the preliminary harvest guideline (HG) for the U.S. fishery in management year 2014-15 is 28,646 mt. The HG is calculated as follows:

$$\text{HG} = (\text{BIOMASS} - \text{CUTOFF}) \bullet \text{FRACTION} \bullet \text{DISTRIBUTION},$$

where HG is the total U.S. quota for the period July 2014 to June 2015, BIOMASS (369,506 mt) is the stock biomass (ages 1+) projected as of July 1, 2014, CUTOFF (150,000 mt) is the lowest level of biomass for which harvest is allowed, FRACTION (15%) is the percentage of biomass above the CUTOFF that can be harvested, and DISTRIBUTION (87%) is the average portion of BIOMASS assumed in U.S. waters. The HG values and catches since 2000 are displayed under Management Performance. The recommended HG will be the lowest since the onset of federal management. The 28,646 mt HG will be divided into seasonal and related allocations during the April 2014 PFMC meeting.

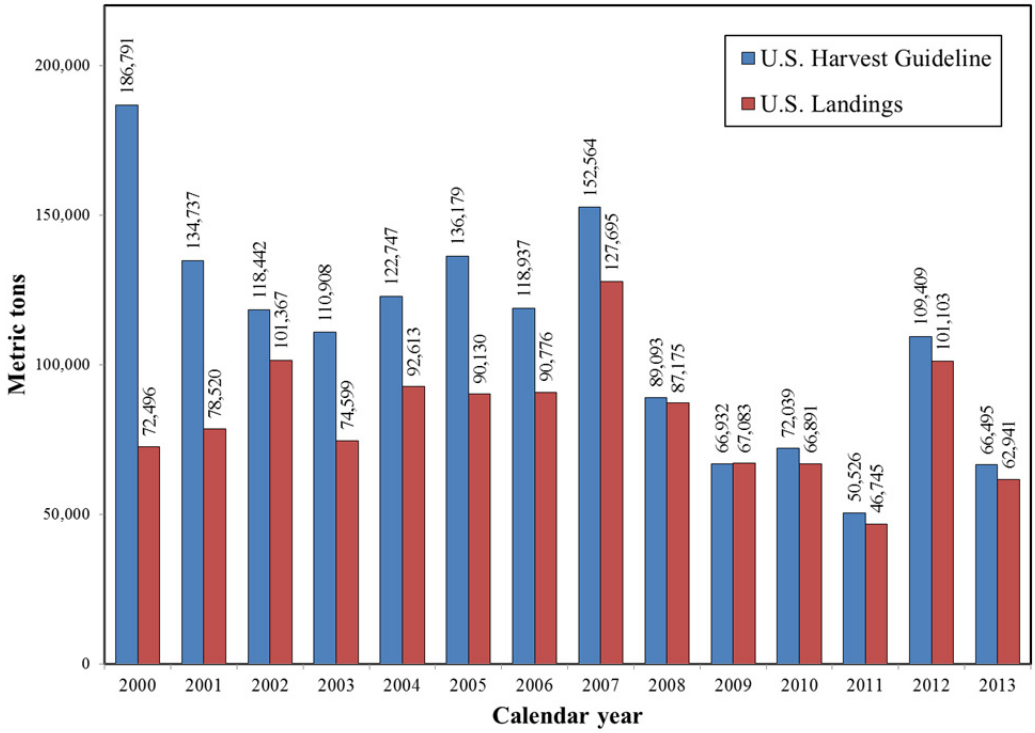
OFL and ABC

Until now, Pacific sardine OFL and ABC calculations have been based on a temperature-independent E_{MSY} average value of 0.18. On March 11, 2014, the PFMC adopted the use of CalCOFI SST data for specifying environmentally-dependent E_{MSY} each year, beginning July 2014. Based on this recent decision, the following table of OFL and ABCs is based on an E_{MSY} = 0.122, which corresponds to the three-year running average of CalCOFI SST for 2011-13 (15.335 °C). The OFL for 2014-15 is calculated to be 39,210 mt.

	Harvest Control Rule Formulas									
	OFL = BIOMASS * F_{MSY} * DISTRIBUTION									
	$ABC_{P\text{-}star}$ = BIOMASS * $BUFFER_{P\text{-}star}$ * E_{MSY} * DISTRIBUTION									
	HG = (BIOMASS - CUTOFF) * FRACTION * DISTRIBUTION									
Harvest Formula Parameters										
BIOMASS (ages 1+, mt)	369,506									
P-star	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05
ABC $Buffer_{Tier\ 1}$	0.9558	0.9128	0.8705	0.8280	0.7844	0.7386	0.6886	0.6304	0.5531
ABC $Buffer_{Tier\ 2}$	0.9135	0.8333	0.7577	0.6855	0.6153	0.5455	0.4741	0.3974	0.3060
CalCOFI SST (2011-2013)	15.335								
E_{MSY}	0.122								
FRACTION	0.15								
CUTOFF (mt)	150,000								
DISTRIBUTION (U.S.)	0.87								
Harvest Control Rule Values (MT)									
OFL =	**39,210**								
$ABC_{Tier\ 1}$ =	37,475	35,792	34,131	32,464	30,757	28,961	26,999	24,719	21,688
$ABC_{Tier\ 2}$ =	35,818	32,672	29,710	26,879	24,126	21,391	18,591	15,583	11,997
HG =	**28,646**								

Management performance

U.S. HG values and catches since the onset of federal management follow:



Unresolved Problems and Major Uncertainties

In this stock assessment, four primary areas of uncertainty warrant further research attention to improve current knowledge of this species' biology and provide robust estimates of total abundance for management purposes on an annual basis. First, there exists considerable uncertainty surrounding absolute levels of recruitment (age-0, as well as age-1 fish) in the most recent years of the modeled time series, which are believed to be strongly related to environmental conditions, particularly, large-scale oceanographic phenomena (e.g., PDO, SST, sea-surface height, etc.). Further research is needed to better inform stock-recruitment estimation/parameterization in the present assessment, including best practices for identifying and accommodating such environmental information in the integrated SS model. Second, stock structure/distribution hypotheses and related catch/composition determinations were addressed in this assessment using environment-based indices vs. port-based as was conducted in all past assessments. Although general consensus from both STAT/STAR panel supported using environmental data to more objectively address subpopulation (northern and southern populations that potentially mix seasonally) assumptions in the model than simply assuming subpopulations can be identified directly from landing site data (e.g., ports), further empirical (otoliths, length/weight, reproductive/genetic tissue, meristics etc.) evidence should be collected annually from fish during periods of mixing to corroborate results from the environment-based index approach. Third, uncertainty surrounding catchability (q) for the primary ATM survey indices of abundance remains largely unresolved at this time and thus, q remains a fixed parameter (1.0) in the model, as assumed in past assessments. That is, while preliminary models presented at the 2014 STAR panel (e.g., model G) produced reasonable estimates of q for the ATM survey, further evaluations/review indicated the scale of important management quantities (stock biomass and recruitment), as well as estimates of q for the survey, remained sensitive to relatively small changes made to the model (see stock-recruitment estimation above). In this context, stability concerning the scale of sardine population estimates has been an ongoing issue since the application of fully integrated, age-structured models to assess the status this stock (Deriso et al. 1995). Fourth, and related to survey abundance parameterizations in the model, data weighting considerations associated with both fishery and survey composition time series largely reflect ad hoc practices for de-emphasizing these data to minimize their impacts on abundance estimation relative to the direct information provided in the survey indices. Further research associated with both data weighting and related selectivity parameterization is needed, particularly pertaining to conditional age-at-length compositions, to address potential model misspecification due to the treatment of composition data in the present assessment. Finally, based on the points above, the 2013 year-class strength is highly uncertain and poorly informed by the available data. This estimate, which may be biased high, factors into calculation of the age 1+ biomass for July 2014. One alternative approach would be to base age-1 biomass for 2014 on an average of the most recent few years and to add this value to the age 2+ biomass for purpose of setting management specifications in 2014-15. This issue was not explored during the STAR panel.

Research and Data Needs

See Research and Data Needs below for a summary of critical areas in need of further attention to generally improve the ongoing Pacific sardine assessment.

INTRODUCTION

Distribution, Migration, Stock Structure, Management Units

Information regarding Pacific sardine (*Sardinops sagax caerulea*) biology and population dynamics is available in Clark and Marr (1955), Ahlstrom (1960), Murphy (1966), MacCall (1979), Leet et al. (2001), as well as references cited below.

The Pacific sardine has at times been the most abundant fish species in the California Current Ecosystem (CCE). When the population is large, it is abundant from the tip of Baja California (23° N latitude) to southeastern Alaska (57° N latitude) and throughout the Gulf of California. Occurrence tends to be seasonal in the northern extent of its range. When sardine abundance is low, as during the 1960s and 1970s, sardines do not occur in commercial quantities north of Baja California.

There is a longstanding, general consensus in the scientific community that sardines off the west coast of North America represent three subpopulations (see review by Smith 2005). A northern subpopulation (northern Baja California to Alaska), a southern subpopulation (outer coastal Baja California to southern California), and a Gulf of California subpopulation were distinguished on the basis of serological techniques (Vrooman 1964) and in studies of oceanography as pertaining temperature-at-capture (Felix-Uraga et al., 2004, 2005; Garcia-Morales 2012; Demer and Zwolinski 2014). An electrophoretic study (Hedgecock et al. 1989) showed, however, no genetic variation among sardines from central and southern California, the Pacific coast of Baja California, or the Gulf of California. Although the ranges of the northern and southern subpopulations can overlap within the Southern California Bight, the adult spawning stocks likely move north and south in synchrony and do not occupy the same space simultaneously to a significant extent (Garcia-Morales 2012). The northern subpopulation (NSP) is exploited by fisheries off Canada, the U.S., and northern Baja California, and is included in the CPS Fishery Management Plan (CPS-FMP; PFMC 1998). The current assessment addresses the above stock structure hypotheses in a more explicit manner, by partitioning southern (Ensenada and Southern California ports) fishery catch and composition data using an environment-based approach described by Demer and Zwolinski (2014) and in the following sections (see Assessment Data)..

Pacific sardines probably migrated extensively during historical periods when abundance was high, moving north as far as British Columbia in the summer and returning to southern California and northern Baja California in the fall. Tagging studies indicate that the older and larger fish moved farther north (Janssen 1938; Clark & Janssen 1945). Migratory patterns were probably complex, and the timing and extent of movement were affected by oceanographic conditions (Hart 1973) and stock biomass. During the 1950s to 1970s, a period of reduced stock size and unfavorably cold sea surface temperatures apparently caused the stock to abandon the northern portion of its range. In recent decades, the combination of increased stock size and warmer sea surface temperatures resulted in the stock re-occupying areas off Central California, Oregon, Washington, and British Columbia, as well as distant-offshore areas off California. During a cooperative U.S.-U.S.S.R. research cruise for jack mackerel in 1991, several tons of sardine were collected 300 nm west of the Southern California Bight (SCB) (Macewicz and Abramenkoff 1993). Resumption of seasonal movement between the southern spawning habitat and the

northern feeding habitat has been inferred by presence/absence of size classes in focused regional surveys (Lo et al. 2011a) and measured directly using the acoustic-trawl method (Demer et al. 2012).

Life History Features Affecting Management

Pacific sardines may reach 41 cm in length, but are seldom longer than 30 cm. They may live up to 15 years, but fish in California commercial catches are usually younger than five years. Sardine are typically larger and two to three years older in regions off the Pacific Northwest. There is evidence for regional variation in size-at-age, with size increasing from south to north and from inshore to offshore (Phillips 1948, Hill 1999). Size- and age-at-maturity may decline with a decrease in biomass, latitude, and temperature (Butler 1987). At relatively low biomass levels, sardines appear to be fully mature at age one, whereas at very high biomass levels, only some of the two-year-olds are mature (MacCall 1979).

Until 1953, sardines fully recruited to the fishery when they were ages three and older (MacCall 1979). Recent fishery data indicate that sardines begin to recruit at age zero and are fully recruited to the southern California fishery (SCA) by age two. Age-dependent availability to the fishery likely depends upon the location of the fishery, with young fish unlikely to be fully available to fisheries located in the north and older fish less likely to be fully available to fisheries south of Point Conception.

Age-specific mortality estimates are available for the entire suite of life history stages (Butler et al. 1993). Mortality is high at the egg and yolk sac larvae stages (instantaneous rates in excess of 0.66 d^{-1}). The adult natural mortality rate has been estimated to be M=0.4 yr^{-1} (Murphy 1966; MacCall 1979) and 0.51 yr^{-1} (Clark and Marr 1955). Zwolinski and Demer (2013b) studied natural mortality using trends in abundance from the acoustic-trawl method (ATM) surveys (2006-2011), accounting for fishery removals, and estimated M=0.52 yr^{-1}. A natural mortality rate of M=0.4 yr^{-1} means that 33% of the adult sardine stock would die each year of natural causes. Sensitivities to assumptions regarding M were addressed in this year's assessment (see Assessment Model).

Pacific sardines spawn in loosely aggregated schools in the upper 50 meters of the water column. The northern subpopulation spawning begins in January off northern Baja California and ends by August off the Pacific Northwest (Oregon, Washington, and Vancouver Island), typically peaking off California in April. Sardine eggs are most abundant at sea-surface temperatures of 13 to 15 ^{o}C, and larvae are most abundant at 13 to 16 ^{o}C. The spatial and seasonal distribution of spawning is influenced by temperature. During periods of warm water, the center of sardine spawning shifts northward and spawning extends over a longer period of time (Butler 1987; Ahlstrom 1960). Recent spawning has been concentrated in the region offshore and north of Point Conception (Lo et al. 1996, 2005). Sardines are oviparous, multiple-batch spawners, with annual fecundity that is indeterminate and age- or size-dependent (Macewicz et al. 1996).

Abundance, Recruitment, and Population Dynamics

Extreme natural variability is characteristic of clupeid stocks, such as Pacific sardine (Cushing 1971). Estimates of sardine abundance from 300 AD through 1970 have been reconstructed from the deposition of fish scales in sediment cores from the Santa Barbara basin off SCA (Soutar and Issacs 1969, 1974; Baumgartner et al. 1992). Sardine populations existed throughout the period with biomass levels varying widely on decadal time scales. Both sardine and anchovy populations tend to vary over periods of roughly 60 years, although sardines have varied more than anchovies. Estimates of sardine biomass inferred from scale-depositions in the 19th and 20th centuries suggest that it peaked at approximately six mmt in 1925 (Soutar and Isaacs 1969; Smith 1978). Declines in sardine populations have generally lasted an average of 36 years and recoveries an average of 30 years.

Sardine spawning biomass, estimated from virtual population analysis methods, averaged 3.5 mmt from 1932 through 1934, fluctuated from 1.2 to 2.8 mmt over the next ten years, then declined steeply from 1945 to 1965, with some short-term reversals following periods of strong recruitment success (Murphy 1966; MacCall 1979). During the 1960s and 1970s, spawning biomass levels were less than about five to ten thousand mt (Barnes et al. 1992). The sardine stock began to increase by an average rate of 27% per annum in the early 1980s (Barnes et al. 1992).

Pacific sardine recruitment is highly variable. Analyses of the sardine stock recruitment relationship have been controversial, with some studies showing a strong density-dependent relationship (production of young sardines declines at high levels of spawning biomass) and others finding no relationship (Clark and Marr 1955; Murphy 1966; MacCall 1979). Jacobson and MacCall (1995) found both density-dependent and environmental factors to be important.

Relevant History of the Fishery

The sardine fishery was first developed in response to demand for food during World War I. Landings increased from 1916 to 1936, peaking at over 700,000 mt. Pacific sardines supported the largest fishery in the western hemisphere during the 1930s and 1940s, with landings in Canada, WA, OR, CA, and Mexico. The population and fishery declined, beginning in the late 1940s and with some short-term reversals, to extremely low levels in the 1970s. There was a southward shift in catch as the fishery collapsed, with landings ceasing in the Pacific Northwest in 1947 through 1948, and in San Francisco in 1951 through 1952. Sardines were primarily reduced to fish meal, oil, and canned food, with small quantities used for bait.

In the early 1980s, sardines were taken incidentally with Pacific and jack mackerel in the SCA mackerel fishery. As sardine continued to increase in abundance, a directed purse-seine fishery was re-established. The incidental fishery for sardines ended in 1991. Besides SCA and CCA, substantial quantities of Pacific sardines are now landed at OR, WA, BC, and ENS. Total annual harvest by the Mexican fishery is not yet regulated by quotas, but there is a minimum legal size limit of 150 mm SL.

Recent Management Performance

Management authority for the U.S. Pacific sardine fishery was transferred to the PFMC in January 2000. The Pacific sardine was one of five species included in the federal CPS-FMP (PFMC 1998). The CPS-FMP includes harvest control rules intended to prevent Pacific sardines from being overfished and to maintain relatively high and consistent, long-term catch levels. Harvest control rules for the sardine are provided at the end of this report. A thorough description of PFMC management actions for sardines, including HG values, may be found in the most recent CPS SAFE document (PFMC 2011). U.S. HG values and landings since 2000 are displayed in Table 1 and Figure 1. Harvests at major fishing regions from ENS to BC are provided in Table 2 and Figure 2a-b.

ASSESSMENT DATA

Biological Parameters

Stock structure

For this assessment, we model the northern subpopulation (NSP, or 'cold stock') that ranges from northern Baja California, México to British Columbia, Canada and extends up to 300 nm offshore (Macewicz and Abramenkoff 1993). In past assessments, the approach has been to assume that all catches landed at ports from ENS to BC were from the northern subpopulation. As mentioned above, there is general consensus that catches landed in ENS and SCA likely represent a mixture of southern subpopulation (during warm months) and northern subpopulation (cold months) (Felix-Uraga et al. 2004, 2005; Garcia-Morales 2012; Zwolinski et al. 2011; Demer and Zwolinski 2014). For this assessment, we applied an objective method to partition data from ENS and SCA ports in order to exclude catch and composition data attributed to the southern subpopulation (see Assessment Model).

Efforts to survey, assess, and manage Pacific sardine in the California Current may depend on accurate differentiation of the purported two migrating stocks (Smith, 2005). A decade ago, a practical method was proposed for differentiating landings from the two stocks using concomitant measurements of sea surface temperature (SST)(Felix-Uraga *et al.*, 2004, 2005). Demer and Zwolinski (2013) independently corroborated and refined the method using regional indices of optimal and good potential habitat for the northern stock (Zwolinski *et al.*, 2011), and SST-based indices associated with the probability of including 99.9 % of all the sardine egg sampled over a 12-year period. The alternative indices equal the proportions of each fishing region containing optimal or good potential habitat for the northern sardine stock habitat (Zwolinski et al. 2011) and SST <16.4°C, respectively. For months when either index is <0.5, (i.e. when the minority of a fishing region probably includes potential northern stock habitat), the commercial landings are attributed to the southern stock, and vice versa. Because sardine landings at Ensenada or San Pedro were often low when the local habitat was transitioning (Felix-Uraga *et al.* 2004, 2005), the efficacy of the method is largely insensitive to the choice of index. To potentially improve the assessment estimates of northern stock biomass, Demer and Zwolinski's SST-index was calculated for the Ensenada and San Pedro regions, monthly since 1980, enabling the exclusion of southern stock sardine landings and their respective length compositions from the SS model.

Growth

The weight-at-length relationship for Pacific sardines (combined sexes) was modeled by the standard power function,

$$W = a\,(L^b);$$

where W is weight (kg) at length L (cm), and a and b are regression coefficients. The length-weight relationship was re-examined for this assessment using least-squares fit to sample data from the modeled period, 1993-2013. Coefficients for the NSP (subscript '2' models) data set were, a = 7.5242e-06, b = 3.2332 (n = 104,326; corrected R^2 = 0.936) (Figure 3).

The largest recorded Pacific sardine was standard length SL = 41.0 cm (Eschmeyer et al. 1983), but the largest Pacific sardine commercially captured fish since 1981 was SL = 29.7 cm. The heaviest sardine weighed 0.323 kg. The oldest recorded Pacific sardine was 15 years old, but commercially-caught Pacific sardine are typically less than seven years old.

Sardine ageing using otolith methods were first described by Walford and Mosher (1943) and elaborated by Yaremko (1996). Pacific sardines are routinely aged by fishery biologists in México, CA, and the PNW using annuli enumerated in whole sagittae. A birth date of July 1 is assumed when assigning year class. Lab-specific ageing errors were calculated and applied as described in Hill et al. (2011).

Sardine growth was first estimated outside the SS model to provide initial parameter values and CV values for length at Age_{min} (0.5 yrs), length at Age_{max} (15 yrs), and growth coefficient K (Figure 4b). A re-analysis of size-at-age from fishery samples (1993-2013) did not indicate sexual dimorphism (Figure 4a) and thus, combined sexes are included in the present assessment model.

Maturity

Maturity-at-length parameters were updated using sardines sampled from survey trawls conducted from 1994 to 2013. Their reproductive state was primarily established through histological examination, although some immature individuals were simply identified through gross visual inspection. Parameters for the logistic maturity function were estimated using,

$$\text{Maturity} = 1/(1+\exp(slope*L-L_{\text{inflexion}}));$$

where slope = -0.89252 and inflexion = 15.44 cm-SL. Maturity-at-length parameters were fixed in the assessment model. Fecundity was fixed at 1 egg/gram body weight. Maturity- and fecundity-at-length vectors are presented in Figure 5a. Maturity-at-age during the spawning season (beginning of S2), as derived from growth estimation in final base model T is presented in Figure 5b.

Natural mortality

The instantaneous rate of adult natural mortality has been estimated to be M = 0.4 yr^{-1} (Murphy 1966; MacCall 1979), 0.51 yr^{-1} (Clark and Marr 1955), and 0.52 yr^{-1} (Zwolinski and Demer

2013b). Consistent with all previous sardine assessments, our base models were parameterized with M = 0.4 yr^{-1} for all ages and years (Murphy 1966, MacCall 1979, Deriso et al. 1996, Hill et al. 1999, Hill et al. 2012). A natural mortality rate of M = 0.4 yr^{-1} means that roughly 33% of the stock die of natural causes each year.
This assessment did examine sensitivity to alternative natural mortality assumptions based on 1) new analyses by Zwolinski and Demer (2013b), where M = 0.52 yr^{-1} for all ages, and 2) using Lorenzen's bent hockey stick function based on the hypothesis that M is higher at younger ages (Butler et al. 1993). A general Lorenzen formulation was applied,

$$M_{\text{age}} = M_c\,(L_{mat}/L_{age}) \text{ for } a<a_{mat};$$

where M_c = 0.4, L_{mat}=15.44 cm-SL, and L_{age} =8 cm for age 0, 13.46 cm for age 1, and a_{mat}=2 years. This resulted in an M_{age} vector of 0.77 yr^{-1} for age-0 fish, 0.46 yr^{-1} for age-1 fish, and 0.4 yr^{-1} for fish ages 2 and older.

Fishery Data

Overview
Available fishery data include commercial landings and biological samples from six regional fisheries: Ensenada (ENS), Southern California (SCA), Central California (CCA), Oregon (OR), Washington (WA), and British Columbia (BC). Standard biological samples include individual weight (kg), standard length (cm), sex, maturity, and otoliths for age determination (in most, but not all cases). A complete list of available landings and port sample data by fishing region, model year, and season is provided in Table 3.

The INAPESCA has collected sardine samples from the port of Ensenada since 1989. Sampling has been comparable to that of the U.S. with respect to randomness, frequency, and types of biological data. INAPESCA has collected roughly 10 random samples of 25 fish per month for size, sex, and reproductive condition, with a random subset being aged using otoliths (Table 3). We include length compositions (catch-weighted semester aggregates provided by INAPESCA) representing the full set of INAPESCA samples collected from mid-1988 through mid-2009. INAPESCA also provided a full complement of conditional age-at-length compositions, however, those data were not included this year due to unresolved issues. No new composition data have been obtained since the previous full assessment (Hill et al. 2011).

The CDFW has collected sardine samples from SCA and CCA ports on a regular basis since 1981. CDFW currently collects 12 random port samples (25 fish per sample) per month from each region. ODFW has collected port samples since 1999, and WDFW since 2000 (Table 3). Oregon and Washington fishery samples are collected at higher frequency due to the compressed fishing season, but each sample contains 25 fish.

The CDFO has sampled the BC sardine fishery since 1998. The CDFO collects 100 fish per sample and requires 50%-100% observer coverage, so many of the BC loads are sampled relative to other fisheries. The CDFO's protocol does include collection of otoliths, however, their ageing efforts have primarily focused on survey samples, with no fishery ages being available for this assessment.

All fishery catches and compositions were compiled based on the sardine's biological year ('model year') to match the July-1 birth date assumption used in age assignments. Each model year is labeled with the first of two calendar years spanned (e.g., model year '1993' includes data from July 1, 1993 through June 30, 1994). Further, each model year has two six-month seasons, where 'S1'=Jul-Dec and 'S2'=Jan-Jun. Major fishery regions were pooled to represent a southern 'MexCal' fleet (ENS+SCA+CCA) and a northern 'PacNW' fleet (OR+WA+BC), where the MexCal fleet was treated with semester-based selectivities ('MexCal_S1' and 'MexCal_S2'). Rationale for this design is provided in Hill et al. (2011).

Landings

Ensenada monthly landings, 1993 to 2002, were compiled using the 'Boletín Anual' series previously produced by INAPESCA's Ensenada office (e.g., Garcia and Sánchez 2003). Monthly landings from 2003 to 2011 were taken from CONAPESCA's web archive of Mexican fishery yearbook statistics (CONAPESCA 2012). Landings for 2012 and the first half of 2013 were provided by Dr. Manuel O. Nevarrez (INAPESCA-Mexico City) as semester totals. Semester aggregate catches in 2012-2013 were equally apportioned across months for purposes of assigning catch to the NSP.

California (SCA and CCA) commercial landings were obtained from CDFW's 'Wetfish Tables' (1993 to 1999, 2013) and the PacFIN database (2000 to 2012). Oregon (OR) and Washington (WA) landings (1999-2013) were also obtained solely from PacFIN. British Columbia monthly landing statistics, 1999 to 2010, were provided by CDFO (Linnea Flostrand and Jordan Mah, pers. comm.).

As stated above, satellite oceanography data were used to characterize ocean climate (SST) within typical fishing zones off Ensenada and Southern California and attribute monthly catch for each fishery to either the southern or northern subpopulation (NSP) Landings by model year-season for each fishing region and stock scenario (port-based versus environment-based NSP) are presented in Table 2 and Figure 2. The current SS model aggregates regional fisheries into a southern 'MexCal' fleet and a northern 'PacNW' fleet. Landings aggregated by model year-season and fleet for each stock scenario are presented in Table 4 and Figure 6.

Length compositions

Length compositions for each fleet and season were the sums of catch-weighted length observations, with monthly landings within each port and season serving as the weighting unit. As indicated above, environmental criteria used to assign landings to subpopulations were also applied to monthly port samples to categorize NSP fish. New catch-based weighting vectors were also calculated for creating aggregate NSP length compositions.

Length compositions were comprised of 0.5-cm bins ranging from 9 to 28 cm standard length (39 bins total). The 9-cm bin reflects all fish $\leq$9.49 cm, the 28-cm bin reflects all fish $\geq$28 cm, and all other bins (9.5 to 27.5 cm) reflect the lower bound of the respective 0.5-cm interval (e.g., the 9.5-cm bin includes fish ranging 9.5 to 9.99 cm).

Total numbers of lengths observed in each fleet-semester stratum were divided by the typical number of fish collected per sampled load (25 fish per sample for most regions, 100 fish per sample in Canada) to calculate the sample sizes for compositions included in the assessment model. Compositions having fewer than two samples per semester were omitted from the model. Length compositions were input as proportions. While raw sample data were not available from the ENS and BC regional fisheries, catch-weighted length distributions, assembled per above, were made available by INAPESCA and CDFO. To combine ENS with SCA-CCA data ('MexCal') and to combine BC with OR-WA data ('PacNW'), the respective length distributions and sample sizes were weighted by catch from each region and summed at the season level. Length compositions and input sample sizes by fleet are displayed in Figure 7, 8, and 9. Length compositions for the two stock structure assumptions (All vs. NSP) are presented side-by-side in these displays.

Age compositions

Age compositions were compiled based on the same fishery samples and weighting methods described above. For the length data/length-based selectivity model scenarios, implied ('ghost') age-compositions were included as model inputs (but omitted from likelihood calculations) to facilitate comparison of model predictions of age composition with the inferred values through examination of model residual patterns. For age data/age-based selectivity model scenarios, length and conditional age-at-length data were disabled and the above aggregate age compositions were included in the model with appropriate sample sizes. Aggregate age-composition data for both stock scenarios are presented in Figures 7, 8, and 9.

Conditional age-at-length compositions, used to estimate growth in length-based models, were constructed from the same fishery samples and weighting methods described above. Age bins included 0, 1, 2, 3, 4, 5, 6, 7, 8-10, 11-15 (10 bins total). The age 11-15 bin served as an accumulator allowing growth to approach maximum length (L_∞). Age compositions were input as proportions of fish in 1-cm length bins. As was done for the length compositions, the number of individuals comprising each bin was divided by the number of fish per sample to set the initial, input sample size. In most cases, age data were available for every length observation. Conditional age-at-length compositions for each fishery are presented in Figures 10-12.

Oregon and Washington fishery ages from model season 2 (S2, Jan-Jun), which would have been included in the PacNW fleet, were omitted from all models due to inter-laboratory inconsistencies in the application of birth-date criteria during this semester. Total OR and WA landings and samples during S2 are typically small, so this omission did not represent a major loss of information to the model.

It is important to note that length data, but not age data, were available for the BC fishery. As a result, length-based models more accurately represent sizes-at-removal for the aggregate PacNW fleet, but age-based models only represent removals-at-age by the OR and WA fleets. The same problem applies to the southern MexCal fleet, where lengths, but not ages, were available from the ENS fishery.

Ageing error
Ageing-error vectors for fishery data were unchanged from Hill et al. (2011). Ageing error vectors (SD at true age) were linked to fishery-specific conditional age-at-length or aggregate age-composition data (Figure 13). For complete details regarding age-reading data sets, model development and assumptions, see Hill et al. (2011), Appendix 2, as well as Dorval et al. 2013.

Fishery-independent Data

Overview
This assessment/review considered four time series obtained from fishery-independent surveys: 1) daily egg production method (DEPM) estimates of female spawning biomass; 2) total egg production (TEP) estimates of total spawning biomass; 3) NWSS aerial photogrammetric surveys of biomass; and 4) acoustic-trawl method (ATM) surveys of biomass. All of these surveys and estimation methods have been vetted through PFMC-SSC Methodology Reviews (panels included representatives from the PFMC-SSC and the Center for Independent Experts). The DEPM/TEP and aerial survey methods were reviewed in May 2009, and the ATM survey was reviewed in February 2011 and included in the 2011 assessment. Survey data are presented in Tables 5-7, Figures 14-20, and Appendices A and B (Zwolinski et al. 2014a, b) of this report.

Daily egg production method spawning biomass
The DEPM and TEP estimates of SSB were based on SWFSC ship-based surveys conducted each April between San Diego and San Francisco. The DEPM index of female SSB is used when adult daily-specific fecundity data are available from the survey. The total egg production (TEP) index of SSB is used when survey-specific fecundity data are unavailable. The DEPM and TEP series have been used for sardine stock assessment since the 1990s, and the surveys and estimation method were reviewed by a STAR panel in May 2009. Both time series are treated as indices of relative SSB (Figure 20), with estimated catchability coefficients (q).

In 2013, the SWFSC conducted the sardine DEPM biomass survey aboard the chartered research vessel R/V *Ocean Starr* (April 8 - May3) and the NOAA ship *Bell M. Shimada* (April 23 - April 30) within the standard DEPM area (CalCOFI line 60 to 95). The *Ocean Starr* covered the area off California from just south of Monterey Bay to Oceanside (CalCOFI lines 68.3 to 91.7) while the *Bell M. Shimada* covered the area from Avila Beach to Half Moon Bay (CalCOFI lines 76.7 to 63.3)(Figure 14). The *Bell M. Shimada* also conducted the standard spring CalCOFI survey from April 8 to April 22. Because egg and larval densities were generally low and no trawls were taken during the CalCOFI survey, only the data from the DEPM portion of *Shimada* were included in the estimation of egg production (*i.e.*, data from April 23 to April 30). The DEPM survey from both research vessels employed all the usual methods for estimating sardine SSB (Lo et al. 2011). The survey included a complete sampling of the 'standard' area for the assessment models' DEPM time series, i.e. San Francisco to San Diego (Figure 14).

The 2013 DEPM index area off California (CalCOFI lines 63.3 to 91.7, about 37.18˚ – 32.36˚N) was 141,397 km^2 (Figure 14). The egg production (P_0) estimate was 1.34/0.05m^2 (CV = 0.299)(Dorval et al. 2014). Female spawning biomass for the standard area was taken as the sum of female spawning biomasses in regions 1 and 2 (Table 6). The female spawning biomass and total spawning biomass (sum) for the DEPM area were estimated to be 82,182 mt (CV = 0.30)

and 144,880 mt (CV = 0.36), respectively (Table 6).

Adult reproductive parameters for the survey are presented in Table 7. The estimated daily specific fecundity was 26.22 (number of eggs/population weight (g)/day) using the following estimates of reproductive parameters from 121 mature females collected from 15 positive trawls: mean batch fecundity (*F*) was 41,339 eggs/batch (CV = 0.06), fraction spawning (*S*) was 0.149 females spawning per day (CV = 0.16), mean female fish weight (W_f) was 138.18 g (CV = 0.03), and sex ratio of females by weight (*R*) was 0.586 (CV = 0.09). Since 2005, trawling has been conducted randomly or at CalCOFI stations, which resulted in sampling adult sardines in both high (Region 1) and low (Region 2) sardine egg-density areas. During the 2013 survey, the number of tows positive for mature female sardines was similar in Regions 1 and 2 (8 and 7 respectively), while three additional tows caught solely male sardines (Dorval et al. 2014).

In the SS model, the DEPM series is treated as an index of female SSB in the middle of S2 (April). Since 2009, the time series of spawning biomass was replaced by female spawning biomass for years when sufficient trawl samples were available and the total egg production for other years as inputs to the stock assessment of Pacific sardines. The 2013 DEPM estimate is considerably lower than in the previous few years (Tables 5 & 6; Figure 20).

Total egg production spawning biomass

Adult sardine samples are needed to calculate the daily specific fecundity for true DEPM estimates. Trawls were not always conducted during the egg production surveys. In the 2007 assessment, we chose to include these data as a Total Egg Production (TEP) series, which is simply the product of egg density (P_0) and spawning area (km^2). Calculated TEP values are provided in Tables 5 and 6 and displayed in Figure 20. TEP was also taken to represent relative SSB (length selectivity option 30) in the model (*q* estimated), but in this case the female fraction was unknown (Tables 5 and 6, Figure 20).

Aerial survey

The Pacific sardine industry (Northwest Sardine Survey, LLC; NWSS) funded aerial photogrammetric surveys of sardine abundance off the coast of OR and WA, beginning with a pilot survey in summer 2008. The pilot survey was critiqued by a PFMC-SSC Methodology Review panel in May 2009. Surveys were subsequently conducted during summer 2009 through 2012 (Jagielo et al. 2009-2012).

Aerial survey methods and results are described by Jagielo et al. (2012). The Aerial survey employs two sampling elements: 1) high-resolution aerial photographs, collected using spotter planes, to estimate the number and surface areas of sardine schools; and 2) non-random point sets targeted on sardine schools, prosecuted with commercial purse-seine vessels, to estimate the relationship between surface area and biomass and the size composition of the schools. Distributions of photographed fish schools and directed point sets, 2009-2012, are presented in Figure 15. Weighted length compositions and biomass estimates from the four surveys are displayed in Figure 16. In past assessments, aerial survey lengths had been fitted with domed-selectivity, however, we consider this to be inconsistent with fits to fishery composition data characterized by asymptotic selectivity and problematic in theoretical terms for surveys in general. Past assessments have treated this abundance time series both as an absolute index

(fixed q=1.0; Hill et al. 2009, 2010), as well as a relative index (estimated q; Hill et al. 2011, 2012).

Acoustic-trawl method survey

The ATM time series is based on SWFSC surveys conducted along the Pacific coast since 2006 (Cutter and Demer 2008; Zwolinski et al. 2011, 2012, and Zwolinski et al. (see Appendices A and B of this report)). The ATM survey and estimation methods were reviewed by a panel in February 2011 and the results from these surveys have been included in the assessment since 2011 (Hill et al. 2011, Hill et al. 2012).

Two new ATM-based biomass estimates were included in this assessment; one from the spring 2013 survey off CA and the other from the summer 2013 SaKe survey spanning San Diego to northern Vancouver Island, Canada. Biomass estimates and associated size distributions from these two surveys are described in detail by Zwolinski et al. (see Appendices A and B of this report). The time series of ATM biomass estimates is presented in Table 5 and Figure 20, and associated biomass-weighted length compositions are displayed in Figure 17. A backlog of otoliths samples collected from survey trawls has been aged, so a full complement of aggregate age composition and conditional age-at-length data was available (Figures 18-19). The ageing error vector used for the SWFSC trawl ages is displayed in Figure 13.

Past assessments (Hill et al. 2011, 2012) have treated the spring and summer ATM biomass estimates as a single, combined time series of absolute biomass (q fixed = 1). Treating the spring and summer surveys with the same selectivity might not be optimal due to fish distributions observed among seasons, i.e., the bulk of sardine (and their habitat) are observed offshore of California during spring, and the majority of sardine (and their habitat) are off the coasts of Oregon and Washington during summer. Additionally, when smaller sardine are present in the ATM survey, it is usually during the spring cruises off California. Given the assumption that seasonal migrations are size-dependent, size and abundance for the spring and summer ATM surveys should theoretically be treated with different selectivity patterns. For these reasons, we explored sensitivity of the model to independent treatment of the spring (model season S2) and summer (model season S1) surveys. Additionally, much sensitivity analysis in this year's assessment addressed fixed vs. estimated catchability (q) assumptions for the ATM surveys (see Assessment Model).

Data Sources Considered but not Used

Following consensus from STAT/STAR discussions in this year's review meeting, the aerial survey was omitted from the assessment model, including all abundance and composition data, given: 1) as noted in past reviews, the vulnerability of this survey method to prevailing ocean conditions potentially affecting catchability (q) over short and long time frames (e.g., water clarity, sea state, water column stratification, and associated changes in vertical distribution) has resulted in highly variable estimates, with field protocols that are inherently difficult to 'control' in survey terms; 2) the survey design is space-restricted and non-synoptic, spanning largely the northern reaches of this species' annual movement/distribution; 3) the survey strictly reflects a species-specific sampling effort that is highly weather dependent; and finally, 4) the basic survey is likely to be conducted on an intermittent basis vs. conducted on a continual basis (e.g., not

fully conducted last summer and no plans for continuing the survey next summer). Also, see *STAR (2011*) and *SSC (2012a, 2012b)* Recommendations and Responses below for further information regarding the utility/drawbacks associated with aerial surveying efforts relative to the flexibility/merits of the ATM survey for assessing total population abundance of this species. It is important to note that the aerial survey could potentially be beneficial to the overall assessment if used in concert (vs. competing) with the primary ATM survey for purposes of evaluating specific areas of uncertainty associated with the acoustic-trawl sampling effort. For example, using aerial-sighted schools to evaluate the ATM's potential 'blind' areas within the upper 10 m of the water column and more coastal areas of the overall survey area that can be more problematic for ATM surveys. If deemed worthwhile, a rigorous 'dual surveying' approach could be employed to ensure results from the two surveys can be compared straightforwardly.

Also, it is important to note that although not utilized in this assessment, aggregate age data and associated age-based selectivity assumptions for modeling fishery and survey compositions (model H, see Hill and Crone 2014) remains a potentially meaningful configuration for future assessments. Such a model scenario represents the most practical approach for meeting the goal of the assessment, given current problems can be resolved accordingly, including obtaining reliable age data from both the Mexico and Canada fisheries, providing weighted age-composition time series for the ATM survey, and conducting more sensitivity analysis for objective comparisons with the length data/length-based selectivity model that has been used for all past assessments.

ASSESSMENT MODEL

History of Modeling Approaches

The Pacific sardine population's dynamics and status prior to the collapse in the mid-1900s was first modeled by Murphy (1966). MacCall (1979) refined Murphy's virtual population analysis (VPA) model using additional data and prorated portions of Mexican landings to exclude the southern subpopulation. Deriso et al. (1996) modeled the recovering population (1982 forward) using CANSAR, a modification of Deriso's (1985) CAGEAN model. CANSAR was subsequently modified by Jacobson (NOAA) into a *quasi*, two-area model CANSAR-TAM to account for net losses from the core model area. The CANSAR and CANSAR-TAM models were used for annual stock assessments and management advice from 1996 through 2004 (e.g., Hill et al. 1999; Conser et al. 2003). In 2004, a STAR panel endorsed the use of an Age Structured Assessment Program (ASAP) model for routine assessments. The ASAP model was used for sardine assessment and management advice from 2005 to 2007 (Conser et al. 2003, 2004; Hill et al. 2006a,b). In 2007, a STAR panel reviewed and endorsed an assessment using Stock Synthesis 2 (Methot 2005, 2007), and the results were adopted for management in 2008 (Hill et al. 2007) as well as an update for 2009 management (Hill et al. 2008). The sardine model was transitioned to Stock Synthesis version 3.03a in 2009 (Methot 2009) and was again used for an updated assessment in 2010 (Hill et al. 2009 & 2010). Stock Synthesis version 3.21d was used for the 2011 full assessment (Hill et al. 2011), the 2012 update assessment (Hill et al. 2012), and the 2013 catch-only projection (Hill 2013).

STAR (2011) and SSC (2012a, 2012b) Recommendations and Responses

The following information serves recommendations and responses provided prior to the STAR meeting in March 2014, i.e., recommendations and associated sensitivity analysis/responses made at the meeting are presented in STAR 2014, as well as generally addressed in *Model Selection and Evaluation* below. Finally, for particular recommendations below, applicable sensitivity analysis in Table 8 is referenced accordingly, given such analysis reflects the initial work undertaken for addressing past review recommendations.

STAR (2011) - Responses to unresolved problems and major uncertainties

1. The ongoing uncertainties, in particular regarding absolute biomass, are likely to persist until the information content of the data increases substantially.
   Response: Agreed, and likely applicable to every stock assessment.
2. The Panel wishes to highlight that the level of variation in terminal biomass evident from the retrospective pattern (on the order of 100,000s of tons from one year to the next is not unexpected, and changes in terminal 1+ biomass estimates of this extent may occur when the 2012 assessment update occur.
   Response: Agreed, and likely to persist for some time, given under/over-estimation of current biomass/recruitment strength (retrospective patterns) is typical in this, as well as most, assessments, particularly those conducted annually for productive, broadly distributed, small pelagic fish populations.
3. The indices of abundance do not exhibit consistent trends even after allowing for the differences in their respective selectivities, and remain in conflict even when the age and length data are greatly down-weighted.
   Response: See model scenarios for Surveys (B) and Biological compositions (C and D) in summary sensitivity Table 8. Also, see *SSC (2012a, 2012b)* G and K responses below.
4. The data set is able to estimate general trends in abundance fairly robustly, but the likelihood is flat over a wide range of current biomass levels, which means that relatively small changes to the data set or assumptions can lead to marked changes in current abundance. The current assessment has somewhat reduced the influence of this lack of information by fixing survey catchability. Ultimately, it is only through further data collection (or the development of informative priors for survey catchability) that these uncertainties may be overcome.
   Response: Agreed. See model scenarios for Surveys (B), Table 8. Also, see R_0 likelihood component profiles associated with models G and T (Figure 42).
5. The STAT evaluated a large number of model configurations to identify a more stable model that fits the data better. However, the residual patterns for the composition data and indices remain unsatisfactory. Furthermore, attempts to split the data by fleet to reduce some of these patterns led to unrealistic results (e.g. Fs > $2yr^{-1}$ in recent years for the MexCal fishery). The Panel identified the need to consider models with sex and spatial-structure, but there was insufficient time to develop, test, and evaluate such models during the Panel meeting.
   Response: As presented in past reviews, the limited information available indicates Pacific sardine growth is generally similar for males and females (e.g., size-at-age, Figure 4a), with sex ratio information indicating more females than males (higher *M* and/or differences in availability for males), depending on year/area evaluated. Given the numerous areas of uncertainty investigated here, configuration of sex-specific models for exploratory sensitivity analysis was considered a low priority and inefficient for meeting the main goal of the

assessment (see Preface). Subpopulation hypotheses and associated distributions in any given year are addressed, to various extents via sensitivity analysis under Stock structure (A), Table 8. Also, see *STAR (2011)* L response below.

6. Further down-weighting the age and length data is warranted given the analyses. However, time is needed to find a model configuration that does not lead to undesirable diagnostics (such as a low value for the root mean square error for the recruitment deviations, or a poor fit to the size-at-age data, as found in initial models examined during the meeting).
   Response: See model scenarios for Biological compositions (C and D models), Table 8.
7. The period covered by the current assessment starts in 1993 (rather than in 1981 as in past assessments). This change was necessary because of a variety of factors, including lack of precise abundance estimates for the years 1981-92, lack of age and length data for the Ensenada fishery (only three years of data), and the fact that the age and length data for southern California were collected from an incidental fishery for sardine for much of this period. In addition, the growth data for these years are inconsistent with the later growth data and was one reason for the previous assessment invoking the assumption of time-varying growth. While the Panel supports the change in start year, dropping the early data means that it is no longer possible to assess the state of the stock prior to 1993, which adds to uncertainty about the dynamics of this population and current biomass levels.
   Response: See *STAR (2011)* H, L, and O responses below. Pacific sardine recruit quickly to the fisheries, are short-lived species (few fish >6-years old), and have exhibited consistent, robust growth over the last one to two decades. Models based on an abbreviated time period are structured/parameterized most efficiently for addressing the primary management goal of this assessment to produce robust estimates of recent stock abundance. Models that include extended time periods would allow for historical contrasts of stock status, but necessarily complicate/confound the current assessment goals by including much more (early) composition data and little to no additional (quality) abundance information.
8. The scarcity of old and large sardines in the data relative to model estimates is a fundamental tension in the assessment that may be due to assumptions about, for example, growth, selectivity, natural mortality, and data weighting.
   Response: Although still indicated, to some extent, in most model scenarios, age data/age-based models reflect efforts to further evaluate this issue. See Biological compositions (C vs. D models) and Stock-recruitment (E models), Table 8. Also, less detailed binning for age composition time series may also provide further insight into this model uncertainty.

STAR (2011) - Responses to research recommendations

A. Continue to explore possible additional fishery-independent data sources. As noted by previous Panels, there would be value in attempting to include the data from the midwater trawl surveys off the west coast of Vancouver Island in the assessment. However, inclusion of a substantial new data source would likely require review which would not be easily accomplished during a standard STAR Panel meeting so would likely need to be reviewed during a Council-sponsored Methodology Panel. Similarly, the information provided on presence of sardine in the SWFSC juvenile rockfish survey should be explored further for possible inclusion in the future assessment.
   Response: This recommendation was addressed in previous review (Hill et al. 2011). The PFMC reviewed a number of requests for CPS survey methodology reviews during 2011-12, including SWFSC's acoustic-trawl survey, Southern California aerial-LIDAR survey, and

Pacific NW satellite imagery survey. However, CDFO's swept-area trawl survey has not been formally proposed for review at this time. The assessment team feels Canada DFO's swept-area trawl survey would be of limited utility in the assessment, given: (1) spatial coverage is limited to areas off Vancouver Island, the northern tail of the stock's distribution, and (2) DFO's biomass estimates (night-time trawls, 2006-2012) are highly variable (CVs = 1.5~3.0) and unlikely an informative time series within the assessment model. The SWFSC's pelagic juvenile rockfish survey has been previously reviewed (Hill et al. 2011) and found to have substantial limitations as a fishery-independent data source for inclusion in the current Pacific sardine assessment, given: (1) the survey (core area) design represents a limited spatial area in relation to this species' biology and movement, (2) the survey was not designed to accurately sample coastal pelagic species in general, which exhibit highly variable depth distributions and overall availabilities to a survey/fishery due largely to prevailing oceanographic conditions (e.g., no sardines were observed in 2010-12), and, (3) as for the Canada DFO trawl survey, a formal methods review of the rockfish survey should be conducted before potentially including results (abundance and/or size-composition data) in the ongoing Pacific sardine assessment. Interpretation of CPS distributions from the juvenile rockfish survey indicate that Pacific sardine (and other CPS) are typically more abundant in the core area during oceanographic regimes of low productivity and/or low upwelling. Finally, an environmental (PDO) index is currently being developed for possible inclusion in future assessments for purposes of better informing S-R and recruitment estimation, i.e., based on the assumption that juvenile survival of age '0' fish is strongly influenced by immediate oceanographic conditions (see Zwolinski and Demer 2013a).

B. The Panel continues to support expansion of coast-wide sampling of adult fish for use when estimating parameters in the DEPM method (and when computing biomass from the acoustic-trawl surveys). It also encourages sampling in Mexican and Canadian waters (aerial and acoustic-trawl surveys).

   Response: The SWFSC continues to attempt coast-wide surveys as frequently as possible for both the DEPM and acoustic-trawl surveys. Since 2011, these surveys have included coast-wide trawl samples of adult fish. Mexico carried out an ATM survey along the outer Baja coast in summer 2012, but specific details of their ATM methods may differ and are not able to be compared straightforwardly to the U.S. ATM. The INAPESCA has a new vessel this year, and plans to conduct regular surveys of the outer Baja coast. It is hoped that collaborative technical exchanges and research surveys will be realized in the near future with particularly Mexico. Finally, two collaborative summer *SaKe* surveys (2012, 2013) with the NWFSC hake survey efforts have been conducted and are incorporated in the summer ATM index.

C. Temperature-at-catch could provide insight into stock structure and the appropriate catch stream to use for assessments, because the southern subpopulation is thought to prefer warmer water. Conduct sensitivity tests to alternative assumptions regarding the fraction of the MexCal catch that comes from the northern subpopulation.

   Response: Subpopulation hypotheses and associated distributions in any given year are addressed under Stock structure (A), and the environment-based method for partitioning catches/compositions was applied for both blended models (G and H), Table 8.

D. The assessment would benefit not only from data from Mexico and Canada, but also from joint assessment, which includes assessment team members from these countries.

Response: A joint Mexico INP-NMFS sardine assessment workshop was held in La Paz in September 2010, which resulted in exchange of information regarding the SS modeling platform, as well as standardized data sets for the respective fisheries off Mexico and the U.S. However, no formal arrangements are in place currently for conducting a collaborative Pacific sardine (or other CPS) assessment between the SWFSC staff and researchers from Mexico or Canada, although limited momentum continues, given the ongoing MexUS-Pacifico forums held annually between NOAA Fisheries and INAPESCA administration staff. We strongly feel such collaboration is needed for accurate assessment of this transboundary species' status, particularly with Mexico, given sardine's hypothesized range and potential mixing with the southern subpopulation, as well as the observed elevated catches over more recent timeframe.

E. Conduct additional studies on stock structure -otolith and microchemistry studies are useful tools for this purpose.

   Response: Past otolith morphometric studies have been conducted (Felix et al. 2005 and Javor 2013), but provide limited findings that can be directly incorporated in the assessment model. Recently, the SWFSC has submitted proposals for funding further research projects for evaluating otolith development and associated banding patterns identified in ageing laboratory efforts. Also, some research has been conducted recently addressing spatial variability of age/growth for this species (see Hill et al. 2011, Appendix 2).

F. The relationship between environmental correlates and abundance should be examined. In particular, the relationship between environmental covariates and overall recruitment levels, as well as recruitment deviations should be explored further.

   Response: See *STAR (2011)* A response above and Stock-recruitment (E models), Table 8.

G. Consider spatial models for Pacific sardine, which can be used to explore the implications of regional recruitment patterns and region-specific biological parameters. These models could be used to identify critical biological data gaps, as well as better represent the latitudinal variation in size-at-age.

   Response: Subpopulation hypotheses and associated distributions in any given year are addressed under Stock structure (A), and the environment-based method for partitioning catches/compositions is applied in models G and H. Explicit spatial models with fish movement (vs. fleets as proxies for movement/availability) have not been explored thoroughly to date. It is likely such a detailed model would have limited value for direct application in an assessment model, but would allow for fishery/spatial model assumptions to be more critically examined in the future. See Hurtado-Ferro et al. (2013) for general simulation study that broadly addresses this issue.

H. Explore models which consider a much longer time-period (e.g., 1931 onwards) to determine whether it is possible to model the entire period and determine whether this leads to a more informative assessment and to provide a broader context for evaluating changes in productivity.

   Response: See *STAR (2011)* 7 response above. The period covered by the current assessment starts in 1993 (rather than in 1981 as in past assessments), given: (1) lack of precise abundance estimates for the years 1981-92, (2) lack of age and length data for the Ensenada fishery (only three years of data), (3) age and length data for southern California were largely collected from an incidental fishery for sardine for much of the early period of the fishery, and (4) growth data for these years is inconsistent with the later growth data (time-varying growth was considered in previous assessment reviews).

I. Modify Stock Synthesis (SS) so that the standard errors of the logarithms of 1+ biomass can be reported. These biomasses are used when computing the Overfishing Level, the Acceptable Biological catch, and the Harvest Level, but the CV used when applying the ABC control rule is currently that associated with spawning biomass and not 1+ biomass.
   Response: This request for technical changes to SS has been received and is to be included in a major version change of the SS model scheduled for release in 2014-15.
J. In relation to the aerial survey: (a) provide the otoliths collected from the point sets to the SWFSC for possible ageing, (b) explore different functional forms for the mean relationship between school density and area (e.g., splines) as well as the variation about the mean curve (e.g., gamma), and (c) consider possible covariates (e.g., average fish size) in the relationship between catch weight and area.
   Response: Presently, there is no information available from laboratory-related research regarding overall abundance estimation associated with the aerial survey.
K. Modify the r4SS package to include a plot of correlations among the residuals for the length data, as well as the fit of the model to the mean length or age in each composition.
   Response: These software changes are forthcoming later this year, i.e., Francis method for weighting data based on correlations between bins (length/age) is to be included, along with the current McAllister and Ianelli method, in the r4SS package used to generate displays associated with the SS modeling framework.
L. Consider a model which explicitly models the sex-structure of the population and the catch.
   Response: The need/justification for a sex-specific assessment model for Pacific sardine has been addressed previously (Hill et al. 2011; STAR 2011), with results from evaluations of length-at-age relations from fishery samples (1993-present) indicating no evidence of sexual dimorphism related to growth. Further, during the 2009 STAR panel, examination of residuals for the age- and length-composition data revealed that growth was apparently not constant over time. Specifically, there was evidence for a shift in growth rates in 1991. To address this in past assessments, growth parameters were modeled in two time blocks: 1981-1990 and 1991-2009 (Hill et al. 2009, 2010). However, it is still unclear whether this change in growth rate was due to density-dependence (compensatory growth) during the early stages of population recovery or some other factor. For example, the early difference in size-at-age could have been due to size-selective schooling, as many of these sardines were sampled from incidental catches (mixed with larger mackerel). Uncertainty around growth and representativeness of early samples was one of several reasons for starting the model in the early 1990s. See *STAR (2011)* 5 response above.
M. Consider a model which has separate fleets for Mexico, California, Oregon-Washington, and Canada.
   Response: Fishery structure in the current models is based on objective evaluations of fishery catches in relation to similarities in fishing processes (selectivity parameterization) and hypothesized fish distributions resulting from hypothesized movement patterns of the stock. Finally, this recommendation was addressed in past assessments/reviews (2007-09), and was a primary reason for combining fisheries as presented here.
N. Develop a relationship between egg production and age which accounts for the duration of spawning, batch fecundity, etc. by age.
   Response: Again, a recommendation previously addressed (assessment/review conducted in 2011), i.e., this laboratory activity was considered a much lower priority research undertaking at this time.

O. Consider model configurations which use age-composition rather than length-composition and conditional age-at-length data given evidence for time- and spatially-varying growth.
   Response: See Biological compositions (D vs. C models) and blended models H vs. G, Table 8. Also, see Model Selection and Evaluation below.
P. Further explore methods to reduce between-reader ageing bias. In particular, consider comparisons among laboratories and assess whether the age-reading protocol can be improved to reduce among-ager variation.
   Response: Some research has been conducted recently addressing spatial variability of age/growth for this species, which has been incorporated in past and this year's assessment (see Hill et al. 2011, Appendix 2). The SWFSC has encouraged further development of the newly established *Small Pelagic Ageing Research Committee* (SPARC) that includes researchers from the USA, Mexico, and Canada.
Q. The reasons for the discrepancy between the observed and expected proportions of old animals in the length and age compositions should be explored further. Possible factors to consider in this investigation include ageing error/ageing bias and the way dome-shaped selectivity has been modeled.
   Response: See *STAR (2011)* 8 response above.
R. Any future management strategy evaluation work to compare control rules should focus on alternatives which are as robust as possible to uncertainty regarding absolute abundance.
   Response: A recently conducted harvest control rule workshop did generally address MSEs associated with Pacific sardine that accounted for uncertainty in abundance (assessment error) and uncertainty in the S-R relationship (Hurtado and Punt 2014). Results from these workshops/paper are to be formally presented early this year to the PFMC (CPSMT 2014).
S. Profiles on key parameters should be included in future draft assessment to facilitate initial review.
   Response: Key parameters profiled in the initial assessment report, as well as the final report here include R_0 (models G/H and T) and M (model T), Figure 42.

SSC (2012a, 2012b) - Responses to research recommendations

A. Consider the spatial-temporal relationship of acoustic and aerial surveys and fishery catches to compare estimates of biomass from stratified areas of the coast between surveys, and to evaluate effect of the timing of fishing on the biomass observed by the surveys in any year. This could take the form of a spatial population model operating on a short time-step (daily or weekly).
   Response: See *SSC (2012a, 2012b)* G, H, J, and K responses below.
B. Consider a Beverton-Holt (B-H) or other S-R relationship in place of the Ricker model to investigate if such a change will stabilize the model relative to the number of recent years of recruitments estimated, while providing a biologically realistic relationship.
   Response: See model scenarios for Stock-recruit (E models), and blended models G and H incorporate a B-H S-R relationship, Table 8.
C. Consider placing a smaller σ_R (as well as bias correction) on the final recruitment estimated to reflect the reduced amount of information available for estimating that recruitment (this will likely require a change in the SS3 platform).
   Response: This treatment of recruitment error is not possible in the current version of SS, and unsure if the recommended change is currently even recognized by the SS development team.

D. Consider the changes within and between years in targeting in considering the proper treatment of fishery selectivities and blocks and proper weighting of these data.
   Response: See blocking/data weighting schemes for Biological compositions (C and D models).
E. Conduct a methodology review on how to compare and best utilize data from the acoustic and aerial surveys in the sardine stock assessment. Among other possible issues, the review should consider if and how to improve their combined use in the assessment and consider incorporating the aerial survey as a minimum estimate (most easily done with a change in SS3, but doable with a prior on q for this survey).
   Response: See *SSC (2012a, 2012b)* A response above, and G, H, J, and K responses below.
F. Consider the proper weighting of both fishery and survey biological data vs. survey time series data. Consider down-weighting biological compositions and emphasizing particular survey time series in future sensitivity analyses, e.g., see Francis (2011).
   Response: See goals of assessment in Preface above and model scenarios for Biological compositions (C and D models), and blended model G, Table 8.
G. The summer ATM survey found that trawls in the northern area had highly mixed species composition.
   Response: During the summer 2012 survey, the nighttime trawls often included, as usual, multiple coastal pelagic species. That is, the night-time ATM trawls are 'random' sets that does not involve targeting a particular species, whereas the aerial survey point-sets explicitly targets sardine schools. Further, the near-surface CPS caught off Oregon and Washington by the ATM survey during late July to early August 2012 included Pacific sardine with 39% mackerels (number proportion). In contrast, near-surface aerially observed CPS schools were attributed almost exclusively to sardine. More of those schools were likely mackerels.
H. Discrepancy between biomass estimate in the northern (WA/OR) portion of the ATM survey area and the fishery landings (as well as the aerial survey estimate).
   Response: Between 07/31/2012 and 08/10/2012, the ATM survey sampled the region encompassed between 44° 47.2'N and 48° 18.0'N and from the 50m to the 1500m depth isobaths. The resulting point estimate of sardine biomass was 13,333 metric tons. The sampling variance was high, resulting in a 95% confidence interval of [3,918, 27,559] metric tons. During the same period, the commercial fishery off Oregon and Washington captured 9,747 mt. Immediately following these operations, the ATM surveyed the area to the north, including northern Washington and Western Vancouver Island. There, the sardine biomass was estimated at 18,675 with a 95% confidence interval of [2661, 54017] metric tons. Admitting that the all the sardine observed off western Vancouver Island migrated from the south, it is likely that by 08/10/2012, 32,008 mt of sardine, with 95% confidence interval of [12,439, 68,945 mt], were available for the Oregon and Washington fisheries. In summary, the ATM survey of the fished regions off Oregon and Washington spanned a couple weeks. In contrast, the surveyed region was fished for multiple months. It is, of course, incorrect to compare quasi-synoptic and time-integrated samples of a migrating population. Finally, the aerial survey point-sets in 2012 covered a small subset of the aerial photo transects and thus, it remains uncertain what portion of the photographed schools outside of that range were indeed sardine. Also, see *SSC (2012a, 2012b)* K response below.
I. Vessel avoidance and the acoustic transducer on the survey vessel missing fish were raised as possible explanations for this discrepancy.

Response: Guided by a validated model of potential sardine habitat, the ATM surveys have consistently spanned the northern sub-population of sardine. During the spring, sardine were found offshore of central and southern California, and roughly 30-70 m deep. During summer, sardine had migrated north to the shallow, coastal regions off Oregon and Washington. ATM surveys conducted during spring and summer of the same year (e.g., 2008, 2012, and 2013) indicate that the estimated biomasses are not statistically different. Therefore, the aforementioned 'possible explanations' for the supposed 'discrepancy' are unsupported.

J. There appear to be discrepancies between survey and fishery data with regard to the timing and location of sardine occurrence. Summer fisheries in the Pacific Northwest encounter sardine in unmixed schools during the day, while the acoustic survey found relatively few sardine north of southern Oregon, typically in mixed assemblages at night. Sardine is sampled by the acoustic survey in offshore areas off California but not in nearshore areas (up to 1 or 2 miles off shore) which account for significant fishery landings. The CPSMT representative supports addressing these discrepancies with concurrent sampling by fishery seasons and geography, as well as by sampling in nearshore areas with vessels suited to that habitat. The timing of surveys relative to fishery prosecution may also affect survey results and this should also be considered.

   Response: See *SSC (2012a, 2012b)* H response above. Although a good suggestion for addressing this issue, no detailed spatial/timing-related evaluations of fishery catches and survey sampling off OR/WA have been conducted to date.

K. The aerial survey used the one complete set of transects (set B) for school number and surface area estimates, while the point sets were taken after completion of the transects, rather than concurrently. More problematically, only 14 acceptable point sets were conducted, and they were not spatially representative of the sardine schools photographed during the transects. Given this lack of spatial coverage of the point sets, and the highly mixed Coastal Pelagic Species found in the ATM trawls in the same area as many of the photographed schools, there are potential species composition problems with the estimates derived from the aerial photographs. However, the composition of photographed schools and ATM trawls are not directly comparable, as the former are taken during the day and the latter at night when CPS are dispersed.

   Response: Agreed. As presented here and illustrated in the overall sensitivity analysis for meeting the main goal of the assessment, the ATM survey is founded on the most objective/defendable field/laboratory protocols for assessing absolute abundance of small pelagic fish stocks in any given year. It is difficult to compare the aerial survey directly with the ATM survey effort, given the less rigorous survey design and biomass estimation methods employed in the latter. That is, aerial survey catchability is likely to be highly variable and difficult to 'control' in survey terms, is space-restricted and non-synoptic, largely reflects a species-specific sampling effort that is highly weather dependent, and finally, likely to be conducted on an intermittent basis vs. conducted on a continual basis and representative of the extended range of this (and other) small pelagic populations. The aerial survey could potentially be used in concert (vs. competing) with the primary ATM survey for purposes of evaluating specific areas of noted uncertainty associated with the acoustic-trawl sampling effort. For example, using aerial-sighted schools to evaluate the ATM's potential 'blind' areas within the upper 10 m of the water column and more coastal areas of the overall survey area that can be more problematic for ATM surveys. If deemed worthwhile, a

rigorous 'dual surveying' approach could be employed to ensure results from the two surveys can be compared straightforwardly.

Changes Between Current and Last Assessment Model

Henceforth, in this final assessment report, information pertains generally to sensitivity analysis, review (STAR), and STAR panel decisions associated with categories/model scenarios presented in Table 8, particularly, model G (one of two blended, 'preferred' model scenarios initially presented at the STAR) and model T (final model from STAR meeting). That is, both the STAT and STAR panel highlighted model G (over blended model H) for beginning further sensitivity analysis at the meeting. Considerable sensitivity analysis was conducted on model G at the meeting to confirm/refute estimates and results from the initial baseline model, as well as further address details of particular data sets/parameterizations/results/diagnostics as identified by the STAR panel during the meeting. Readers should consult both the initial draft assessment report (Hill and Crone 2014) and final review report (STAR 2014) for background information regarding various model scenarios investigated in the initial sensitivity analysis and bases for final choices, assumptions, and parameterizations associated with final base model T. Ultimately, model T represented a nearly similar configuration and outcome as model G, with a few key differences noted below.

Table 8 presents summary statistics for all of the model scenarios associated with the alternative stock structure hypothesis for Pacific sardine based on practical methods for differentiating/partitioning both catch and associated composition time series for the MexCal fishery between southern and northern subpopulations using environmental information, including sea surface temperature time series and regional indices of optimal and good potential habitat (Felix-Uraga et al. 2004, 2005; Smith 2005; Garcia-Morales et al. 2012, and Demer and Zwolinski 2014). Stock structure was considered one of the highest priority categories in the sensitivity analysis conducted in 2014, given the assumptions concerning spatial/temporal ranges of this transboundary population impact final fishery catches and compositions (for MexCal fisheries) used in the assessment. Finally, general consensus from the STAR 2014 was that this species' biology is strongly driven by environmental factors and the use of satellite/oceanographic data to partition landings accordingly was deemed more objective than relying on the current allocation scheme based simply on region (port) where the landing was made.

Differences between model X6e_2013, model G, and model T follow:

- **Model X6e_2013 –** Final model (SS ver. 3.21d) used to conduct most recent projections for formal management (SSC 2012b, Hill et al. 2012, Hill 2013), Figure 21.
  a. assessment is based on a 'fishing' year that spans July 1st-June 30th (July 1st birthdate assumption).
  b. model time period is from 1993-12, with two seasons ('semesters,' S1=Jul-Dec and S2=Jan-Jun) per fishing year (a year/semester model time-step).
  c. sexes are combined.
  d. catch/composition (MexCal) time series derived using the port-based method.

e. two fisheries (MexCal and PacNW), with an annual selectivity pattern for the PacNW fleet, and selectivity patterns by semester for the MexCal fleet (MexCal_S1 and MexCal_S2).
f. length and conditional age-at-length compositions for all fisheries and the ATM and aerial surveys.
g. length-based/dome-shaped selectivity with time-blocking (1993-98, 1999-12) for the MexCal fisheries and length-based/asymptotic selectivity for the PacNW fishery.
h. Ricker stock-recruitment relationship with estimated steepness (σ_R = 0.727, tuned).
i. spawning occurs in S2 and recruitment in S1.
j. virgin (R_0) and initial recruitment offset (R_1) are estimated.
k. recruitment deviations associated with SSB are estimated from 1987-10.
l. initial fishing mortality (F) set to 0 for all fleets (non-equilibrium model using the initial age composition method in SS).
m. hybrid-F estimation method is used.
n. natural mortality (M) = 0.4 yr^{-1} for all ages.
o. DEPM and TEP survey time series reflect measures of spawning biomass and catchability (q) is estimated.
p. aerial survey time series reflect measures of biomass, with length-based/dome-shaped selectivity and q estimated.
q. ATM survey time series reflect measure of biomass for a single combined (spring and summer) survey, with length-based/asymptotic selectivity and q fixed (1.0).
r. data weighting (varied) for all survey abundance and fishery/survey composition time series.

- **Model G** – One of two 'blended' models (G and H) from the initial sensitivity analysis conducted prior to the STAR meeting and collectively, served as meaningful scenarios (configurations) for beginning the review and focused discussion. Essentially, models G and H were parameterized similarly, but included different biological compositions and selectivity assumptions, i.e., model G included length data and employed length-based selectivity as in past assessments and model H incorporated age data/age-based selectivity. Review consensus, both STAT and STAR, deemed model H less desirable/lower quality than model G at this time, given the absence of age data from both Canada and Mexico fisheries (for further informing the PacNW and MexCal fisheries, respectively), and the ATM age compositions represented unweighted estimates, i.e., these concerns were not applicable to model G, given length data were available from other countries and ATM length compositions were weighted accordingly. Presented list of data and parameterizations associated with model G follows the list for model X6e_2013 above.
  a. same as X6e_2013.
  b. model time period is from 1993-13, with two seasons ('semesters,' S1=Jul-Dec and S2=Jan-Jun) per fishing year (a year/semester model time-step).
  c. same as model X6e-2013.
  d. catch/composition (MexCal) time series derived using the environmental-based method (see stock structure category point above).
  e. same as model X6e_2013.
  f. length and conditional age-at-length compositions for all fisheries and the two ATM surveys (spring and summer, see q below); also see p below.

g. length-based/dome-shaped selectivity with time-blocking (1993-98, 1999-13) for the MexCal fisheries and length-based/asymptotic selectivity for the PacNW fishery.
h. Beverton-Holt stock-recruitment relationship with steepness fixed (0.8).
i. same as model X6e_2013.
j. same as model X6e_2013.
k. recruitment deviations associated with SSB are estimated from 1987-12.
l. same as model X6e_2013.
m. same as model X6e_2013.
n. same as model X6e_2013.
o. same as model X6e_2013.
p. aerial survey time series omitted, both index of abundance and length-composition data.
q. ATM survey time series reflect measures of biomass for two split (spring and summer), with length-based/asymptotic selectivity and *q* estimated for both surveys (see f above).
r. data weighting (0.5) for all fishery/survey conditional age-at-length compositions, and no other weighting applied to survey abundance time series or fishery/survey length compositions.

- **Model T** – Final model from sensitivity analysis conducted at the STAR meeting. Model T is similar to model G, except for f, q, and r below. Presented list of data and parameterizations associated with model G follows the lists for model X6_2013 and model G above.
  a. same as X6e_2013 and model G.
  b. same as model G.
  c. same as model X6e_2013 and model G.
  d. same as model G.
  e. same as model X6e_2013 and model G.
  f. length and conditional age-at-length compositions for all fisheries, and length compositions but no conditional age-at-length compositions for spring and summer ATM surveys.
  g. same as model G.
  h. same as model G.
  i. same as model X6e_2013 and model G.
  j. same as model X6e_2013 and model G.
  k. same as model G.
  l. same as model X6e_2013 and model G.
  m. same as model X6e_2013 and model G.
  n. same as model X6e_2013 and model G.
  o. same as model X6e_2013 and model G.
  p. same as model G.
  q. ATM survey time series reflect measures of biomass for two split (spring and summer) surveys, with *q* fixed (1.0) for both surveys.
  r. data weighting (0.2) for all fishery conditional age-at-length compositions, and no other weighting applied to survey abundance time series or fishery/survey length compositions.

Model Description

Assessment program with last revision date

The STAT transitioned from Stock Synthesis (SS) version 3.21d to version 3.24s (compiled 12/16/2013; Methot 2013, Methot and Wetzel 2013) for conducting the stock assessment in 2014. The SS model is founded on the AD Model Builder software environment, which serves as a suite of C++ libraries of automatic differentiation code for nonlinear statistical optimization (Otter Research 2001). The modeling framework allows for the full integration of both population size and age structure, with explicit parameterization both spatially and temporally. The model incorporates all relevant sources of variability and estimates goodness of fit in terms of the original data, allowing for final estimates of precision that accurately reflect uncertainty associated with the sources of data used as input in the overall modeling effort.

The SS model comprises three sub-models: (1) a population dynamics sub-model, where abundance, mortality, and growth patterns are incorporated to create a synthetic representation of the true population; (2) an observation sub-model that defines various processes and filters to derive expected values for different types of data; and (3) a statistical sub-model that quantifies the difference between observed data and their expected values and implements algorithms to search for the set of parameters that maximizes goodness of fit (Methot 2013; Methot and Wetzel 2013). This modeling platform is also very flexible in terms of estimation of management quantities typically involved in forecast analysis. Finally, from an international context, the SS model is rapidly gaining popularity, with SS-based stock assessments being conducted on numerous marine species throughout the world.

Definitions of fleets and areas

Data from major fishing regions are aggregated to represent southern and northern fleets (fisheries). The southern 'MexCal' fleet includes data from three major fishing areas at the southern end of the stock's distribution: northern Baja California (Ensenada, Mexico), southern California (Los Angeles to Santa Barbara), and central California (Monterey Bay). Fishing can occur throughout the year in the southern region. However, availability-at-size/age changes due to migration. Selectivity for the southern 'MexCal' fleet was therefore modeled separately for seasons 1 and 2 (semesters, S1 and S2).

The 'PacNW' fleet (fishery) includes data from the northern range of the stock's distribution, where sardines are typically abundant between late spring and early fall. The PacNW fleet includes aggregate data from Oregon, Washington, and Vancouver Island (British Columbia, Canada). The majority of fishing in the northern region typically occurs between July and October (S1).

Likelihood components and model parameters

A complete list of model parameters for base model T is provided in Table 9. The total objective function for the base model T included likelihood component contributions from: 1) fits to catch time series; 2) fits to the DEPM, TEP, and ATM survey abundance indices; 3) fits to length compositions from the three fleets and ATM surveys; 4) fits to conditional age-at-length data from the three fleets; 5) deviations about the spawner-recruit relationship; and 6) minor

contributions from soft-bound penalties associated with particular estimated parameters (Table 10).

Selectivity assumptions

Length data from the MexCal and PacNW fisheries were fit using length-based selectivity. The MexCal compositions were based on domed-shaped selectivity (using a 'double-normal' function), given the assumption that not all larger sardines were available to the Baja California and California fisheries from 1993 onward. At that stage in the population's recovery, large spawning events were observed off central California (Lo et al. 1996), and sardines were captured in trawls 300 nm off the California coast (Macewicz and Abramenkoff 1993). Selectivity for the MexCal fleet was estimated by season and in two time blocks (1993-1998, 1999-2011) to better account for both seasonal- and decadal-scale shifts in sardine availability to the southern region. The PacNW fishery length compositions were fit using asymptotic selectivity. Large sardines are typically found in the northern region, and it is assumed the largest sardines typically migrate to northern feeding habitats in the summer. The 2007 STAR recommended fitting PacNW length compositions based on two time blocks (breakpoint at 2003/2004) to better fit a decrease in sizes observed following the large 2003 recruitment event. While the additional time block had resulted in a slightly better fit to the PacNW length compositions (Hill et al. 2007), the time blocking was removed in recent and this year's assessment, given no theoretical basis for its application. Finally, in this context, further sensitivity analysis surrounding time-blocking was conducted prior to and at the review meeting in 2014, but again was not considered a meaningful parameterization, largely given the extent to which data weighting investigations were identified as the more meaningful evaluations to address potential selectivity misspecification and compromised fits to the composition data.

Stock-recruitment constraints and components

Pacific sardines are believed to have a broad spawning season, beginning in January off northern Baja California and ending by July off the Pacific Northwest. The SWFSC's annual egg production surveys are timed to capture (as efficiently as possible) the peak of spawning activity off the central and southern California coast during April. In our semester-based model, we calculated SSB at the beginning of S2. Recruitment was specified to occur in S1 of the following model year (consistent with the July-1 birth date assumption). In past assessments, a Ricker stock-recruitment (S-R) relationship has been assumed following Jacobson and MacCall (1995), however, following recommendations from past reviews, a Beverton-Holt S-R was investigated in the current assessment. Sensitivity analysis that addressed plausible values for steepness (0.5-0.9 for clupeids, see Myers et al. 1999) produced robust results that were generally similar to model configurations that were based on a Ricker S-R form.

In base model T, virgin recruitment (R_0) and initial recruitment offset (R_1) were estimated and steepness was fixed (0.8). Assumptions concerning recruitment variability (σ_R) to apply in S-R estimation was adjusted from 0.73 to 0.75 for strictly rounding purposes, given largely subjective basis for modeling underlying recruitment uncertainty in S-R calculations, i.e., Pacific sardine recruitment is highly variable in any given year and likely highly correlated with prevailing oceanographic conditions (e.g., large-scale environmental indices, such as the PDO, Zwolinski and Demer 2014). Recruitment deviations were estimated as separate vectors for the early and main data periods in the overall model. Early recruitment deviations for the initial population

were estimated from 1987 (6 years before the start of the model). A recruitment bias adjustment ramp (Methot and Taylor 2011) was applied to the early period (Figure 37d). Main period recruitment deviations were estimated from 1993-12, which means that the 2013 year class was freely estimated from the data.

It is important to note that there exists little to no data in the assessment to directly evaluate recent recruitment strength (e.g., absolute numbers of age-0, 6-9 cm fish), with the exception of length data from the southern fisheries (MexCal), which in past years, have caught these juveniles sporadically during their first semester of life (S1). Age-0 fish are not encountered by the ATM survey, with reliable identification of age-1 fish typically only during strong recruitment years. Implied age-selectivities (product of length selectivity and the age-length key) from the fisheries and surveys are displayed in Figures 26b and 30b, respectively. In the ATM spring survey, fish are 50% selected by age 2. Fish caught in the MexCal_S2 fishery (1999-2013 block) are ~70% selected by age 0 (approaching their first birthday) and fully selected by age 1 (approaching their second birthday). In the MexCal_S1 fishery (same time block), fish are fully selected by age 2.

Further evaluations of influential environmental measures and as importantly, robust approaches for using this information in the ongoing assessment model are critical to meeting the primary goal of the assessment and provide reliable estimates of absolute abundance on an annual basis. See STAR (2014) and Research and Data Needs below.

Selection of first modeled year and treatment of initial population

The initial population was calculated by estimating early recruitment deviations from 1987-1992, six years prior to the model start year. Initial *F* values were fixed to zero, following recommendations from past assessments/reviews (see STAR 2011). The 'early years' recruitment deviations are applied to the initial equilibrium age frequency to adjust this composition before the time series start, whereby the model applies the initial *F* level to an equilibrium age composition to get a preliminary numbers-at-age time series, then applies the recruitment deviations for the specified number of younger ages in this initial vector. If the number of estimated ages in the initial age composition is less than the total number of age groups assumed in the model (as is the case with Pacific sardine assessment), then the older ages will retain their equilibrium levels. Because the older ages in the initial age composition will have progressively less information from which to estimate their true deviation, the start of the bias adjustment was set accordingly (see Methot 2013; Methot and Wetzel 2013).

Convergence criteria

The iterative process for determining numerical solutions in the model was continued until the difference between successive likelihood estimates was <0.0001. Final gradient for the base model was 8.77*e*-6.

Critical assumptions and consequences of assumption failures

In this assessment, there exists considerable uncertainty surrounding absolute levels of recruitment (age-0, as well as age-1 fish) in the most recent years of the estimated time series of numbers-at-age, which can comprise a substantial portion of the total biomass of short-lived, small pelagic species such as Pacific sardine in some years (Figure 47-48 and see Stock-recruitment constraints and components above). Further, it is important to note that the most

recent samples from both fisheries and surveys indicate recruitment remains at depressed levels and thus, extended periods of weak compensation exhibited by the population in recent years, which is expected to produce a plateaued or decreasing total stock biomass in the immediate future. Additionally, a major change regarding stock structure assumptions and related partitioning of catches/compositions between hypothesized southern and northern sub-populations was made in this year's assessment, which resulted in considerable amounts of both catch and composition data being omitted from MexCal fisheries for particular seasons (see Changes Between Current and Last Assessment Model above). A third area of uncertainty in this ongoing assessment regards catchability (q) assumptions for the primary (ATM) survey abundance indices in the model, which are currently fixed at 1.0 for the two, seasonally (spring and summer) split ATM surveys. Sensitivity analysis that addressed a parallel model scenario to base model T (as well as for model G) with estimated *q's* for the ATM surveys (0.6 and 0.82 for spring and summer surveys, respectively) produced generally similar findings in terms of derived management quantities of interest as the fixed *q's* configuration (1.0 for both surveys). However, as expected, such assumptions/constraints concerning the survey's underlying probability of detection (q=1.0) indicated more notable potential conflicts between the data sources (survey abundance vs. composition data) about absolute abundance and thus, this critical assumption would benefit from continued evaluation in ongoing assessment development for this species (e.g., see diagnostic display Figure 42). Finally, considerable time at the meeting was devoted to data weighting approaches applied to composition data for purposes of de-emphasizing these time series in the overall model (relative to the emphasis on the survey abundance time series), given notable sensitivity of the results, particularly to the conditional age-at-length composition data (see Preface, STAR 2014, and Francis 2011). In this context, only limited time was available for evaluating alternative approaches for fitting composition data without compromising fits to the abundance indices, e.g., model scenarios that included time-varying assumptions for particular fishery and/or survey compositions were considered less desirable, primarily given little information for objective determination of appropriate blocking schemes to employ.

Model Selection and Evaluation

In preparation for the review meeting, model scenarios were developed systematically, based on four broad categories highlighted and emphasized in past reviews as areas of uncertainty (choices/assumptions for data/parameterizations) that warranted further attention: stock structure, surveys, biological compositions, and stock-recruit relations (Table 8 and STAR (2011) and SSC (2012a, 2012b) Recommendations and Responses). Data and parameterizations associated with the final base model T were based on discussions/sensitivity analysis during the meeting regarding the four primary categories above (see STAR 2014). In this context, model selection (justification/decisions) concerning important choices, assumptions, parameterizations incorporated in model T are presented in various areas in this assessment report. Critical areas of sensitivity analysis and subsequent model selection pertaining to this assessment involved: 1) stock structure (catch/composition estimation using environment-based vs. port-based information), see Changes Between Current and Last Assessment Model; 2) survey indices of abundance (see Fishery-independent Data and Critical assumptions and consequences of assumption failures); 3) stock-recruitment relationships (Beverton-Holt vs. Ricker), see Stock-recruitment constraints and components; and biological-composition data (fitting composition

data without compromising fits to abundance indices), see Selectivity assumptions. Finally, although substantial baseline progress has been made regarding these four categories/considerations in the current assessment model, additional research is needed to improve understanding and reduce uncertainty surrounding each parameterization (see Research and Data Needs).

It is important to note that the STAT/STAR panel agreed that the age data/age-based selectivity model scenario (model H, Hill and Crone 2014) represents a promising, straightforward configuration for meeting the primary goal of the assessment (current estimate of absolute biomass determined annually), given the model scenario would include the most meaningful data that are available from sampling in-the-field to laboratory activities to accommodating/treating in the integrated age-structured SS model for assessing the status of this species. In this context, see the review report (STAR 2014) and *Research and Data Needs* for priority areas to consider in the future and the critical need for continued support of the newly established *Small Pelagic Ageing Research Cooperative* (SPARC) between NOAA, CDFW, ODFW, WDFW, Canada, and Mexico.

Base Model Results

Parameter estimates and errors
Base model T parameter estimates and standard errors (SE) are presented in Table 9.

Growth and fits to conditional age-at-length data
Modeled length-at-age is displayed in Figure 22. Length at age 0.5 was estimated to be 11.8 cm SL, L_∞ was 23.5 cm, and the growth coefficient K was 0.386. Standard deviations for growth parameters are provided in Table 9. Fits to conditional age-at-length data are shown in Figures 23-25. Most conditional age-at-length compositions fit reasonably well, with the exceptions of MexCal_S1 in 2001-2003 (Figure 23) and PacNW in 2008-2010 (Figure 25).

Selectivity estimates and fits to fishery length-composition data
Length selectivity estimates for each fleet and time period are displayed in Figure 26a. Implied age selectivities (product of length selectivity and the age-length key) for each fleet and period are shown in Figure 26b. The MexCal fleets (S1 and S2) captured progressively smaller fish between the early and latter time blocks (Figure 26a).

Model fits to fleet length frequencies, implied age-frequencies, Pearson residuals, and observed and effective samples sizes are displayed in Figures 27-29. Results are grouped by fleet so the reader can examine fits to length compositions, bubble plots of Pearson residuals, and corresponding fits to implied age compositions on opposing pages. Results indicate random residual patterns for most data and fleets. The MexCal_S1 and S2 fleet length data were poorly fit in 2012 and 2013, when larger sardine were taken by the fishery (Figures 27-28). The PacNW fleet displayed notable residuals patterns for strong year classes (1997, 1998, and 2003) moving through the fishery (Figure 29).

Selectivity estimates and fits to survey length-composition data
Length selectivity estimates for surveys are displayed in Figure 30a and implied age selectivities for each survey are shown in Figure 30b. Selectivities for the ATM spring and summer surveys are notably different, with the spring survey selecting for smaller, younger sardine than in summer (Figure 30). We presume this difference is due to spatial differentiation of the migrating stock distribution the spring (off California) and summer (primarily PacNW) seasons.

Model fits to ATM survey length compositions, Pearson residuals, and observed and effective samples sizes are displayed in Figures 31-32. Fits to the ATM survey length data are less than optimal, with notable misfits to the spring 2010 composition (Figure 31).

Fits to survey indices of abundance
Model fits to the DEPM, TEP, and ATM spring and summer survey time series are displayed in both arithmetic and log scale in Figures 33-36. Model fits to the ATM surveys were reasonable (near mean estimates and within error bounds, Figures 33-34), with the exception of the estimate for the initial survey year 2005 (spring 2006 survey), which was notably under-estimated based on this (and all other) modeling scenarios (Figure 33). Fits to the spring ATM survey also displays a trend in the residuals (over-fitting in 2010-2013) that was not evident in results for pre-STAR model G (Hill and Crone 2014).

Fits to the DEPM and TEP surveys are displayed in Figures 35-36. Both time series are poorly fit compared to the ATM time series, however, the fit to the DEPM survey is slightly better than the fitted TEP time series. Catchability coefficient (q) for the DEPM series of female SSB was estimated to be 0.16, and the TEP series was best fit with q=0.55.

Population numbers- and biomass-at-age
Model T estimates of summary biomass (age 0+, age 1+, and SSB) and number-at-age are provided in Table 11a. Corresponding estimates of population biomass-at-age are shown in Table 11b.

Stock-recruitment relationship
Recruitment was modeled using the Beverton-Holt stock-recruitment relationship (σ_R=0.75). Steepness estimates for preliminary model runs typically bounded high (h=1), so steepness was fixed at 0.8 – a value considered reasonable for clupeid stocks (see Myers et al. 1999). The Beverton-Holt stock-recruitment relationship for base model T is displayed in Figure 37a. Recruitment deviations for the main era were estimated from SSB years 1993 to 2012 (2013 Year Class) (Figure 37b). Asymptotic standard errors for recruitment deviations are displayed in Figure 37c and the S-R bias adjustment ramp (Methot and Taylor 2011) is shown in Figure 37d.

Spawning stock biomass
Base model estimates (with 95% confidence intervals) of total SSB are provided in Table 12 and Figure 38a. The estimate of virgin SSB was 0.78 mmt. SSB increased throughout the 1990s, peaking at 1.01 million metric tons (mmt) in 1999 and 1.12 mmt in 2007 (Table 12, Figure 38a).

Recruitment
Estimated time series of recruit (age-0) abundance is provided in Table 12 and Figures 38b and 40. Virgin recruitment (R_0) for base model T was estimated to be 4.828 billion age-0 fish. Recruitments (year-class abundance) peaked at 13.5 billion fish in 1997, 20.9 billion in 2003, 16.2 billion in 2005, and 8.1 billion in 2009. The 2010 to 2012 year classes were among the weakest in recent history. The 2013 year class, derived primarily from the B-H predicted curve, was poorly estimated (CV=0.73; Table 12, Figures 38b and 40), but is included in calculation of the age 1+ biomass for July 2014.

Stock biomass for PFMC management
Stock biomass, used for setting management specifications, is defined as the sum of the biomass for ages 1 and older. Model estimates of stock biomass are provided in Table 11a and displayed in Figures 39 and 49. Stock biomass increased throughout the 1990s, peaking at 1.27 mmt in 1999 and 1.42 mmt in 2007. Stock biomass is projected to be 369,506 mt as of July 2014, but may be biased high given uncertainty in the strength of the 2013 year class and recent recruitment trends (Figure 38b). The 2013 year-class estimate factors into calculation of the age 1+ biomass for July 2014, but is based largely on the predicted stock-recruitment curve. One alternative approach would be to base age-1 biomass for 2014 on an average of the most recent few years (e.g. 2011-2013; see Table 11b and Figure 48) and to add this value to the age 2+ biomass for purpose of setting management specifications in 2014-15 (Figure 49).

Harvest and exploitation rates
Harvest rates (catch per selected biomass, continuous-F) by fleet are displayed in Figure 41a. Instantaneous F estimates were all within a plausible range of values and less than 0.7 in most seasons.

Exploitation rate is defined as the calendar year catch divided by the total mid-year biomass (July-1, ages 0+). U.S. and total exploitation rates for the NSP are shown in Figure 41b. Exploitation rate for the U.S. fishery peaked at 14.4% in 2012 and total exploitation peaked at 18.4% that same year (Figure 41b).

Uncertainty and Sensitivity Analysis

Likelihood profile for virgin recruitment
Likelihood profiles for virgin recruitment (R_0) can provide insight as to which data components are influencing scale in a stock assessment model. Pre-STAR model G and base model T were profiled for ln(R_0) values ranging from 14.8 to 16.4 (Figure 42). In the case of model G, the total likelihood surface was smooth and had a global minimum at R_0=15.489. All survey data fit best at moderate and higher R_0 values. Model G fleet length compositions fit best at low values of R_0, with PacNW lengths have the most influence on scale. ATM lengths fit best at higher values of R_0. Most conditional age-at-length data, in particular, the PacNW fleet, but also the MexCal_S2 fleet fit better at high values of R_0. So, while the total likelihood surface was smooth, there was conflict among the various data components within the model, in particular, the length compositions versus conditional age-at-length data for the PacNW fleet.

The R_0 profile for base model T, where ATM *q*s are fixed at 1, displays an uneven surface, with a global minimum at R_0=15.3 and a local minimum at R_0=15.7 (Figure 42). The R_0 estimate for base model T was 15.389, which is within the saddle of the global minimum, but slightly higher than the overall minimum (15.3). Likelihood profiles for the individual model components are likewise uneven and, in some cases, displaying different patterns than from pre-STAR model G (Figure 42). So while assuming a fixed *q*=1 may ultimately provide more stability in scaling, the model may yet change unpredictably when additional data are included due to this inherent tension in the model.

Likelihood profile for natural mortality

Natural mortality (*M*) was profiled for base model T (*M*=0.4) using values ranging from 0.24 yr^{-1} to 0.56 yr^{-1} in 0.02 yr^{-1} increments. Likelihood profiles for key model components (surveys, lengths, ages, and total) are displayed in Figure 43. As noted above, the likelihood surface for model T was uneven due to fixing of catchability parameters for the ATM time series. The likelihood profile for M displayed similar characteristics and are thus somewhat difficult to interpret for some individual components. The total likelihood was best fit for *M*=0.36, with a local minimum at *M*=0.46. ATM Spring had minima at 0.34-0.38 and 0.42-0.44. Most length composition data fit better at lower values of *M*, but PacNW lengths fit better at *M*=0.42-0.44. Conditional age-at-length data tended to fit best at higher *M* values.

Sensitivity to data weighting

For the most part, the review meeting focused primarily on sensitivity analysis pertaining to appropriate data weighting methods for meeting the assessment goal. In particular, conditional age-at-length compositions were identified as problematic in the present assessment model configuration, given the extent to which these data inform not only growth estimation, but also produce conflicts with selectivity parameterizations associated with both fisheries and the ATM surveys. Final base model T includes de-emphasized conditional age-at-length compositions for all fisheries and omits such information from the ATM survey that had been used in past assessment. However, continued examinations are needed of model fits to composition data based on both data weighting schemes, as well as time-vary assumptions for particular fisheries (e.g., PacNW), see Research and Data Needs.

Retrospective analysis

Retrospective analysis can provide another means of examining model properties and characterizing uncertainty. A retrospective analysis of base model T was performed, where data were incrementally removed from the end year back to 2008 (STAR 2014). Stock biomass estimates for these analyses are displayed in Figure 44. The model displayed some systematic pattern of under-estimation for recent years, with the greatest change in scale occurring for the model ending in 2012 (Figure 44).

Historical analysis

Model T estimates of stock biomass and recruitment are compared to recent assessments in Figures 45-46. Full and updated SS models since 2009 (Hill et al. 2009-2013) were included in the comparison. Biomass and recruitments are similar in trend across models, with some differences in scale for peak and low periods (Figures 45-46).

HARVEST CONTROL RULES FOR THE 2014-15 MANAGEMENT CYCLE

Harvest guideline

Based on results from final base model T, the preliminary harvest guideline (HG) for the U.S. fishery in management year 2014-15 is 28,646 mt (Table 13). The HG is calculated as follows:

$$HG = (BIOMASS - CUTOFF) \bullet FRACTION \bullet DISTRIBUTION,$$

where HG is the total U.S. quota for the period July 2014 to June 2015, BIOMASS (369,506 mt) is the stock biomass (ages 1+) projected as of July 1, 2014, CUTOFF (150,000 mt) is the lowest level of biomass for which harvest is allowed, FRACTION (15%) is the percentage of biomass above the CUTOFF that can be harvested, and DISTRIBUTION (87%) is the average portion of BIOMASS assumed in U.S. waters. The HG values and catches since 2000 are displayed in Figure 1. The recommended HG will be the lowest since the onset of federal management. The 28,646 mt HG will be divided into seasonal and related allocations during the April 2014 PFMC meeting.

OFL and ABC

Until now, Pacific sardine OFL and ABC calculations have been based on a temperature-independent E_{MSY} average value of 0.18. On March 11, 2014, the PFMC adopted the use of CalCOFI SST data for specifying environmentally-dependent E_{MSY} each year, beginning July 2014. Based on this recent decision, the table of OFL and ABCs is based on an E_{MSY} = 0.122, which corresponds to the three-year running average of CalCOFI SST for 2011-13 (15.335 °C) (Table 13). The OFL for 2014-15 is calculated to be 39,210 mt.

RESEARCH AND DATA NEEDS

The following list presents three related areas for addressing a critical understanding of spawner-recruit relations and estimation, both spatially and temporally, for this species of the CCE. Unarguably, uncertainty surrounding underlying Pacific sardine stock-recruitment (S-R) variability/scale, estimation, and model parameterization is the most important area for future research efforts. Figure 47-48 illustrates the contribution and variability of recruitment to the total biomass in any given year. Consequently, further evaluation and/or new research focus should be directed toward the following areas of research to address the primary goal of the assessment, to provide accurate measures of total population biomass and related derived management quantities useful to fishery management following a short-term schedule. The following list represents a synthesis of important areas of future research previously noted in the report, and highlights critical collaborative work needed in the field, laboratory, and analysis/modeling. Finally, the STAR (2014) provides further details on each of the needs listed here (see Technical Merits and/or Deficiencies of the Assessment). Collectively, both lists present the most important areas of research to focus on, both immediately and long-term, to most efficiently address the management goal.

Stock-Recruitment: Dynamics, Data, Assumptions/Estimation/Modeling

Field

Relative to the other marine resource surveys available to the assessment, the ATM survey produces the most objective (say scientifically accurate and representative) information for determining absolute abundance of this population on a systematic basis. Minimally, a synoptic survey needs to be continually supported and conducted at least seasonally and ideally, in both the spring and summer, given recruitment variability and uncertainty as noted above. The long-term CalCOFI surveys collect valuable information, in terms of providing: a longer-term index of abundance in the current model; and egg/larval abundance and distribution data for informing/complementing and corroborating/refuting findings from the primary ATM surveys relied on in this assessment (see STAR 2014 for further discussion and related research details applicable to the ATM and DEPM surveys).

Laboratory

Age and growth studies and continued production ageing efforts in the laboratory are critical to a better understanding of stock structure and distribution of hypothesized sub-populations and ultimately, total catch determination for the northern sub-population used in management. Foremost, the newly established *Small Pelagic Ageing Research Cooperative* (SPARC) between NOAA, CDFW, ODFW, WDFW, Canada, and Mexico is considered a high priority undertaking, given: 1) the utility of age data/compositions to the ongoing assessment development for this and other members of the small pelagic fish assemblage and the importance of standardized protocols for ageing fish across the various countries/laboratories; and 2) a recognized international working group such as this can arrange/conduct needed projects in the most efficient manner. For example, validation studies that address the critical stock structure assumption based on environmental indices for partitioning catches/compositions adopted in this assessment should be conducted to confirm/refute this method for separating the northern and southern subpopulations using the habitat-related model. This will entail collection of morphometric, otolith morphology/micro-chemistry, and genetic data from fish in the mixing/transition areas between the two subpopulations and subsequently, can be evaluated using straightforward statistical methods to identify/verify potential differences based on empirical evidence from actual samples of fish collected systematically in the field.

Analysis

The following areas represent additional (sensitivity) analysis that would benefit the ongoing assessment, including:

1) Continued evaluations of the most plausible/robust assumption for modeling spawner-recruit dynamics in the stock assessment model. For example, Beverton-Holt vs. Ricker form, steepness considerations, potential environmental data/indices for informing recent recruit estimation, and accommodation of environmental information in the model (internally, based on potential oceanographic covariates within the S-R parameterization itself or externally, based on an environmental index (e.g., PDO) derived outside the model and treated as a ‘survey’ index of fully-selected age-0 fish in the model). The STAR (2014) presents specific analysis-related considerations to further pursue regarding estimation of both age-0 and age-1 recruitment in the most recent year of the assessment model.

2) Further examinations are needed regarding reliability/robustness of catchability (*q*) assumptions associated with the primary ATM survey indices, including: fixed vs. estimated approaches; split surveys according to season-based cruises or combined into a single annual-based index; and using informative priors in *q* estimation/parameterization.
3) Model fits to biological-composition time series, particularly the conditional age-at-length data, are variable, indicate various residual patterns, and can be sensitive to relatively minor changes (e.g., inclusion/omission of particular fishery/survey compositions). In this assessment/review, substantial sensitivity analysis was conducted based on various weighting methods. To date, data weighting schemes investigated included the McAllister and Ianelli method as part of the internal SS model modeling framework, as well as both ad hoc weighting approaches and using Francis (2011) methods that include correlation variability inherent in composition data, but often ignored for practical purposes in calculations of effective sample sizes. However, further sensitivity analysis is needed to better understand the extent to which fitting composition data using time-varying selectivity assumptions/parameterizations and/or data weighting approaches provides the most robust estimates of total biomass that are needed to meet the goal of the assessment.

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TABLES

Table 1. U.S. Pacific sardine harvest guidelines (HG) and landings since the onset of federal management.

Year	U.S. HG	U.S. Landings
2000	186,791	72,496
2001	134,737	78,520
2002	118,442	101,367
2003	110,908	74,599
2004	122,747	92,613
2005	136,179	90,130
2006	118,937	90,776
2007	152,564	127,695
2008	89,093	87,175
2009	66,932	67,083
2010	72,039	66,891
2011	50,526	46,745
2012	109,409	101,103
2013	66,495	61,646

Table 2. Pacific sardine landings (mt) for major fishing regions off northern Baja California (Ensenada, Mexico), the United States, and British Columbia (Canada). ENS and SCA landings are presented as totals and northern subpopulation (NSP) portions.

Calendar Yr-Sem	Model Yr-Seas	ENS Total	ENS NSP	SCA Total	SCA NSP	CCA	OR	WA	BC
1993-2	1993-1	13,396.8	0.0	3,728.8	487.6	335.2	0.0	0.0	0.0
1994-1	1993-2	5,711.6	2,994.5	7,738.5	7,722.5	628.8	0.0	0.0	0.0
1994-2	1994-1	15,165.4	6,079.3	2,607.4	1,029.2	1,730.2	0.0	0.0	0.0
1995-1	1994-2	18,227.3	11,183.6	28,122.2	28,122.2	442.7	0.0	0.0	0.0
1995-2	1995-1	17,168.9	0.0	8,439.2	1,508.1	4,485.2	0.0	0.0	22.7
1996-1	1995-2	15,665.9	11,643.9	14,409.4	12,435.9	2,485.9	0.0	0.0	0.0
1996-2	1996-1	23,398.8	4,394.2	10,761.5	1,123.9	6,399.2	0.0	0.0	0.0
1997-1	1996-2	13,498.4	8,911.1	11,523.5	9,905.0	342.6	0.0	0.0	43.5
1997-2	1997-1	54,940.6	0.0	21,313.3	0.0	13,018.2	0.0	0.0	27.2
1998-1	1997-2	20,238.8	4,980.8	19,094.1	16,800.1	2,746.7	0.8	0.0	0.0
1998-2	1998-1	27,573.4	3,792.0	12,880.5	8,799.1	6,334.0	0.2	0.0	488.1
1999-1	1998-2	34,759.8	31,656.8	24,049.9	23,880.8	7,740.8	50.1	0.0	24.3
1999-2	1999-1	23,809.6	6,203.7	18,813.1	2,649.3	6,143.2	725.0	0.0	0.2
2000-1	1999-2	33,933.4	23,716.6	34,119.2	33,339.8	1,285.0	205.0	62.2	162.4
2000-2	2000-1	33,911.9	5,526.6	12,715.5	8,084.4	10,082.4	9,324.0	4,703.2	1,559.0
2001-1	2000-2	16,544.9	9,937.5	29,343.4	24,467.3	774.4	2,288.0	48.5	0.4
2001-2	2001-1	29,526.4	3,609.5	18,318.3	1,474.0	6,467.0	10,492.0	10,788.5	1,265.5
2002-1	2001-2	17,421.7	13,552.0	26,620.6	25,991.6	1,574.8	2,724.0	412.3	0.5
2002-2	2002-1	29,423.6	0.0	22,745.3	4,059.7	12,503.0	19,987.0	14,799.8	738.9
2003-1	2002-2	15,514.3	12,405.4	20,379.6	18,639.6	5,085.7	503.0	93.9	0.4
2003-2	2003-1	25,827.5	6,081.9	9,909.5	1,896.1	2,362.6	24,755.0	11,510.0	977.3
2004-1	2003-2	11,212.9	3,922.9	15,232.0	15,232.0	2,145.7	2,203.5	235.3	179.6
2004-2	2004-1	30,684.0	2,373.9	17,161.5	1,512.5	13,162.6	33,908.3	8,564.1	4,258.4
2005-1	2004-2	17,323.0	11,186.6	15,419.0	13,948.1	115.3	691.9	324.0	0.4
2005-2	2005-1	37,999.5	4,396.7	14,833.6	1,508.6	7,824.9	44,316.2	6,605.0	3,231.4
2006-1	2005-2	17,600.9	11,214.6	17,157.7	16,504.9	2,032.6	101.7	0.0	0.0
2006-2	2006-1	39,636.0	0.0	16,128.2	4,909.8	15,710.5	35,546.5	4,099.0	1,575.4
2007-1	2006-2	13,981.4	13,320.0	26,343.6	19,900.7	6,013.3	0.0	0.0	0.0
2007-2	2007-1	22,865.5	11,928.2	19,855.0	5,350.3	28,768.8	42,052.3	4,662.5	1,522.3
2008-1	2007-2	23,487.8	15,618.2	24,127.2	24,114.3	2,515.3	0.0	0.0	0.0
2008-2	2008-1	43,378.3	5,930.0	6,962.1	21.8	24,195.7	22,939.9	6,435.2	10,425.0
2009-1	2008-2	25,783.2	20,244.4	9,250.8	9,221.3	11,079.9	0.0	0.0	0.0
2009-2	2009-1	30,128.0	0.0	3,310.3	29.8	13,935.1	21,481.6	8,025.2	15,334.3
2010-1	2009-2	12,989.1	7,904.2	19,427.7	19,427.7	2,908.8	437.1	510.9	421.7
2010-2	2010-1	43,831.8	9,171.2	9,924.7	562.7	1,397.1	20,414.9	11,869.6	21,801.3
2011-1	2010-2	18,513.8	11,588.5	12,526.4	12,515.4	2,713.3	0.1	0.0	0.0
2011-2	2011-1	51,822.6	17,329.6	5,115.4	11.9	7,358.4	11,023.3	8,008.4	20,718.8
2012-1	2011-2	10,235.0	6,823.3	11,906.2	10,018.8	3,672.7	2,873.9	2,931.7	0.0
2012-2	2012-1	39,575.0	0.0	6,896.1	883.6	568.7	39,744.1	32,509.6	19,172.0
2013-1	2012-2	9,780.0	6,520.0	2,636.0	769.7	84.2	149.3	1,421.4	0.0
2013-2	2013-1	40,509.0	0.0	3,654.8	0.0	739.0	27,535.9	25,425.2	0.0

Table 3. Pacific sardine length and age samples available for major fishing regions off northern Baja California (Mexico), the United States, and Canada.

Calendar Yr-Sem	Model Yr-Seas	ENS Length	ENS Age	SCA Length	SCA Age	CCA Length	CCA Age	OR Length	OR Age	WA Length	WA Age	BC Length	BC Age
1993-2	1993-1	83	0	22	15	0	0	0	0	0	0	0	0
1994-1	1993-2	33	0	105	31	0	0	0	0	0	0	0	0
1994-2	1994-1	37	0	26	26	0	0	0	0	0	0	0	0
1995-1	1994-2	38	0	278	121	0	0	0	0	0	0	0	0
1995-2	1995-1	51	0	59	35	0	0	0	0	0	0	0	0
1996-1	1995-2	27	0	61	60	11	11	0	0	0	0	0	0
1996-2	1996-1	43	0	34	33	88	87	0	0	0	0	0	0
1997-1	1996-2	21	0	59	58	2	2	0	0	0	0	0	0
1997-2	1997-1	50	0	54	53	55	55	0	0	0	0	0	0
1998-1	1997-2	18	0	60	59	5	5	0	0	0	0	0	0
1998-2	1998-1	41	0	54	53	52	51	0	0	0	0	0	0
1999-1	1998-2	58	0	61	61	14	14	1	1	0	0	0	0
1999-2	1999-1	41	0	49	49	0	0	3	3	0	0	3	0
2000-1	1999-2	46	0	58	58	0	0	4	4	0	0	0	0
2000-2	2000-1	51	0	56	56	0	0	32	31	36	35	29	0
2001-1	2000-2	46	0	68	68	4	4	7	7	4	4	6	0
2001-2	2001-1	29	0	67	67	28	28	28	28	54	54	12	0
2002-1	2001-2	37	0	65	65	13	12	10	10	17	9	3	0
2002-2	2002-1	36	0	70	10	35	30	50	47	125	64	93	0
2003-1	2002-2	18	0	70	70	19	19	1	1	7	4	3	0
2003-2	2003-1	41	0	61	60	8	8	38	37	109	56	92	0
2004-1	2003-2	201	0	67	67	8	8	5	5	12	6	0	0
2004-2	2004-1	205	0	69	69	24	23	35	35	61	32	67	0
2005-1	2004-2	168	0	71	70	1	1	2	2	6	3	0	0
2005-2	2005-1	115	0	73	72	24	23	14	14	54	27	65	0
2006-1	2005-2	53	0	67	66	32	31	0	0	0	0	0	0
2006-2	2006-1	46	0	61	61	58	58	12	12	15	15	0	0
2007-1	2006-2	22	0	74	72	47	46	3	3	0	0	0	0
2007-2	2007-1	46	0	72	72	68	68	80	80	10	10	23	0
2008-1	2007-2	43	0	53	53	15	15	0	0	0	0	0	0
2008-2	2008-1	83	0	25	25	30	30	80	80	14	14	229	0
2009-1	2008-2	50	0	20	20	20	20	0	0	0	0	0	0
2009-2	2009-1	0	0	13	12	23	23	82	81	12	12	285	0
2010-1	2009-2	0	0	62	62	37	36	3	1	2	2	2	0
2010-2	2010-1	0	0	25	25	13	13	64	26	8	8	287	0
2011-1	2010-2	0	0	22	21	11	11	0	0	0	0	0	0
2011-2	2011-1	0	0	22	22	22	22	34	33	10	10	362	0
2012-1	2011-2	0	0	48	47	16	16	8	8	7	7	0	0
2012-2	2012-1	0	0	44	41	18	17	83	82	37	37	106	0
2013-1	2012-2	0	0	16	16	2	2	0	0	3	0	0	0
2013-2	2013-1	0	0	39	0	5	0	54	0	66	0	0	0

Table 4. Pacific sardine landings (mt) by model year-season and SS fleet for total catch and NSP catch scenarios.

		Total Catch Models (A1 Scenarios)			NSP Catch Models (A2 Scenarios)		
Calendar Yr-Sem	Model Yr-Seas	MexCal_S1	MexCal_S2	PacNW	MexCal_S1	MexCal_S2	PacNW
1993-2	1993-1	17,460.78	0.00	0.00	822.80	0.00	0.00
1994-1	1993-2	0.00	14,078.85	0.00	0.00	11,345.83	0.00
1994-2	1994-1	19,503.00	0.00	0.00	8,838.65	0.00	0.00
1995-1	1994-2	0.00	46,792.12	0.00	0.00	39,748.42	0.00
1995-2	1995-1	30,093.29	0.00	22.68	5,993.28	0.00	22.68
1996-1	1995-2	0.00	32,561.24	0.00	0.00	26,565.72	0.00
1996-2	1996-1	40,559.48	0.00	0.00	11,917.29	0.00	0.00
1997-1	1996-2	0.00	25,364.55	43.54	0.00	19,158.65	43.54
1997-2	1997-1	89,272.03	0.00	27.22	13,018.20	0.00	27.22
1998-1	1997-2	0.00	42,079.67	0.82	0.00	24,527.60	0.82
1998-2	1998-1	46,787.92	0.00	488.25	18,925.15	0.00	488.25
1999-1	1998-2	0.00	66,550.51	74.39	0.00	63,278.38	74.39
1999-2	1999-1	48,765.83	0.00	725.20	14,996.21	0.00	725.20
2000-1	1999-2	0.00	69,337.59	429.59	0.00	58,341.39	429.59
2000-2	2000-1	56,709.77	0.00	15,586.16	23,693.38	0.00	15,586.16
2001-1	2000-2	0.00	46,662.67	2,336.90	0.00	35,179.21	2,336.90
2001-2	2001-1	54,311.70	0.00	22,545.99	11,550.53	0.00	22,545.99
2002-1	2001-2	0.00	45,617.11	3,136.84	0.00	41,118.36	3,136.84
2002-2	2002-1	64,671.88	0.00	35,525.69	16,562.71	0.00	35,525.69
2003-1	2002-2	0.00	40,979.60	597.29	0.00	36,130.69	597.29
2003-2	2003-1	38,099.55	0.00	37,242.26	10,340.64	0.00	37,242.26
2004-1	2003-2	0.00	28,590.55	2,618.43	0.00	21,300.55	2,618.43
2004-2	2004-1	61,008.15	0.00	46,730.80	17,048.96	0.00	46,730.80
2005-1	2004-2	0.00	32,857.28	1,016.32	0.00	25,249.92	1,016.32
2005-2	2005-1	60,658.00	0.00	54,152.62	13,730.19	0.00	54,152.62
2006-1	2005-2	0.00	36,791.15	101.70	0.00	29,752.00	101.70
2006-2	2006-1	71,474.68	0.00	41,220.90	20,620.28	0.00	41,220.90
2007-1	2006-2	0.00	46338.25	0.00	0.00	39234.00	0.00
2007-2	2007-1	71489.22	0.00	48237.10	46047.30	0.00	48237.10
2008-1	2007-2	0.00	50130.29	0.00	0.00	42247.81	0.00
2008-2	2008-1	74536.03	0.00	39800.10	30147.46	0.00	39800.10
2009-1	2008-2	0.00	46113.91	0.00	0.00	40545.56	0.00
2009-2	2009-1	47373.39	0.00	44841.15	13964.90	0.00	44841.15
2010-1	2009-2	0.00	35325.50	1369.73	0.00	30240.66	1369.73
2010-2	2010-1	55153.61	0.00	54085.91	11130.97	0.00	54085.91
2011-1	2010-2	0.00	33753.60	0.09	0.00	26817.27	0.09
2011-2	2011-1	64296.47	0.00	39750.49	24700.00	0.00	39750.49
2012-1	2011-2	0.00	25813.96	5805.63	0.00	20514.89	5805.63
2012-2	2012-1	47039.78	0.00	91425.63	1452.24	0.00	91425.63
2013-1	2012-2	0.00	12500.25	1570.78	0.00	7373.93	1570.78
2013-2	2013-1	44761.01	0.00	52961.07	739.00	0.00	52961.07
2014-1	2013-2	0.00	13280.00	1500.00	0.00	13280.00	1500.00
2014-2	2014-1	45000.00	0.00	5000.00	739.00	0.00	5000.00
2015-1	2014-2	0.00	10000.00	1500.00	0.00	10000.00	1500.00

Table 5. Fishery-independent indices of Pacific sardine relative abundance. Complete details regarding calculation of DEPM and TEP estimates are provided in Tables 6 and 7. In the SS model, indices had a lognormal error structure with units of standard error of loge(index). Variances of the observations were available as a CVs, so the S.E.s were approximated as sqrt(log$e$(1+CV^2)).

Model yr-seas	DEPM	S.E. ln(index)	TEP	S.E. ln(index)	Aerial	S.E. ln(index)	Acoustic	S.E. ln(index)
1993-2	69,065	0.29	---	---	---	---	---	---
1995-2	---	---	97,923	0.40	---	---	---	---
1996-2	---	---	482,246	0.21	---	---	---	---
1997-2	---	---	369,775	0.33	---	---	---	---
1998-2	---	---	332,177	0.34	---	---	---	---
1999-2	---	---	1,252,539	0.39	---	---	---	---
2000-2	---	---	931,377	0.38	---	---	---	---
2001-2	---	---	236,660	0.17	---	---	---	---
2002-2	---	---	556,177	0.18	---	---	---	---
2003-2	145,274	0.23	---	---	---	---	---	---
2004-2	459,943	0.55	---	---	---	---	---	---
2005-2	---	---	651,994	0.25	---	---	1,947,063	0.30
2006-2	198,404	0.30	---	---	---	---	---	---
2007-2	66,395	0.27	---	---	---	---	751,075	0.09
2008-1	---	---	---	---	---	---	801,000	0.30
2008-2	99,162	0.24	---	---	---	---	---	---
2009-1	---	---	---	---	1,236,911	0.90	---	---
2009-2	58,447	0.40	---	---	---	---	357,006	0.41
2010-1	---		---	---	173,390	0.40	---	---
2010-2	219,386	0.27	---	---	---	---	493,672	0.30
2011-1	---	---	---	---	201,888	0.29	---	---
2011-2	113,178	0.27	---	---	---	---	469,480	0.28
2012-1	---	---	---	---	696,251	0.37	340,831	0.33
2012-2	82182	0.29	---	---	---	---	305,146	0.24
2013-1	---	---	---	---	---	---	313,746	0.27

Table 6. The spawning biomass related parameters: daily egg production/0.05m^2 (P_0),daily mortality rate (z), survey area (km^2), two daily specific fecundities: (RSF/W), and (SF/W); s. biomass, female spawning biomass, total egg production (TEP) and sea surface temperature for 1986, 1987, 1994, 2004, 2005 and 2007-2013.

Calendar year	Season	Region	[1]P_0/0.05m^2 (cv)	Z (CV)	[2]RSF/W based on S_1	[3]RSF/W based on S_{12}	[3]FS/W based on S_{12}	[4]Area (km^2)	[5]S. biomass (cv)	S. biomass females (cv)	S. biomass females (Sum of R1andR2) (cv)	Total egg production (TEP)	Mean temper-ature (°C) for positive eggs	Mean temper-ature (°C) from Calvet
1986 (Aug)	1986	[6]S	1.48(1)	1.59(0.5)	38.31	43.96	72.84	6478	4362 (1.00)	2632 (1)		9587.44		
		N	0.32(0.25)		8.9	13.34	23.89	5333	2558 (0.33)	1429 (0.28)		1706.56		
		whole	0.95(0.84)		23.61	29.89	49.97	11811	7767 (0.87)	4491 (0.86)	4061 (0.66)	11220.45	18.7	18.5
1987 (Jul)	1987	1	1.11(0.51)	0.66(0.4)	38.79	37.86	57.05	22259	13050 (0.58)	8661 (0.56)		24707.49		
		2	0					15443	0	0		0		
		whole	0.66(0.51)		38.79	37.86	57.05	37702	13143 (0.58)	8723 (0.56)	8661 (0.56)	25637.36	18.9	18.1
1994	1993	1	0.42(0.21)	0.12(0.91)	11.57	11.42	21.27	174880	128664 (0.30)	69065 (0.30)		73449.6		
		2	0(0)	-				205295	0	0		0		
		whole	0.193(0.21)		11.57	11.42	21.27	380175	128531 (0.31)	68994 (0.30)	69065 (0.30)	73373.775	14.3	14.7
2004	2003	1	3.92(0.23)	0.25(0.04)	27.03	26.2	42.37	68204	204118 (0.27)	126209 (0.26)		267359.68		
		2	0.16(0.43)		-	-	-	252416	30833 (0.45)	19065 (0.44)		40386.56		
		whole	0.96(0.24)		27.03	26.2	42.37	320620	234958 (0.28)	145297 (0.27)	145274 (0.23)	307795.2	13.4	13.7
2005	2004	1	8.14(0.4)	0.58(0.2)	31.49	25.6	46.52	46203	293863 (0.45)	161685 (0.42)		376092.42		
		2	0.53(0.69)		3.76	3.2	7.37	207417	686168 (0.86)	298258 (0.89)		109931.01		
		whole	1.92(0.42)		15.67	12.89	27.11	253620	755657 (0.52)	359209 (0.50)	459943 (0.60)	486950.4	14.21	14.1
2007	2006	1	1.32(0.2)	0.13(0.36)	12.06	13.37	27.54	142403	281128 (0.42)	136485 (0.36)		187971.96		
		2	0.56(0.46)		24.48	23.41	38.94	213756	102998 (0.67)	61919 (0.62)		119703.36		
		whole	0.86(0.26)		15.68	16.17	31.52	356159	380601 (0.39)	195279 (0.36)	198404 (0.31)	306296.74	13.7	13.6
2008	2007	1	1.45(0.18)	0.13(0.29)	57.4	53.89	68.54	53514	29798 (0.20)	22642 (0.19)		77595.3		
		2	0.202(0.32)		13.84	12.6	22.57	244435	78359 (0.45)	43753 (0.42)		49375.87		
		whole	0.43(0.21)		21.82	20.31	32.2	297949	126148 (0.40)	79576 (0.35)	66395 (0.28)	128118.07	13.1	13.1
2009	2008	1	1.76(0.22)	0.25(0.19)	19.50	20.37	36.12	74966	129520 (0.31)	73048 (0.29)		131940.16		
		2	0.15(0.27)		14.25	14.34	22.97	199929	41816 (0.38)	26114 (0.38)		29989.35		
		whole	0.59(0.22)		17.01	17.53	29.11	274895	185084 (0.28)	111444 (0.27)	99162 (0.24)	162188.05	13.6	13.5

Table 6 (cont.).

Calendar year	Season	Region	P0/0.05m2 (cv)	Z (CV)	RSF/W based on S_1	RSF/W based on S_{12}	FS/W based on S_{12}	Area (km^2)	S. biomass (cv)	S. biomass females (cv)	S. biomass females (Sum of R1andR2) (cv)	Total egg production (TEP)	Mean temper-ature (°C) for positive eggs	Mean temper-ature (°C) from Calvet
2010	2009	1	1.70(0.22)	0.33(0.23)	21.08	24.02	51.56	27462	38875 (0.44)	18111 (0.39)		46685.4		
		2	0.22(0.42)		14.55	16.20	26.65	244311	66345 (0.58)	40336 (0.58)		53748.42		
		whole	0.36(0.29)		16.08	18.07	31.49	271773	108280 (0.46)	62131 (0.46)	58447 (0.42)	97838.28	13.7	13.9
2011	2010	1	5.57(0.24)	0.51(0.14)	19.03	24.26	41.16	41878	192332 (0.31)	113340 (0.30)		233260.5		
		2	0.487(0.33)		11.40	14.67	25.04	272603	181016 (0.48)	106046 (0.49)		132757.7		
		whole	1.16(0.26)		14.85	19.04	32.40	314481	383286 (0.32)	225155 (0.32)	219386 (0.28)	364798.0	13.5	13.6
2012	2011	1	5.28 (0.27)	0.66(0.11)	17.76	19.25	42.17	32322	177289 (0.37)	80930 (0.33)		170660.16		
		2	0.24 (0.27)		15.34	14.67	35.52	238669	78102 (0.60)	32248 (0.46)		57280.56		
		whole	0.84 (0.27)		16.14	16.14	37.65	270991	282110 (0.43)	120902 (0.36)	113178 (0.27)	227632.44	13.57	13.3
2013	2012	1	5.47 (0.29)	0.64(0.16)	32.35	27.41	47.91	29176	116455 (0.40)	66633 (0.36)		159592.72		
		2	0.27 (0.44)		13.20	24.71	39.00	112221	24547 (0.48)	15549 (0.49)		30299.67		
		whole	1.34 (0.299)		26.22	26.22	44.70	141397	144880 (0.36)	84972 (0.33)	82182 (0.30)	198471.98	13.51	13.47

1: P_0 for the whole is the weighted average with area as the weight.

2. The estimates of adult parameters for the whole area were unstratified and RSF/W was based on original S_1 data of day-1 spawning females. For 2004, 27.03 was based on sex ratio= 0.618 while past biomass used RSF/W of 21.86 based on sex ratio = 0.5.(Lo et al. 2008)

3. The estimates of adult parameters for the whole area were unstratified. Batch fecundity was estimated with error term. For 1987 and 1994, estimates were based on S_1 using data of day-1 spawning females. For 2004, all trawls were in region 1 and value was applied to region 2,

4. Region 1, since 1997, is the area where the eggs/min from CUFES ≥1 and prior to 1997, is the area where the eggs/0.05m^2 >0 from CalVET tows

5: For the spawning biomasses, the estimates for the whole area uses unstratified adult parameters

6. Within southern and northern area, the survey area was stratified as Region 1 (eggs/0.05m2>0 with embedded zero) and Region 2 (zero eggs)

Table 7. Pacific sardine female adult parameters for surveys conducted in the standard daily egg production method (DEPM) sampling area off California (1994 includes females from off Mexico).

		1994	1997	2001	2002	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Midpoint date of trawl survey		22-Apr	25-Mar	1-May	21-Apr	25-Apr	13-Apr	2-May	24-Apr	16-Apr	27-Apr	20-Apr	8-Apr	19-Apr	25-Apr
Beginning and ending dates of positive collections		04/15-05/07	03/12-04/06	05/01-05/02	04/18-04/23	04/22-04/27	03/31-04/24	05/01-05/07	04/19-04/30	04/13-04/27	04/17-05/06	04/12-04/27	03/23-04/25	04/08-04/28	04/18-05/03
N collections with mature females		37	4	2	6	16	14	7	14	12	29	17	30	16	15
N collection within Region 1		19	4	2	6	16	6	2	8	4	15	3	14	8	8
Average surface temperature (°C) at collection locations		14.36	14.28	12.95	12.75	13.59	14.18	14.43	13.6	12.4	12.93	13.62	13.12	13.18	13.65
Female fraction by weight	**R**	0.538	0.592	0.677	0.385	0.618	0.469	0.451	0.515	0.631	0.602	0.574	0.587	0.429	0.586
Average mature female weight (grams): with ovary	$\mathbf{W_f}$	82.53	127.76	79.08	159.25	166.99	65.34	67.41	81.62	102.21	112.40	129.51	127.59	141.36	138.17
without ovary	$\mathbf{W_{of}}$	79.33	119.64	75.17	147.86	156.29	63.11	64.32	77.93	97.67	106.93	121.34	119.38	131.58	129.76
Average batch fecundity[a] (mature females, oocytes)	**F**	24283	42002	22456	54403	55711	17662	18474	21760	29802	29790	39304	38369	38681	41339
Relative batch fecundity (oocytes/g)		294	329	284	342	334	270	274	267	292	265	303	301	274	298
N mature females analyzed		583	77	9	23	290	175	86	203	187	467	313	244	126	121
N active mature females		327	77	9	23	290	148	72	187	177	463	310	244	125	119
Spawning fraction of mature females[b]	**S**	0.074	0.133	0.111	0.174	0.131	0.124	0.0698	0.114	0.1186	0.1098	0.1038	0.1078	0.1376	0.149
Spawning fraction of active females[c]	$\mathbf{S_a}$	0.131	0.133	0.111	0.174	0.131	0.155	0.083	0.134	0.1187	0.1108	0.1048	0.1078	0.1388	0.153
Daily specific fecundity	$\mathbf{\frac{RSF}{W}}$	11.7	25.94	21.3	22.91	27.04	15.67	8.62	15.68	21.82	17.53	18.07	19.04	16.14	26.22

[a] 1994-2001 estimates were calculated using F_b = -10858 + 439.53 W_{of} (Macewicz et al. 1996), 2004 used F_b = 356.46W_{of}. (Lo and Macewicz 2004), 2005 used F_b = -6085 + 376.28 W_{of} (Lo and Macewicz 2006), 2006 used F_b = -396 + 293.39 W_{of} (Lo et al. 2007a), 2007 used F_b = 279.23W_{of} (Lo et al. 2007b), 2008 used F_b = 305.14W_{of} (Lo et al. 2008), 2009 used F_b = -4598 + 326.78W_{of} + e (Lo et al. 2009), 2010 used F_b = 5136 + 287.37W_{of} + e (Lo et al. 2010), 2011 used F_b = -2252 + 347.6W_{of} + e (Lo et al. 2011b), and 2012 used F_b = -12724 + 402.3W_{of} + e (Lo et al. 2013).

[b] Mature females include females that are active and those that are postbreeding (incapable of further spawning this season). S_1 was used for years prior to 2009 and S_{12} was used staring 2009.

[c] Active mature females are capable of spawning and have ovaries containing oocytes with yolk or postovulatory follicles less than 60 hours old.

Table 8. Likelihood components and derived quantities of interest for model A2 and its scenarios, including base model T (next page).

ESTIMATES	TRANSITION		STOCK	SURVEYS				BIOLOGICAL COMPOSITIONS									
								Length composition						Age composition			
	X6e_2013	X6e_2014	A2	B2d	B2h	B2i	B2j	C2b	C2c	C2d	C2e	C2f	C2g	D2a	D2b	D2c	D2d
Likelihood																	
DEPM Survey	0.72	0.72	13.86	14.47	14.36	14.15	---	12.27	12.45	12.44	10.17	14.18	12.46	7.55	10.08	8.17	5.32
TEP Survey	-0.02	-0.02	7.56	7.88	7.74	7.77	---	7.37	8.57	8.91	7.51	7.57	8.09	9.47	8.93	9.57	8.66
Aerial Survey	1.22	1.22	3.61	3.93	3.84	---	---	4.03	3.30	3.70	3.39	3.68	2.93	3.59	3.59	3.32	3.30
ATM Survey (all or Spring)	-1.76	-1.76	-2.00	-0.77	-1.22	-1.29	-0.75	-3.11	-2.50	-1.03	-2.94	-1.65	-4.61	-2.44	-2.74	-0.25	-2.90
ATM Survey (Summer)	---	---	---	---	-3.50	-3.49	-3.48	---	---	---	---	---	---	---	---	---	---
Subtotal - Survey	**0.15**	**0.15**	**23.04**	**25.52**	**21.22**	**17.14**	**-4.23**	**20.56**	**21.82**	**24.03**	**18.14**	**23.78**	**18.87**	**18.17**	**19.87**	**20.81**	**14.38**
MexCal_S1 Length	398.70	398.70	198.13	199.04	199.56	199.65	199.31	198.49	200.58	182.26	201.29	197.06	33.38	---	---	---	---
MexCal_S2 Length	329.36	329.36	196.21	196.15	197.16	196.72	199.33	195.79	192.65	183.67	196.76	195.25	33.34	---	---	---	---
PacNW Length	219.00	219.00	422.68	419.63	420.82	421.63	418.30	429.08	336.09	394.88	429.67	421.98	71.81	---	---	---	---
Aerial Length	25.16	25.14	42.78	42.96	42.69	---	---	41.85	43.27	42.26	43.38	63.83	6.33	---	---	---	---
ATM Length (all or Spring)	181.74	181.74	83.91	85.35	44.42	44.46	45.15	81.47	87.41	78.46	85.68	84.54	16.01	---	---	---	---
ATM Length (Summer)	---	---	---	---	35.61	35.77	35.61	---	---	---	---	---	---	---	---	---	---
Subtotal - Length	**1153.95**	**1153.94**	**943.70**	**943.15**	**940.26**	**898.22**	**897.70**	**946.68**	**860.00**	**881.53**	**478.38**	**962.65**	**160.88**	**---**	**---**	**---**	**---**
MexCal_S1 Age	279.24	279.24	233.28	233.90	233.22	232.94	233.14	236.37	235.32	236.90	233.75	234.13	212.09	107.23	107.22	104.70	43.63
MexCal_S2 Age	234.71	234.70	246.32	246.37	245.80	245.98	245.82	248.65	252.07	263.67	246.54	247.12	215.85	107.36	106.95	108.74	43.18
PacNW Age	198.89	198.89	354.16	353.95	353.17	353.23	351.26	341.39	321.87	418.84	355.01	355.85	251.67	119.11	120.16	130.66	51.05
ATM Age (all or Spring)	52.11	52.11	116.99	110.91	71.05	70.74	69.00	129.99	121.76	118.06	118.16	116.50	105.53	48.11	48.17	45.52	39.26
ATM Age (Summer)	---	---	---	---	43.17	42.71	42.08	---	---	---	---	---	---	---	---	---	---
Subtotal - Age	**764.94**	**764.94**	**950.75**	**945.13**	**946.40**	**945.60**	**941.30**	**826.41**	**931.03**	**518.73**	**476.73**	**953.60**	**785.13**	**381.82**	**382.49**	**389.61**	**177.11**
MexCal_S1 Size-at-age	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	98.64	---
MexCal_S2 Size-at-age	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	118.10	---
PacNW Size-at-age	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	190.33	---
ATM Size-at-age (all or Spring)	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	76.61	---
ATM Size-at-age (Summer)	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Subtotal - Size-at-age	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**483.68**	**---**
Catch	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Recruitment	14.71	14.71	13.95	14.88	13.90	14.05	16.20	14.92	13.35	13.89	7.70	13.97	5.34	6.96	6.84	8.97	4.24
Forecast Recruitment	0.50	0.50	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Parameter Softbounds	0.009	0.006	0.034	0.038	0.035	0.029	0.029	0.032	0.031	0.031	0.028	0.028	0.023	0.006	0.006	0.006	0.005
Total	**1934.27**	**1934.25**	**1931.47**	**1928.70**	**1921.82**	**1875.05**	**1851.00**	**1808.61**	**1826.23**	**1438.21**	**980.98**	**1954.02**	**970.24**	**406.95**	**409.20**	**903.08**	**195.74**
ATM q																	
ATM q (all or Spring)	1(fixed)	1(fixed)	1(fixed)	3.062	0.887	0.939	0.984	1(fixed)	1(fixed)	1(fixed)	1(fixed)	1(fixed)	1(fixed)	1(fixed)	1(fixed)	1(fixed)	1(fixed)
ATM q (Summer)	---	---	---	---	1.444	1.565	1.690	---	---	---	---	---	---	---	---	---	---
Estimated parameters	65	65	69	70	73	70	70	69	75	69	69	66	69	63	63	66	63
Derived quantities																	
$\ln(R_0)$	15.64	15.64	15.51	15.17	15.31	15.27	15.20	15.76	15.60	15.56	15.61	15.51	15.39	15.20	15.25	15.22	15.26
Stock biomass (mt) - unfished	1,135,950	1,136,030	1,008,430	706,880	815,329	784,271	726,737	1,292,770	1,070,970	1,068,470	1,106,880	1,001,560	893,708	796,558	791,022	814,429	843,020
Stock biomass (mt) - 2013_2	378,120	378,064	375,282	197,868	257,977	234,857	223,761	458,116	422,407	409,636	422,869	387,745	384,158	296,297	288,665	302,993	343,077
Stock biomass (mt) - 2014_1	---	---	435,846	253,418	324,838	300,639	283,824	516,477	482,876	468,711	513,515	447,852	490,774	405,967	398,111	407,527	467,345

Table 8 (cont.). Likelihood components and derived quantities of interest for model A2 and its scenarios, including base model T.

ESTIMATES	2013 FINAL	STOCK	S-R	NATURAL MORTALITY					BLENDED		FINAL STAR
	X6e_2013	A2	E2	F2a - 0.3	F2a - 0.4	F2a - 0.52	F2a - 0.6	F2b	G	H	T
Likelihood											
DEPM Survey	0.72	13.86	13.98	16.07	13.86	12.29	11.96	13.82	12.69	7.42	11.91
TEP Survey	-0.02	7.56	7.59	8.02	7.56	7.64	7.94	7.58	9.12	9.39	12.89
Aerial Survey	1.22	3.61	3.63	3.29	3.61	3.75	3.73	3.60	---	---	---
ATM Survey (all or Spring)	-1.76	-2.00	-2.06	0.20	-2.00	-2.70	-2.42	-1.97	-1.03	-0.03	2.42
ATM Survey (Summer)	---	---	---	---	---	---	---	---	-3.41	-3.52	-3.10
Subtotal - Survey	**0.15**	**23.04**	**23.14**	**27.58**	**23.04**	**20.99**	**21.22**	**23.03**	**17.37**	**13.26**	**24.12**
MexCal_S1 Length	398.70	198.13	197.39	197.16	198.13	199.44	200.37	197.98	182.52	---	167.00
MexCal_S2 Length	329.36	196.21	195.67	196.20	196.21	197.53	197.55	196.36	183.22	---	170.56
PacNW Length	219.00	422.68	422.99	421.08	422.68	426.93	431.73	422.59	395.44	---	367.69
Aerial Length	25.16	42.78	42.75	42.51	42.78	43.02	43.20	42.76	---	---	---
ATM Length (all or Spring)	181.74	83.91	83.39	84.76	83.91	84.33	85.95	83.82	40.89	---	41.04
ATM Length (Summer)	---	---	---	---	---	---	---	---	33.26	---	31.57
Subtotal - Length	**1153.95**	**943.70**	**942.19**	**941.71**	**943.70**	**951.24**	**958.80**	**943.52**	**835.32**	---	**777.85**
MexCal_S1 Age	279.24	233.28	233.37	237.70	233.28	230.52	230.85	231.93	236.16	110.05	49.57
MexCal_S2 Age	234.71	246.32	247.06	257.24	246.32	237.93	236.13	246.12	264.40	106.67	63.27
PacNW Age	198.89	354.16	353.98	361.42	354.16	347.55	342.06	354.23	417.60	116.39	101.70
ATM Age (all or Spring)	52.11	116.99	117.44	121.57	116.99	112.21	108.14	116.52	70.96	28.92	---
ATM Age (Summer)	---	---	---	---	---	---	---	---	45.71	14.54	---
Subtotal - Age	**764.94**	**950.75**	**951.85**	**977.93**	**950.75**	**928.21**	**917.17**	**948.80**	**517.41**	**376.57**	**214.54**
MexCal_S1 Size-at-age	---	---	---	---	---	---	---	---	---	---	---
MexCal_S2 Size-at-age	---	---	---	---	---	---	---	---	---	---	---
PacNW Size-at-age	---	---	---	---	---	---	---	---	---	---	---
ATM Size-at-age (all or Spring)	---	---	---	---	---	---	---	---	---	---	---
ATM Size-at-age (Summer)	---	---	---	---	---	---	---	---	---	---	---
Subtotal - Size-at-age	---	---	---	---	---	---	---	---	---	---	---
Catch	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Recruitment	14.71	13.95	15.22	18.36	13.95	12.61	12.10	13.91	14.65	7.89	17.27
Forecast Recruitment	0.50	---	---	---	---	---	---	---	---	---	---
Parameter Softbounds	0.009	0.034	0.034	0.034	0.034	0.040	0.040	0.034	0.031	0.005	0.004
Total	**1934.27**	**1931.47**	**1932.42**	**1965.62**	**1931.47**	**1913.08**	**1909.32**	**1929.29**	**1384.78**	**397.73**	**1033.79**
ATM q											
ATM q (all or Spring)	1 (fixed)	1 (fixed)	1 (fixed)	1 (fixed)	1 (fixed)	1 (fixed)	1 (fixed)	1 (fixed)	0.712	1.607	1 (fixed)
ATM q (Summer)	---	---	---	---	---	---	---	---	1.046	1.648	1 (fixed)
Estimated parameters	65	69	68	69	69	69	69	69	69	66	63
Derived quantities											
$\ln(R_0)$	15.64	15.51	15.60	14.71	15.51	16.66	17.30	15.94	15.49	15.19	15.39
Stock biomass (mt) - unfished	1,135,950	1,008,430	1,100,110	733,542	1,008,430	1,957,040	2,801,140	1,005,480	991,994	795,098	905,000
Stock biomass (mt) - 2013_2	378,120	375,282	378,647	331,025	375,282	642,887	843,361	375,451	331,752	152,050	337,081
Stock biomass (mt) - 2014_1	---	435,846	401,120	358,020	435,846	799,360	1,137,130	435,846	362,020	209,126	369,506

Table 8 (cont'd). Description of model scenarios in Table 8.

X6e_2013 – most recent assessment model (Hill et al. 2013).
X6e_2014 – X6e_2013 using the most recent version of SS model (ver. 3.24s).
A2 – MexCal catch/composition=environment-based
B2d – A2, with ATM *q* estimated
B2h – A2, with ATM *q* estimated and split into two surveys (spring and summer)
B2i – A2, with ATM *q* estimated/split into two surveys, aerial omitted
B2j – A2, with ATM *q* estimated/split into two surveys, aerial/DEPM/TEP omitted
C2b – A2, with ATM conditional age-at-length compositions omitted
C2c – A2, with PacNW selectivity blocked (4-yr)
C2d – A2, with all conditional age-at-length compositions downweighted (0.5)
C2e – A2, with all compositions downweighted (0.5), conditional age-at-length and length
C2f – A2, with asymptotic selectivity for aerial
C2g – A2, with all compositions downweighted (Francis method)
D2a – A2, with age data/age-based selectivity, growth fixed (internal V-B)
D2b – A2, with growth fixed (external V-B)
D2c – A2, with growth estimated, mean length-at-age time series included
D2d – Al, with growth fixed (internal V-B), age compositions downweighted (Francis method)
E2 – A2, with B-H S-R (steepness=0.8)
F2a_ 0.3-0.6 – A1, with *M* profile
F2b – A2, with Lorenzen M
G – blended, length data/length-based selectivity model
H – blended, age data/age-based selectivity model
T – length data/length-based selectivity model, ATM catchabilities fixed (q=1), ATM spring & summer selectivities independent, ATM CondAL data not used, fishery CondAL data downweighted (λ=0.2), Aerial survey not used.

Table 9. Parameters and asymptotic standard deviations for base model T.

Parameter	Phase	Min	Max	Initial Value	Final Value	Std Dev	Status
NatM_p_1_Fem_GP_1	-3	0.3	0.7	0.4000	0.4000	_	fixed
L_at_Amin_Fem_GP_1	3	3	15	10.0000	11.7754	0.2718	OK
L_at_Amax_Fem_GP_1	3	20	30	25.0000	23.4636	0.1806	OK
VonBert_K_Fem_GP_1	3	0.05	0.99	0.4000	0.3855	0.0232	OK
CV_young_Fem_GP_1	3	0.05	0.3	0.1400	0.1274	0.0071	OK
CV_old_Fem_GP_1	3	0.01	0.1	0.0500	0.0491	0.0030	OK
Wtlen_1_Fem	-3	-3	3	0.0000	0.0000	_	fixed
Wtlen_2_Fem	-3	-3	5	3.2332	3.2332	_	fixed
Mat50%_Fem	-3	9	19	15.4400	15.4400	_	fixed
Mat_slope_Fem	-3	-20	3	-0.8925	-0.8925	_	fixed
Eggs/kg_inter_Fem	-3	0	10	1.0000	1.0000	_	fixed
Eggs/kg_slope_wt_Fem	-3	-1	5	0.0000	0.0000	_	fixed
SR_LN(R0)	1	3	25	16.0000	15.3899	0.1018	OK
SR_BH_steep	-6	0.2	1	0.8000	0.8000	_	fixed
SR_sigmaR	-3	0	2	0.7500	0.7500	_	fixed
SR_R1_offset	2	-15	15	0.0000	-0.3356	0.2587	OK
Early_InitAge_6	_	_	_	_	-0.3790	0.6395	act
Early_InitAge_5	_	_	_	_	-0.4169	0.6278	act
Early_InitAge_4	_	_	_	_	-0.3988	0.6224	act
Early_InitAge_3	_	_	_	_	-0.0771	0.6092	act
Early_InitAge_2	_	_	_	_	0.3516	0.4843	act
Early_InitAge_1	_	_	_	_	1.2824	0.2787	act
Main_RecrDev_1993	_	_	_	_	0.8290	0.1904	act
Main_RecrDev_1994	_	_	_	_	-0.2509	0.2708	act
Main_RecrDev_1995	_	_	_	_	0.2351	0.2073	act
Main_RecrDev_1996	_	_	_	_	1.2799	0.1377	act
Main_RecrDev_1997	_	_	_	_	0.8195	0.1550	act
Main_RecrDev_1998	_	_	_	_	-0.8884	0.2622	act
Main_RecrDev_1999	_	_	_	_	-0.7929	0.2092	act
Main_RecrDev_2000	_	_	_	_	-0.0824	0.1419	act
Main_RecrDev_2001	_	_	_	_	-2.0683	0.3507	act
Main_RecrDev_2002	_	_	_	_	1.7539	0.1109	act
Main_RecrDev_2003	_	_	_	_	0.9213	0.1747	act
Main_RecrDev_2004	_	_	_	_	1.4853	0.1163	act
Main_RecrDev_2005	_	_	_	_	0.2177	0.2075	act
Main_RecrDev_2006	_	_	_	_	0.6903	0.1530	act
Main_RecrDev_2007	_	_	_	_	-0.2729	0.2417	act
Main_RecrDev_2008	_	_	_	_	0.7689	0.1334	act
Main_RecrDev_2009	_	_	_	_	-0.8222	0.2546	act
Main_RecrDev_2010	_	_	_	_	-1.5699	0.2761	act
Main_RecrDev_2011	_	_	_	_	-2.0573	0.4508	act
Main_RecrDev_2012	_	_	_	_	-0.1959	0.6890	act
LnQ_base_4_DEPM	5	-3	3	-1.3900	-1.8502	0.1561	OK
LnQ_base_5_TEP	5	-3	3	-0.6900	-0.5997	0.1631	OK
LnQ_base_8_ATM_Spring & Summer	-5	-3	3	0.0000	0.0000	_	fixed

Table 9 (cont.). Parameters and asymptotic standard deviations for base model T.

Parameter	Phase	Min	Max	Initial Value	Final Value	Std Dev	Status
SizeSel_1P_1_MexCal_S1_NSP	4	10	28	18.0000	18.5134	0.3667	OK
SizeSel_1P_2_MexCal_S1_NSP	-4	-5	3	-4.9850	-4.9850	_	fixed
SizeSel_1P_3_MexCal_S1_NSP	4	-1	9	2.5000	2.9077	0.1959	OK
SizeSel_1P_4_MexCal_S1_NSP	4	-1	9	4.0000	0.5753	0.5684	OK
SizeSel_1P_5_MexCal_S1_NSP	-4	-10	10	-10.0000	-10.0000	_	fixed
SizeSel_1P_6_MexCal_S1_NSP	4	-10	10	-10.0000	-3.4271	1.0621	OK
SizeSel_1P_1_MexCal_S1_NSP_BLK1repl_1999	4	10	28	18.0000	17.0451	0.1980	OK
SizeSel_1P_2_MexCal_S1_NSP_BLK1repl_1999	-4	-5	3	-4.9980	-4.9980	_	fixed
SizeSel_1P_3_MexCal_S1_NSP_BLK1repl_1999	4	-1	9	2.5000	2.1075	0.1372	OK
SizeSel_1P_4_MexCal_S1_NSP_BLK1repl_1999	4	-1	9	4.0000	-0.0949	0.4573	OK
SizeSel_1P_5_MexCal_S1_NSP_BLK1repl_1999	-4	-10	10	-10.0000	-10.0000	_	fixed
SizeSel_1P_6_MexCal_S1_NSP_BLK1repl_1999	4	-10	10	-10.0000	-2.4192	0.2287	OK
SizeSel_2P_1_MexCal_S2_NSP	4	10	28	18.0000	16.4577	0.2923	OK
SizeSel_2P_2_MexCal_S2_NSP	-4	-5	3	-4.9930	-4.9930	_	fixed
SizeSel_2P_3_MexCal_S2_NSP	4	-1	9	2.5000	1.8849	0.1993	OK
SizeSel_2P_4_MexCal_S2_NSP	4	-1	9	4.0000	1.8145	0.3861	OK
SizeSel_2P_5_MexCal_S2_NSP	-4	-10	10	-10.0000	-10.0000	_	fixed
SizeSel_2P_6_MexCal_S2_NSP	4	-10	10	-10.0000	-2.2433	0.5862	OK
SizeSel_2P_1_MexCal_S2_NSP_BLK1repl_1999	4	10	28	18.0000	14.6115	0.2116	OK
SizeSel_2P_2_MexCal_S2_NSP_BLK1repl_1999	-4	-5	3	-4.9970	-4.9970	_	fixed
SizeSel_2P_3_MexCal_S2_NSP_BLK1repl_1999	4	-1	9	2.5000	1.6284	0.2177	OK
SizeSel_2P_4_MexCal_S2_NSP_BLK1repl_1999	4	-1	9	4.0000	2.2416	0.1742	OK
SizeSel_2P_5_MexCal_S2_NSP_BLK1repl_1999	-4	-10	10	-10.0000	-10.0000	_	fixed
SizeSel_2P_6_MexCal_S2_NSP_BLK1repl_1999	4	-10	10	-10.0000	-3.0857	0.3432	OK
SizeSel_3P_1_PacNW	4	10	28	19.0000	20.9834	0.2330	OK
SizeSel_3P_2_PacNW	-4	-5	10	2.5000	2.5000	_	fixed
SizeSel_3P_3_PacNW	4	-5	10	5.0000	1.8487	0.1242	OK
SizeSel_3P_4_PacNW	-4	-5	10	5.0000	5.0000	_	fixed
SizeSel_3P_5_PacNW	-4	-10	10	-10.0000	-10.0000	_	fixed
SizeSel_3P_6_PacNW	-4	-10	10	10.0000	10.0000	_	fixed
SizeSel_8P_1_ATM_Spring	4	10	28	18.0000	23.2458	1.7109	OK
SizeSel_8P_2_ATM_Spring	-4	-5	3	3.0000	3.0000	_	fixed
SizeSel_8P_3_ATM_Spring	4	-1	9	2.5000	3.4423	0.5041	OK
SizeSel_8P_4_ATM_Spring	-4	-1	9	4.0000	4.0000	_	fixed
SizeSel_8P_5_ATM_Spring	-4	-10	10	-10.0000	-10.0000	_	fixed
SizeSel_8P_6_ATM_Spring	-4	-10	10	10.0000	10.0000	_	fixed
SizeSel_9P_1_ATM_Summer	4	10	28	18.0000	22.8332	0.9872	OK
SizeSel_9P_2_ATM_Summer	-4	-5	3	3.0000	3.0000	_	fixed
SizeSel_9P_3_ATM_Summer	4	-1	9	2.5000	2.2279	0.5083	OK
SizeSel_9P_4_ATM_Summer	-4	-1	9	4.0000	4.0000	_	fixed
SizeSel_9P_5_ATM_Summer	-4	-10	10	-10.0000	-10.0000	_	fixed
SizeSel_9P_6_ATM_Summer	-4	-10	10	10.0000	10.0000	_	fixed

Table 10. Likelihood components and data weightings for base model T.

COMPONENT	-log(L)	MexCal_S1	MexCal_S2	PacNW	DEPM	TEP	ATM_Spring	ATM_Summer
Catch	1.08383E-14	4.87797E-15	4.84106E-15	1.11925E-15	---	---	---	---
Survey	24.123	---	---	---	11.912	12.894	2.419	-3.102
Length comp	777.847	167.000	170.558	367.685	---	---	41.037	31.567
Age comp	214.543	49.571	63.271	101.701	---	---	---	---
Recruitment	17.270							
Parm softbounds	0.00414167							
TOTAL	1033.79							

VARIANCE ADJUSTMENTS	MexCal_S1	MexCal_S2	PacNW	DEPM	TEP	ATM_Spring	ATM_Summer
Index_extra_CV	---	---	---	0.0	0.0	0.0	0.0
effN_mult_Lencomp	1.0	1.0	1.0	---	---	1.0	1.0
effN_mult_Agecomp	1.0	1.0	1.0			1.0	1.0

LAMBDA WEIGHTINGS	MexCal_S1	MexCal_S2	PacNW	DEPM	TEP	ATM_Spring	ATM_Summer
Survey	---	---	---	1.0	1.0	1.0	1.0
Length comp	1.0	1.0	1.0	---	---	1.0	1.0
Age comp	0.2	0.2	0.2	---	---	0.0	0.0

Table 11a. Summary biomass and population numbers-at-age (1,000s) by model year and semester for base model T.

		SUMMARY BIOMASS (mt)			POPULATION NUMBERS-AT-AGE (1,000s of fish)										
Calendar Yr-Sem	Model Yr-Seas	Age 0+	Age 1+	SSB	0 (R)	1	2	3	4	5	6	7	8	9	10+
---	VIRG	942,828	905,000	---	4,827,830	3,236,190	2,169,280	1,454,120	974,722	653,376	437,971	293,581	196,793	131,914	268,214
---	VIRG	941,335	849,880	776,158	3,952,690	2,649,570	1,776,060	1,190,530	798,035	534,939	358,580	240,364	161,121	108,002	219,595
---	INIT	674,041	646,997	---	3,451,490	2,313,600	1,550,850	1,039,570	696,843	467,108	313,112	209,885	140,690	94,307	191,750
---	INIT	672,974	607,591	554,886	2,825,840	1,894,220	1,269,730	851,126	570,527	382,435	256,354	171,839	115,187	77,212	156,992
1993-2	1993-1	795,260	717,990	---	9,861,620	6,610,440	1,798,510	808,461	404,426	274,064	196,436	209,885	140,690	94,307	191,750
1994-1	1993-2	907,236	720,432	601,201	8,073,600	5,406,210	1,469,670	660,842	330,805	224,275	160,783	171,808	115,171	77,203	156,976
1994-2	1994-1	1,005,700	940,175	---	8,362,780	6,570,310	4,339,240	1,183,700	536,031	269,355	182,907	131,215	140,254	94,033	191,225
1995-1	1994-2	1,092,370	934,009	792,142	6,844,420	5,337,230	3,504,470	958,025	435,935	219,759	149,455	107,289	114,714	76,922	156,447
1995-2	1995-1	1,098,840	1,076,150	---	2,895,720	5,506,340	4,125,050	2,735,830	763,415	351,258	177,901	121,225	87,099	93,168	189,610
1996-1	1995-2	1,105,740	1,050,890	913,715	2,370,310	4,487,010	3,349,700	2,224,410	622,503	286,972	145,474	99,168	71,265	76,237	155,165
1996-2	1996-1	1,081,970	1,044,780	---	4,746,280	1,916,520	3,525,690	2,650,930	1,786,360	503,888	233,066	118,312	80,703	58,013	188,424
1997-1	1996-2	1,060,600	970,734	906,839	3,884,010	1,552,200	2,832,680	2,136,150	1,449,090	410,563	190,298	96,691	65,982	47,441	154,113
1997-2	1997-1	1,098,390	992,710	---	13,487,400	3,142,040	1,221,690	2,244,810	1,716,750	1,173,450	333,530	154,799	78,701	53,722	164,148
1998-1	1997-2	1,167,370	912,050	862,620	11,034,900	2,533,290	973,871	1,796,910	1,387,230	954,161	272,006	126,408	64,305	43,908	134,197
1998-2	1998-1	1,221,420	1,154,910	---	8,488,040	8,902,180	1,975,840	766,008	1,438,030	1,120,590	773,801	220,952	102,759	52,293	144,887
1999-1	1998-2	1,272,050	1,111,390	947,369	6,943,540	7,153,920	1,565,830	609,960	1,158,050	909,227	630,094	180,201	83,866	42,694	118,330
1999-2	1999-1	1,222,800	1,210,690	---	1,546,230	5,530,830	5,351,400	1,189,790	478,612	924,603	731,263	508,315	145,573	67,797	130,255
2000-1	1999-2	1,184,770	1,155,490	1,011,470	1,265,560	4,451,360	4,282,890	962,985	389,661	753,852	596,389	414,586	118,733	55,297	106,239
2000-2	2000-1	1,073,400	1,060,020	---	1,706,800	948,210	3,211,010	3,282,890	765,189	313,777	609,911	483,394	336,304	96,351	131,133
2001-1	2000-2	971,030	938,722	889,929	1,396,350	743,660	2,472,240	2,580,380	607,556	249,589	485,200	384,532	267,515	76,642	104,306
2001-2	2001-1	877,893	850,859	---	3,450,280	1,032,350	526,183	1,874,060	2,036,970	486,818	201,047	391,636	310,660	216,218	146,305
2002-1	2001-2	798,441	733,127	709,131	2,822,880	811,929	405,434	1,464,030	1,600,900	382,738	158,010	307,740	244,089	169,878	114,945
2002-2	2002-1	696,224	692,564	---	467,052	1,979,030	532,441	295,226	1,133,780	1,268,180	305,631	126,571	246,846	195,921	228,731
2003-1	2002-2	587,714	578,877	538,750	381,930	1,511,720	391,688	221,559	857,733	959,118	230,942	95,597	186,403	147,934	172,698
2003-2	2003-1	653,179	489,455	---	20,895,400	257,725	939,150	277,771	169,943	677,291	765,163	184,974	76,702	149,687	257,646
2004-1	2003-2	783,437	388,039	416,424	17,089,000	197,960	691,133	205,323	125,465	498,211	561,762	135,696	56,250	109,759	188,903
2004-2	2004-1	922,633	853,213	---	8,859,730	13,542,200	154,575	550,320	165,246	101,350	402,976	454,620	109,842	45,539	241,814
2005-1	2004-2	1,011,770	844,007	616,788	7,250,750	10,795,600	117,738	400,596	116,772	70,701	279,828	315,184	76,106	31,544	167,473
2005-2	2005-1	1,179,690	1,053,120	---	16,153,700	5,800,220	8,547,870	94,614	324,642	94,917	57,530	227,794	256,625	61,972	162,071
2006-1	2005-2	1,313,250	1,007,320	868,822	13,222,400	4,672,120	6,637,210	70,383	234,945	67,904	40,992	162,086	182,504	44,063	115,215
2006-2	2006-1	1,400,650	1,364,200	---	4,651,700	10,552,700	3,688,290	5,331,910	57,129	191,435	55,404	33,464	132,347	149,037	130,083
2007-1	2006-2	1,410,470	1,322,380	1,098,180	3,807,240	8,469,160	2,895,580	4,130,380	43,837	146,206	42,238	25,495	100,808	113,508	99,065
2007-2	2007-1	1,420,150	1,360,980	---	7,550,930	3,002,740	6,573,790	2,306,030	3,339,970	35,649	119,135	34,444	20,798	82,248	173,459
2008-1	2007-2	1,356,660	1,213,750	1,117,080	6,176,690	2,335,270	4,958,790	1,757,510	2,553,610	27,220	90,875	26,262	15,854	62,692	132,208
2008-2	2008-1	1,300,960	1,278,360	---	2,884,120	4,781,000	1,764,780	3,894,750	1,412,360	2,069,620	22,127	73,958	21,384	12,913	158,772
2009-1	2008-2	1,198,010	1,143,420	1,037,970	2,359,450	3,739,150	1,345,340	3,004,680	1,094,540	1,603,090	17,128	57,229	16,544	9,990	122,826
2009-2	2009-1	1,149,770	1,085,930	---	8,147,000	1,798,490	2,764,510	1,044,730	2,402,340	884,636	1,300,620	13,917	46,529	13,456	108,054
2010-1	2009-2	1,098,530	944,273	900,161	6,666,920	1,430,310	2,149,190	809,379	1,853,810	680,612	999,336	10,688	35,726	10,331	82,951
2010-2	2010-1	1,042,180	1,029,270	---	1,647,580	5,156,890	1,079,620	1,685,690	649,311	1,499,590	552,179	811,684	8,685	29,039	75,842
2011-1	2010-2	942,246	911,047	806,697	1,348,410	4,124,820	841,204	1,292,020	491,930	1,129,670	415,075	609,674	6,522	21,803	56,936
2011-2	2011-1	861,722	855,648	---	775,148	1,043,940	3,118,110	660,804	1,038,360	398,709	918,343	337,816	496,445	5,312	64,147
2012-1	2011-2	738,011	723,342	680,004	633,987	805,521	2,324,610	499,216	788,000	302,219	695,359	255,667	375,643	4,019	48,529
2012-2	2012-1	647,185	643,160	---	513,704	479,719	588,685	1,786,560	394,821	629,645	242,363	558,441	205,457	301,969	42,257
2013-1	2012-2	501,138	491,408	473,374	420,532	388,305	453,821	1,284,950	271,855	425,992	162,997	374,806	137,791	202,453	28,323
2013-2	2013-1	465,228	437,821	---	3,497,860	325,831	293,742	356,064	1,029,790	219,562	344,992	132,146	304,008	111,790	187,255
2014-1	2013-2	403,335	337,081	333,268	2,863,470	264,129	229,001	262,854	734,560	154,458	241,551	92,374	212,384	78,078	130,767
2014-2	2014-1	404,433	369,506	---	---	2,159,810	192,262	176,026	208,566	589,646	124,495	195,006	74,627	171,641	168,826

Table 11b. Biomass-at-age (metric tons) by model year and semester for base model T.

		POPULATION BIOMASS-AT-AGE (METRIC TONS)										
Calendar Yr-Sem	Model Yr-Seas	0	1	2	3	4	5	6	7	8	9	10+
1993-2	1993-1	77,270	253,877	130,473	84,865	53,373	41,892	33,060	37,653	26,341	18,172	38,285
1994-1	1993-2	186,804	298,884	131,239	78,800	47,356	36,151	28,028	31,554	21,906	15,036	31,478
1994-2	1994-1	65,526	252,335	314,790	124,254	70,742	41,173	30,783	23,540	26,260	18,119	38,180
1995-1	1994-2	158,363	295,070	312,943	114,237	62,406	35,423	26,053	19,705	21,820	14,981	31,372
1995-2	1995-1	22,689	211,473	299,252	287,183	100,750	53,692	29,940	21,747	16,308	17,953	37,857
1996-1	1995-2	54,843	248,066	299,122	265,243	89,114	46,257	25,359	18,213	13,555	14,847	31,115
1996-2	1996-1	37,189	73,605	255,771	278,271	235,751	77,022	39,224	21,225	15,110	11,179	37,621
1997-1	1996-2	89,867	85,814	252,953	254,719	207,444	66,179	33,173	17,758	12,550	9,239	30,904
1997-2	1997-1	105,679	120,671	88,628	235,640	226,565	179,369	56,132	27,770	14,735	10,352	32,848
1998-1	1997-2	255,321	140,054	86,965	214,267	198,589	153,802	47,416	23,216	12,231	8,551	26,960
1998-2	1998-1	66,507	341,892	143,337	80,409	189,781	171,289	130,228	39,638	19,239	10,076	29,019
1999-1	1998-2	160,657	395,507	139,826	72,733	165,781	146,559	109,837	33,096	15,952	8,315	23,790
1999-2	1999-1	12,115	212,414	388,217	124,893	63,164	141,331	123,069	91,190	27,255	13,064	26,087
2000-1	1999-2	29,282	246,095	382,454	114,828	55,782	121,514	103,962	76,143	22,584	10,769	21,358
2000-2	2000-1	13,373	36,416	232,943	344,608	100,984	47,963	102,646	86,719	62,966	18,566	26,210
2001-1	2000-2	32,308	41,113	220,766	307,690	86,975	40,232	84,580	70,623	50,883	14,926	20,935
2001-2	2001-1	27,034	39,648	38,172	196,722	268,825	74,413	33,836	70,258	58,165	41,663	29,157
2002-1	2001-2	65,315	44,888	36,204	174,574	229,177	61,694	27,544	56,520	46,428	33,084	23,015
2002-2	2002-1	3,660	76,005	38,626	30,990	149,628	193,849	51,437	22,706	46,217	37,752	45,353
2003-1	2002-2	8,837	83,576	34,977	26,419	122,789	154,601	40,258	17,557	35,455	28,811	34,434
2003-2	2003-1	163,724	9,898	68,131	29,158	22,428	103,528	128,775	33,184	14,361	28,843	51,150
2004-1	2003-2	395,398	10,944	61,717	24,483	17,961	80,307	97,926	24,922	10,699	21,376	37,704
2004-2	2004-1	69,420	520,094	11,214	57,768	21,808	15,492	67,820	81,557	20,566	8,775	48,120
2005-1	2004-2	167,765	596,838	10,514	47,768	16,716	11,396	48,779	57,887	14,476	6,143	33,491
2005-2	2005-1	126,571	222,760	620,105	9,932	42,844	14,509	9,682	40,866	48,048	11,941	32,431
2006-1	2005-2	305,935	258,300	592,690	8,393	33,634	10,945	7,146	29,769	34,714	8,581	23,146
2006-2	2006-1	36,448	405,281	267,567	559,696	7,539	29,262	9,324	6,003	24,779	28,718	26,035
2007-1	2006-2	88,090	468,220	258,570	492,515	6,275	23,567	7,363	4,682	19,174	22,106	19,905
2007-2	2007-1	59,165	115,321	476,896	242,066	440,786	5,449	20,050	6,179	3,894	15,848	34,493
2008-1	2007-2	142,914	129,106	442,811	209,569	365,562	4,388	15,841	4,823	3,016	12,210	26,423
2008-2	2008-1	22,598	183,616	128,026	408,836	186,393	316,354	3,724	13,268	4,004	2,488	31,649
2009-1	2008-2	54,592	206,720	120,136	358,284	156,689	258,404	2,986	10,511	3,147	1,946	24,597
2009-2	2009-1	63,835	69,072	200,551	109,666	317,044	135,222	218,890	2,497	8,712	2,593	21,683
2010-1	2009-2	154,257	79,075	191,919	96,512	265,382	109,709	174,203	1,963	6,795	2,012	16,704
2010-2	2010-1	12,909	198,052	78,321	176,949	85,692	229,221	92,930	145,614	1,626	5,596	15,267
2011-1	2010-2	31,199	228,042	75,118	154,063	70,422	182,093	72,355	111,973	1,240	4,246	11,495
2011-2	2011-1	6,074	40,093	226,203	69,365	137,035	60,945	154,554	60,603	92,949	1,024	12,875
2012-1	2011-2	14,669	44,533	207,583	59,528	112,806	48,715	121,214	46,956	71,450	783	9,774
2012-2	2012-1	4,025	18,424	42,706	187,537	52,106	96,245	40,789	100,183	38,468	58,186	8,517
2013-1	2012-2	9,730	21,468	40,525	153,220	38,917	68,666	28,413	68,837	26,209	39,429	5,724
2013-2	2013-1	27,407	12,514	21,310	37,376	135,904	33,561	58,061	23,707	56,919	21,541	36,928
2014-1	2013-2	66,254	14,602	20,449	31,343	105,156	24,897	42,107	16,965	40,397	15,206	25,957
2014-2	2014-1	---	82,948	13,948	18,478	27,525	90,131	20,952	34,983	13,972	33,074	33,495

Table 12. Derived SSB (mt) and recruits (year-class abundance, billions of age-0 fish) for base model T. SSB estimates are calculated at the beginning of Season 2 of each model year, e.g. the 2013 value is SSB January 2014. Recruits are age-0 fish calculated at the beginning of each model year (July).

Model year	SSB (mt)	SSB Std Dev	Year class abundance (billions)	Recruits Std Dev
Virgin	776,158	78,284	4.828	0.492
1993	601,201	124,461	3.451	0.951
1994	792,142	150,467	8.363	1.731
1995	913,715	165,750	2.896	0.838
1996	906,839	158,846	4.746	1.054
1997	862,620	143,290	13.487	1.921
1998	947,369	137,789	8.488	1.297
1999	1,011,470	134,525	1.546	0.422
2000	889,929	119,525	1.707	0.368
2001	709,131	97,968	3.450	0.502
2002	538,750	79,127	0.467	0.175
2003	416,424	67,014	20.895	2.673
2004	616,788	89,430	8.860	1.636
2005	868,822	115,871	16.154	2.017
2006	1,098,180	134,709	4.652	1.012
2007	1,117,080	136,349	7.551	1.166
2008	1,037,970	126,448	2.884	0.742
2009	900,161	112,589	8.147	1.207
2010	806,697	104,196	1.648	0.458
2011	680,004	94,716	0.775	0.239
2012	473,374	80,309	0.514	0.251
2013	333,268	65,697	3.498	2.559
2014	306,237	74,121	---	---

Table 13. Pacific sardine harvest control rules for the 2014-15 management year based on stock biomass estimated in base model T.

Harvest Control Rule Formulas
OFL = BIOMASS * F_{MSY} * DISTRIBUTION
$ABC_{P\text{-}star}$ = BIOMASS * $BUFFER_{P\text{-}star}$ * E_{MSY} * DISTRIBUTION
HG = (BIOMASS - CUTOFF) * FRACTION * DISTRIBUTION

Harvest Formula Parameters									
BIOMASS (ages 1+, mt)	369,506								
P-star	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05
ABC $Buffer_{Tier\ 1}$	0.9558	0.9128	0.8705	0.8280	0.7844	0.7386	0.6886	0.6304	0.5531
ABC $Buffer_{Tier\ 2}$	0.9135	0.8333	0.7577	0.6855	0.6153	0.5455	0.4741	0.3974	0.3060
CalCOFI SST (2011-2013)	15.335								
E_{MSY}	0.122								
FRACTION	0.15								
CUTOFF (mt)	150,000								
DISTRIBUTION (U.S.)	0.87								
Harvest Control Rule Values (MT)									
OFL =	**39,210**								
$ABC_{Tier\ 1}$ =	37,475	35,792	34,131	32,464	30,757	28,961	26,999	24,719	21,688
$ABC_{Tier\ 2}$ =	35,818	32,672	29,710	26,879	24,126	21,391	18,591	15,583	11,997
HG =	**28,646**								

FIGURES

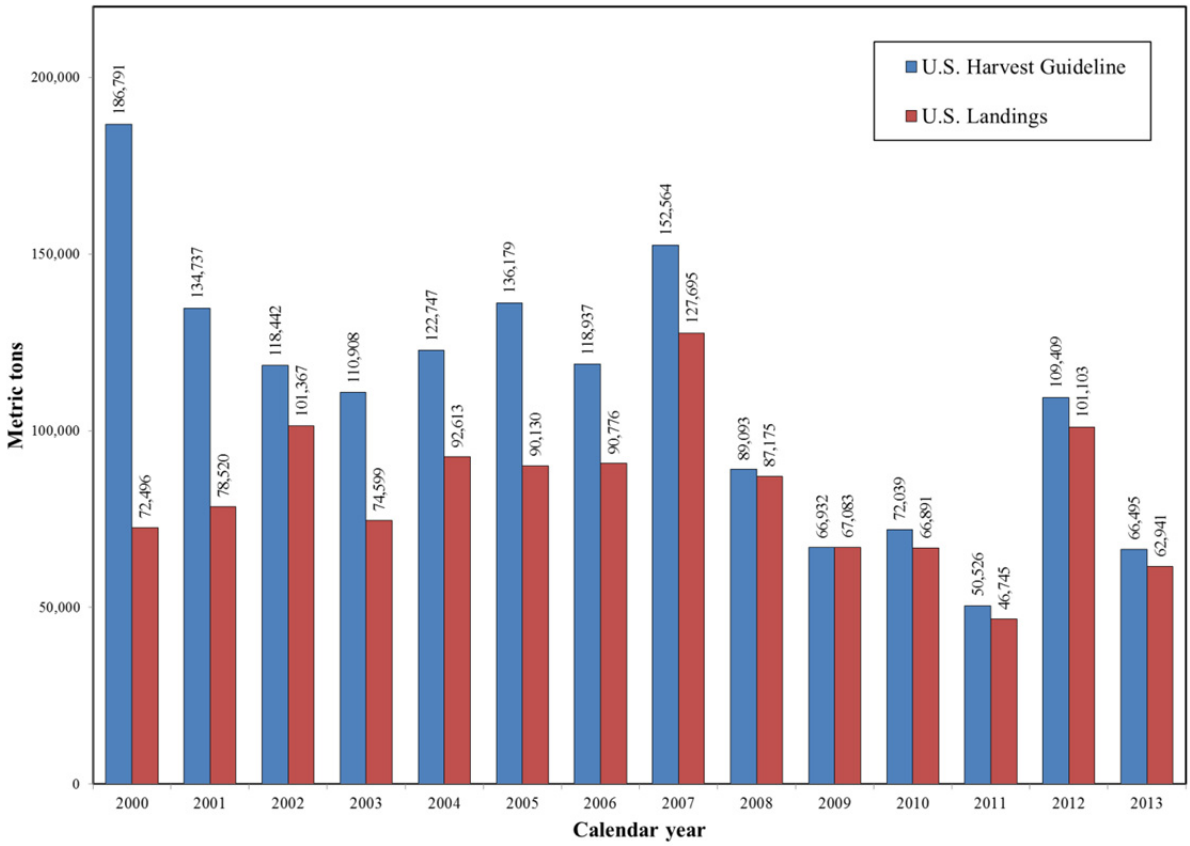


Figure 1. U.S. Pacific sardine harvest guidelines and landings since the onset of federal management.

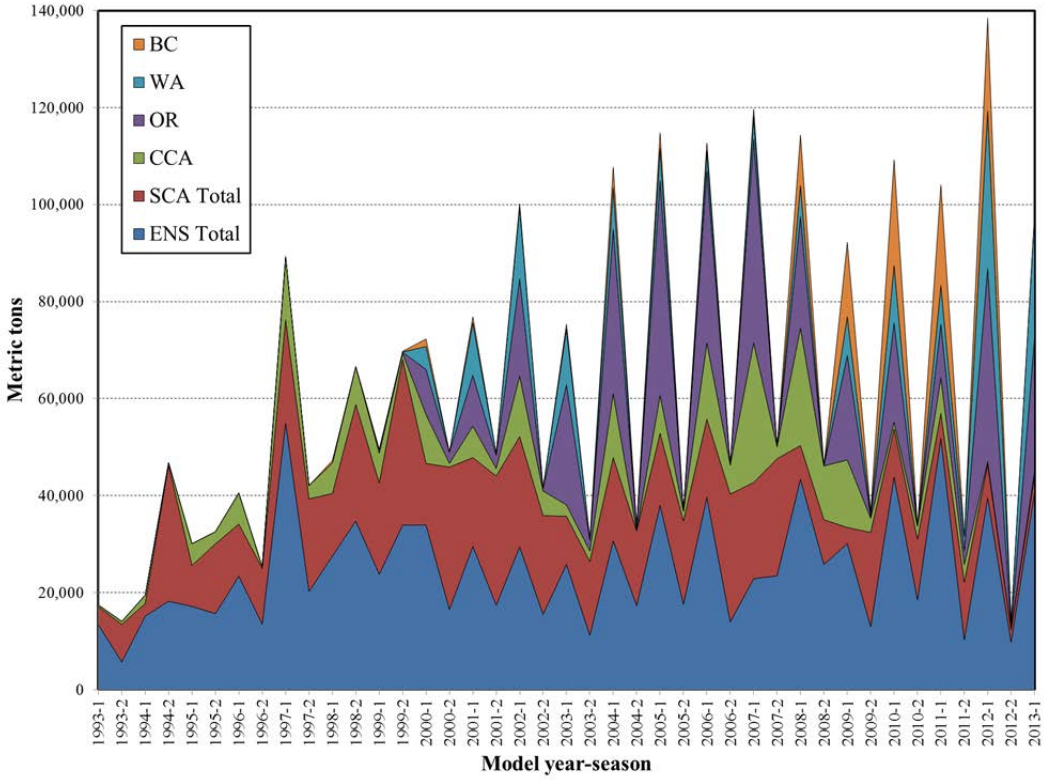


Figure 2a. Pacific sardine total landings (mt) by major fishing region.

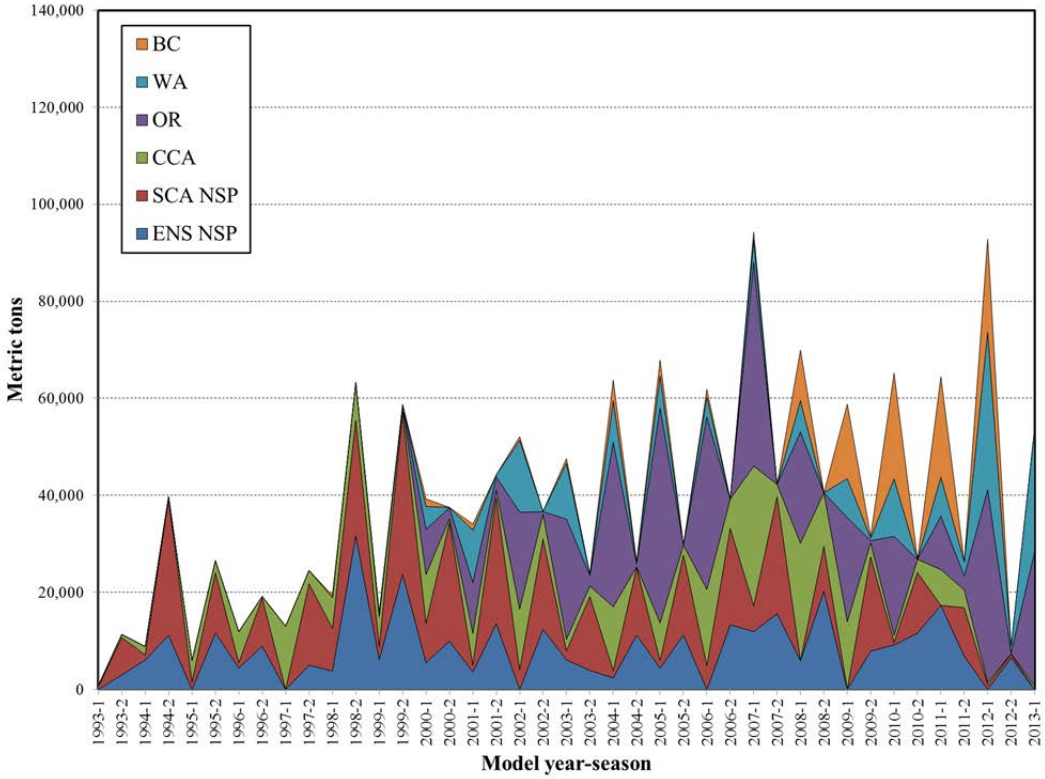


Figure 2b. Pacific sardine NSP landings (mt) by major fishing region.

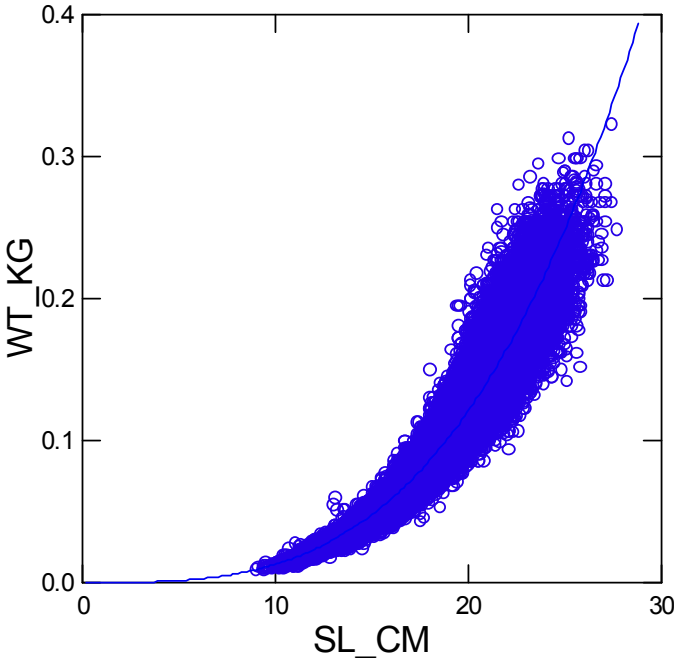


Figure 3. Weight-at-length regression from NSP fishery samples as applied in model T, where: *a* = 7.5242e-06 and *b* = 3.2332 (n=104,326, R^2 = 0.936).

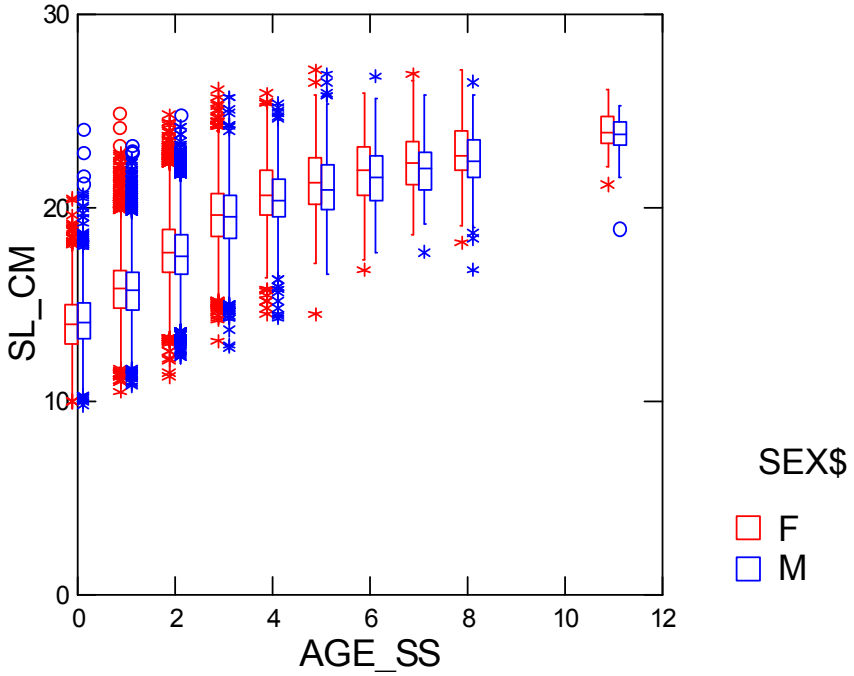


Figure 4a. Length-at-age by sex from fishery samples. Box symbols indicate median and quartile ranges for the raw data. The SS model is based on pooled sexes.

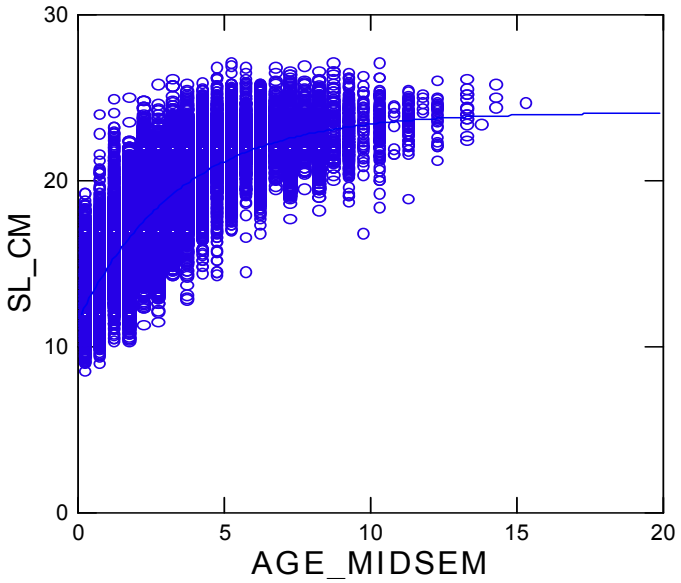


Figure 4b. von Bertalanffy growth from NSP fishery samples, sexes combined, as estimated outside of the SS model (t_0 = -2.01, K = 0.318, L_∞ = 23.788).

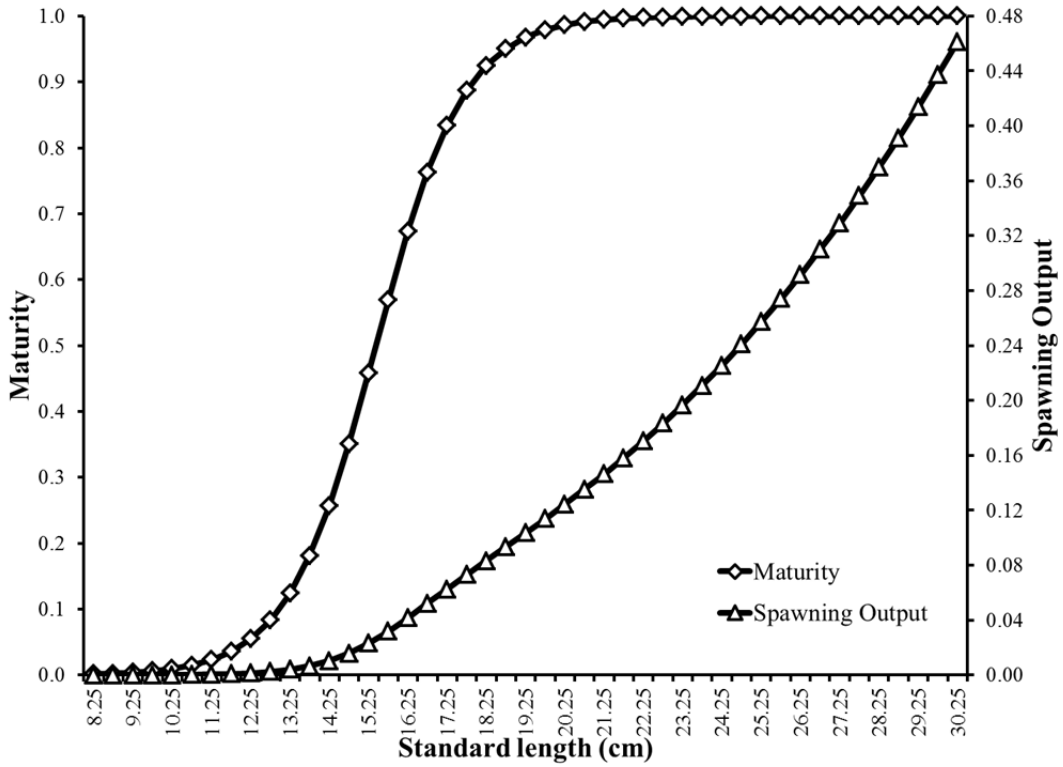


Figure 5a. Maturity (L_{50} = 15.44 cm) and spawning output as a function of length.

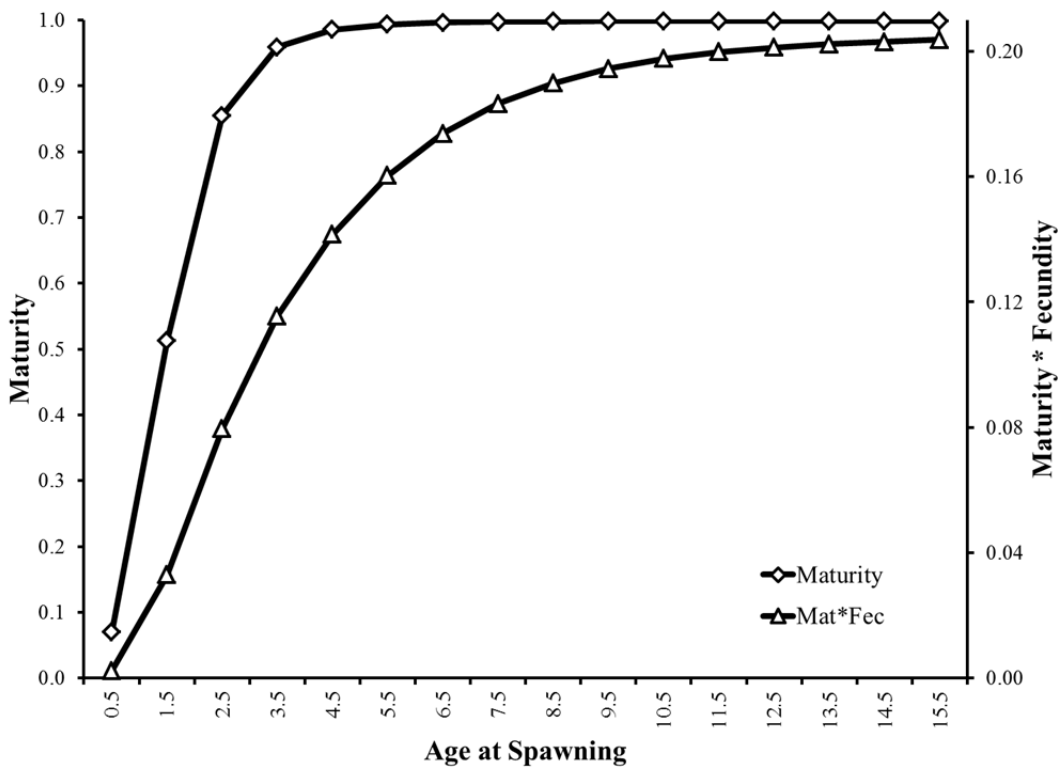


Figure 5b. Maturity and fecundity as a function of age derived from growth in model T.

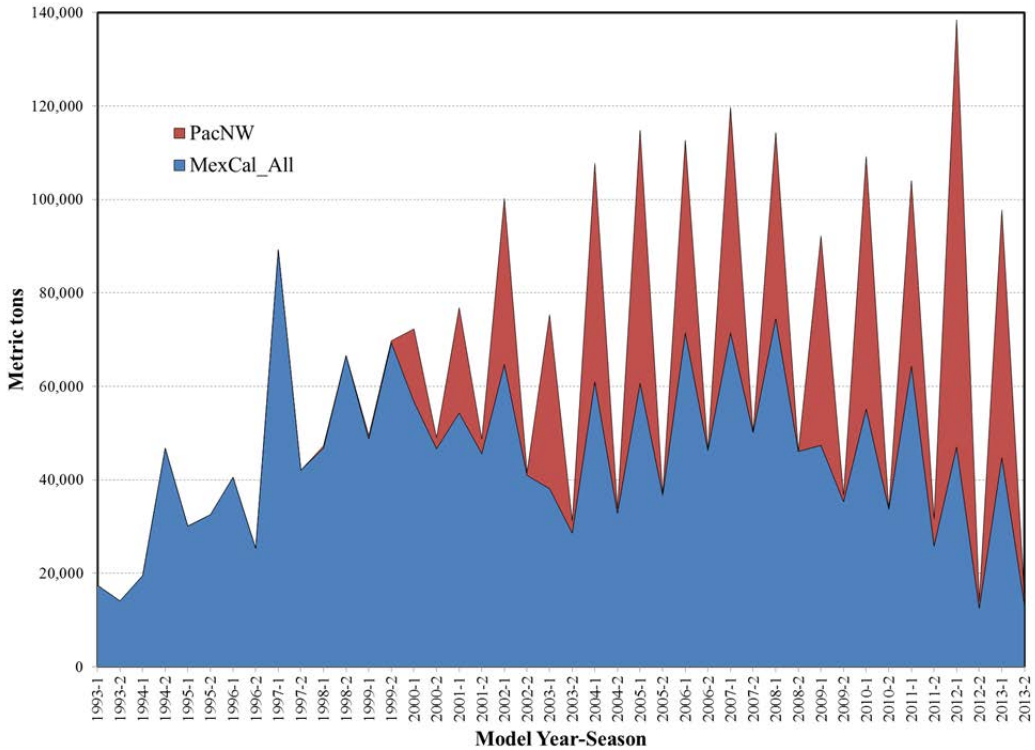


Figure 6a. Pacific sardine landings (mt) by fleet, model year and semester as used in model A1 model scenarios (total catch).

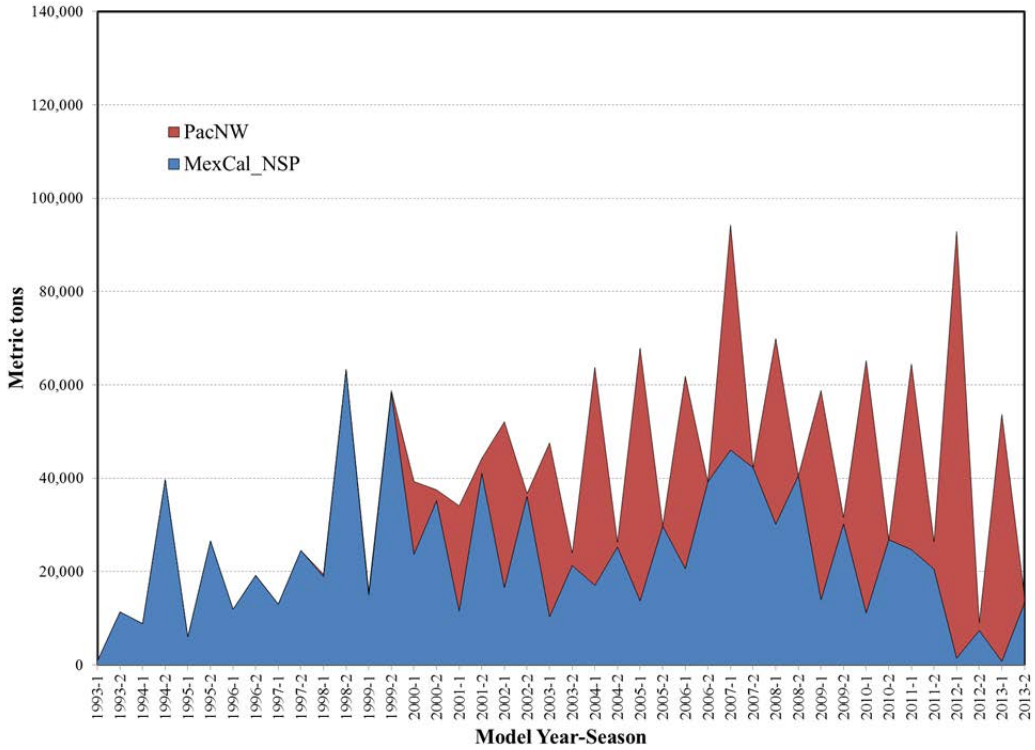


Figure 6b. Pacific sardine landings (mt) by fleet, model year and semester as used in NSP model scenarios, including final base model T.

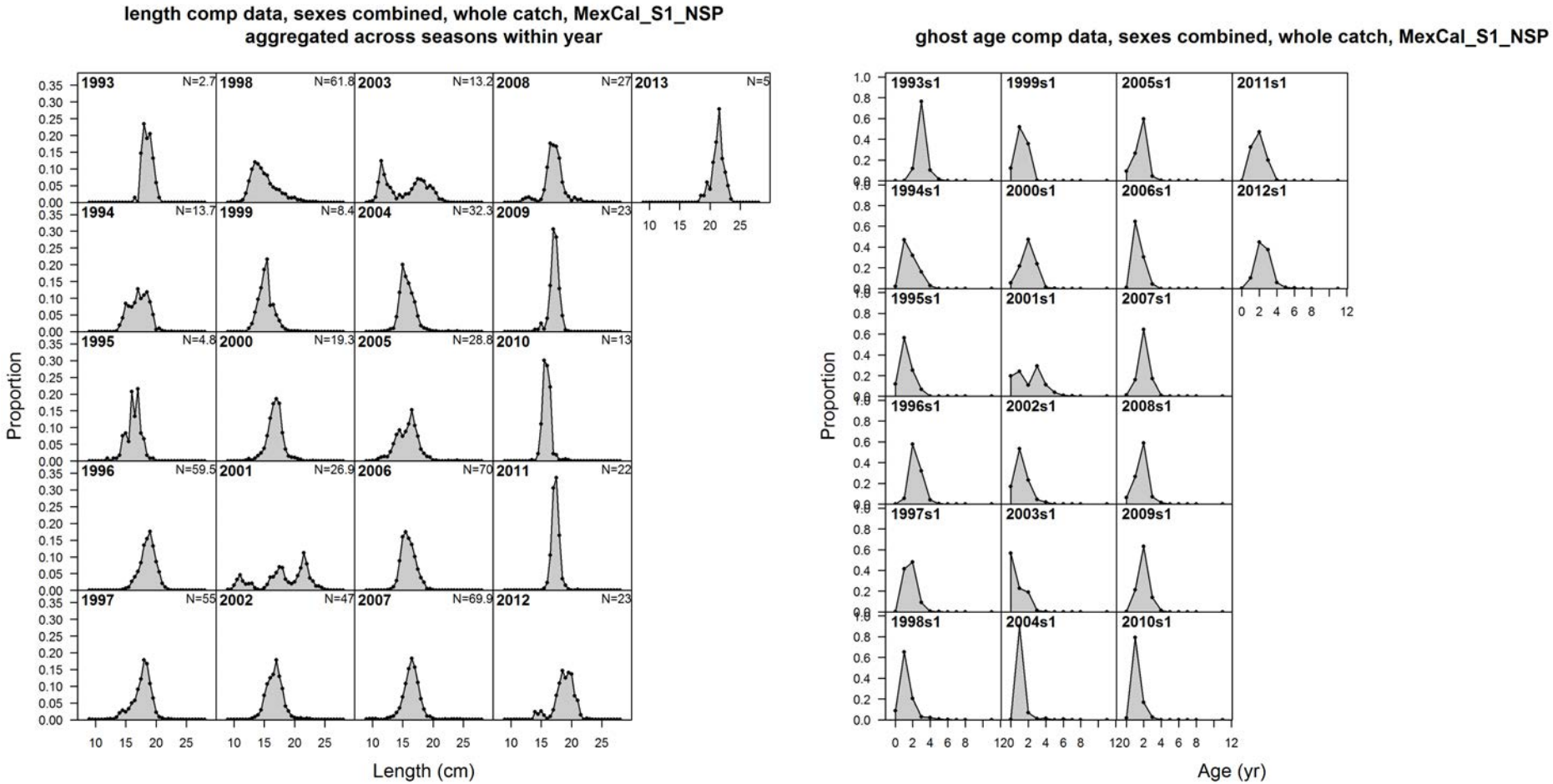


Figure 7. Length-composition (left panel) and implied age composition (right panel) data for the MexCal_S1 fleet.

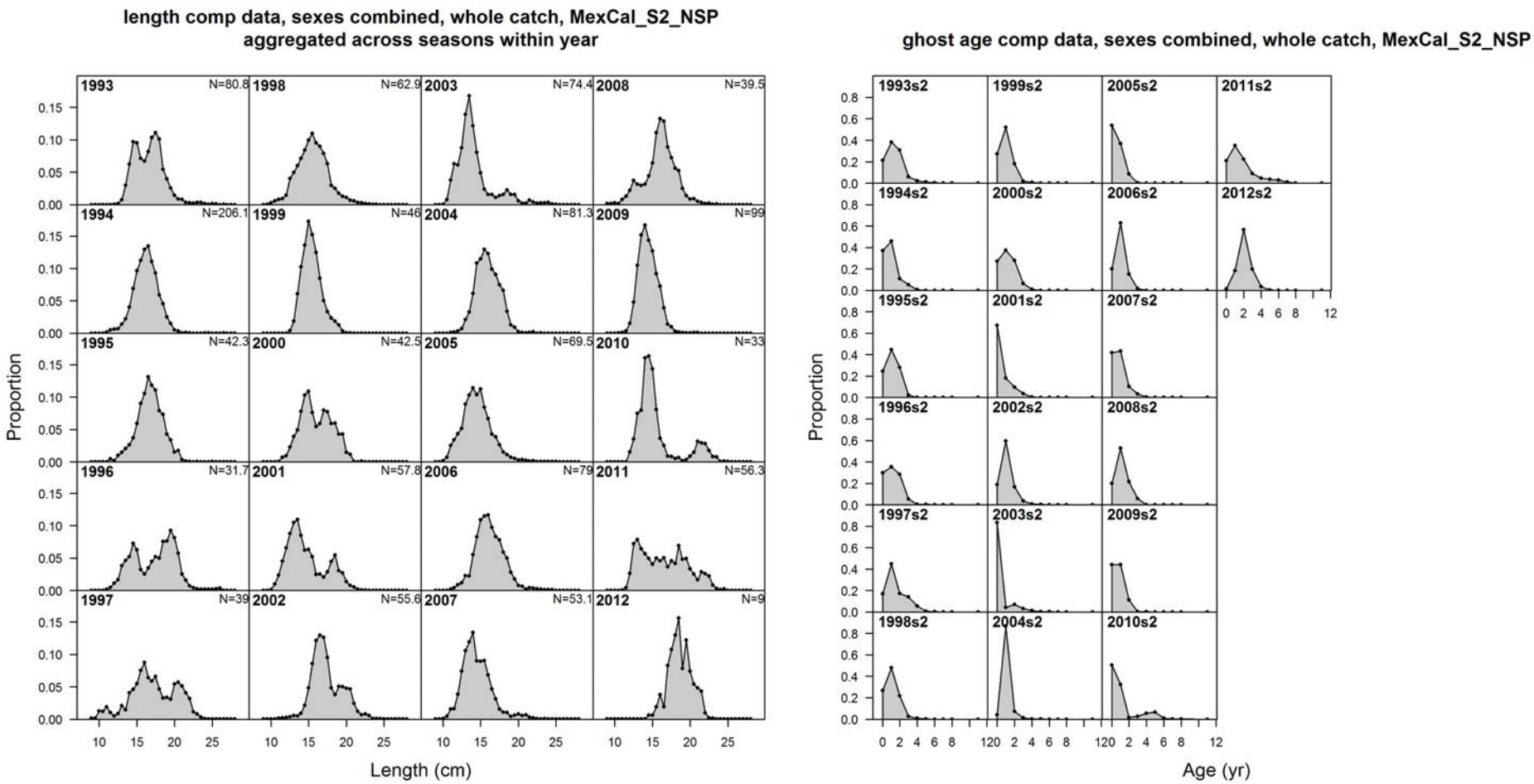


Figure 8. Length-composition (left panel) and implied age composition (right panel) data for the MexCal_S2 fleet.

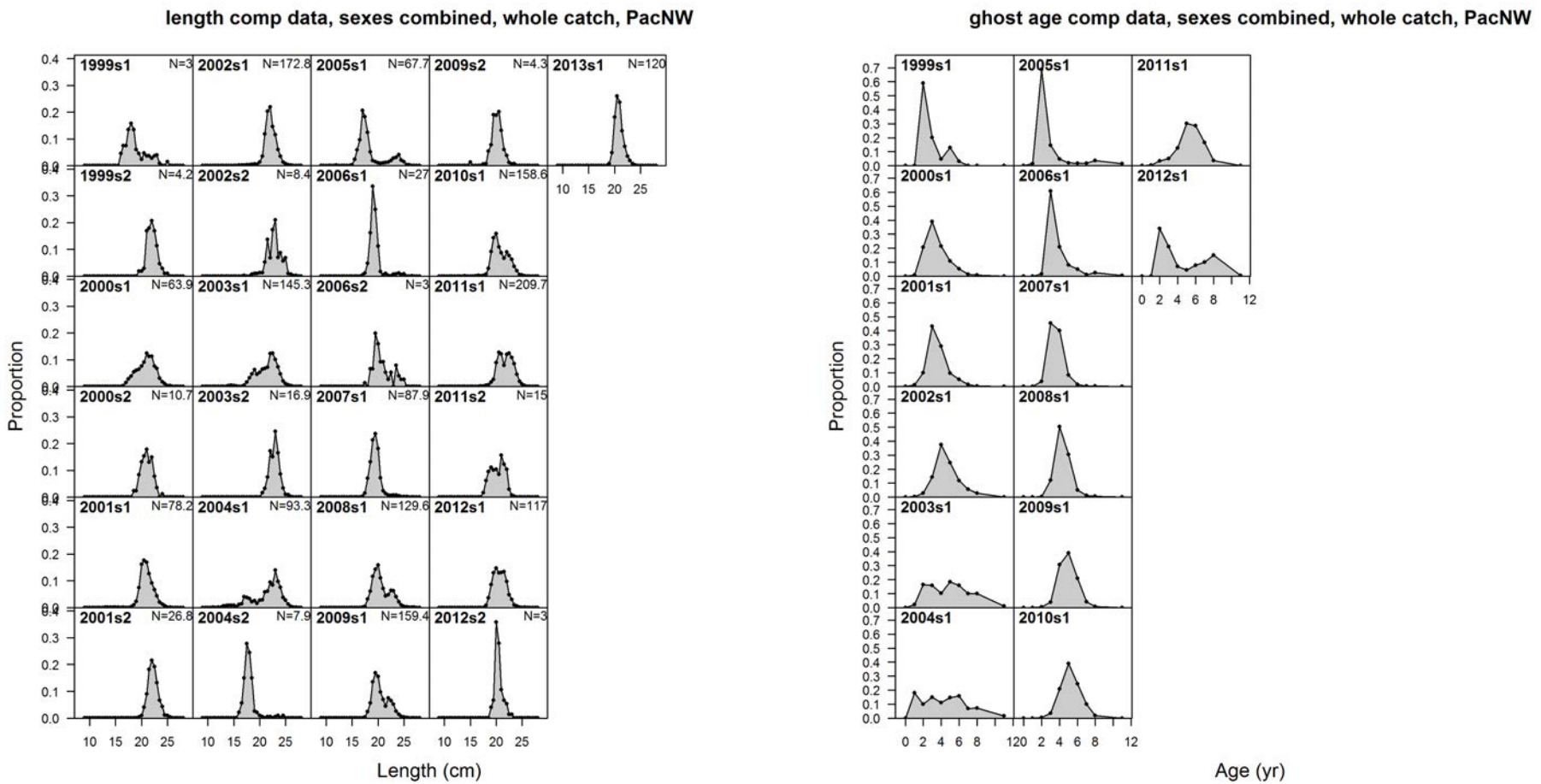


Figure 9. Length-composition (left panel) and implied age-composition (right panel) data for the PacNW fleet.

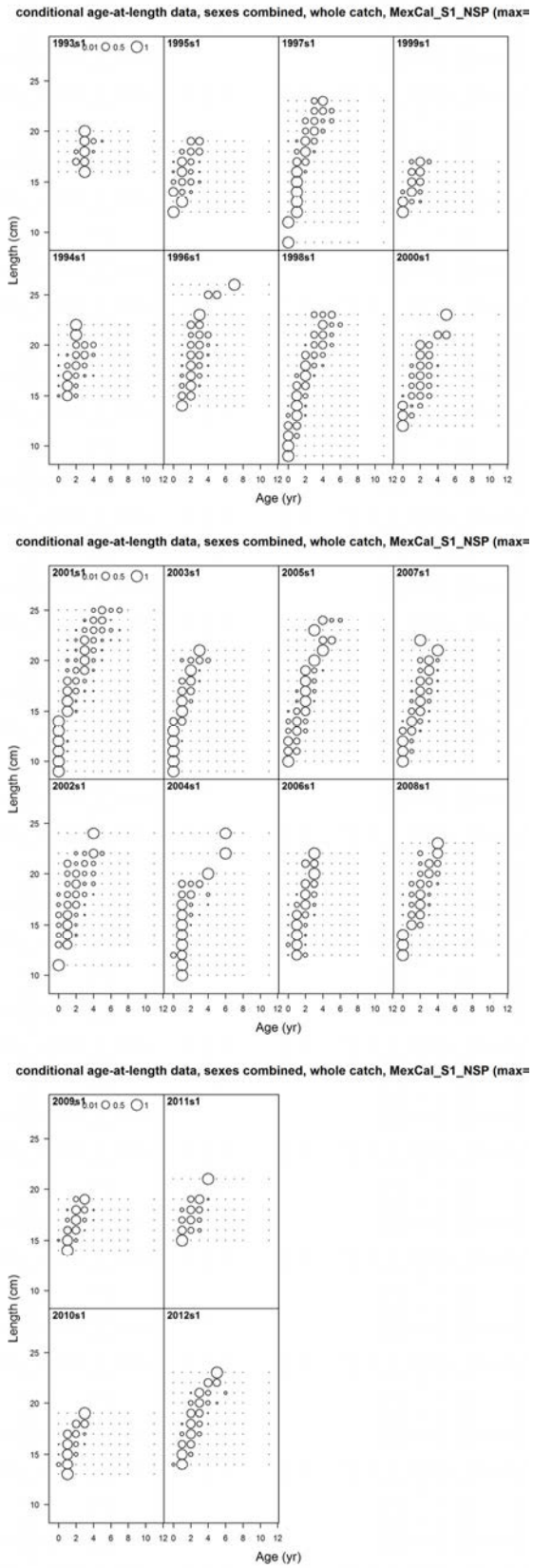


Figure 10. Conditional age-at-length data for the MexCal_S1 fleet.

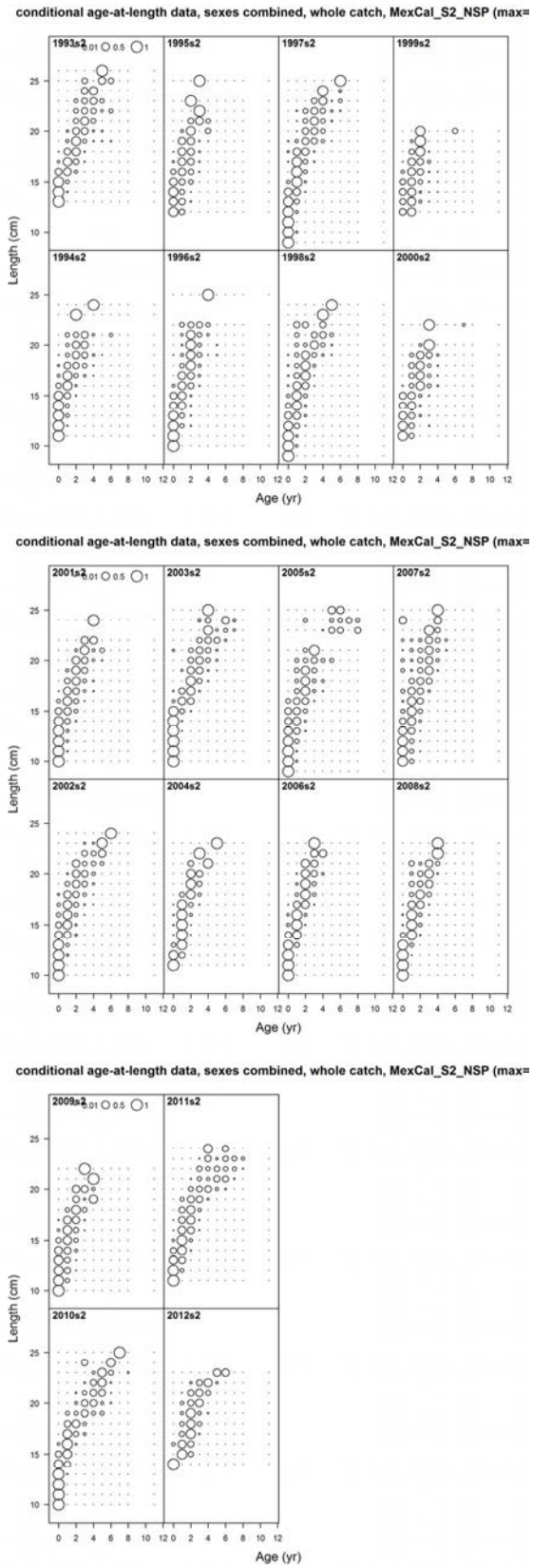


Figure 11. Conditional age-at-length data for the MexCal_S2 fleet.

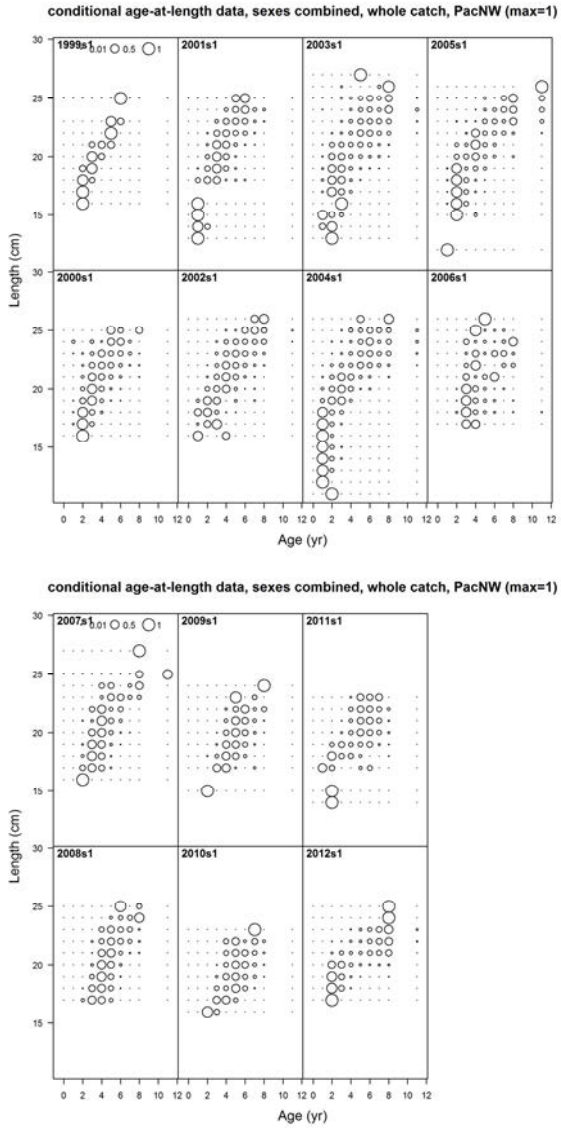


Figure 12. Conditional age-at-length data for the PacNW fleet.

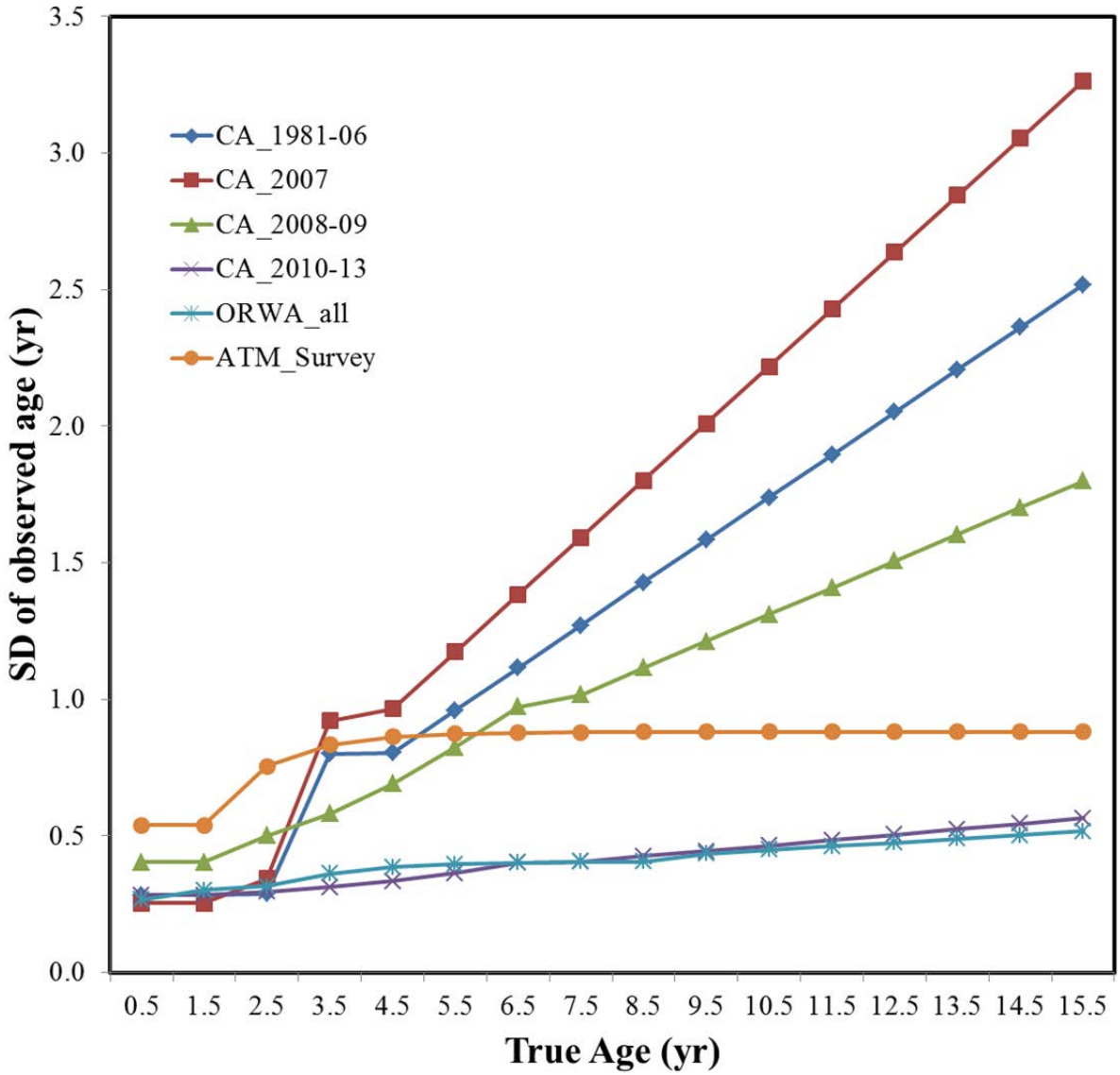


Figure 13. Laboratory- and year-specific ageing errors applied in all models.

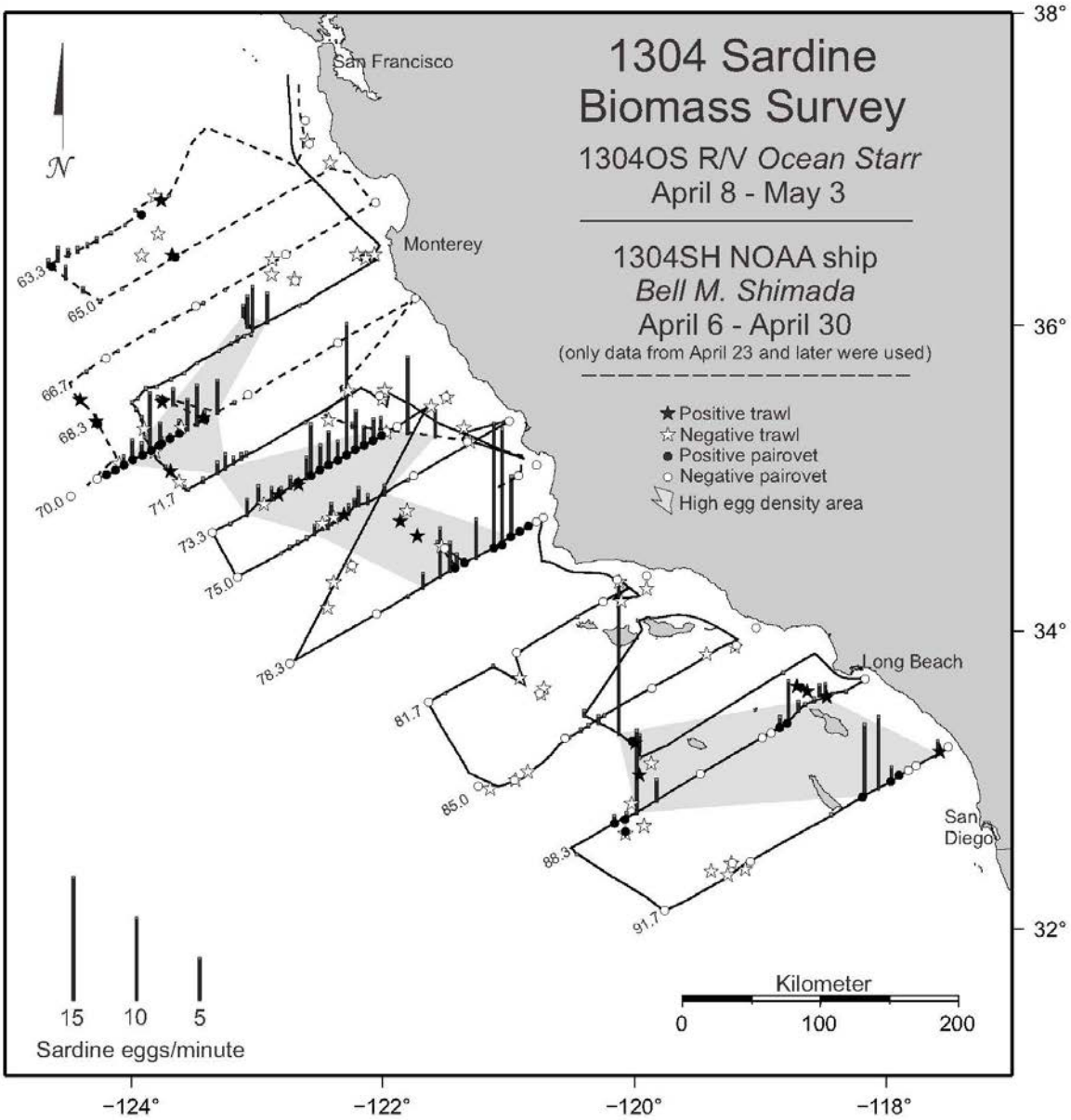


Figure 14. Distribution of CUFES, and Pairovet, and adult trawl samples from the SWFSC 1304 sardine survey in the standard sampling area for the DEPM index, conducted onboard the R/V *Ocean Starr* and the NOAA ship *Bell M. Shimada* during spring 2013.

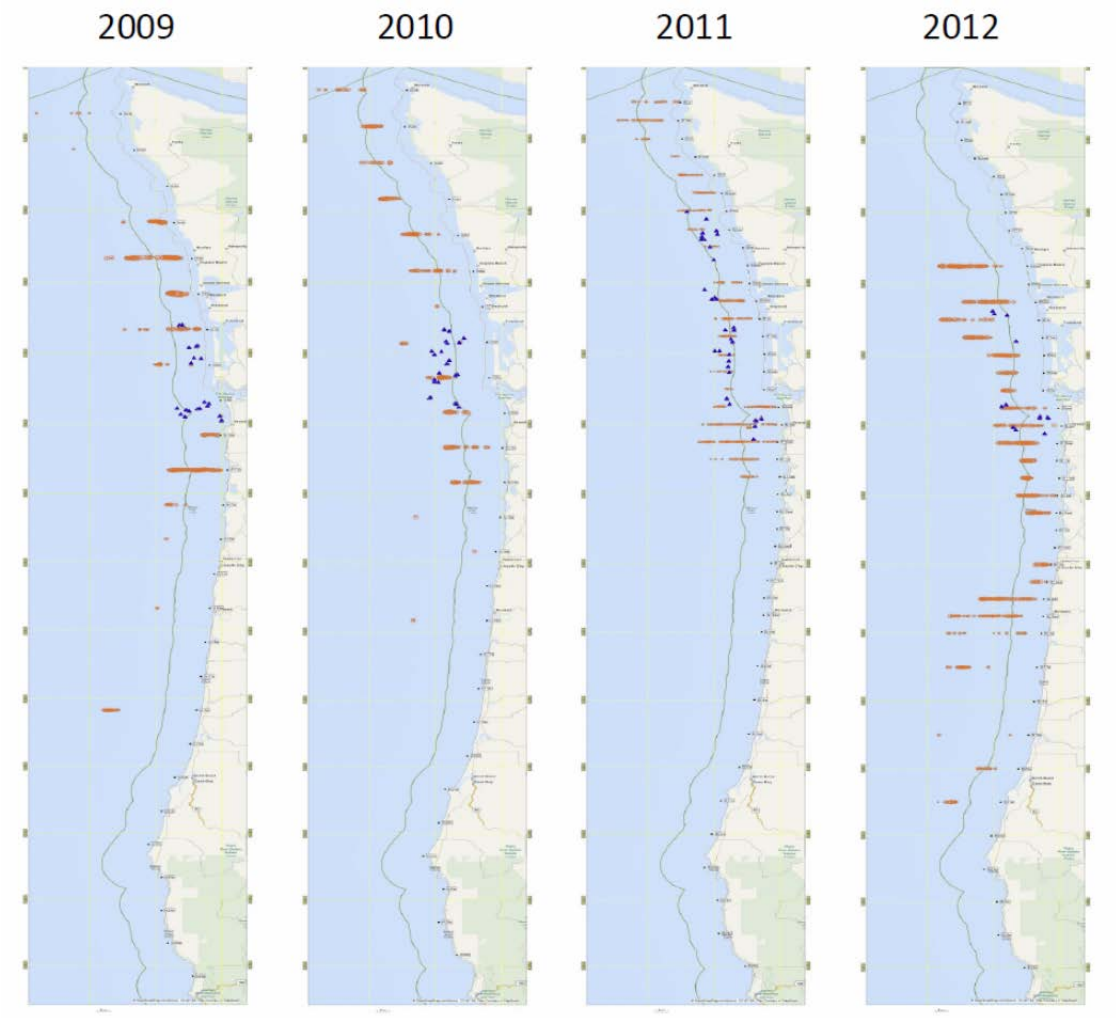


Figure 15. NWSS aerial survey distributions of fish schools observed from photographs and sardine-directed point sets (blue markers) (from Jagielo et al. 2012).

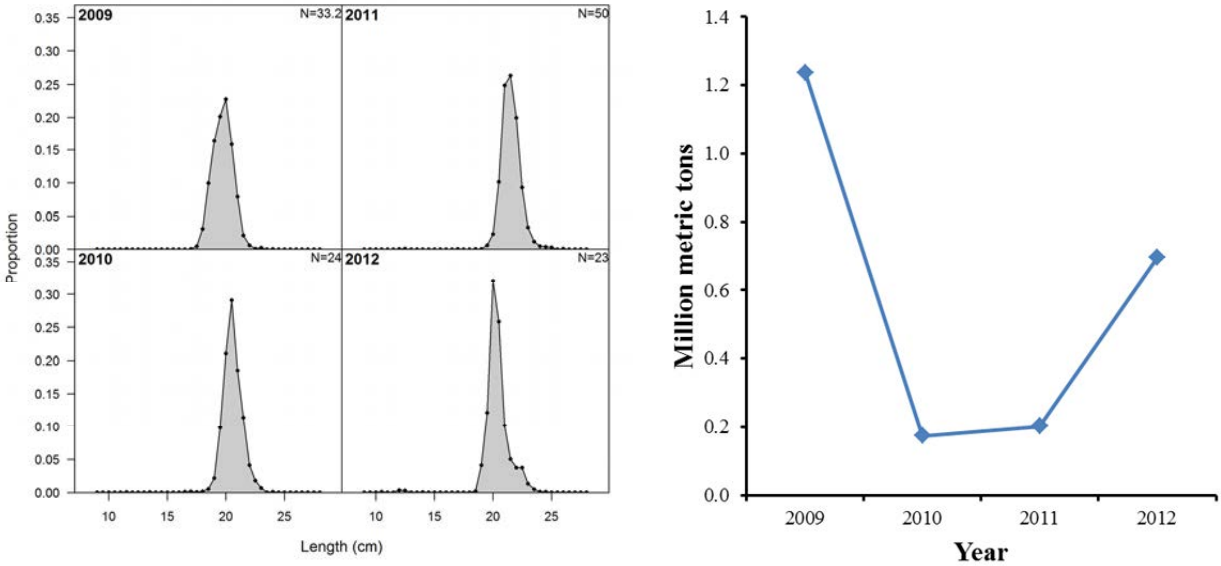


Figure 16. Length compositions (left) and biomass estimates (right) for the NWSS aerial survey.

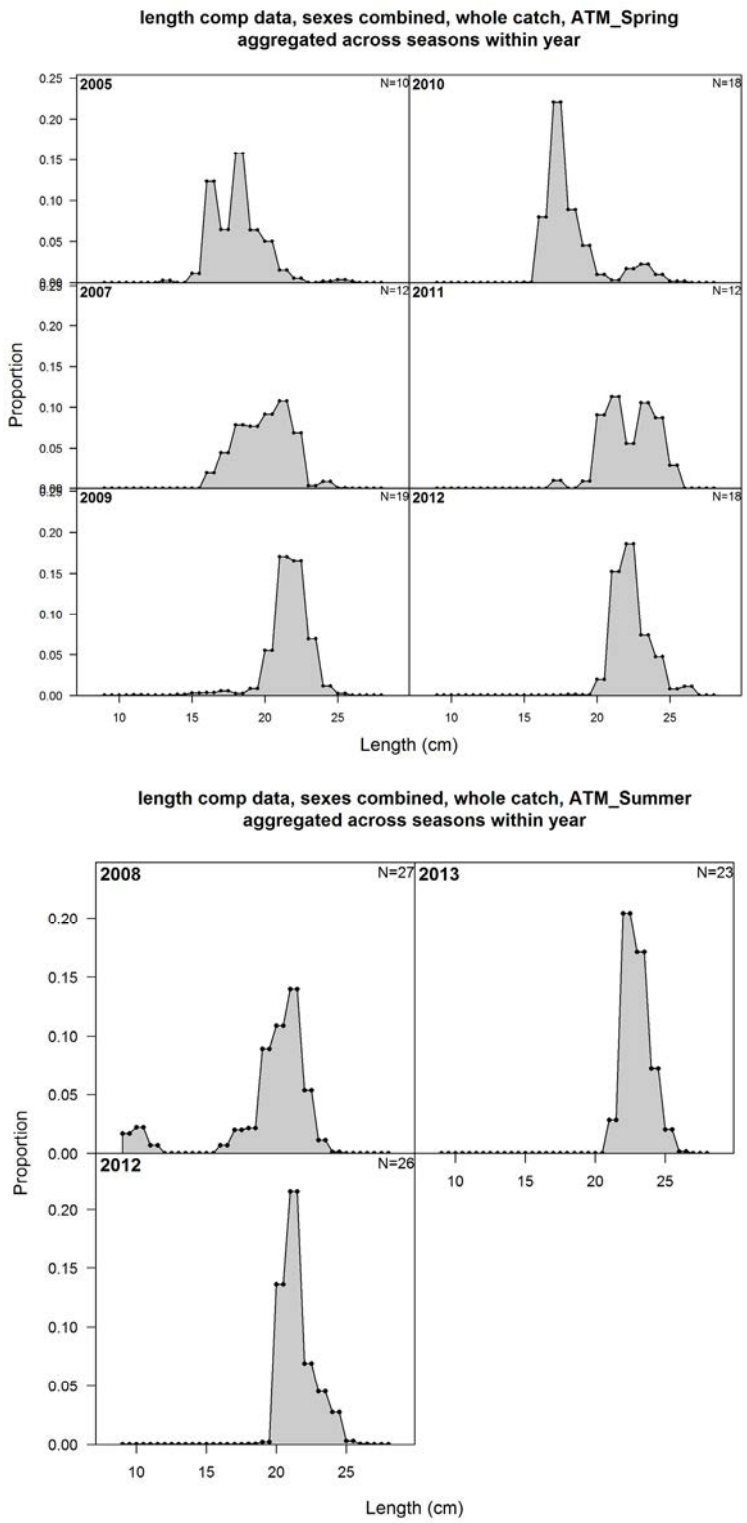


Figure 17. Length-composition data (1-cm resolution) for the ATM Spring (upper panel) and Summer (lower panel) surveys.

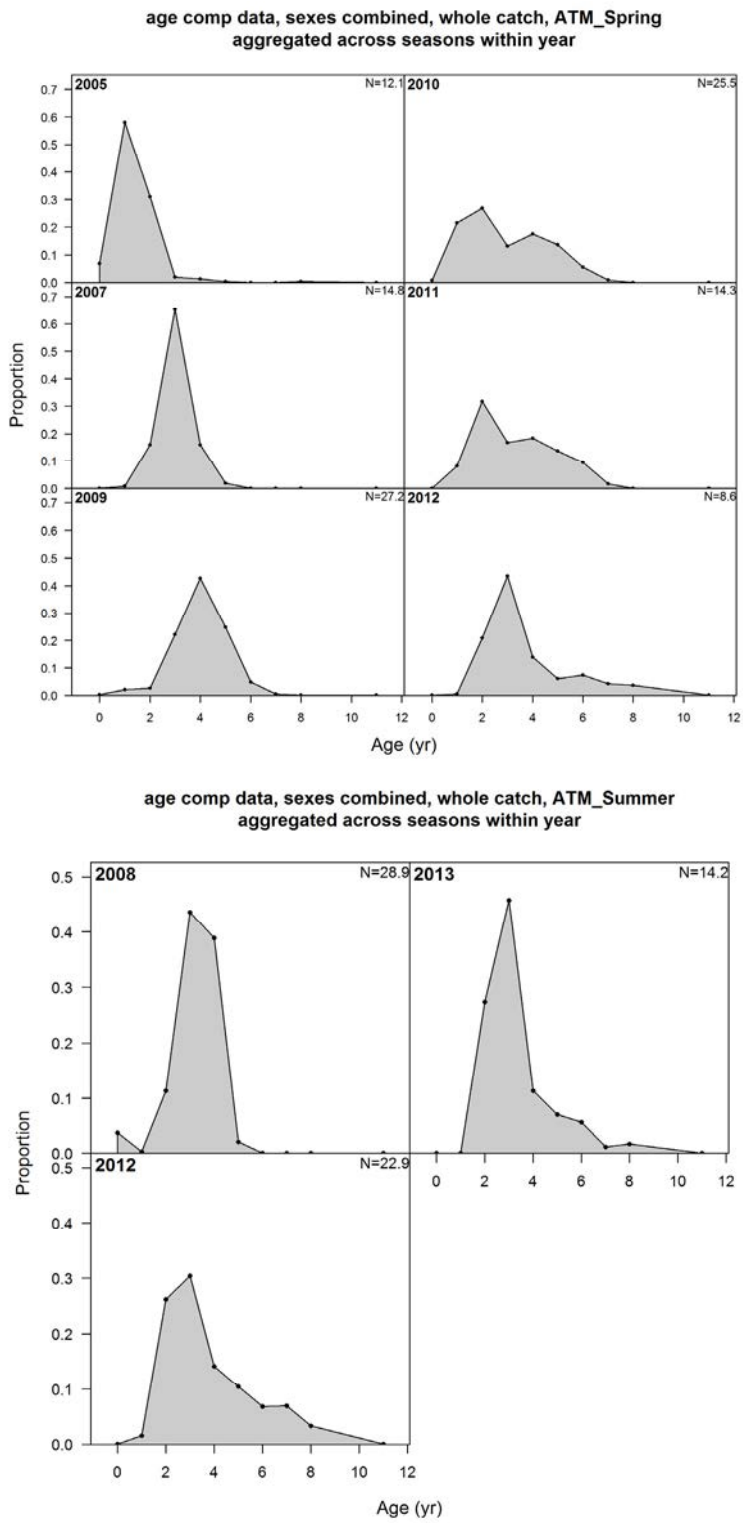


Figure 18. Implied age-composition data for the ATM Spring (upper panel) and Summer (lower panel) surveys.

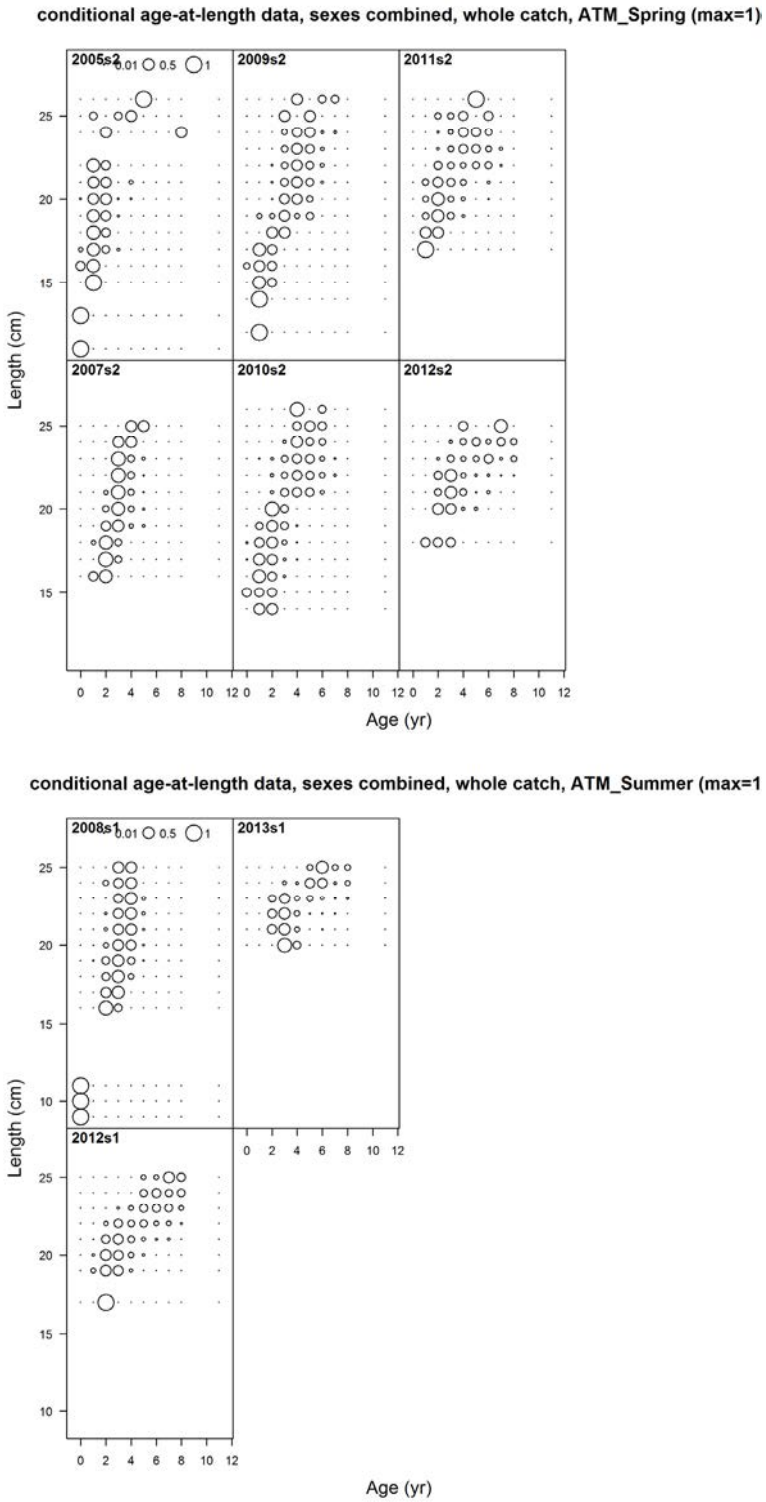


Figure 19. Conditional age-at-length composition data for the ATM Spring (upper) and Summer (lower) surveys.

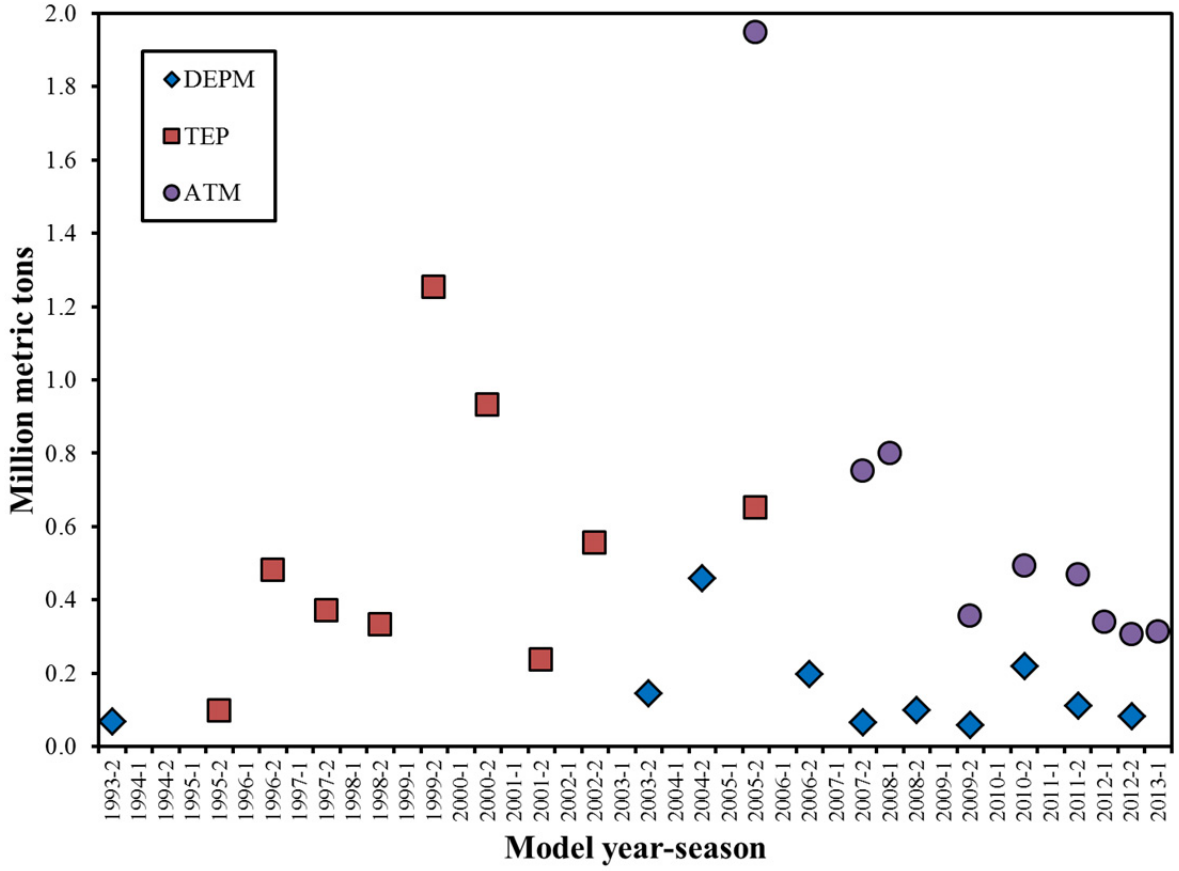


Figure 20. Survey indices of abundance (biomass units) included in final base model T. TEP is modeled as total SSB, and DEPM as female SSB. Error bars for survey estimates are shown in subsequent displays for model fits to respective surveys.

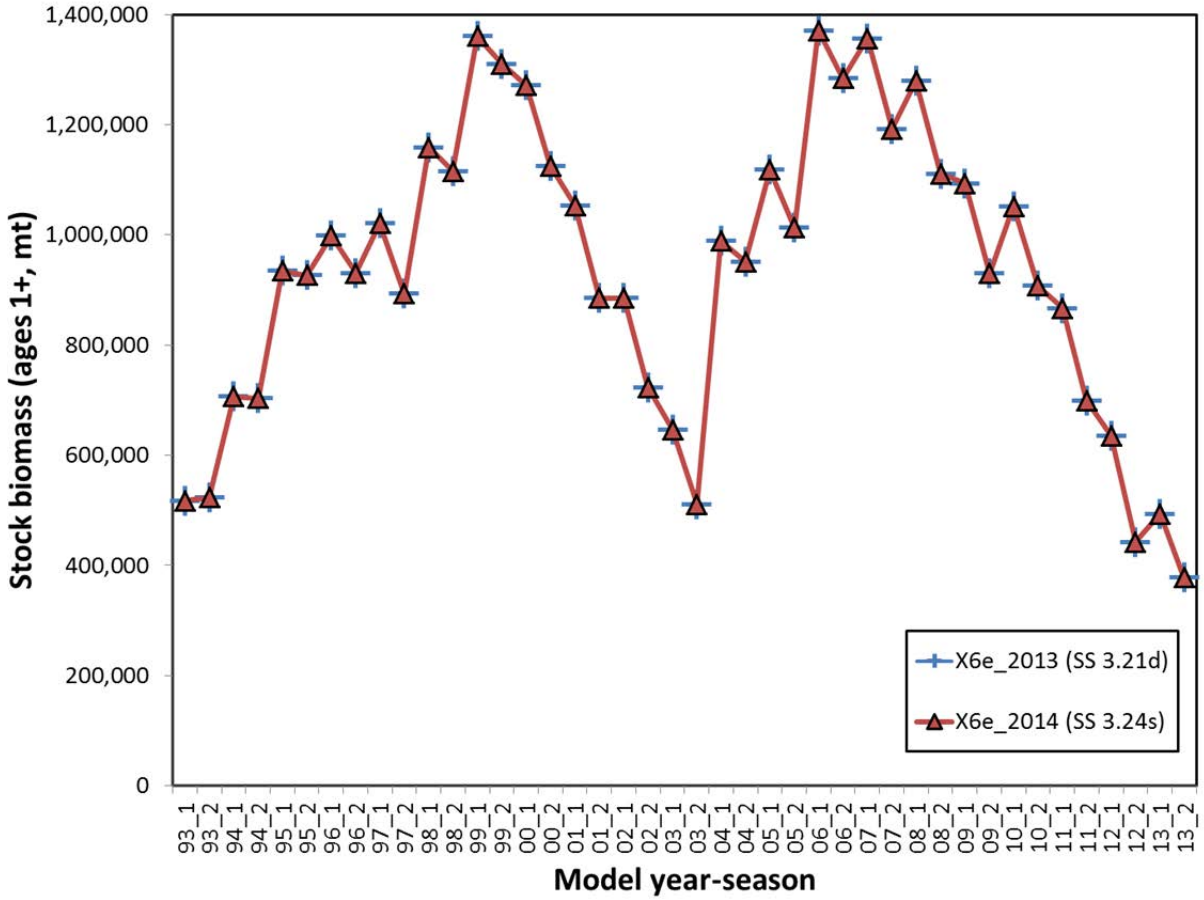


Figure 21. Estimated biomass (*B*) time series for the final assessment model used by management in 2013 (Hill 2013), as modeled with SS 3.21d, and the same data modeled with SS 3.24s.

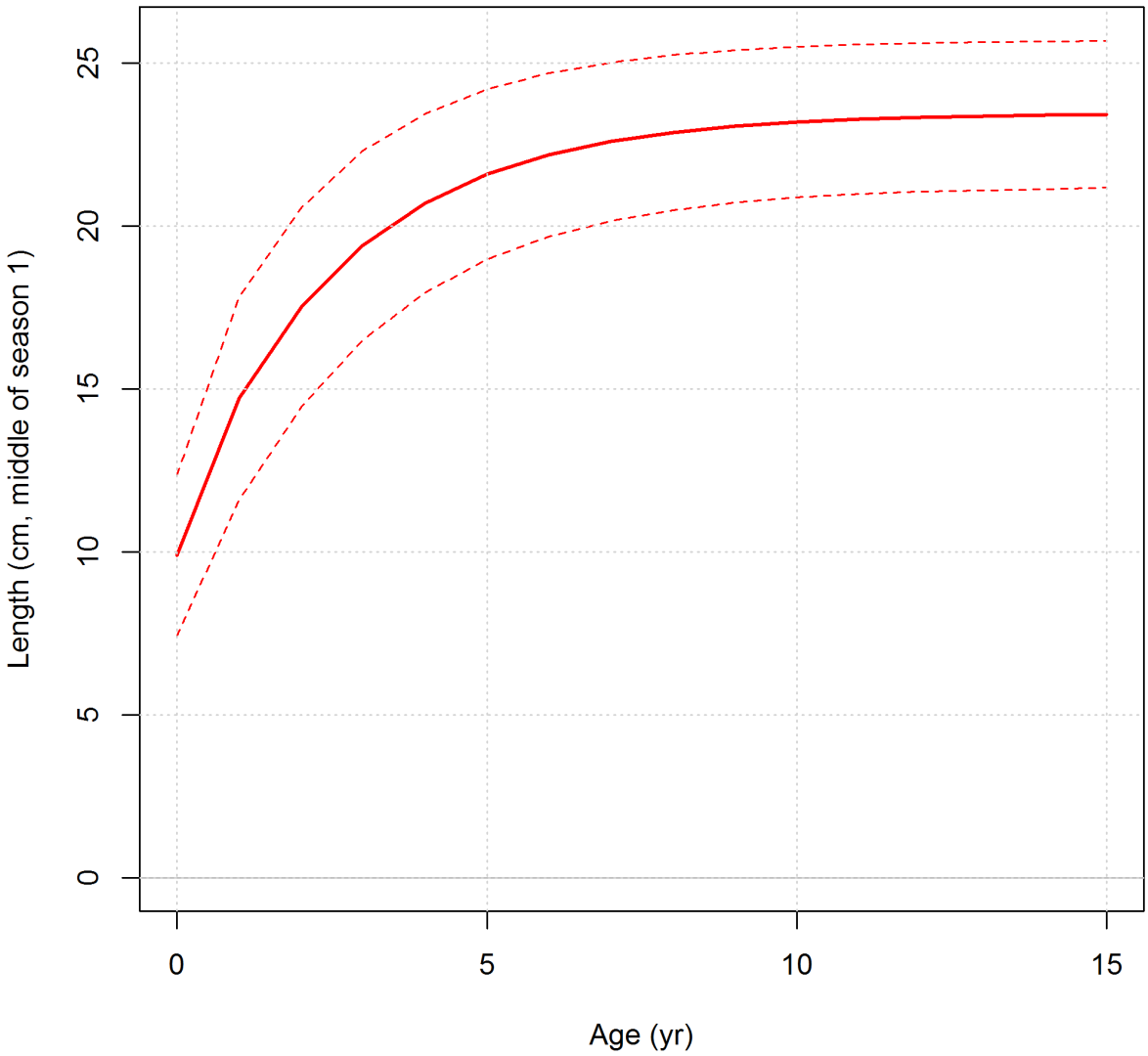
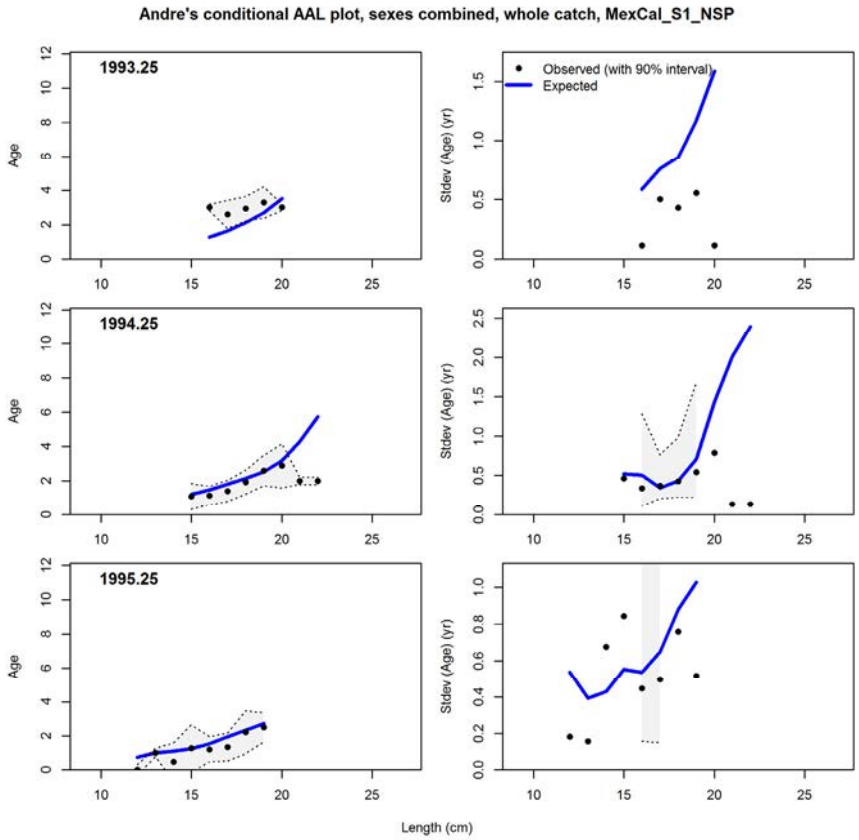


Figure 22. Length-at-age relationship estimated in base model T ($L_{0.5yr}$ = 11.7754 (0.0491), L_{∞} = 23.4636 (0.1274), K = 0.3855).



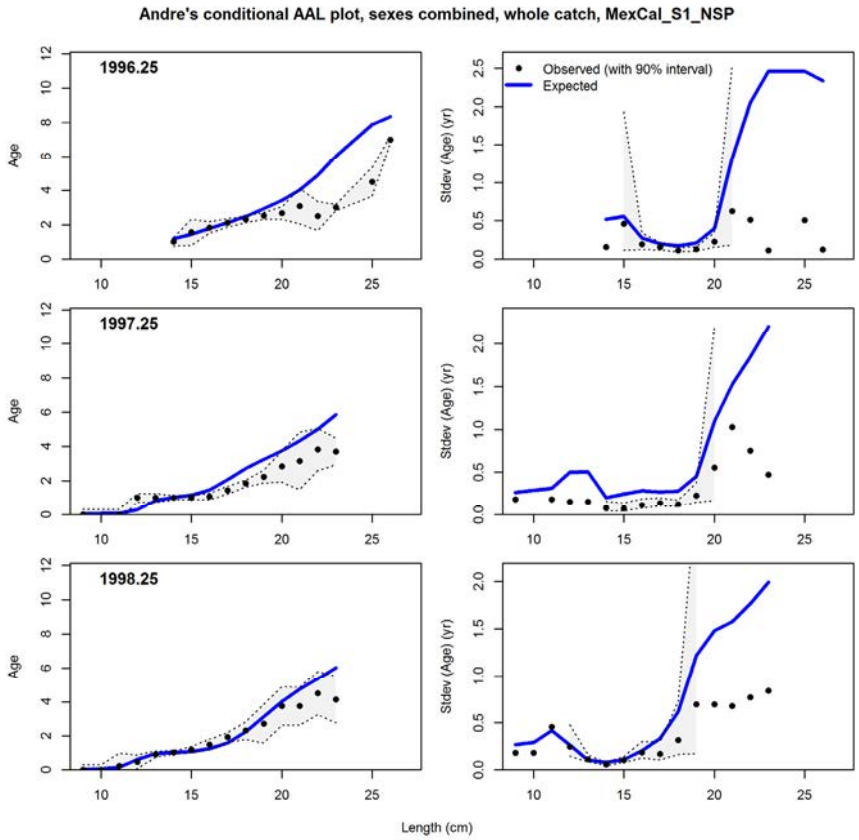
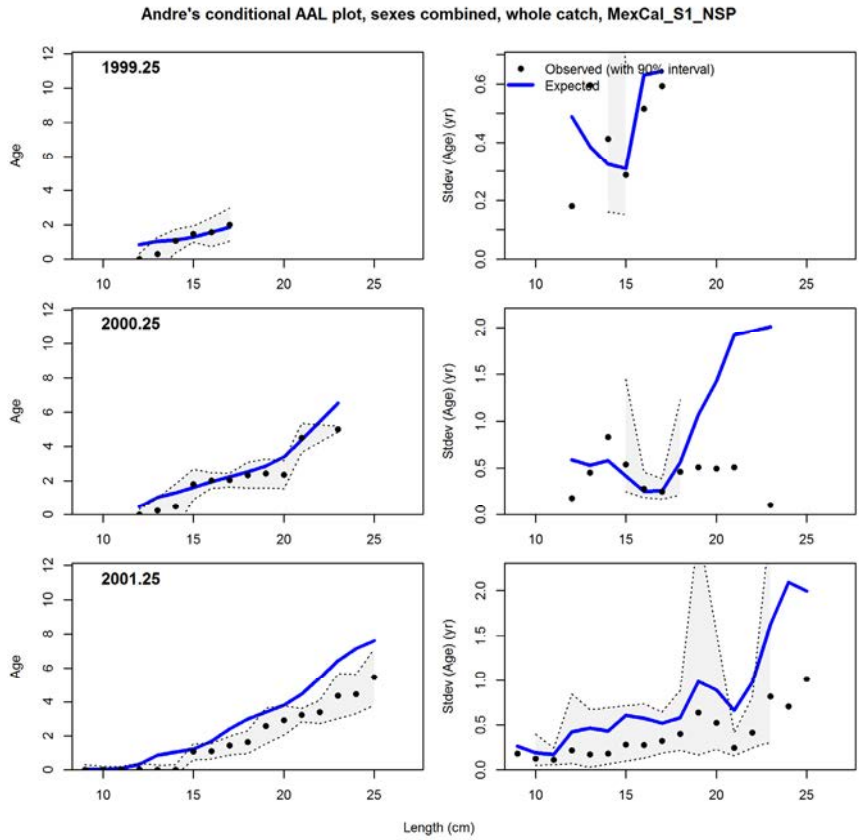


Figure 23. Model T fit to conditional age-at-length compositions for the MexCal_S1 fleet.



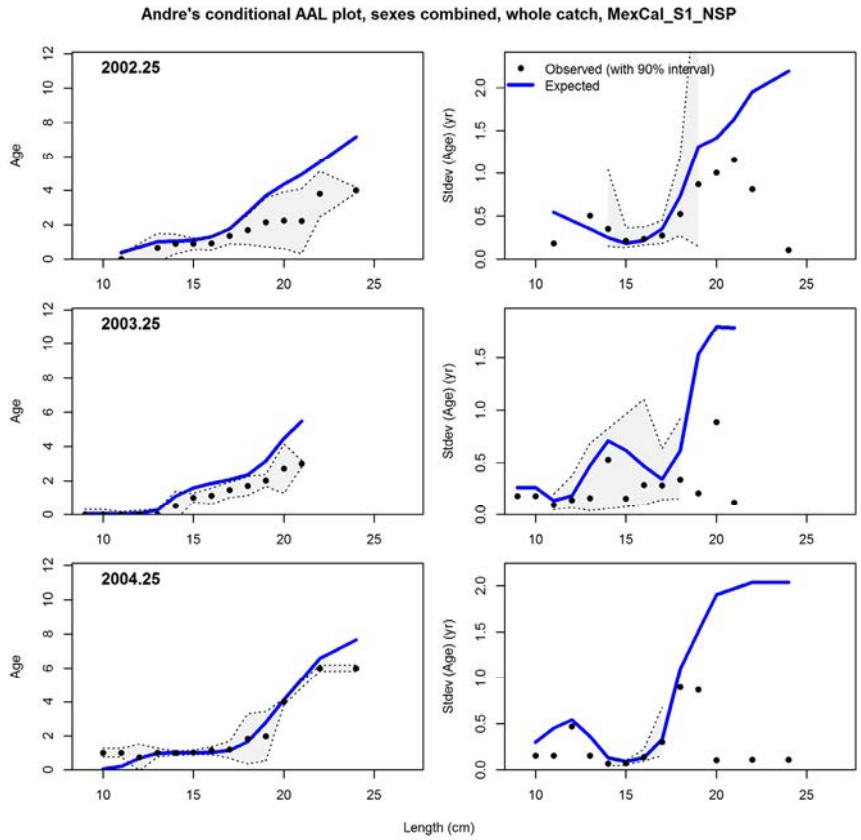
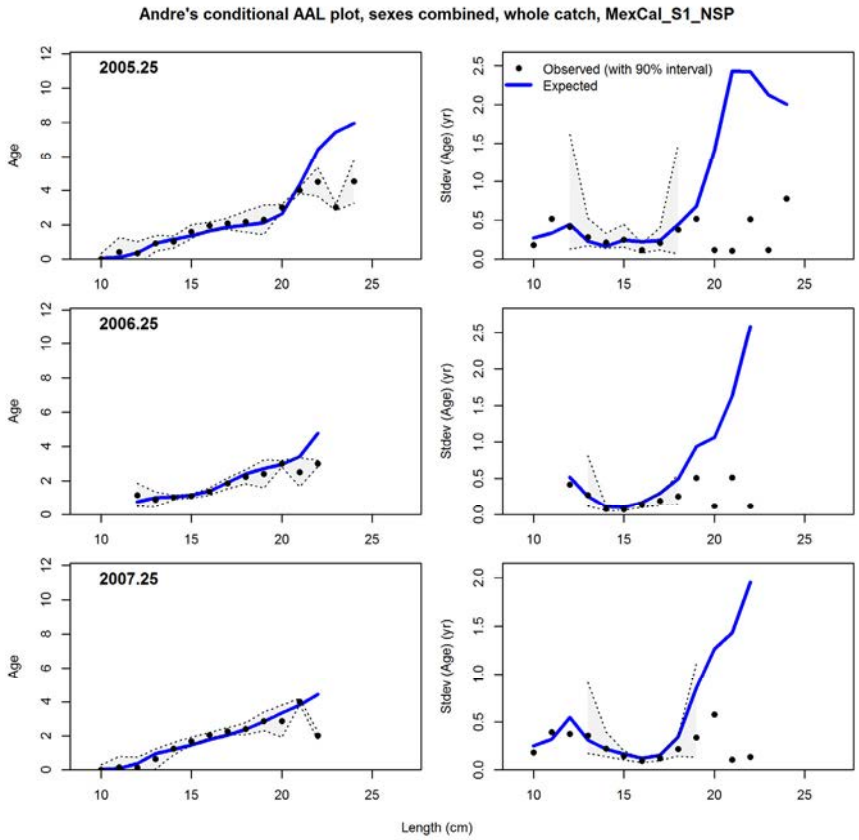


Figure 23 (cont.). Model T fit to conditional age-at-length compositions for the MexCal_S1 fleet.



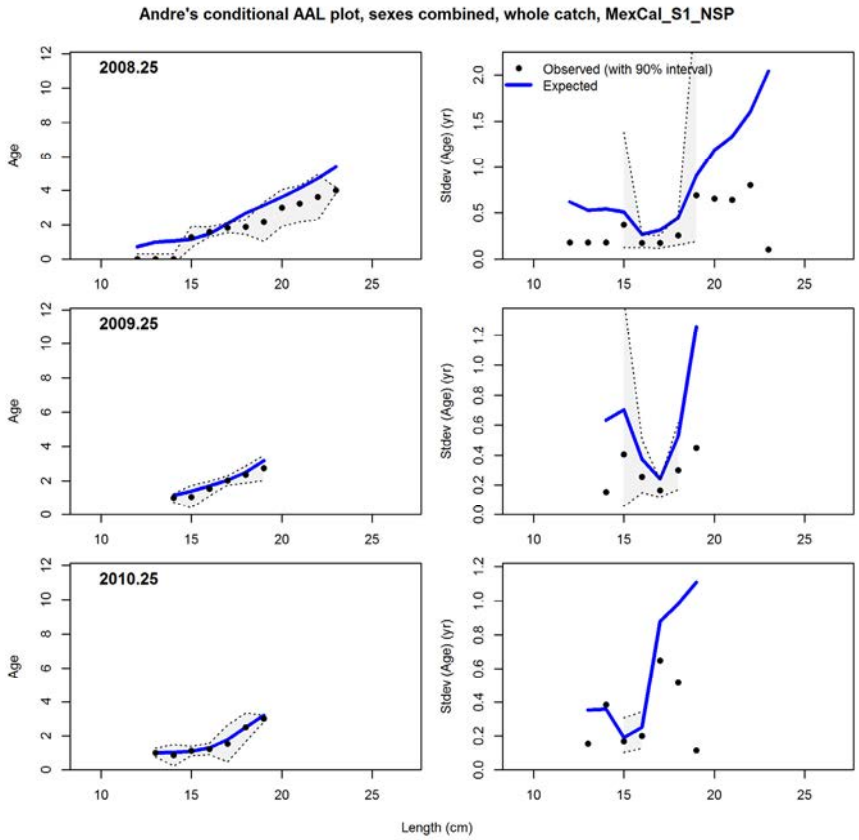


Figure 23 (cont.). Model T fit to conditional age-at-length compositions for the MexCal_S1 fleet.

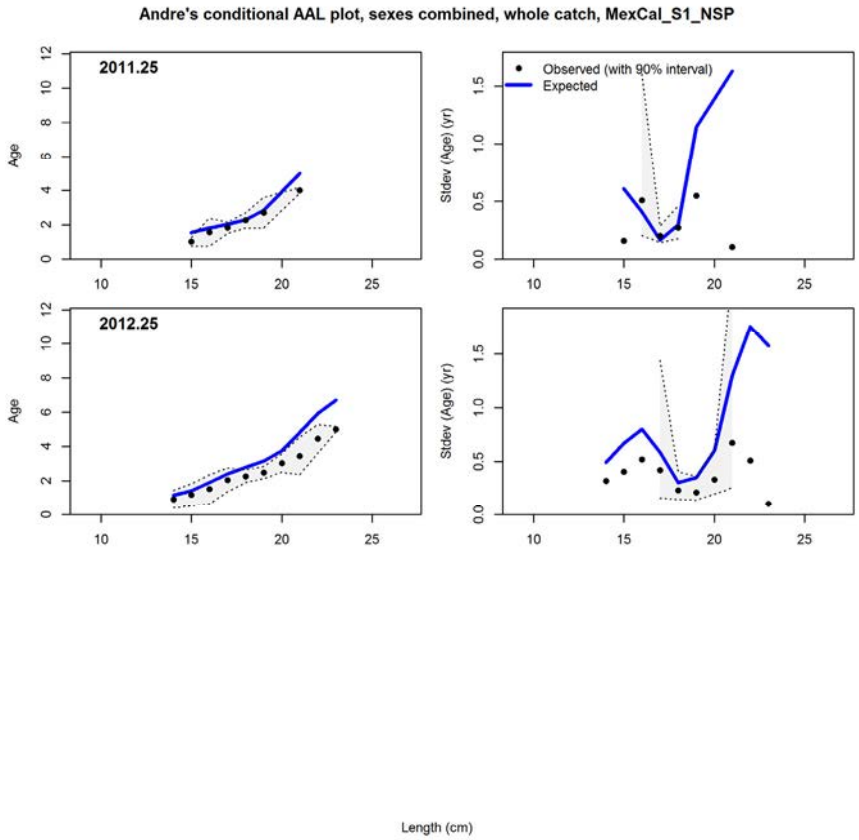
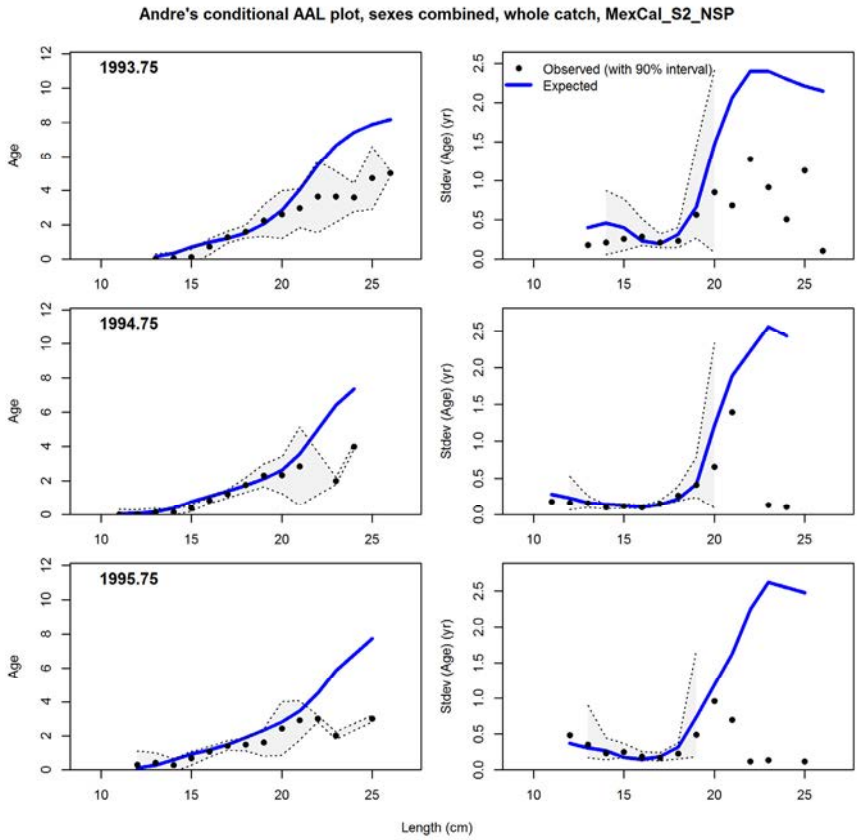


Figure 23 (cont.). Model T fit to conditional age-at-length compositions for the MexCal_S1 fleet.



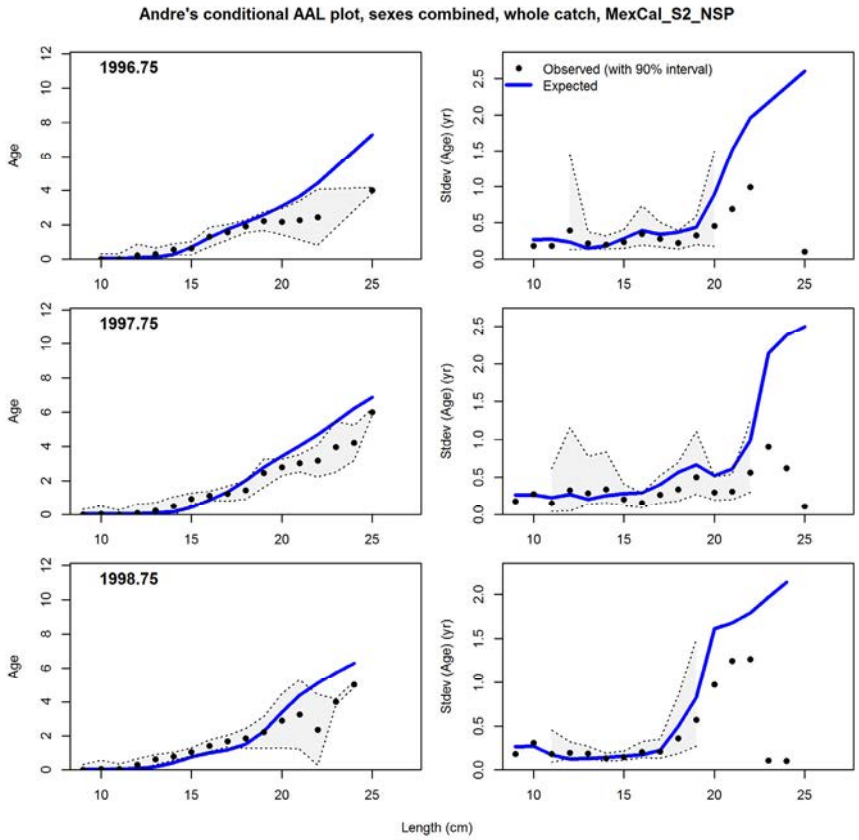
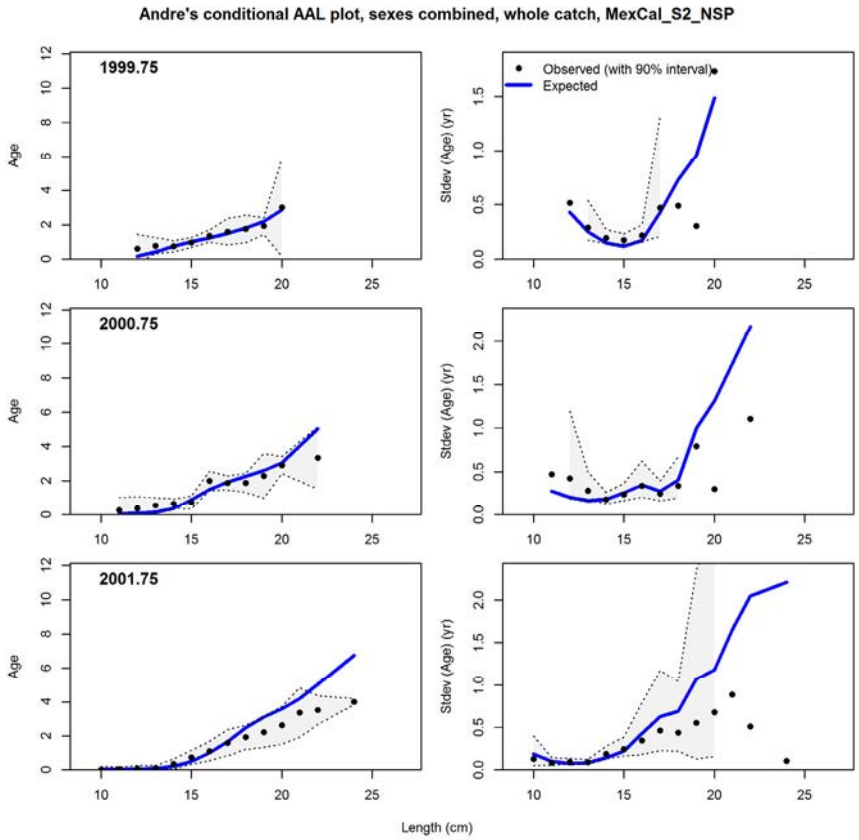


Figure 24. Model T fit to conditional age-at-length compositions for the MexCal_S2 fleet.



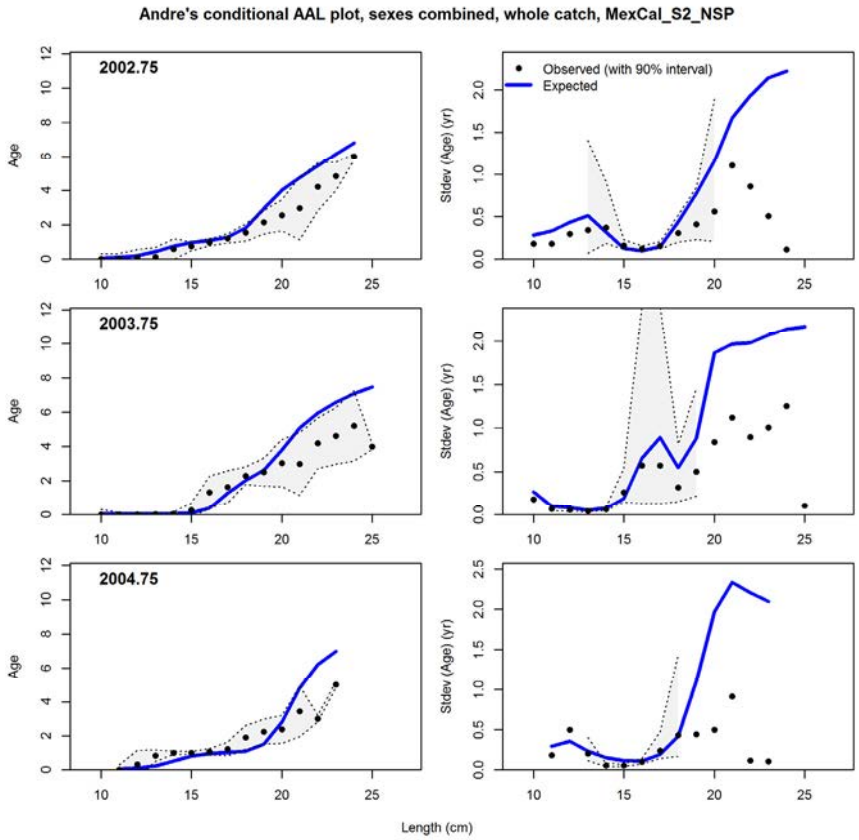
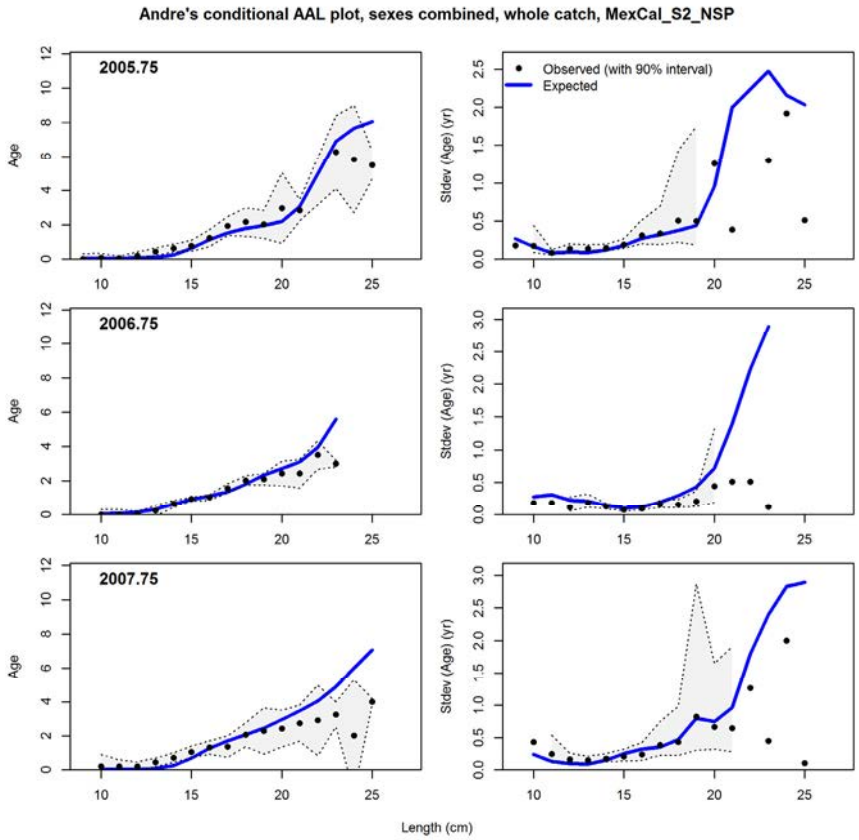


Figure 24 (cont.). Model T fit to conditional age-at-length compositions for the MexCal_S2 fleet.



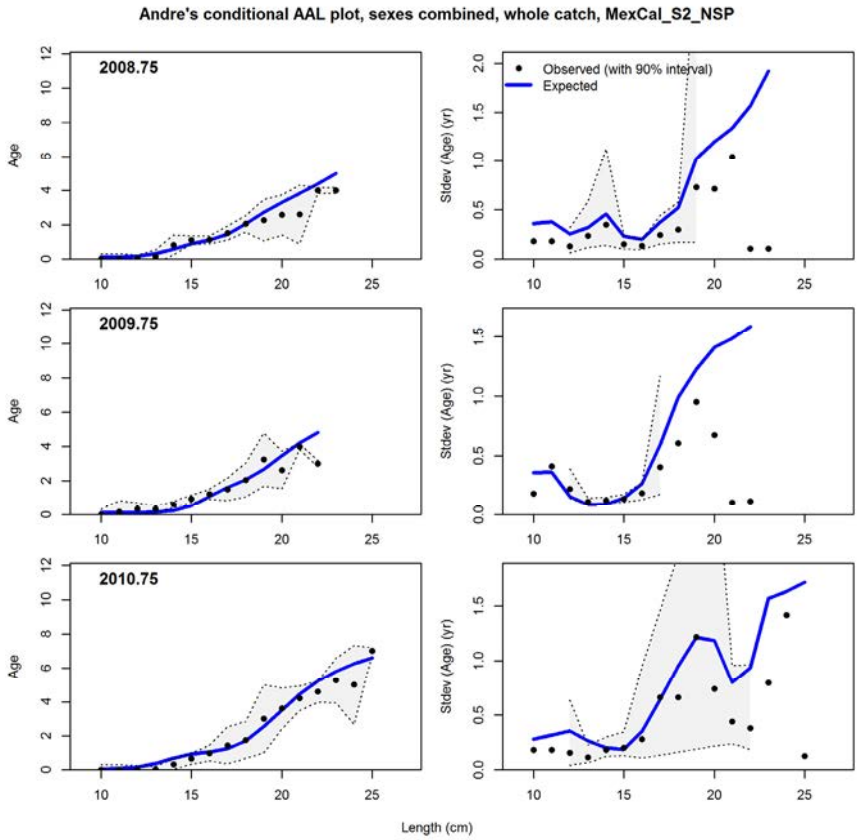


Figure 24 (cont.). Model T fit to conditional age-at-length compositions for the MexCal_S2 fleet.

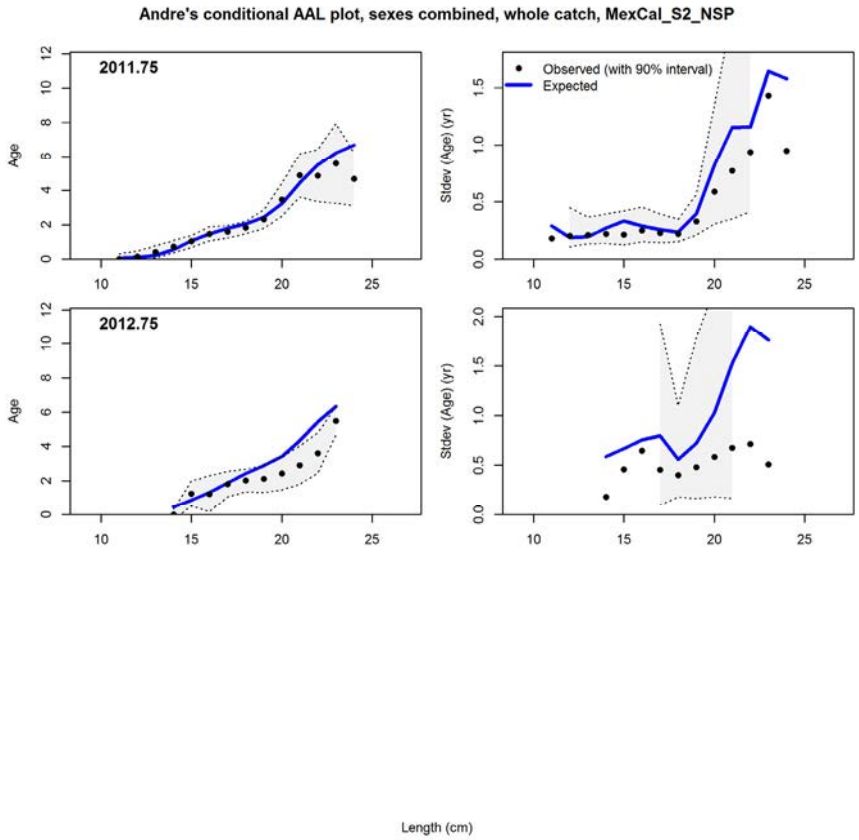
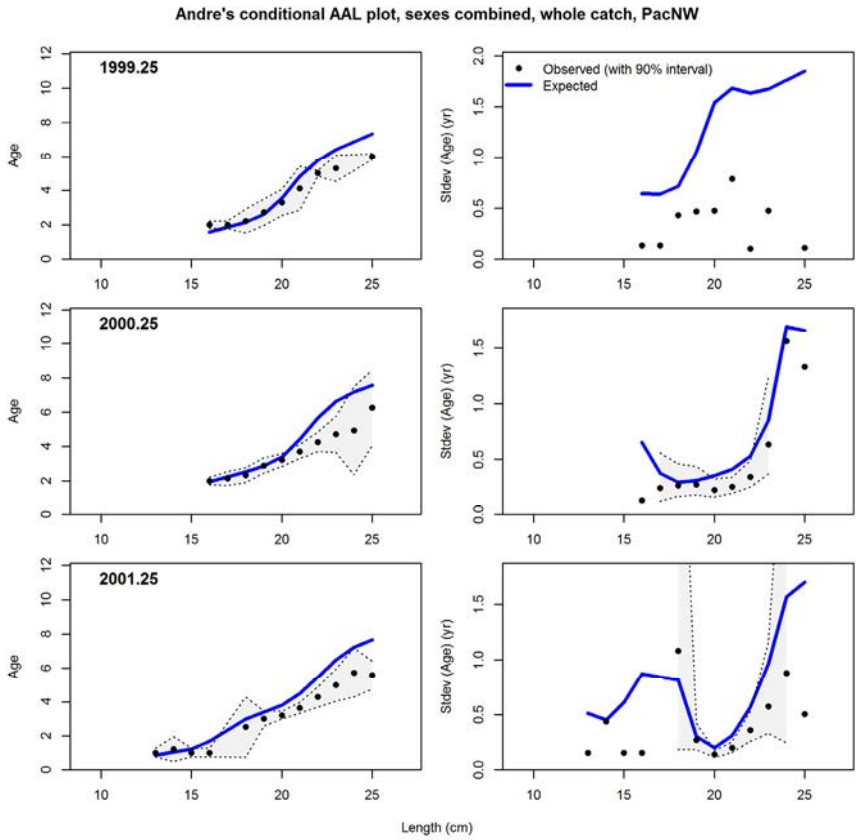


Figure 24 (cont.). Model T fit to conditional age-at-length compositions for the MexCal_S2 fleet.



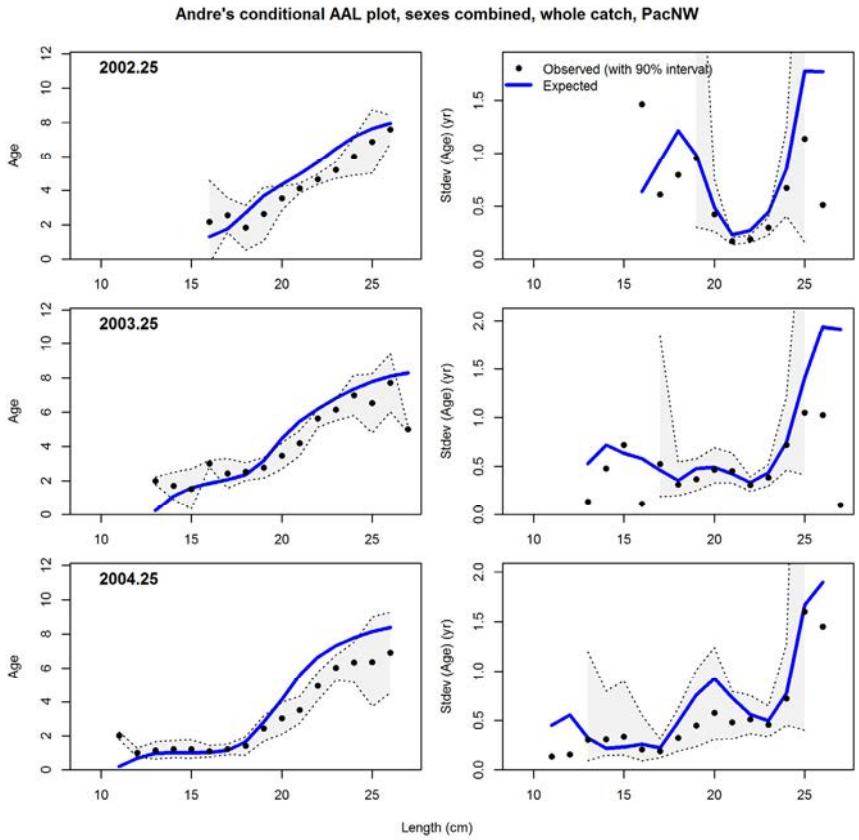
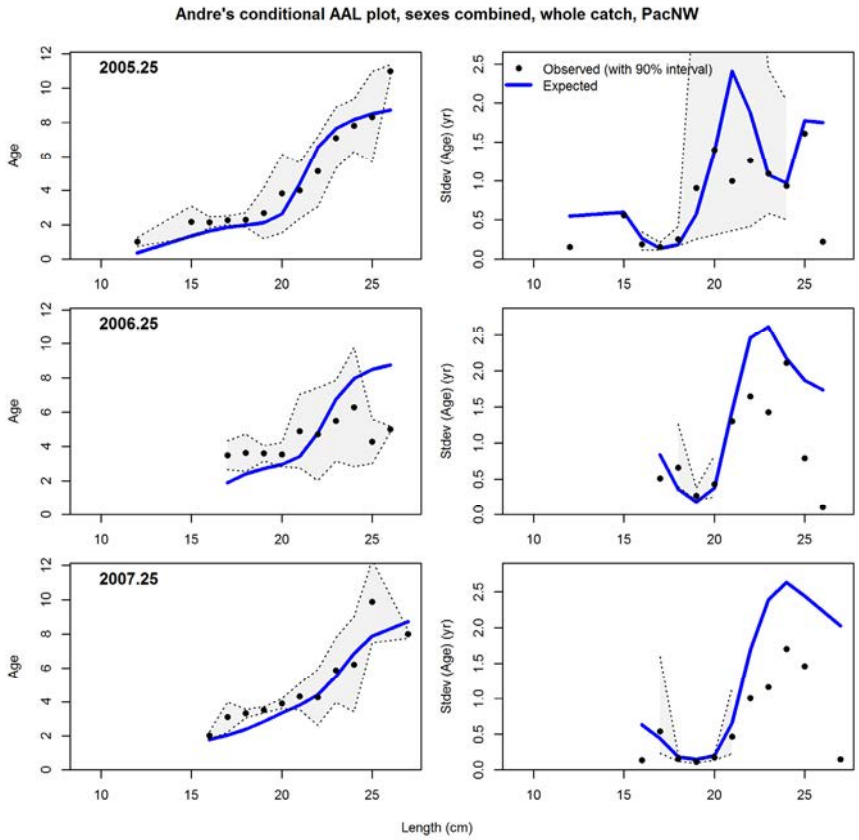


Figure 25. Model T fit to conditional age-at-length compositions for the PacNW fleet.



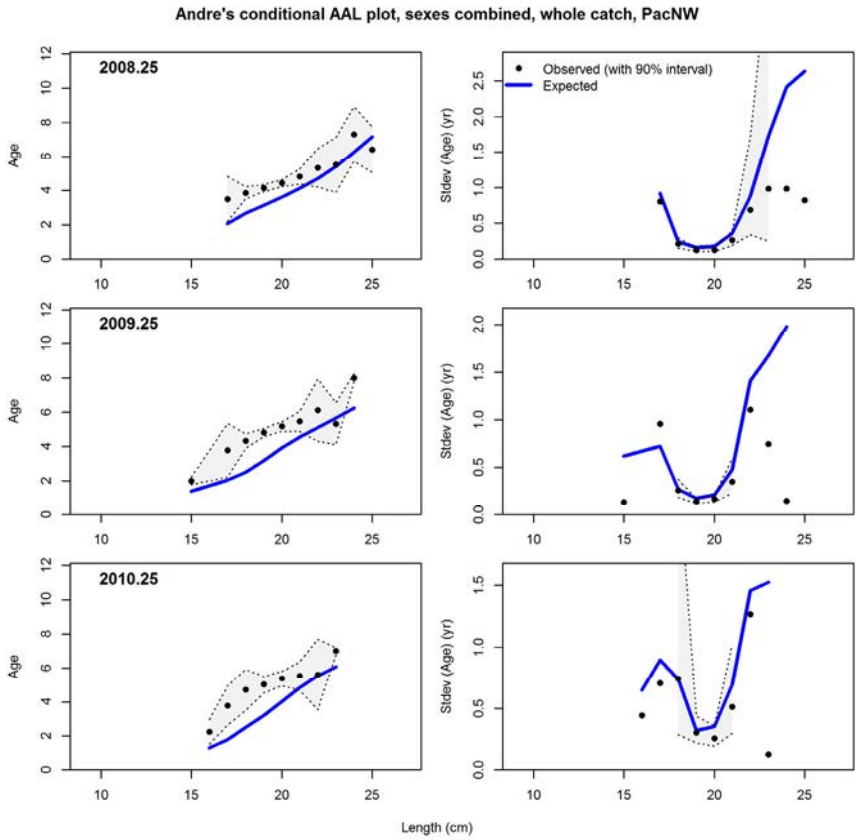


Figure 25 (cont.). Model T fit to conditional age-at-length compositions for the PacNW fleet.

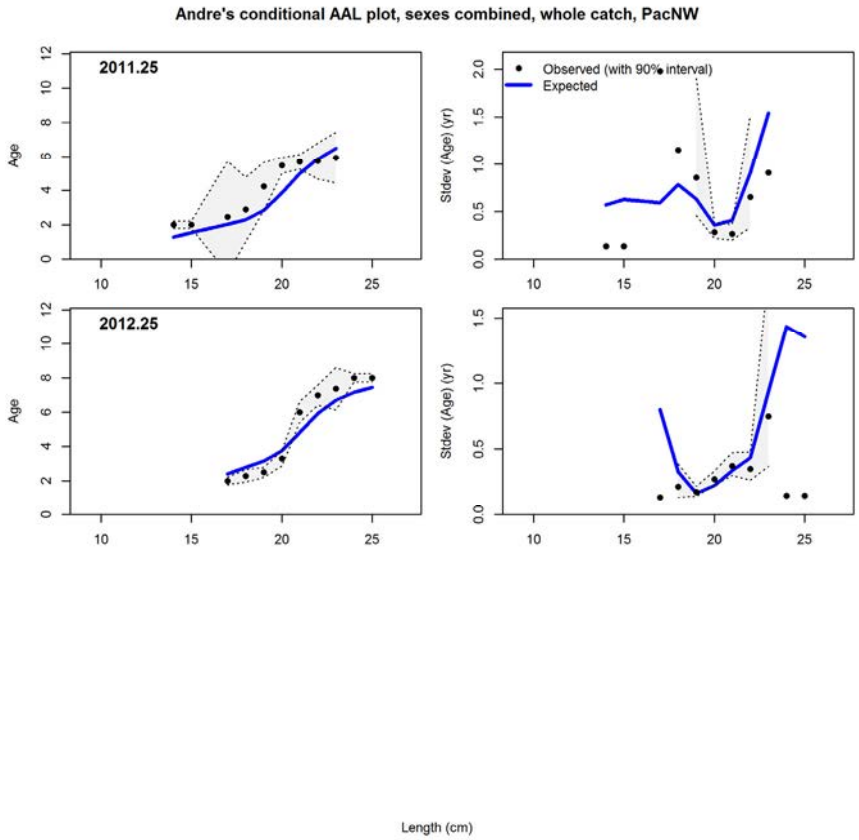


Figure 25 (cont.). Model T fit to conditional age-at-length compositions for the PacNW fleet.

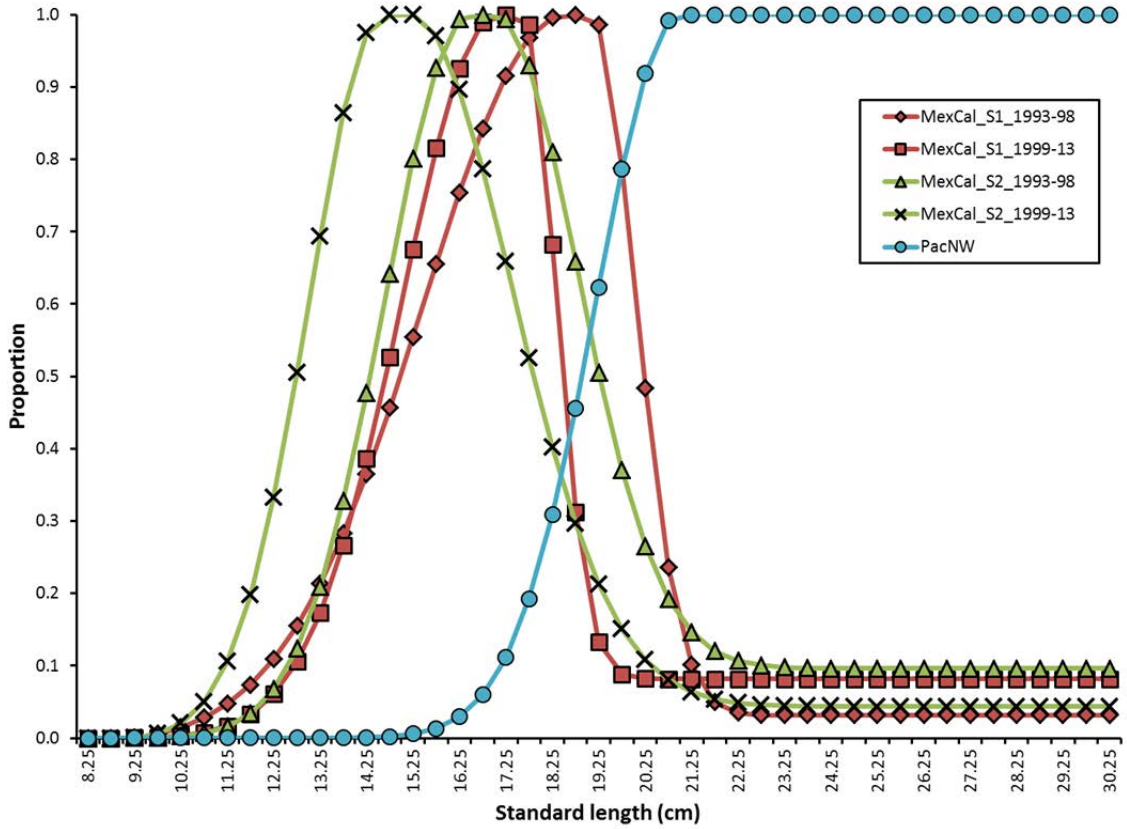


Figure 26a. Length-based selectivity patterns for fleets in base model T.

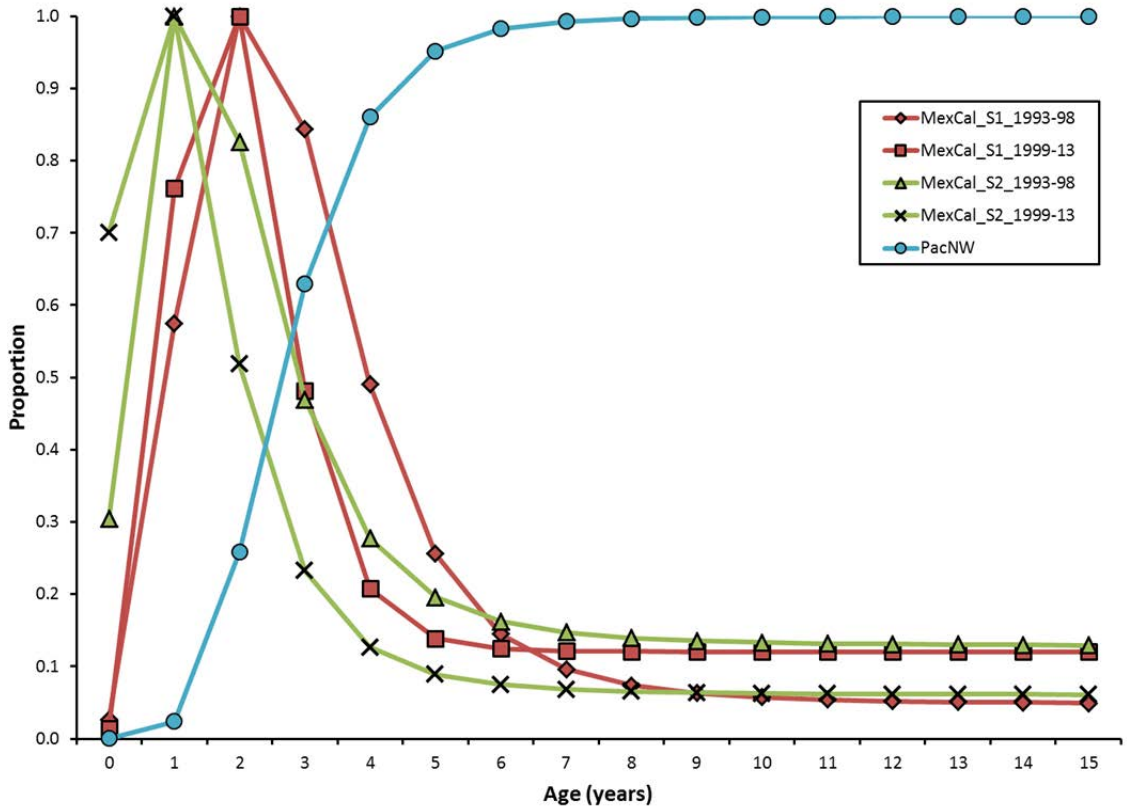


Figure 26b. Implied age-selectivity patterns for fleets in base model T.

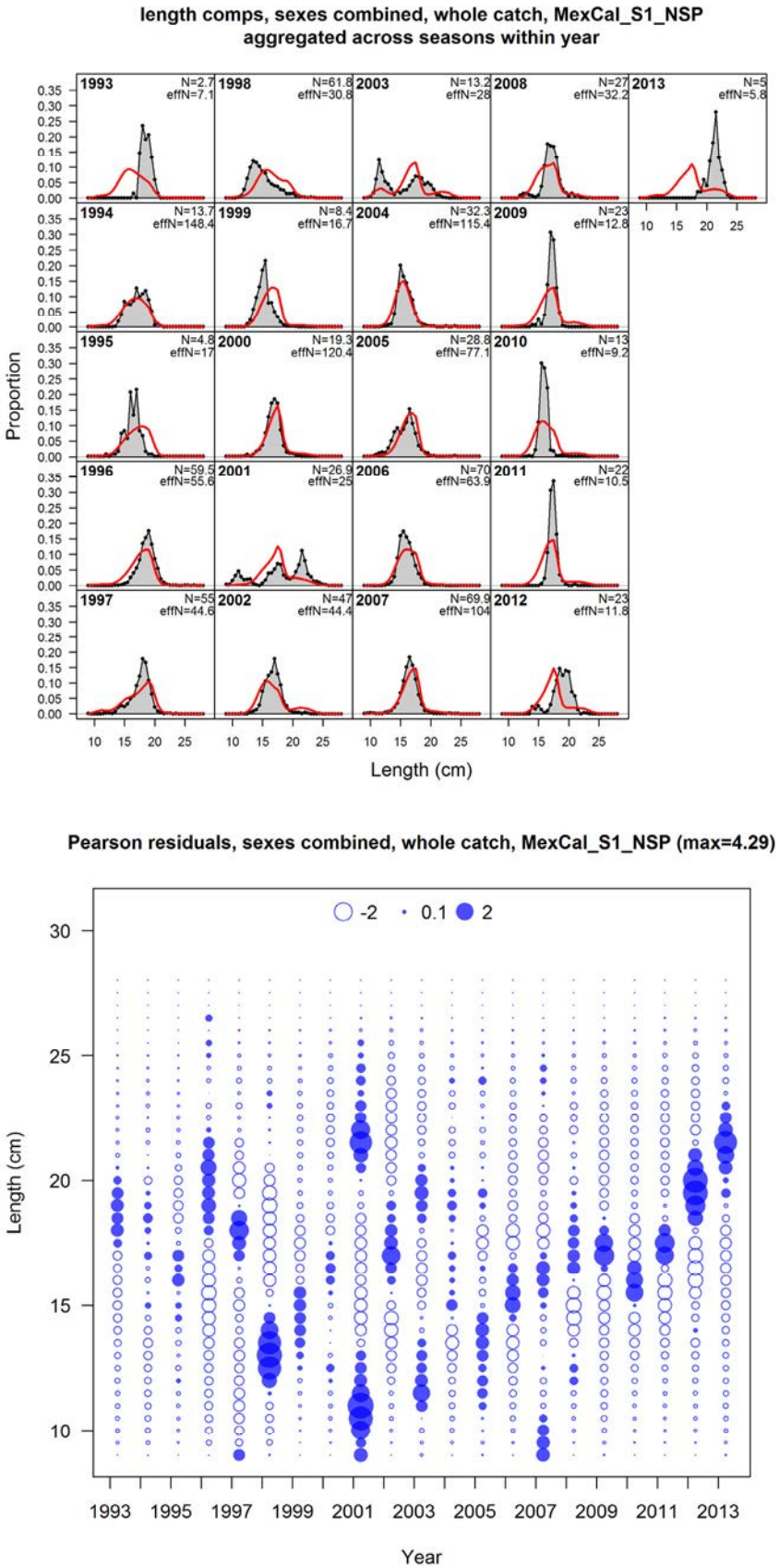


Figure 27a. Fits to length compositions and associated residual plot for MexCal_S1 fishery for base model T.

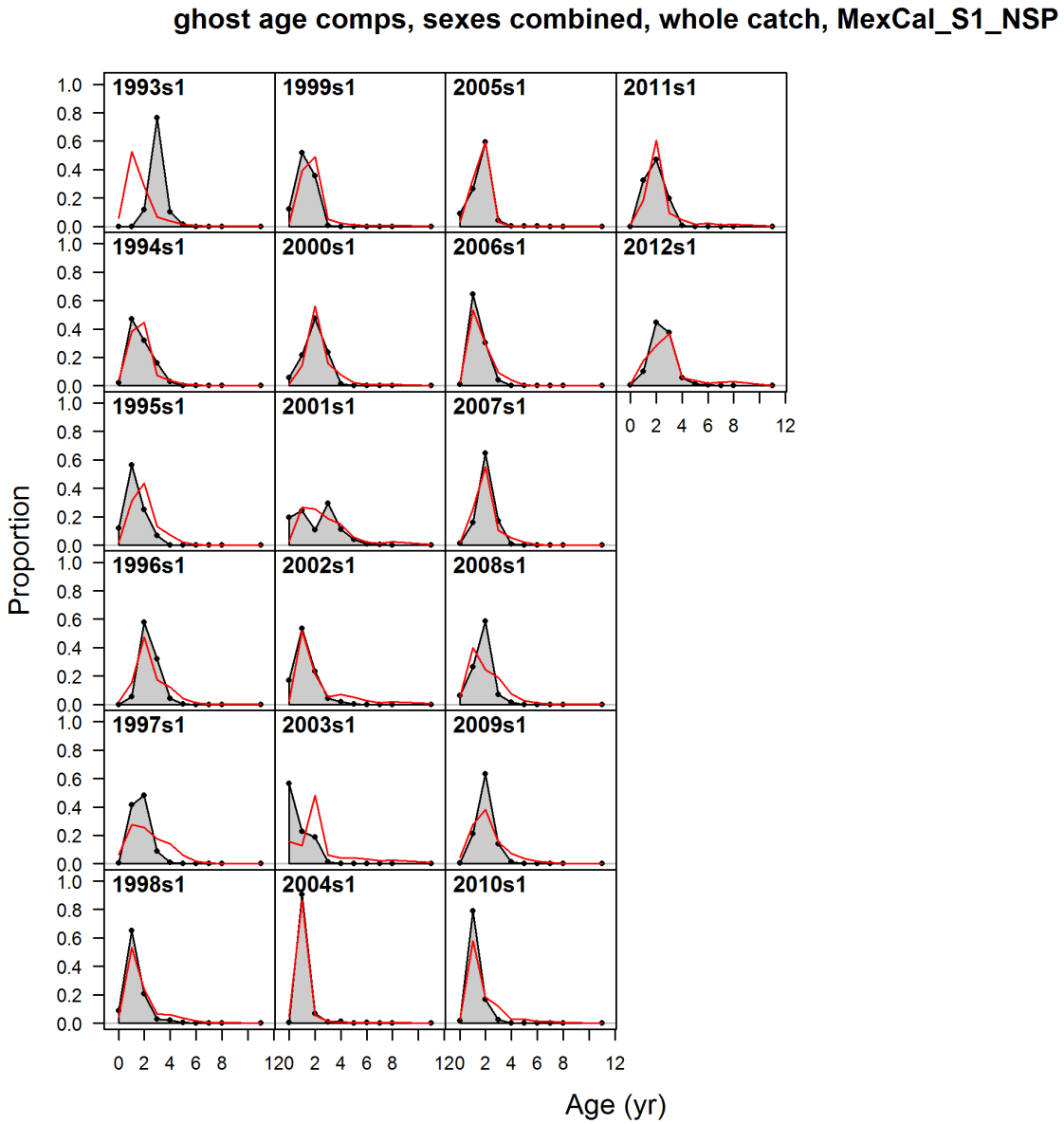


Figure 27b. Fits to implied age compositions for MexCal_S1 fleet in base model T.

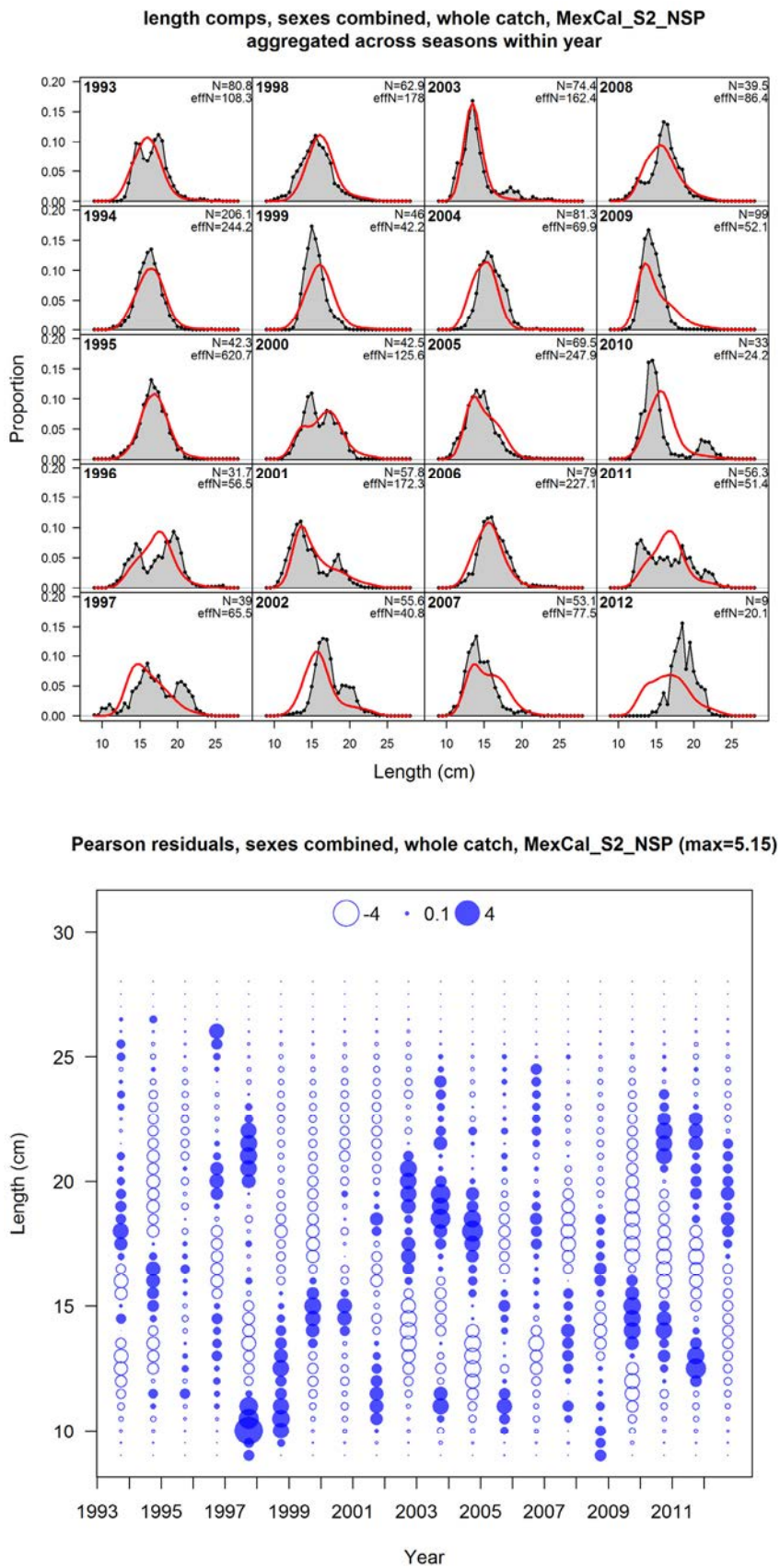


Figure 28a. Fits to length compositions and associated residual plot for MexCal_S2 fleet for base model T.

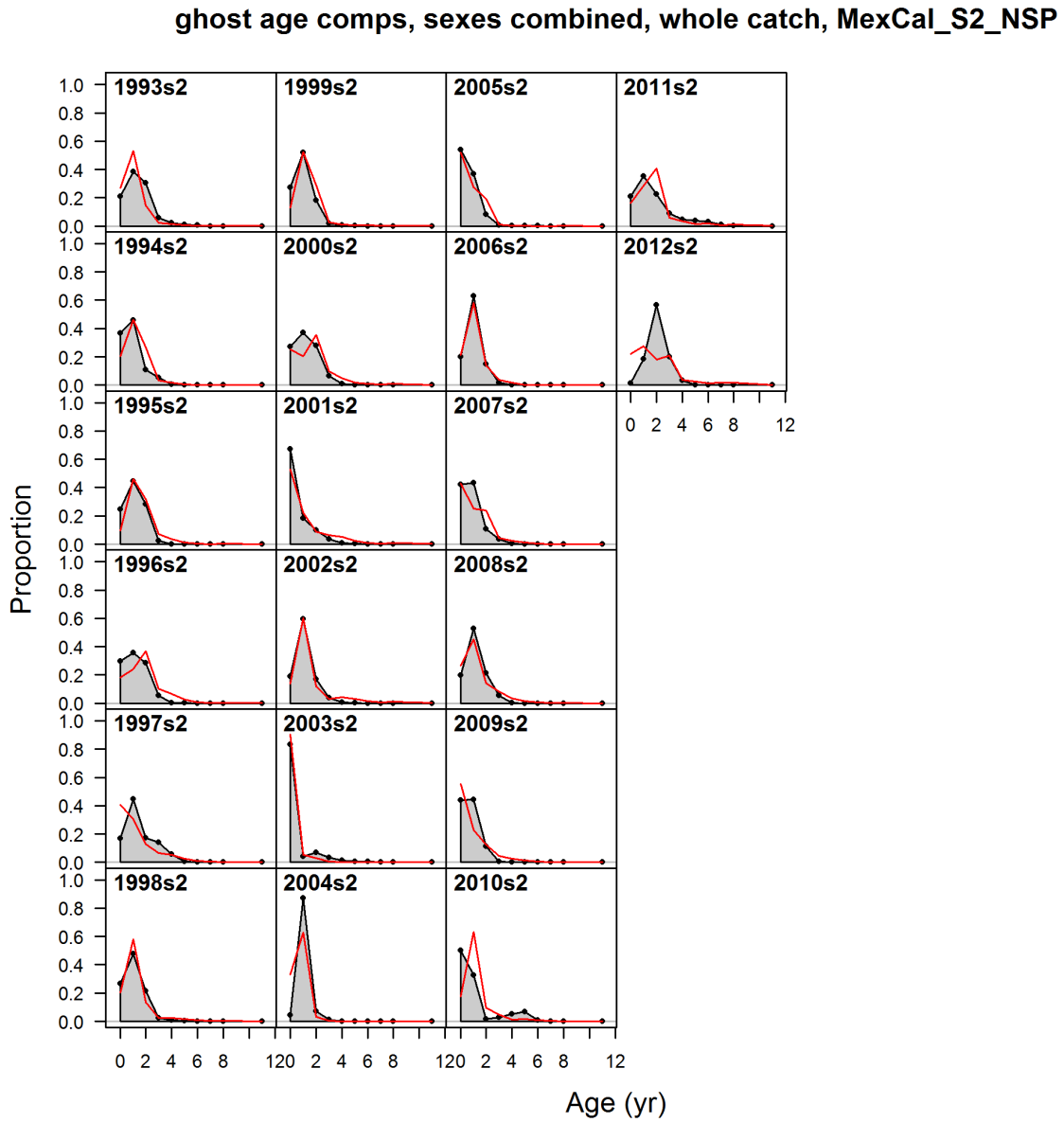


Figure 28b. Fits to implied age-compositions for MexCal_S2 fleet for base model T.

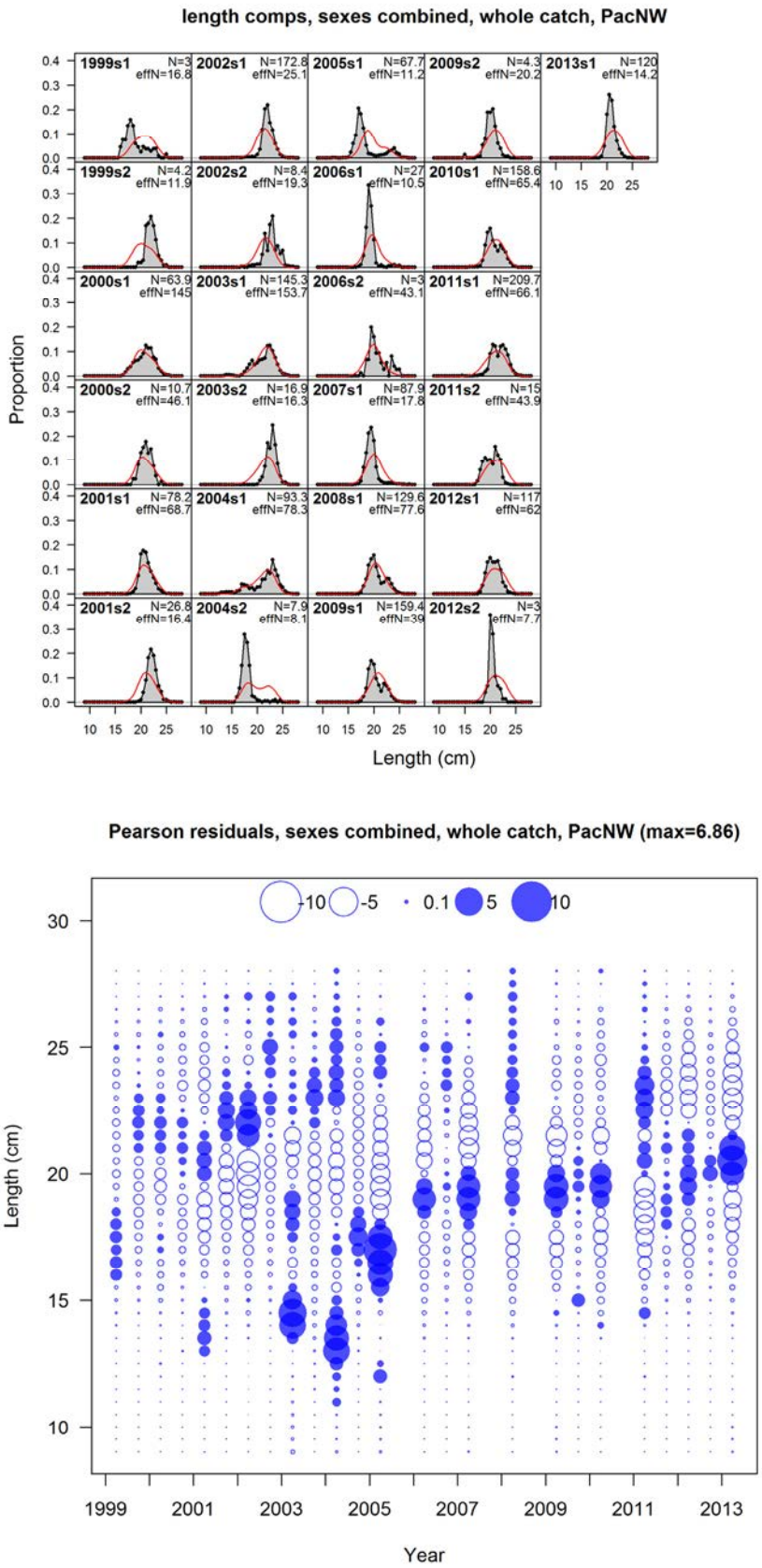


Figure 29a. Fits to length compositions and associated residual plot for PacNW fishery for base model T.

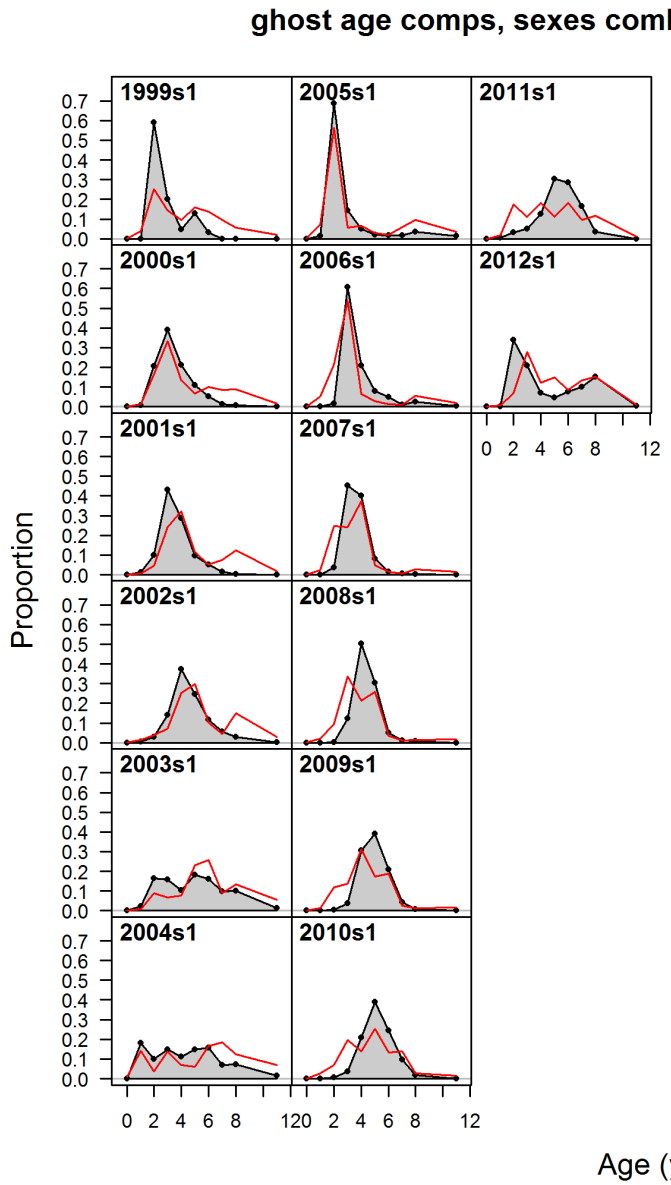


Figure 29b. Fits to implied age compositions for PacNW fishery for base model T.

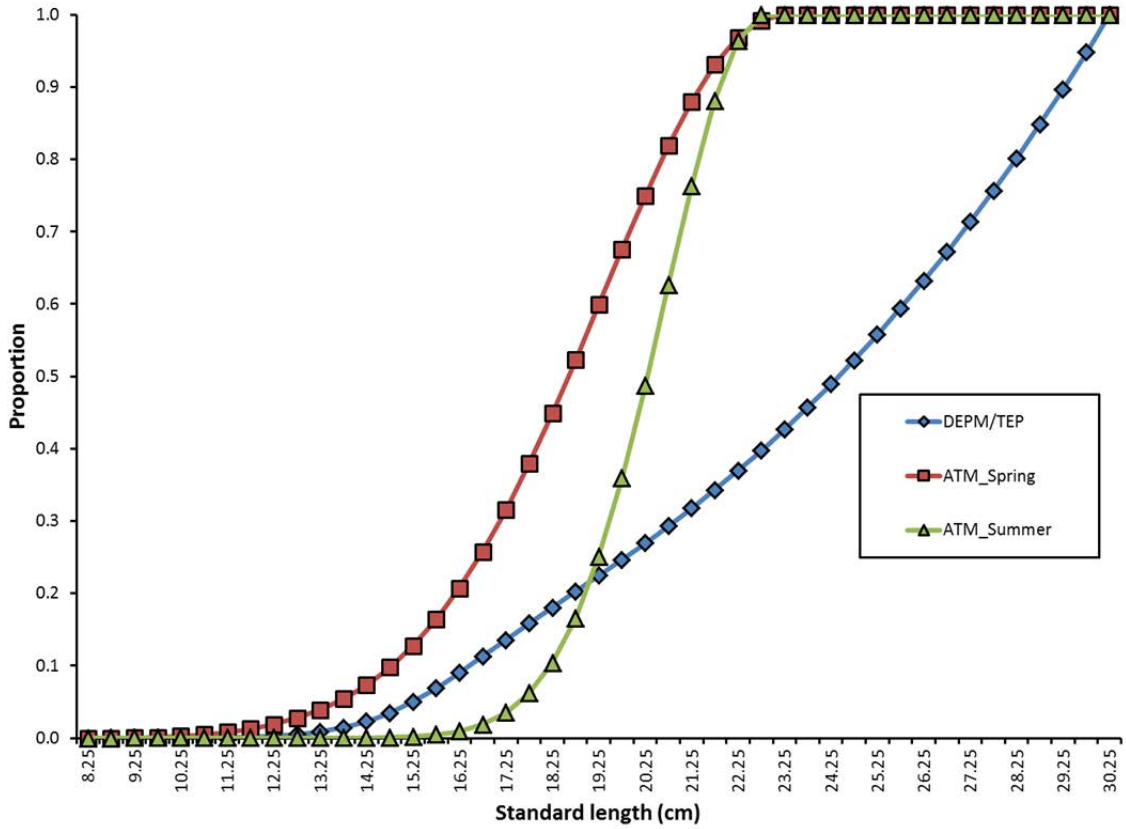


Figure 30a. Length-based selectivity patterns for surveys in base model T.

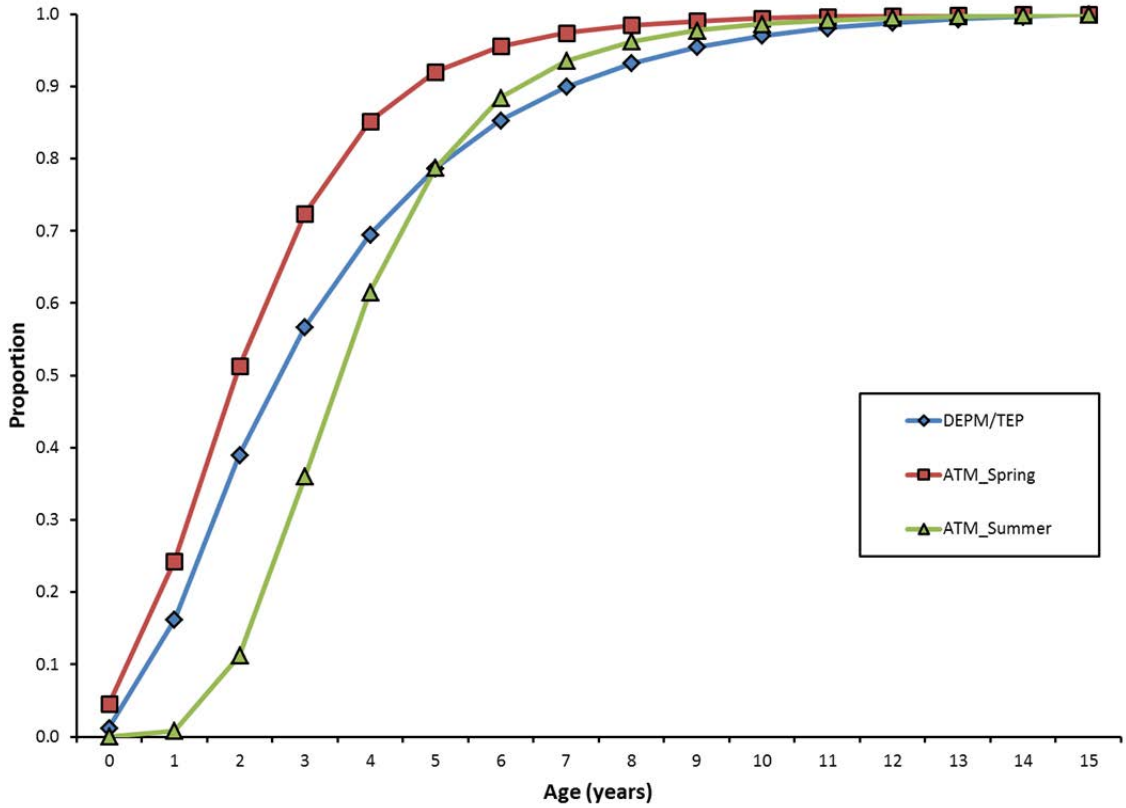


Figure 30b. Implied age-selectivity patterns for surveys in base model T.

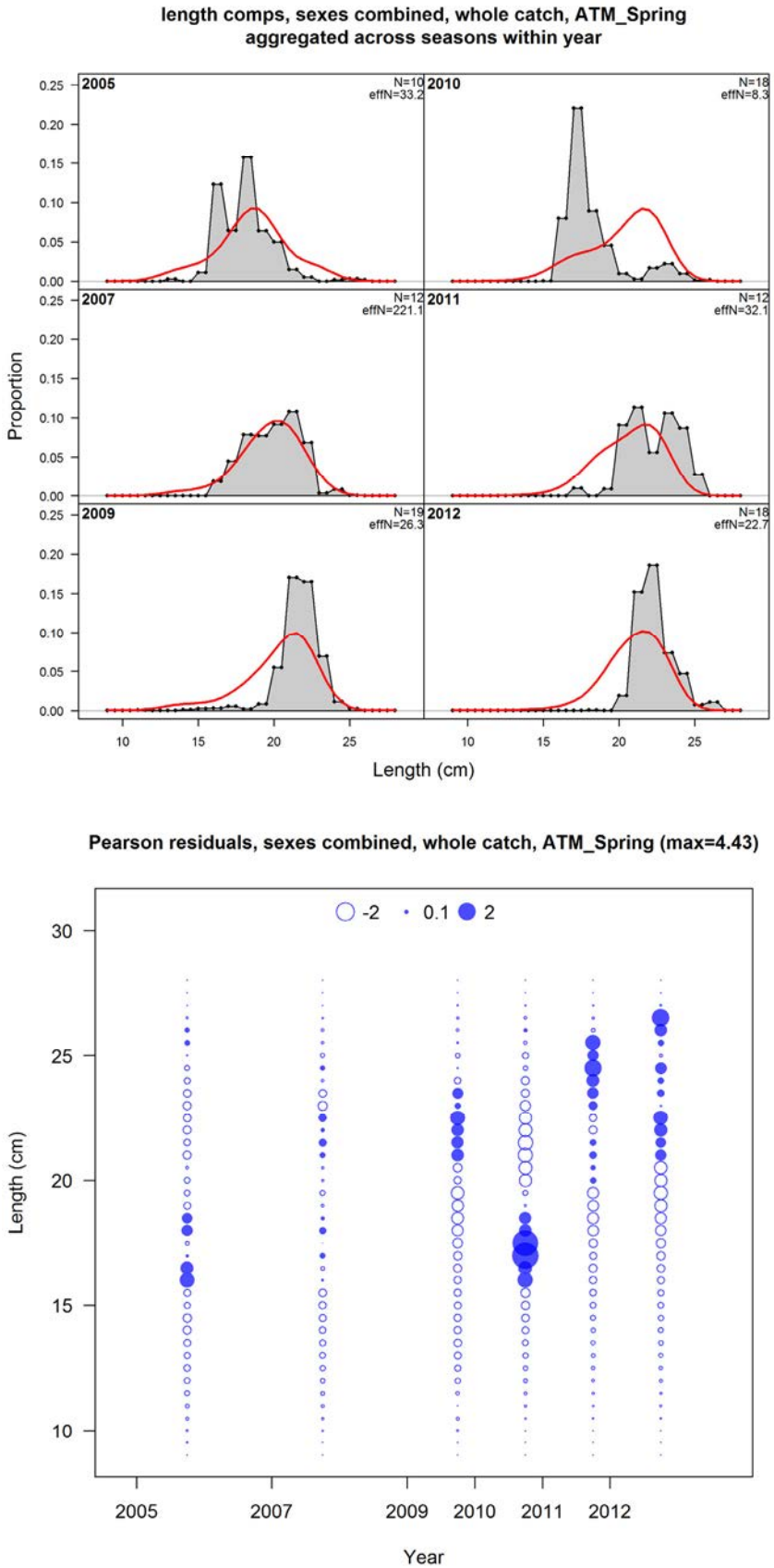


Figure 31. Fits to length compositions and associated residual plot for the Spring ATM survey for base model T.

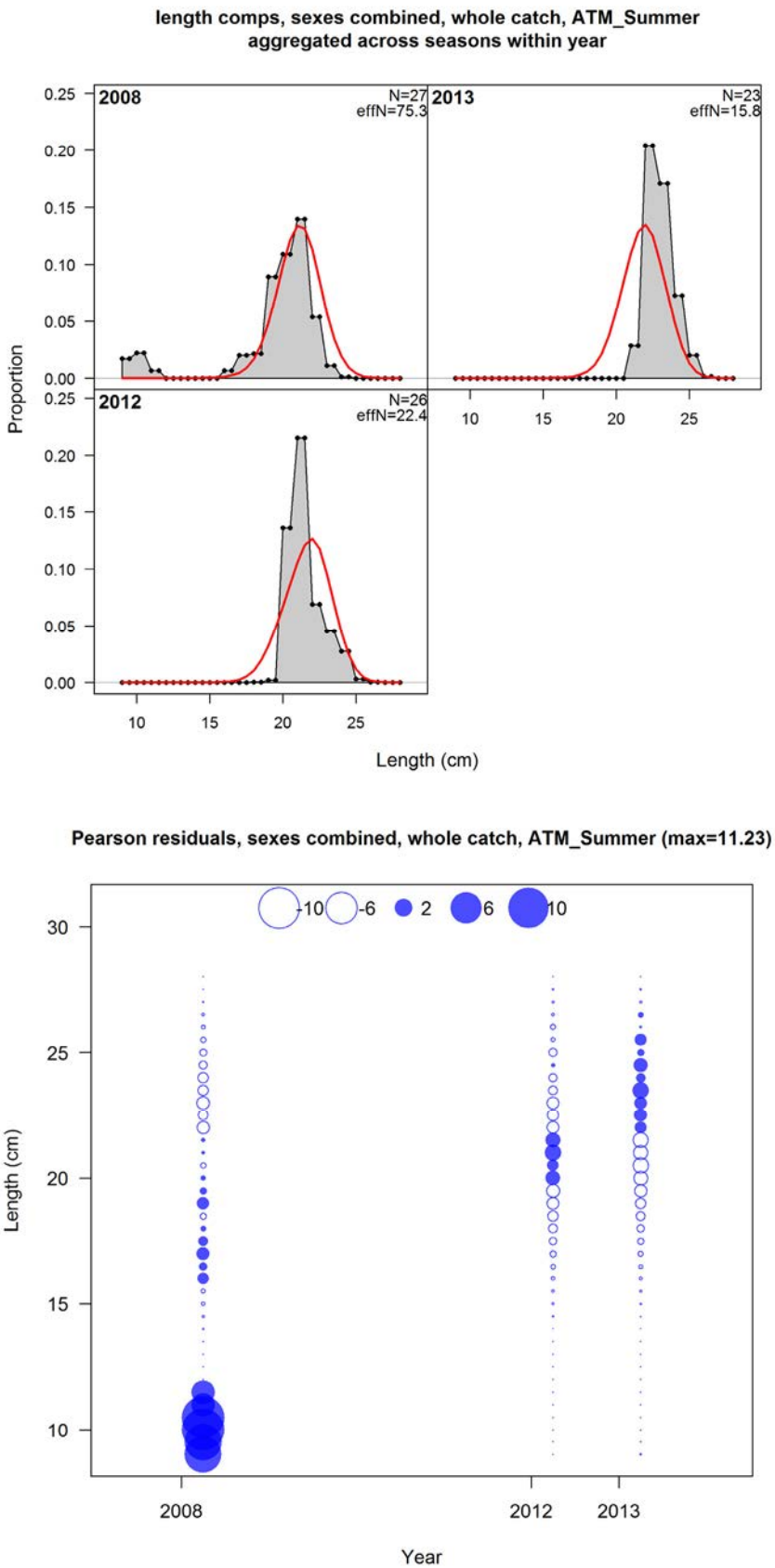
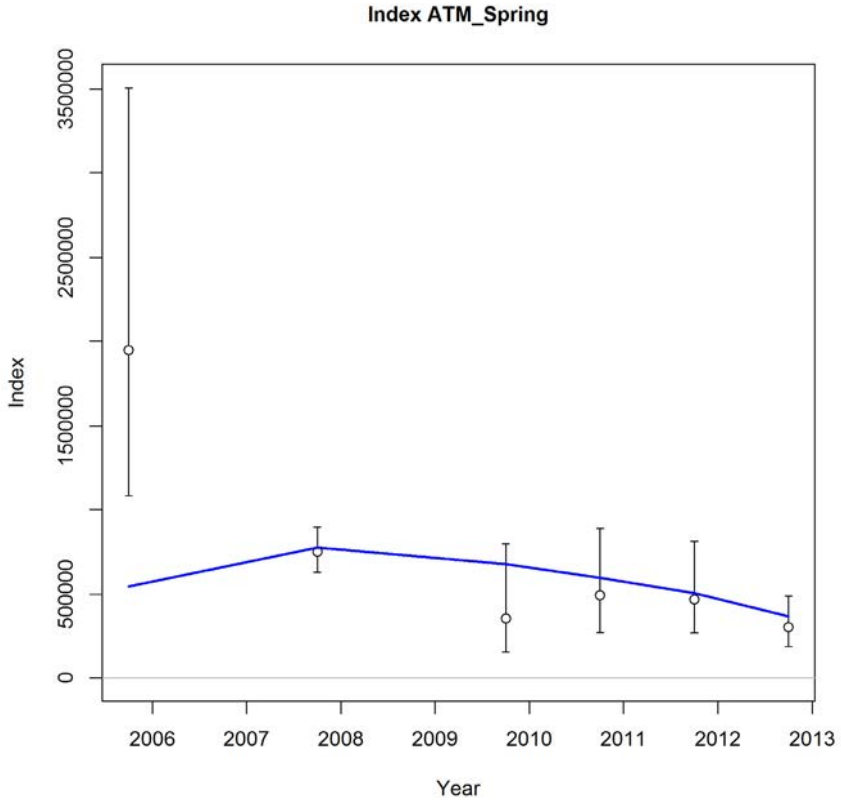


Figure 32. Fits to length compositions and associated residual plot for the Summer ATM survey for base model T.



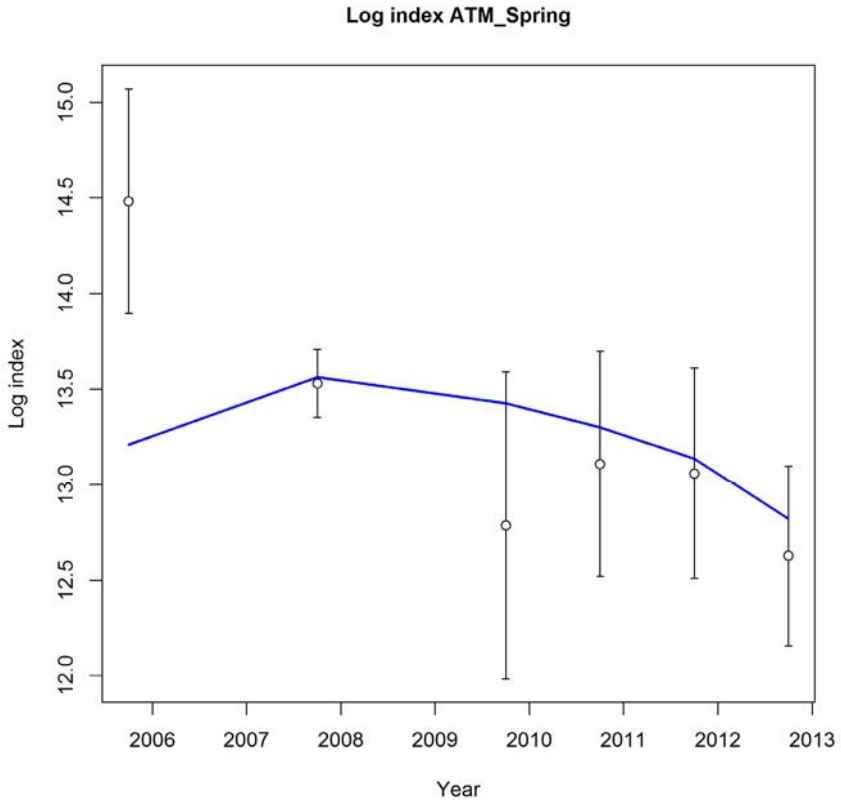
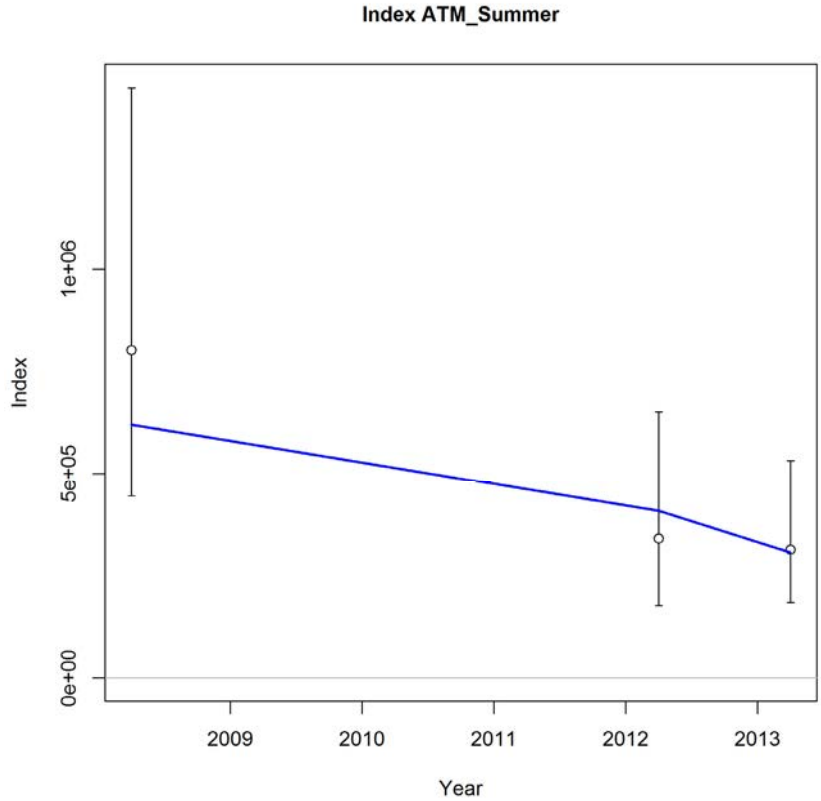


Figure 33. Fits to Spring ATM survey abundance index for base model T: arithmetic (upper) and log (lower) scales. *q*=1.0 (fixed).



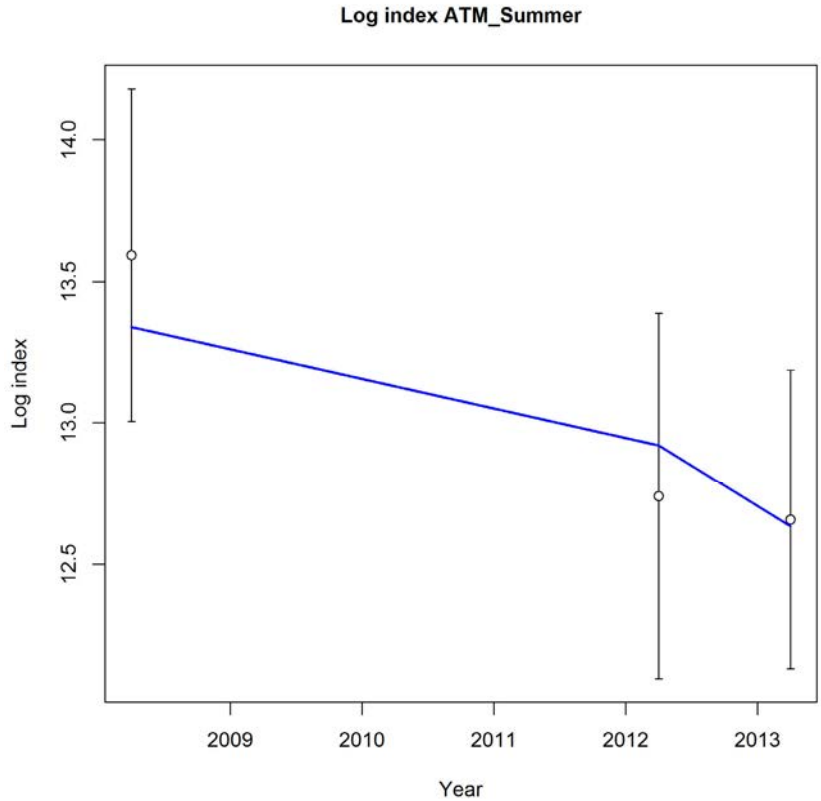
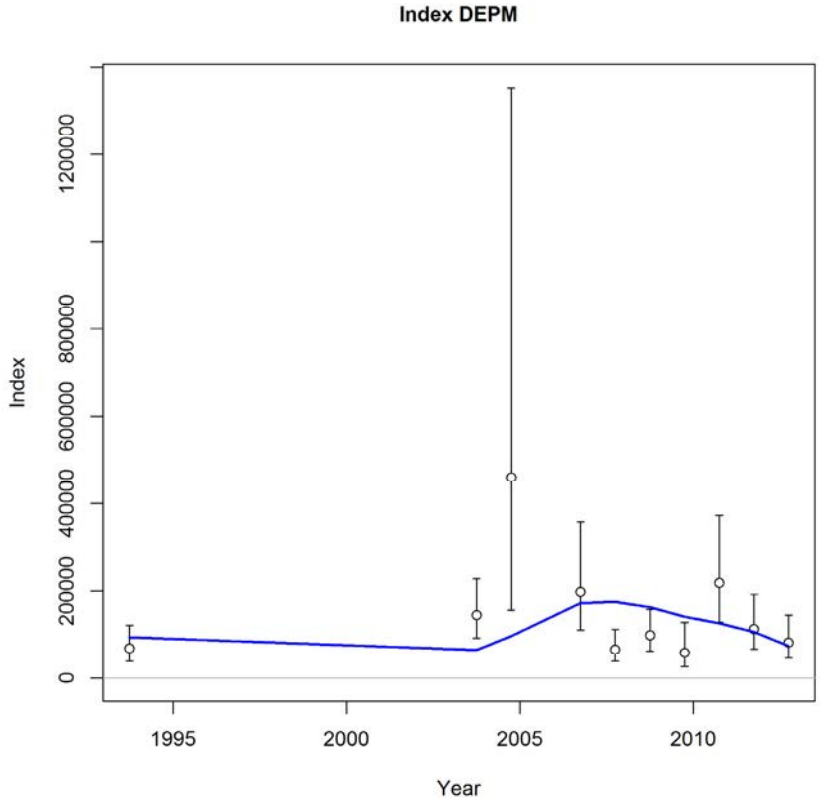


Figure 34. Fits to Summer ATM survey abundance index for base model T: arithmetic (upper) and log (lower) scales. *q*=1.0 (fixed).



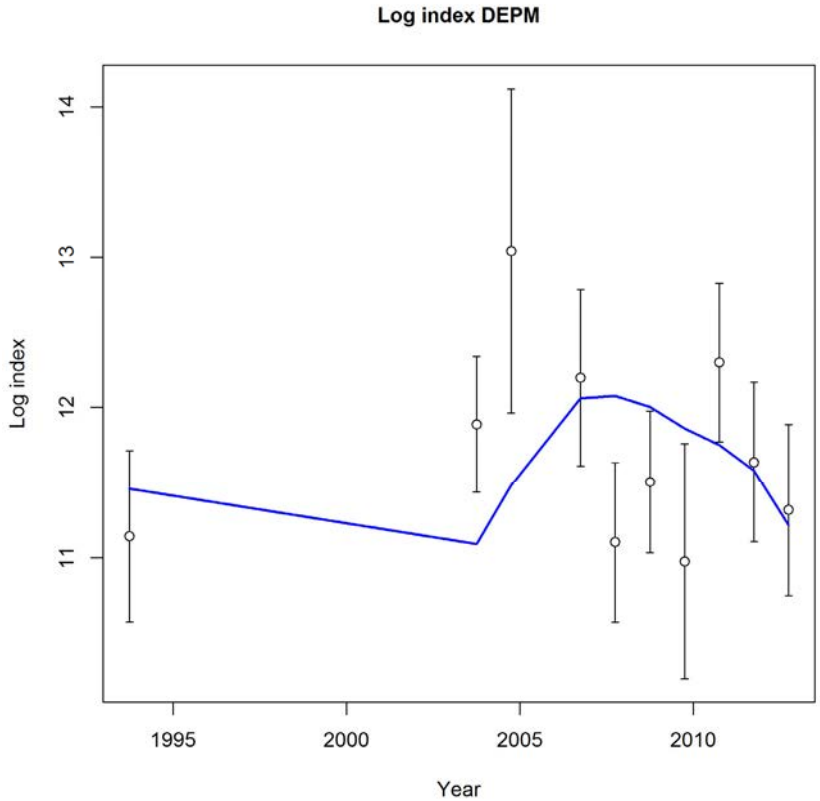


Figure 35. Fits to DEPM survey abundance index for base model T: arithmetic (upper) and log (lower) scales. *q*=0.1572.

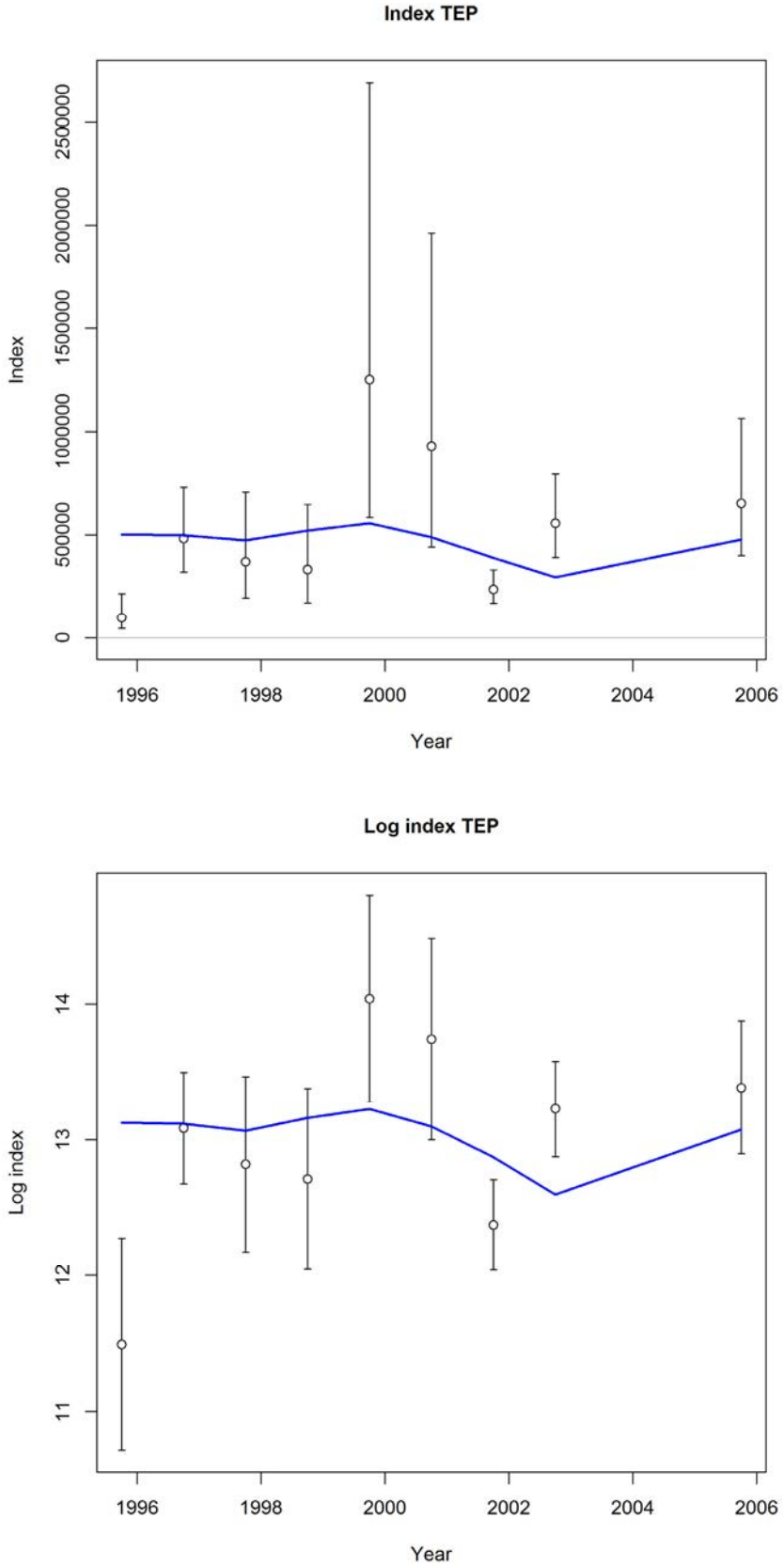


Figure 36. Fits to TEP survey abundance index for base model T: arithmetic (upper) and log (lower) scales. *q*=0.549.

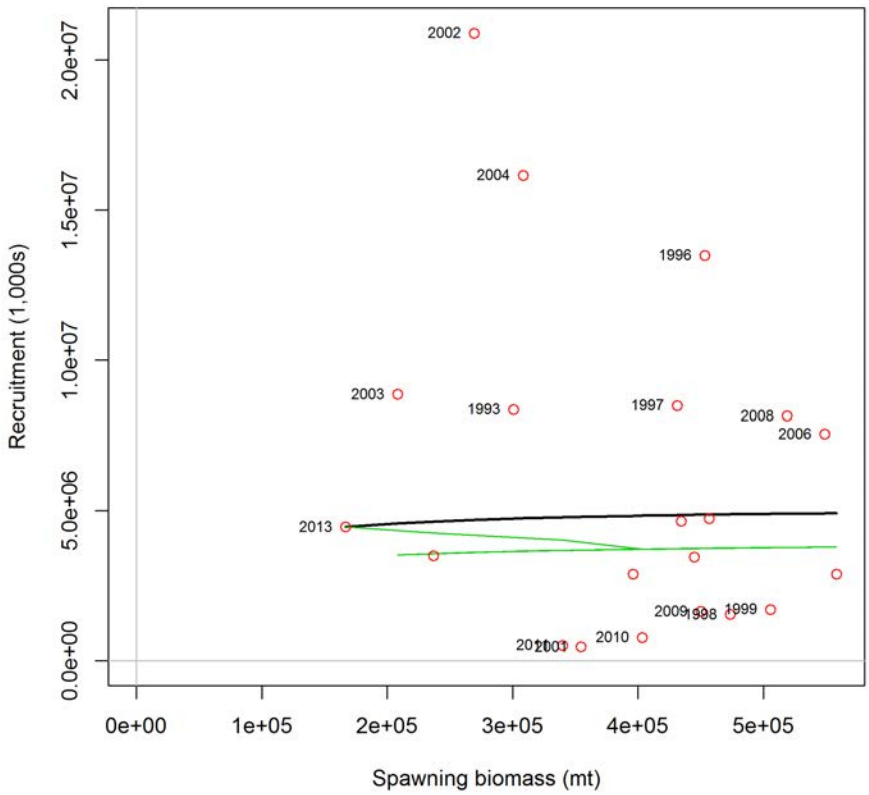


Figure 37a. Estimated stock-recruitment (Beverton-Holt) relationship for base model T. Year labels represent year of SSB producing the subsequent year class.

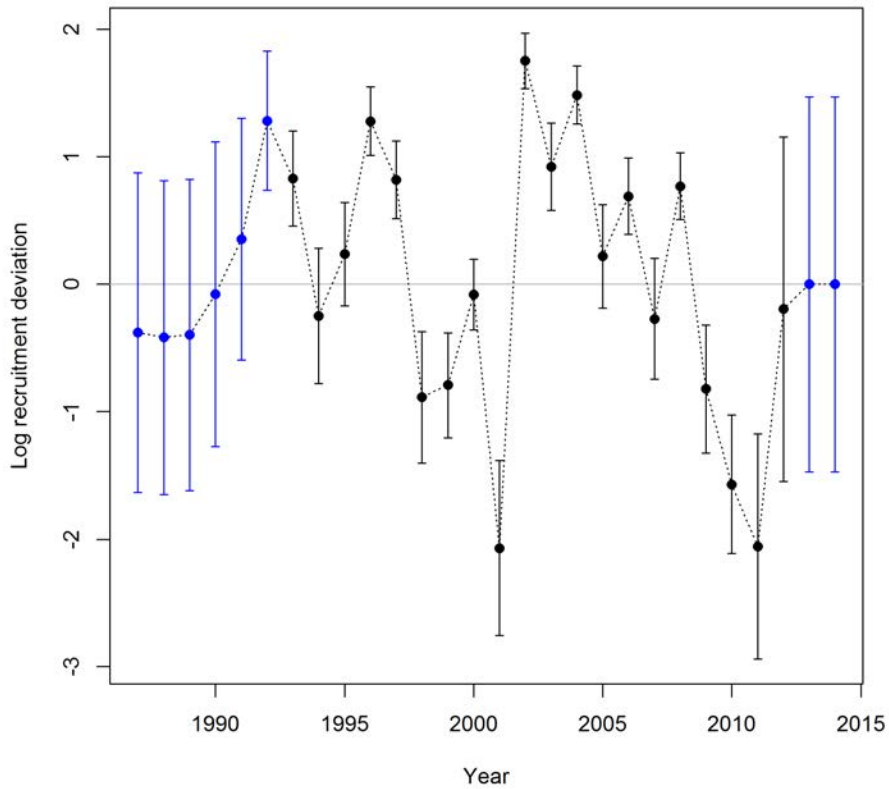


Figure 37b. Recruitment deviations and standard errors estimated in base model T (σ_R = 0.75). Year labels represent year of SSB producing the subsequent year class.

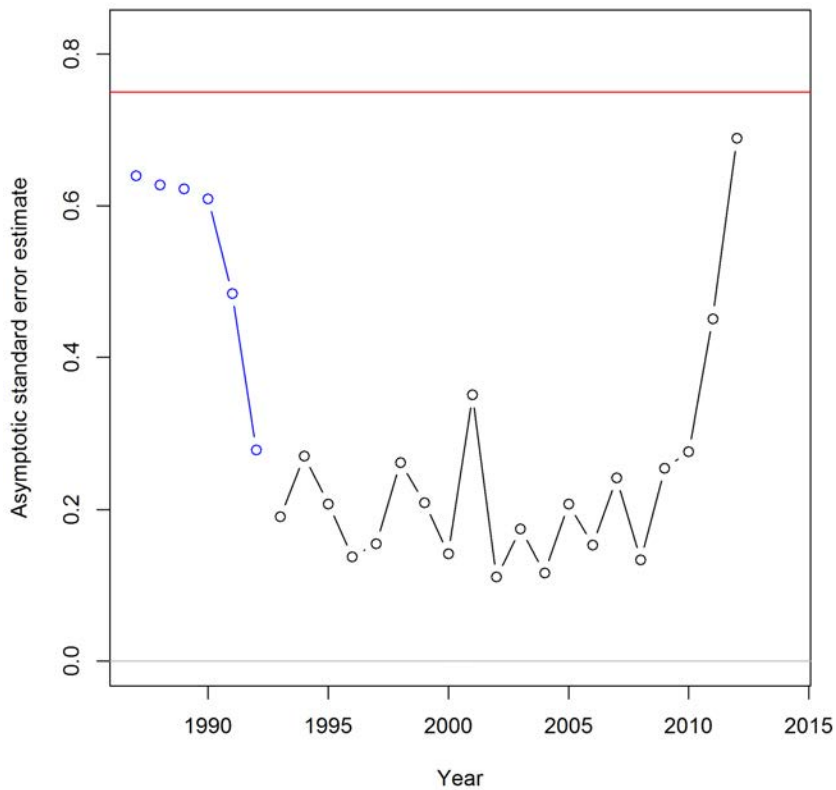


Figure 37c. Asymptotic standard errors for estimated recruitment deviations in base modelT.

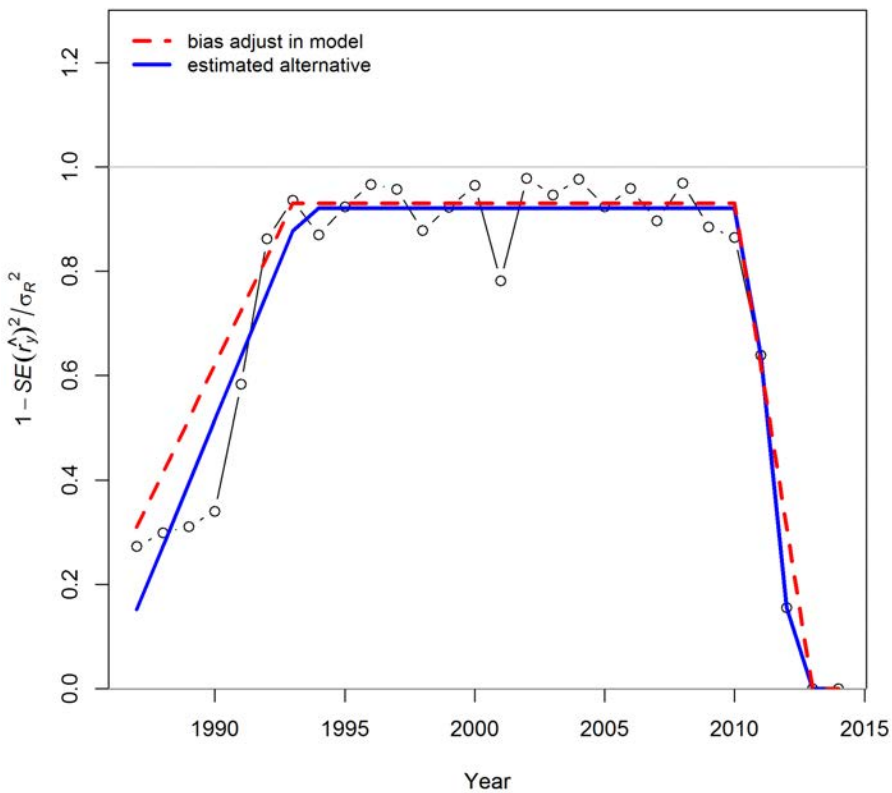


Figure 37d. S-R bias adjustment ramp applied in base model T.

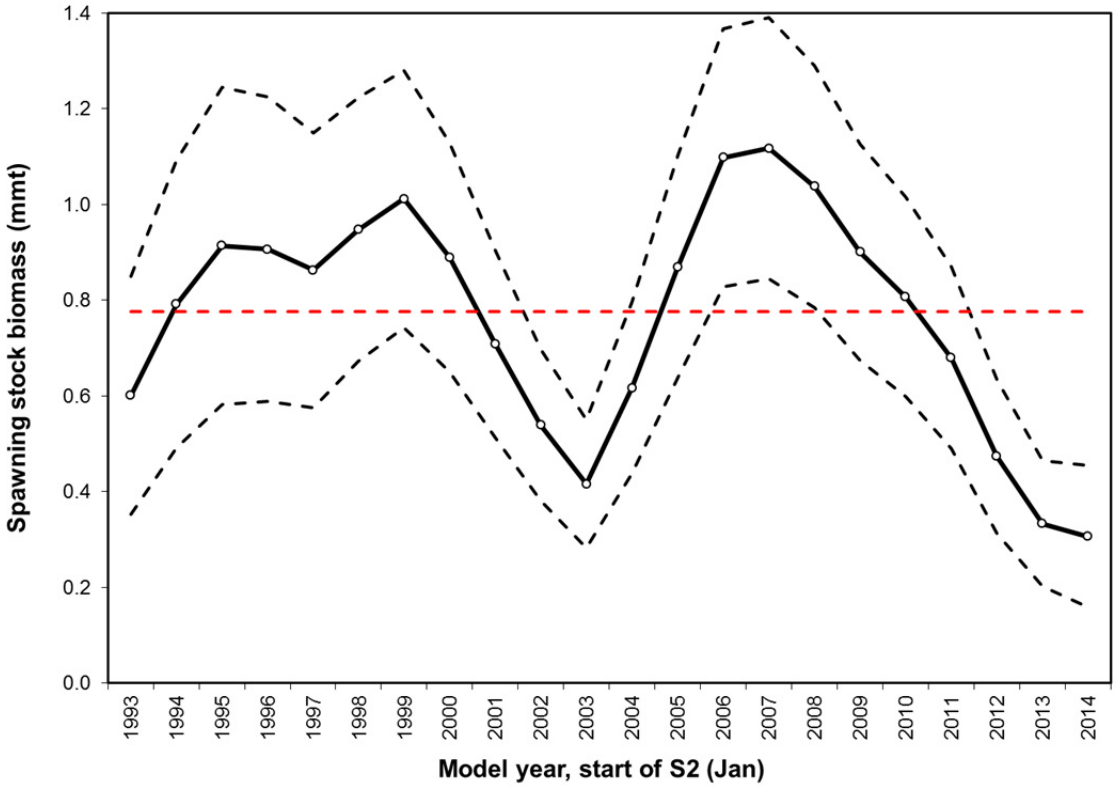


Figure 38a. Spawning stock biomass with ~95% confidence intervals for base model T. Red line is SSB-zero.

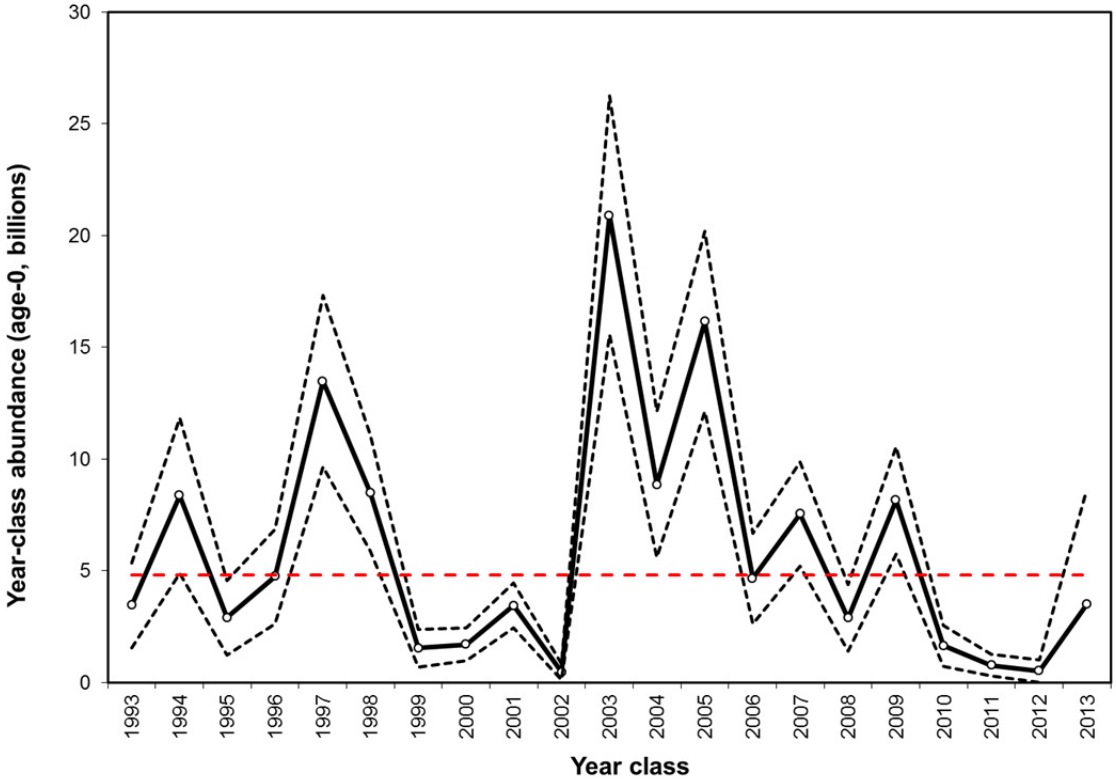


Figure 38b. Year-class abundance with ~95% confidence intervals for base model T. Red line is R-zero.

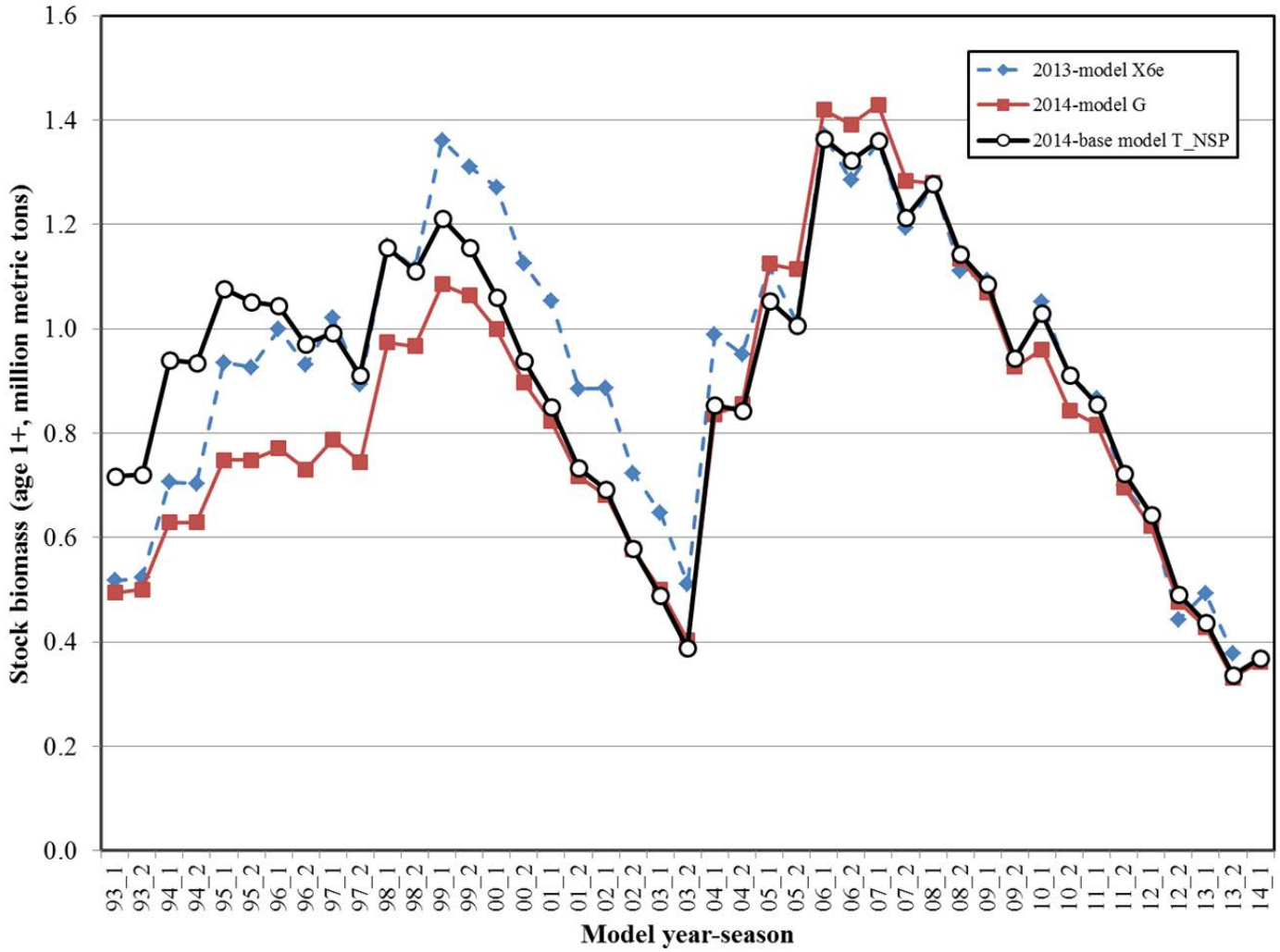


Figure 39. Estimated stock biomass (age 1+ fish) time series for fisheries for most recent management model X6e_2013, model G and base model T.

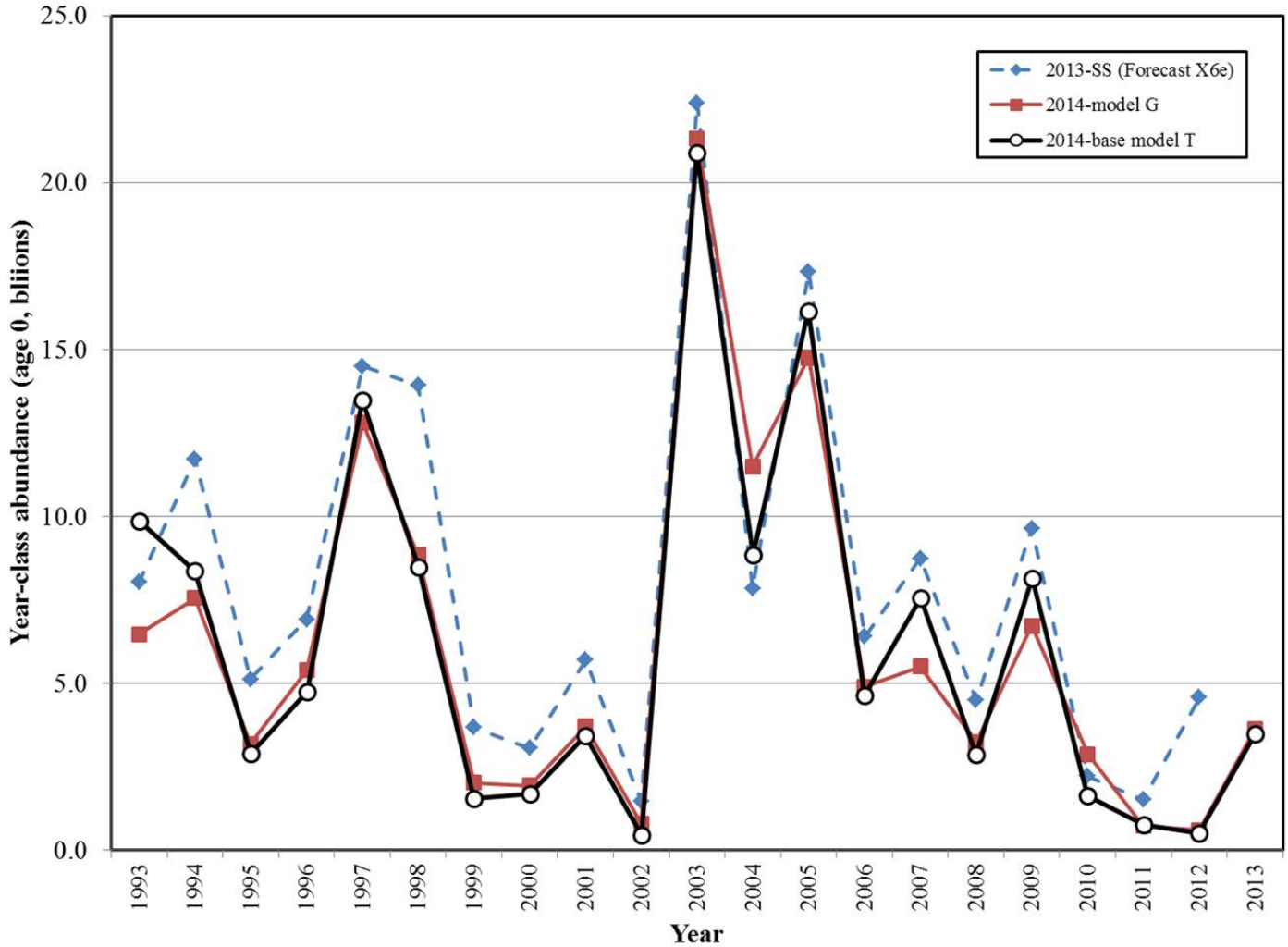


Figure 40. Estimated recruitment (age 0 fish) time series for fisheries for most recent management model X6e_2013, model G and base model T.

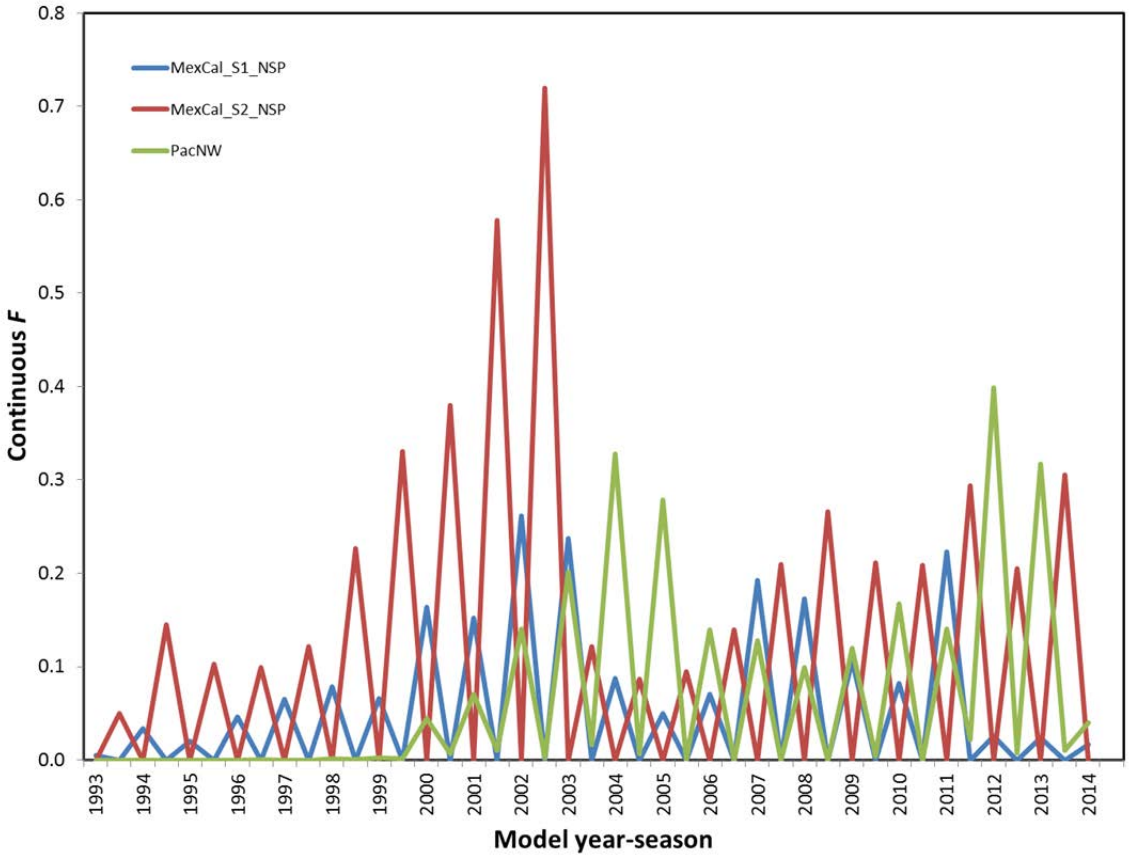


Figure 41a. Estimated fishing mortality (*F*) time series for fisheries for base model T.

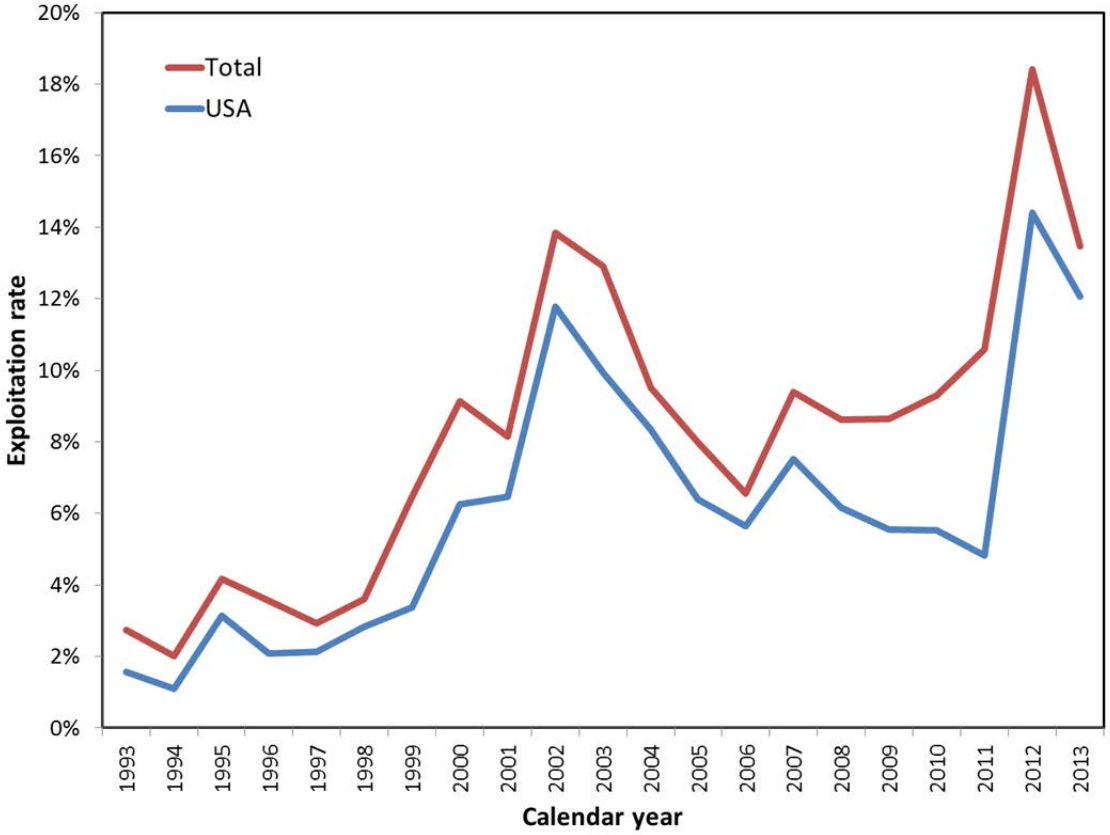


Figure 41b. Annual exploitation rate (CY landings / July total biomass) for base model T.

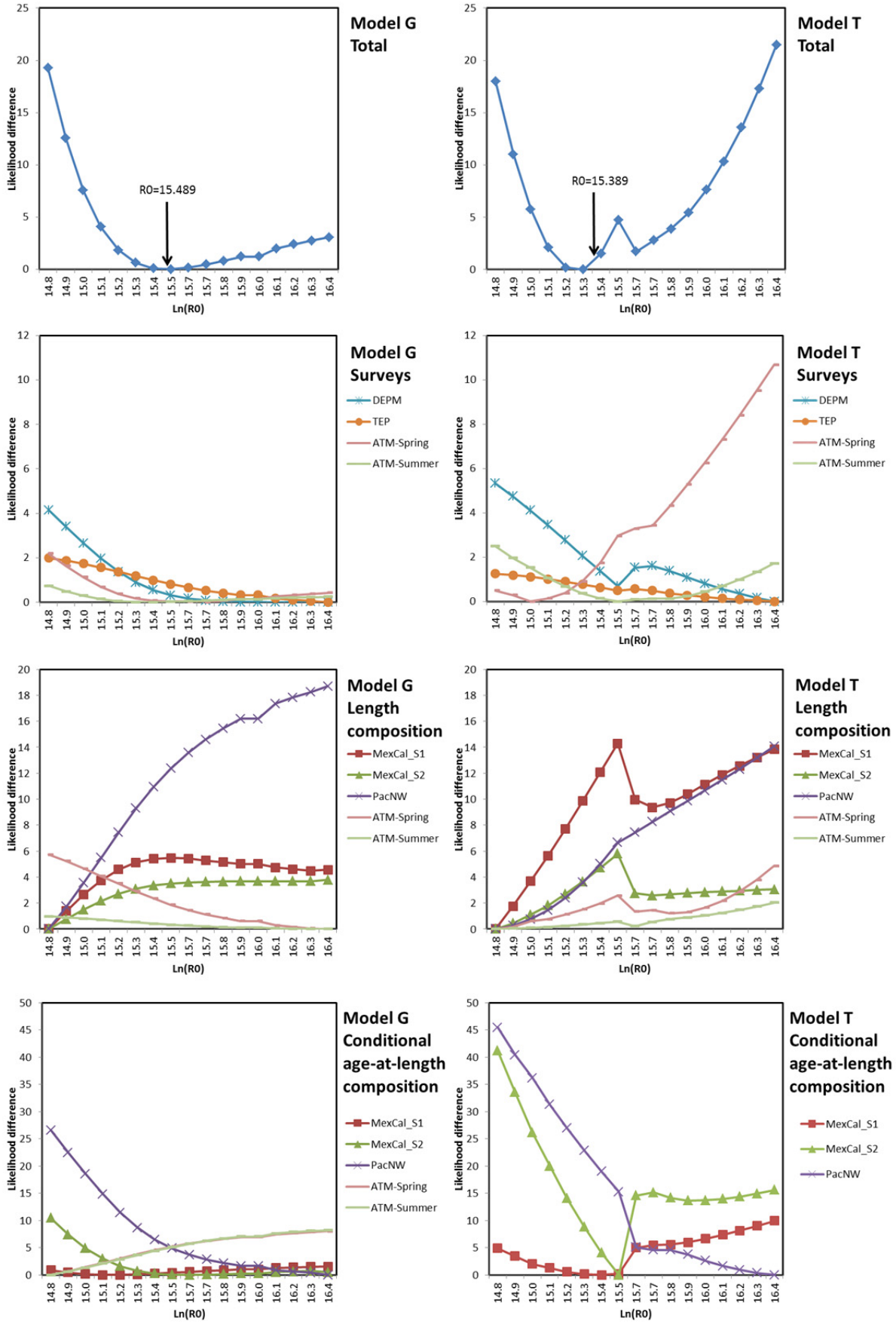


Figure 42. R_0 profiles for model G (left) and base model T (right) components.

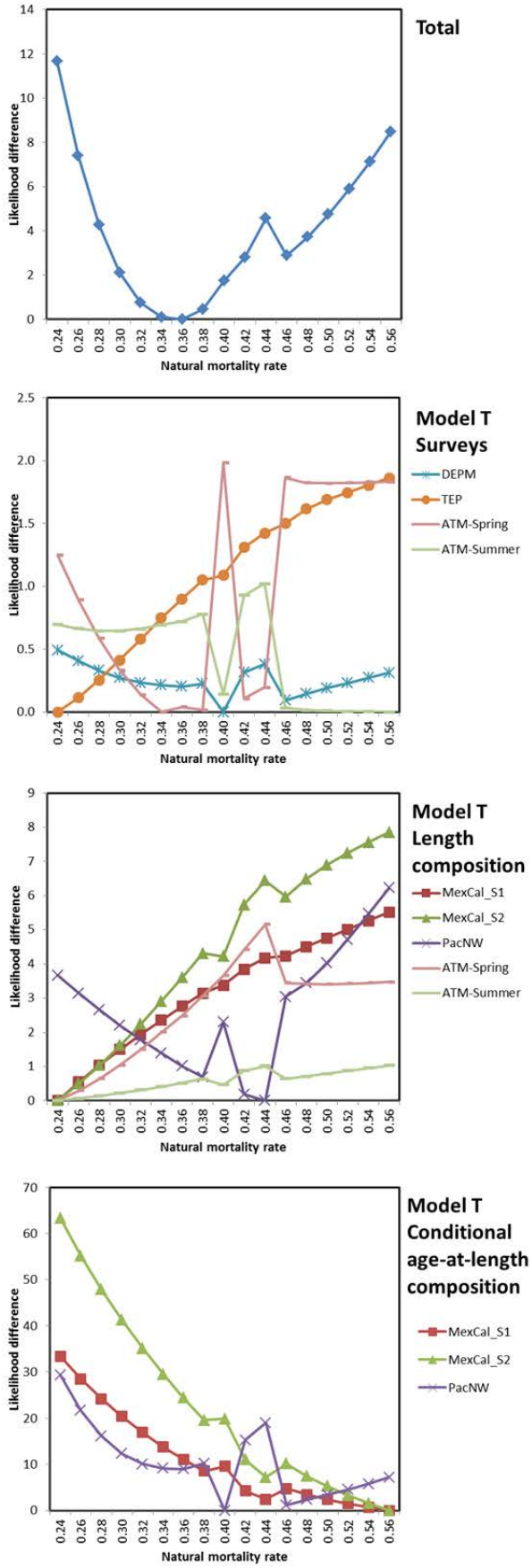


Figure 43. Natural mortality rate profiles for base model T components

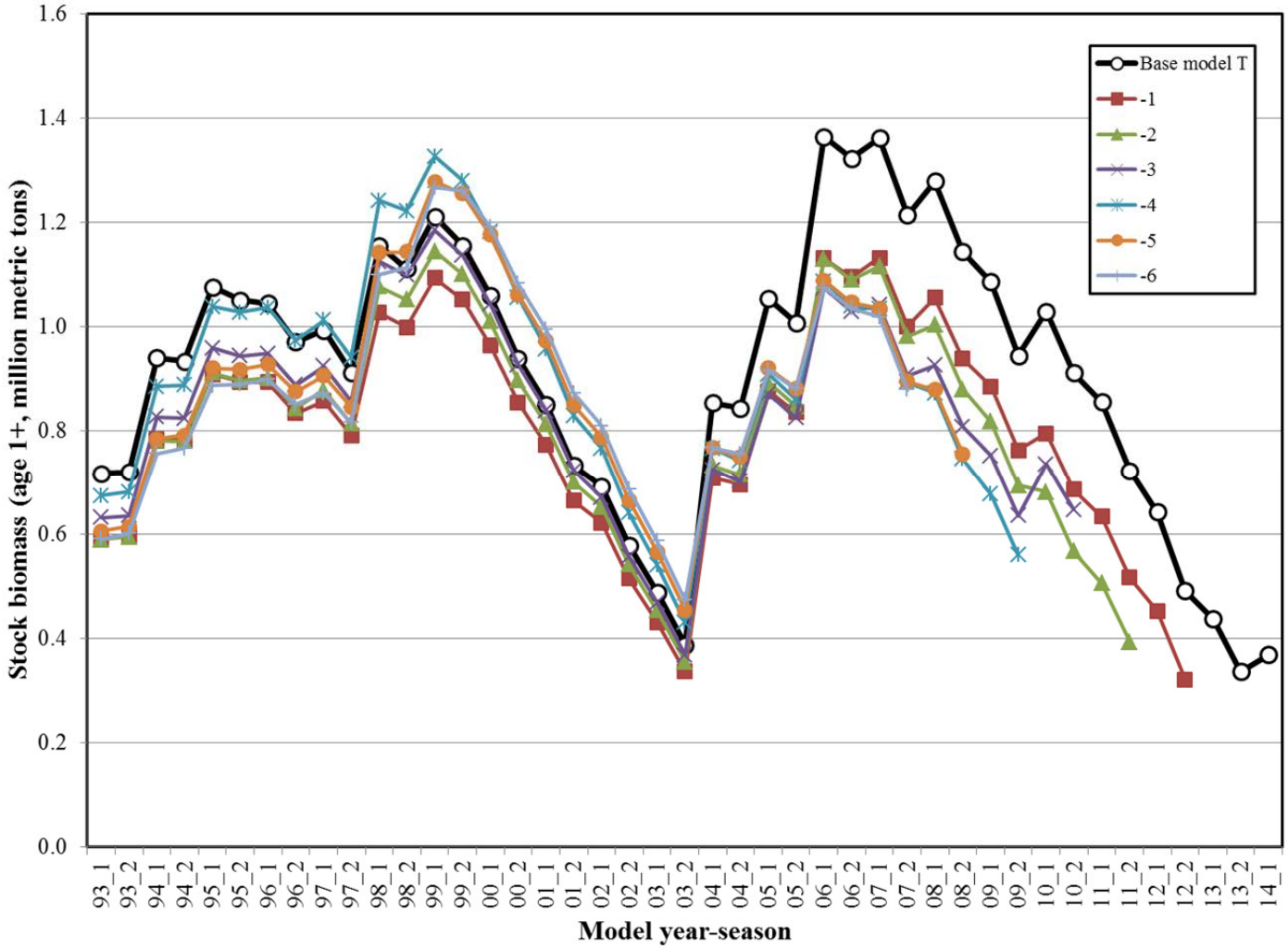


Figure 44. Retrospective analysis of stock biomass (age 1+) for base model T..

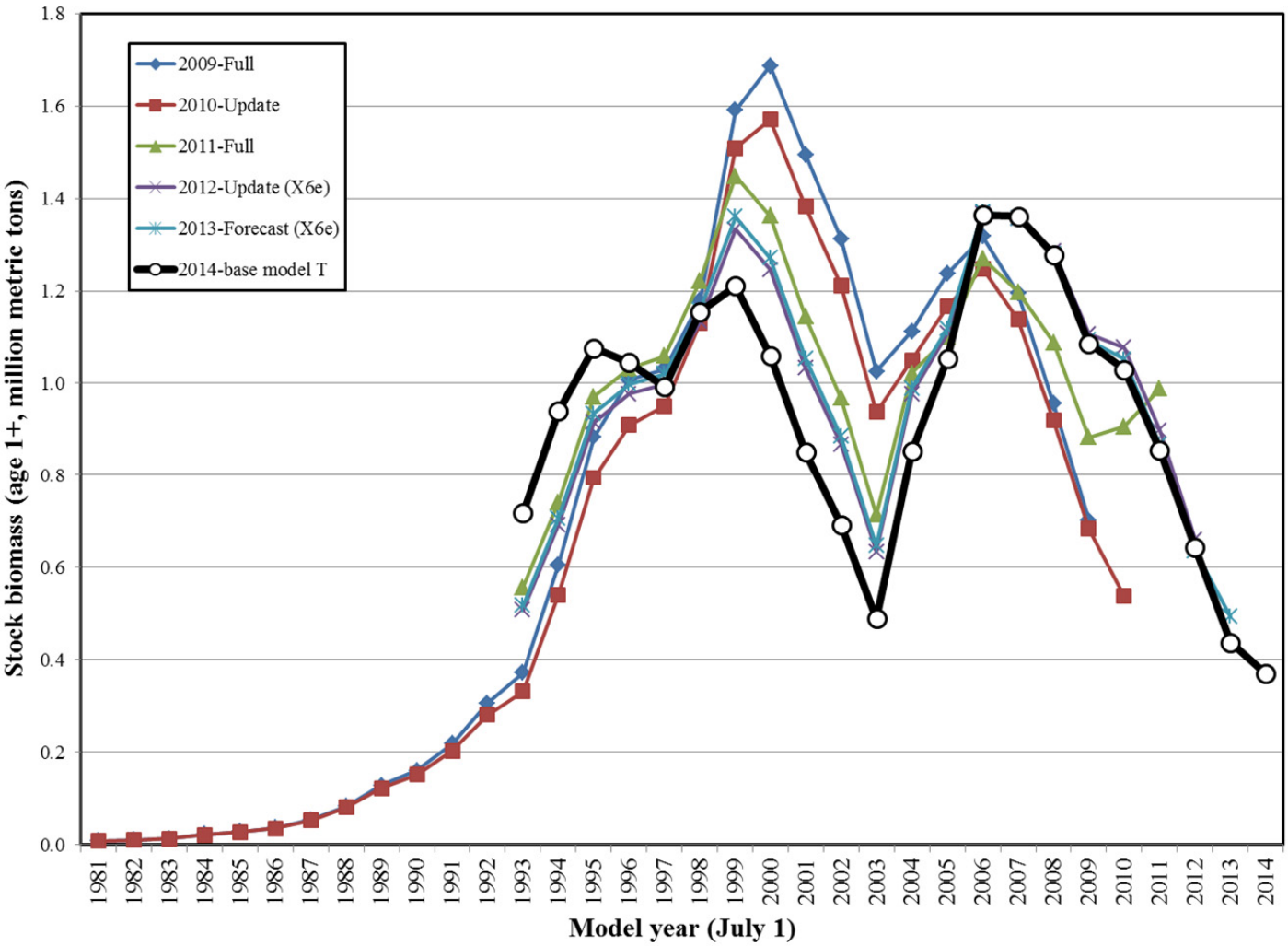


Figure 45. Estimated stock biomass (age 1+ fish) time series for fisheries for the base model and past management models.

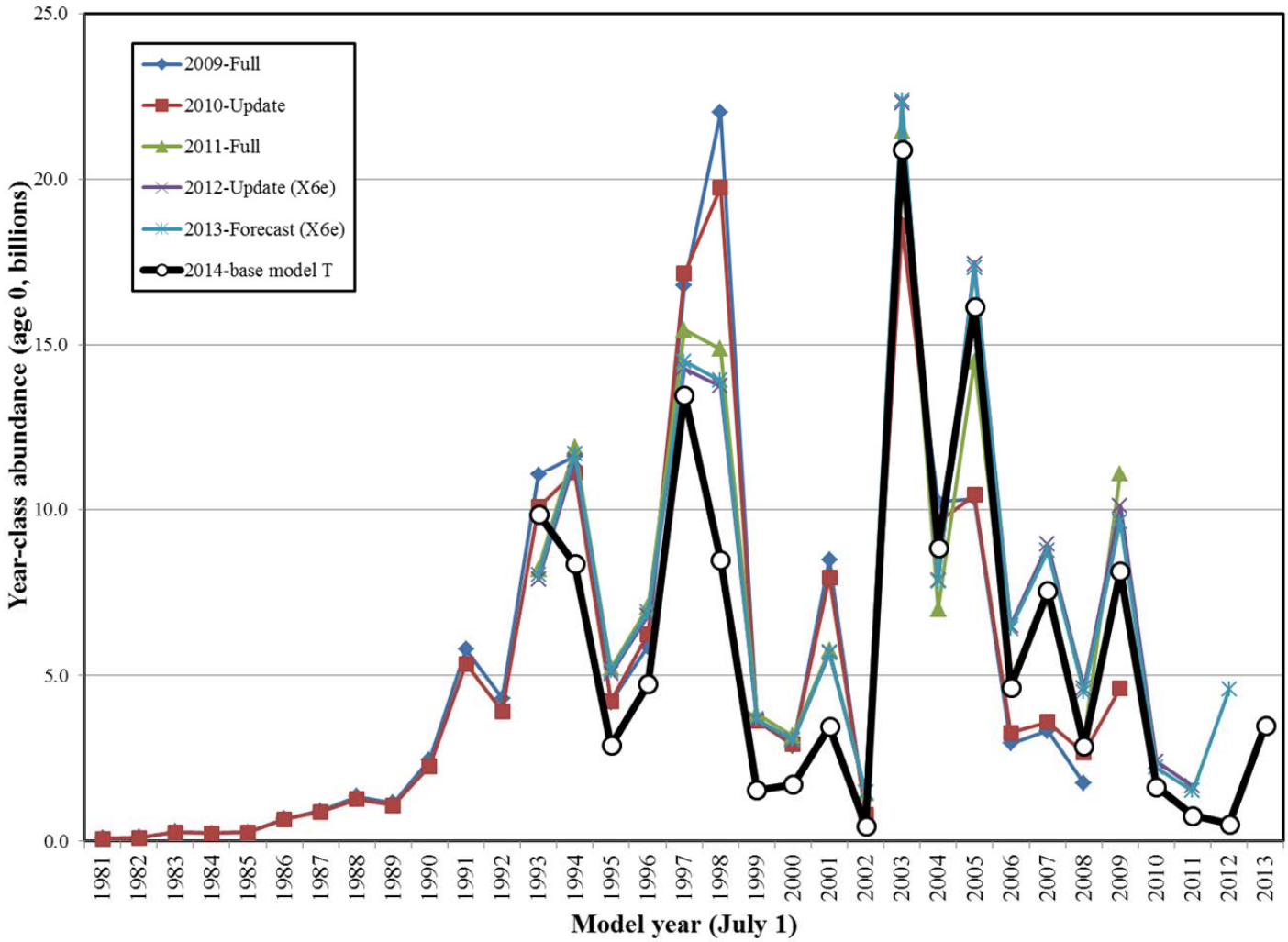


Figure 46. Estimated recruitment (age 0 fish) time series for fisheries for the base model and past management models.

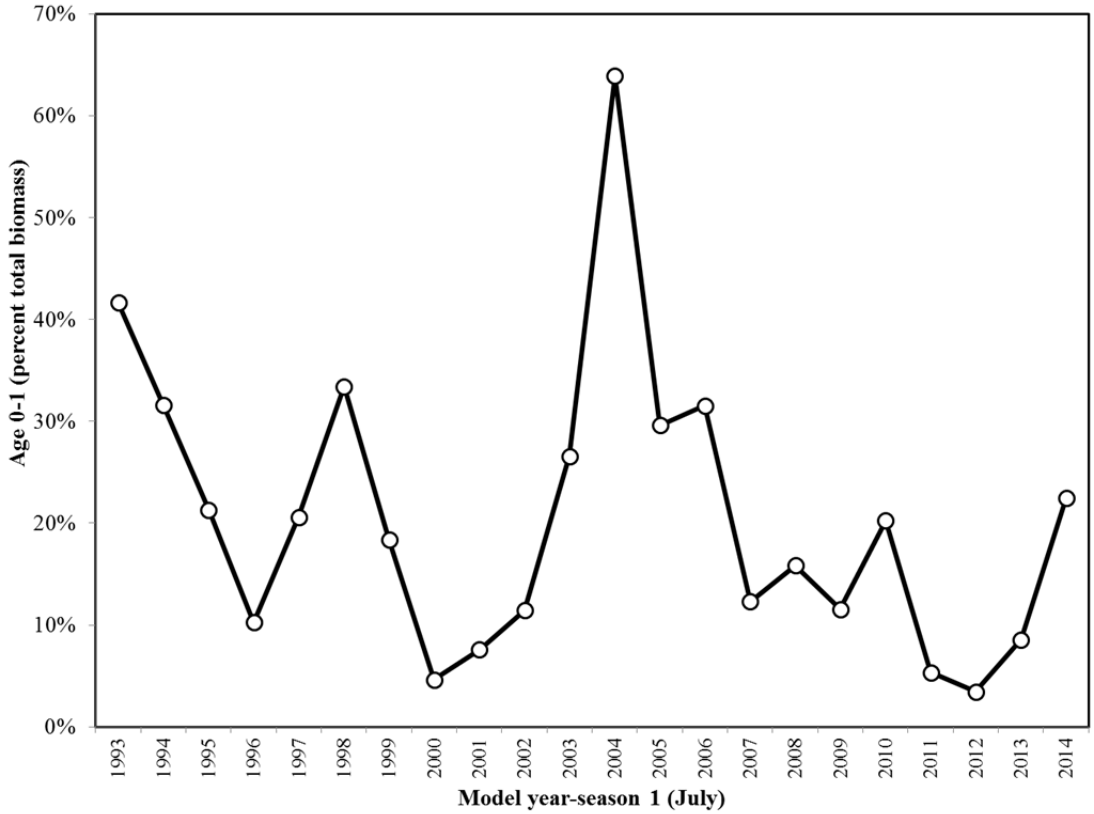


Figure 47. Age 0-1 biomass as percentage of total population biomass (base model T).

Figure 48. Biomass of age-1 sardine (base model T).

Figure 49. Base model T stock biomass (age 1+) for a range of possible projection scenarios for July 2014: 1) the 2013year-class is estimated from the S-R curve (default); 2) age-1 biomass in 2014 is based on the age-1 biomass averaged from 2011-13; and 3) age-1 biomass in July 2014 is zero (i.e. 2013 year-class failure).

APPENDICES

APPENDIX A

Acoustic-trawl estimates of sardine biomass off California during Spring 2013

Juan Zwolinski, David A. Demer, Beverly J. Macewicz, George R. Cutter Jr., Brian Elliot, Scott Mau, David Murfin, Josiah S. Renfree, Thomas S. Sessions, and Kevin Stierhoff

This report summarizes results from the spring 2013 acoustic-trawl method (ATM) survey off central and southern California (Fig. 1). The survey was conducted from NOAA FSV *Bell M. Shimada* and chartered FV *Ocean Starr*.

The ATM survey totaled 2791 n.mi. of east-west tracklines between the US and Mexico border and San Francisco, and spanning offshore beyond the expected distribution of the northern stock of Pacific sardine (Fig. 1). From sunrise to sunset, multifrequency echosounders were used to sample acoustic backscatter from epipelagic coastal pelagic species (CPS). During nighttime, up to 4 surface trawls were used to identify the proportions of CPS and their lengths. Due to their temporal-spatial proximity, data from trawl catches conducted each night were combined into clusters. Day and night, a continuous underway fish egg sampler (CUFES) was used to sample CPS eggs within 5m of the sea-surface. Overall, 15 of the 26 clusters included CPS, and these clusters included, in average 28 sardine. Overall, 416 sardine were caught in the survey area.

Post-survey strata were defined with considerations to the sampling intensity, the presence of CPS in the echosounder and net samples, and the existence and abundance of sardine eggs in the CUFES samples (Fig. 1). The coastal region and the far offshore oceanic transects had no sardine (Fig. 2). The remaining survey area was split into two strata (north and south; Fig. 2) for biomass estimations (Table 1).

The northern stratum contained the largest concentration of CPS backscatter; trawl clusters with sardine; and CUFES samples with sardine eggs (Figs. 1, 2 and 3). The two strata (Table 1) contained a total sardine biomass of 0.305 Mt ($CI_{95\%}$ = [0.167; 0.454]; *CV*

= 24.4%). The sampled population had a modal standard length (*SL*) at ~ 22 cm (Table 2; Fig. 4).

Table 1. Sardine biomass by stratum for the spring 2013 survey.

Stratum		Transect		Trawls		Sardine		
Name	**Area (n.mi.)**	**Number**	**Distance (n.mi.)**	**CPS clusters**	**Number of sardine**	**Biomass (1000 tons)**	**95% confidence interval (1000 tons)**	***CV***
North	24094	12	1210	10	363	286.4	148.3 – 428.7	26.0
South	11466	5	505	6	53	18.8	5.2 – 33.0	36.3
Total	**35560**	**17**	**1715**	**16**	**416**	**305.1**	**166.6 – 453.6**	**24.4**

Table 2. Sardine abundance versus standard length for the spring 2013 survey.

Standard length (cm)	**Abundance (number);**
8	0
9	0
10	0
11	0
12	0
13	0
14	0
15	0
16	0
17	0
18	3657973
19	1828987
20	81284877
21	641628498
22	783577984
23	311376788
24	199652238
25	31872240
26	46746359
27	0
28	0
29	0
30	0

Figure 1. Acoustic backscatter from coastal pelagic fish species (CPS, left), acoustic proportions of CPS in trawl clusters (middle), and sardine egg densities from continuous underway fish egg sampler (CUFE; right).

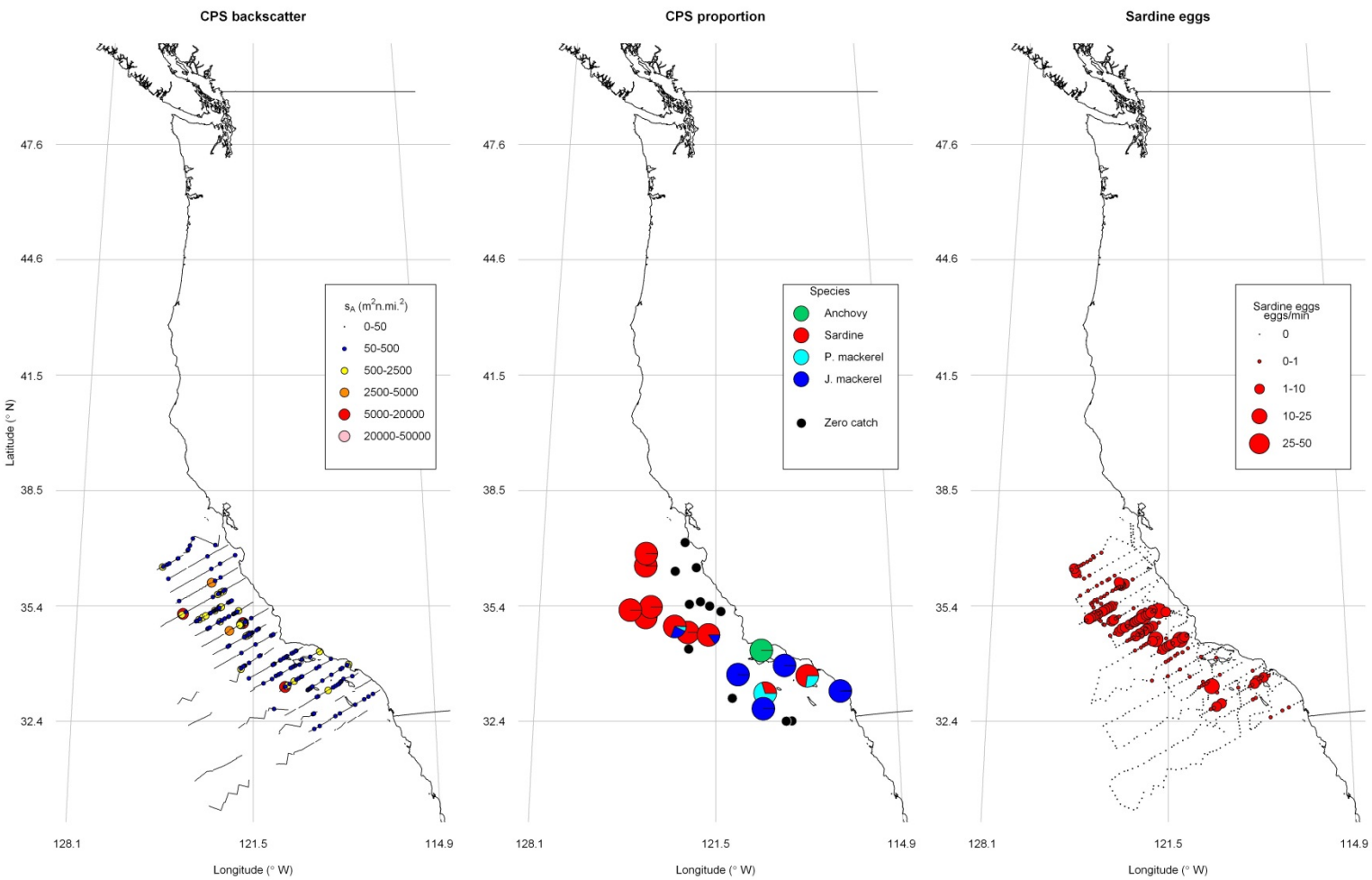


Figure 2. Sardine biomass densities versus stratum (Table 1) estimated using the acoustic-trawl method (ATM). The numbers in blue represent the location of trawl clusters with at least 1 CPS.

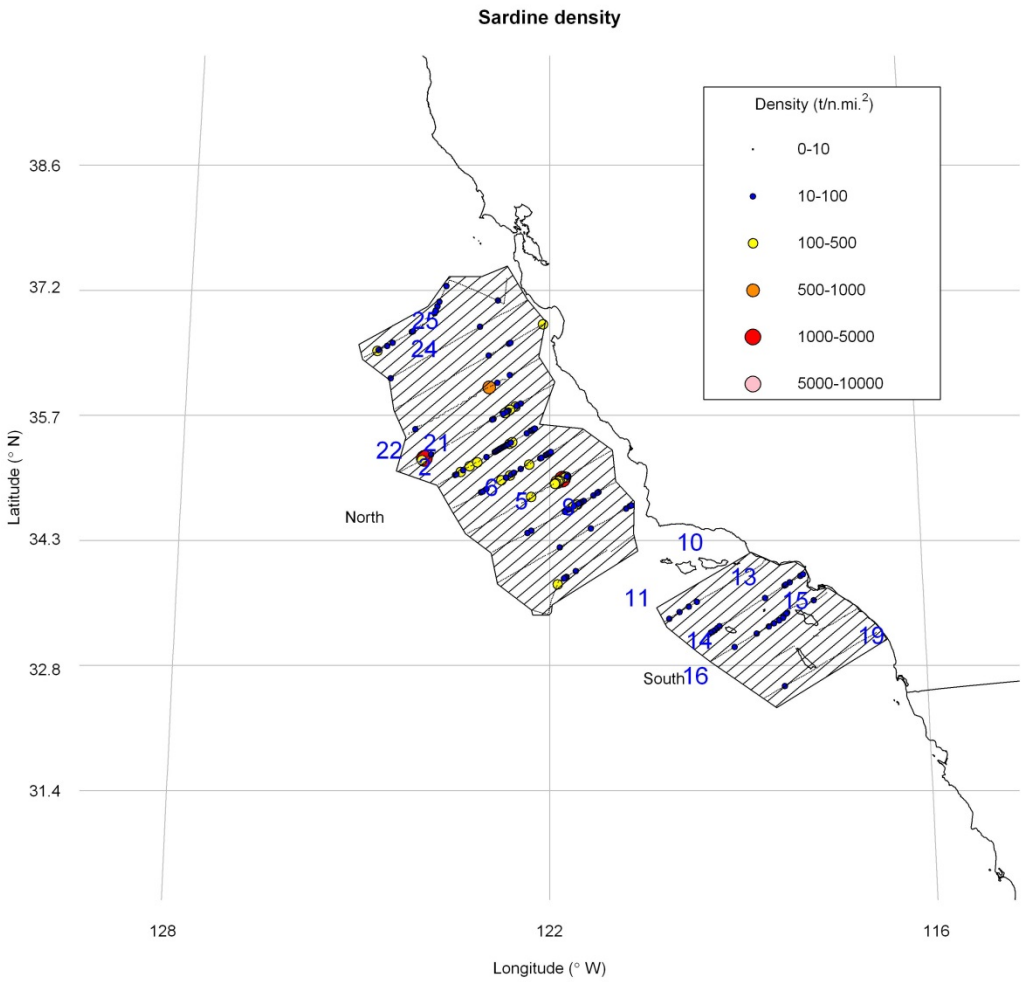


Figure 3. Distributions of sardine lengths versus trawl cluster, the total number of sardine caught in each cluster, and the proportions of the sardine abundances within each respective stratum represented by these data. The locations of the trawl clusters are shown in Fig. 2.

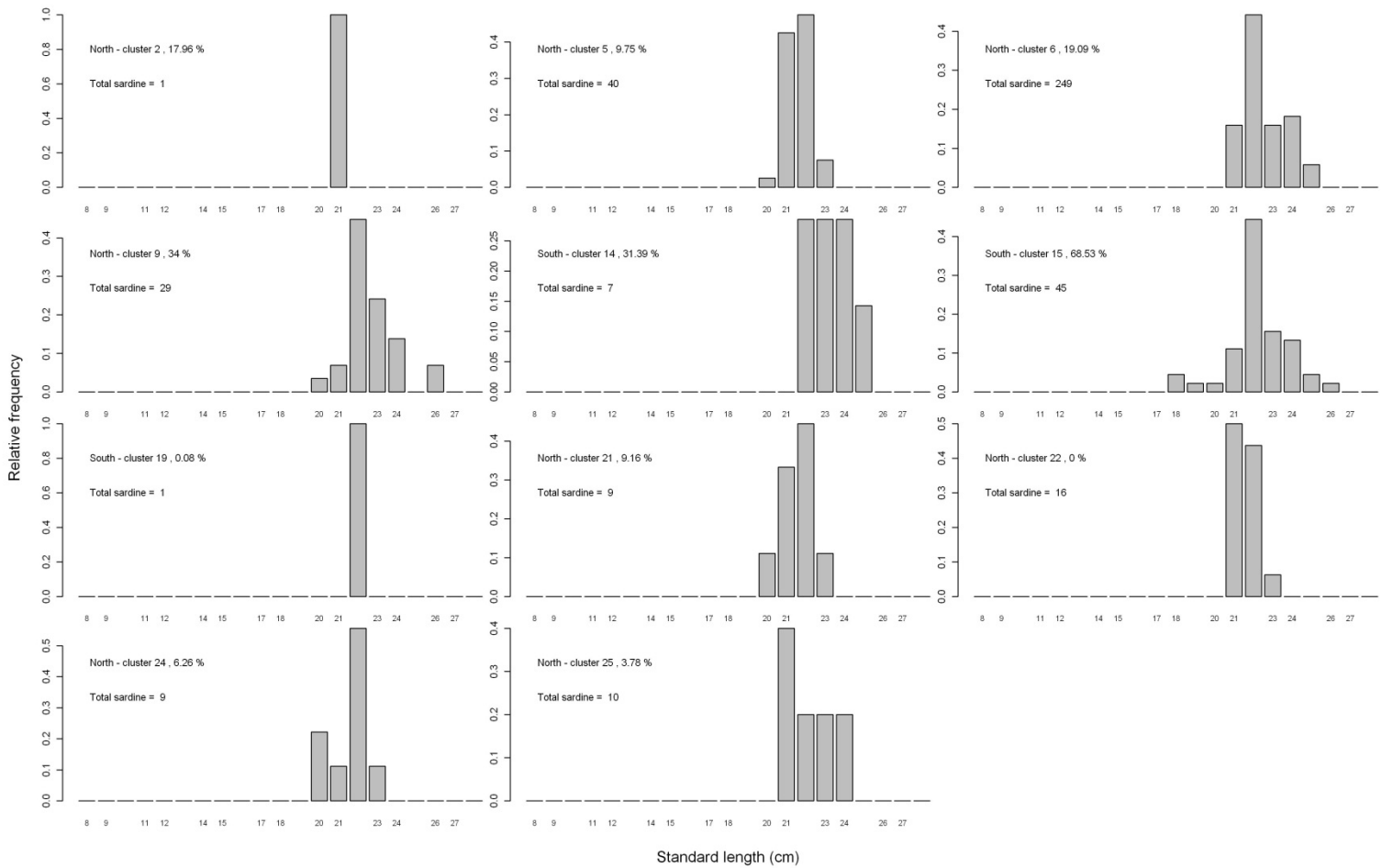
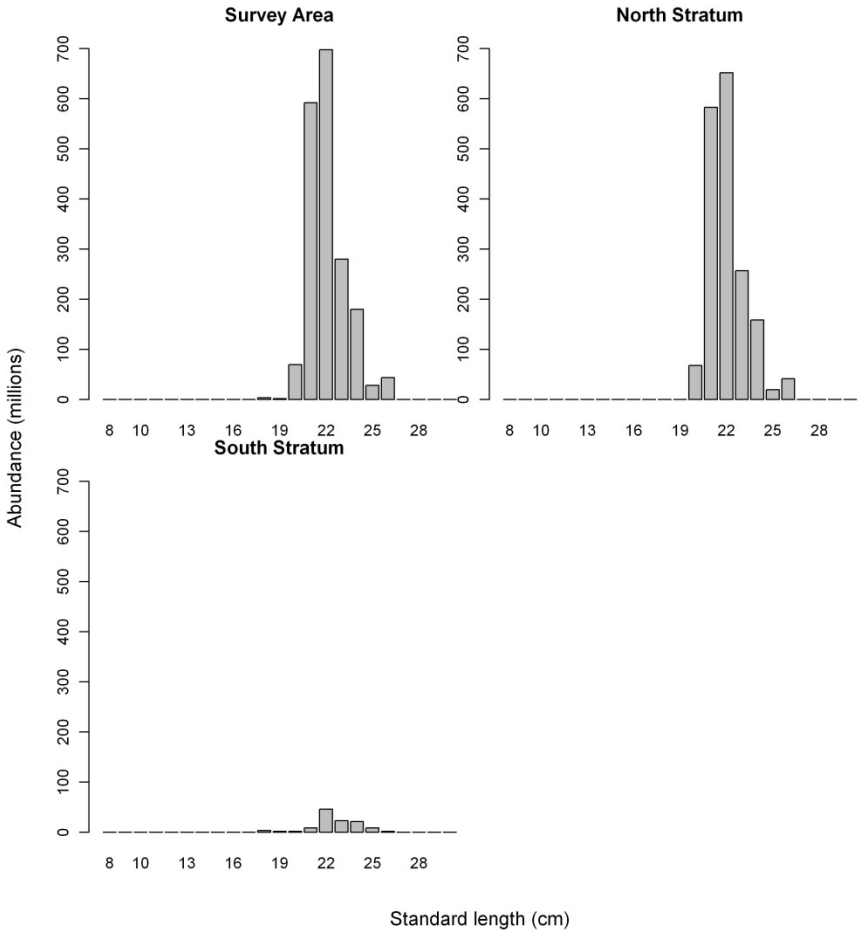


Figure 4. Sardine abundance versus standard length and stratum for the spring 2013 survey. Abundance per length class for the survey is provided in **table 2**.



APPENDIX B

Acoustic-trawl estimates of sardine biomass off California during the Summer SaKe 2013 survey

Juan Zwolinski, David A. Demer, Beverly J. Macewicz, George R. Cutter Jr., Brian Elliot, Scott Mau, David Murfin, Josiah S. Renfree, Thomas S. Sessions, and Kevin Stierhoff

This report summarizes results from the SaKe 2013 acoustic-trawl method (ATM) survey off the west coast of USA and West Vancouver Island (Fig. 1). The survey was conducted from NOAA FSV *Bell M. Shimada*.

The ATM survey totaled ~ 4420 n.mi. of east-west tracklines between the US and Mexico border and the northern end of Vancouver Island (Canada), spanning the expected distribution of the northern stock of Pacific sardine (Fig. 1). Offshore, the survey extended to the longest of a distance of 35 miles off the coast or the 1500 m isobath. From sunrise to sunset, multifrequency echosounders were used to sample acoustic backscatter from epipelagic coastal pelagic species (CPS). During nighttime, up to 4 surface trawls were used to identify the proportions of CPS and their lengths. Due to their temporal-spatial proximity, data from trawl catches conducted each night were combined into clusters. Overall, 32 catch clusters included CPS, and these clusters included an average catch of 223 sardine.

Post-survey strata were defined with considerations to the sampling intensity, the presence of acoustic CPS targets and net samples (Fig. 1). Sardine were predominantly found in the vicinity of the Columbia River mouth, and between San Francisco and Monterey Bay (Fig. 2). For biomass estimation, the survey area was split into three strata (Table 1; Fig 2).

The Washington-Oregon stratum contained the largest concentration of CPS backscatter and sardine catches; (Figs. 1, 2 and 3). The three strata (Table 1) contained a total sardine biomass of 0.314 Mt ($CI_{95\%}$ = [0.166; 0.517]; *CV* = 27.5%). The sampled population had a modal standard length (*SL*) at ~ 22 cm (Table 2).

A salient result of this survey is the absence of sardine off Vancouver Island. This is the first time that it occurred since the sardine resumed their migrations in the mid 1990s. Also, in line with the results from the summer survey in 2012, no sardine were found south of Monterey Bay.

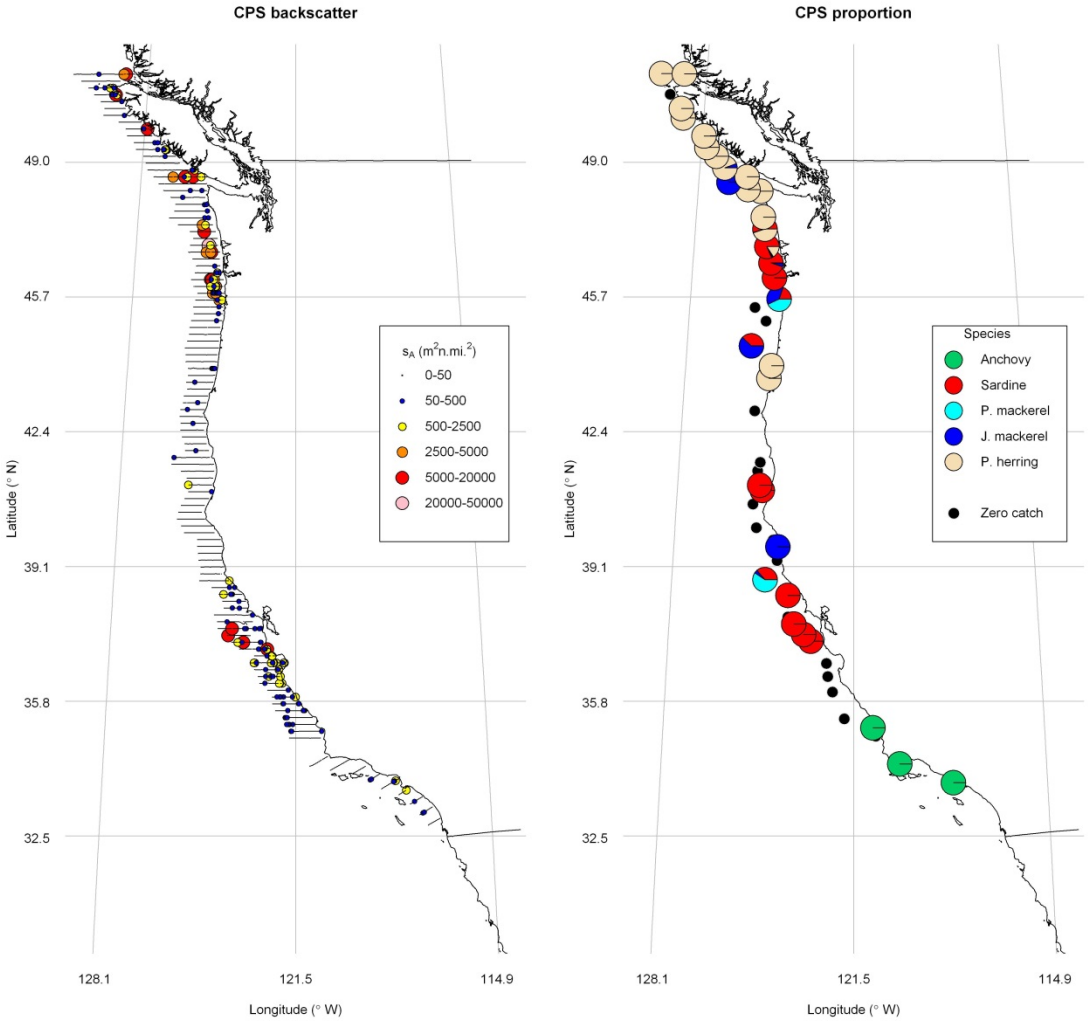
Table 1. Sardine biomass by stratum for the 2013 SaKe survey.

Stratum		**Transect**		**Trawls**		**Sardine**		
Name	**Area (n.mi.)**	**Number**	**Distance (n.mi.)**	**CPS clusters**	**Number of sardine**	**Biomass (1000 tons)**	**95% confidence interval (1000 tons)**	***CV***
Washington-Oregon	5627	14	560	6	6650	210.3	75.3 – 410.7	37.7
Oregon-California	17824	44	1751	10	1092	9.8	1.4 – 19.5	53.7
Central California	2039	4	204	3	254	93.7	22.5 – 145.6	34.9
Total	**26391**	**62**	**2516**	**18**	**2011**	**313.7**	**166.1 – 517.0**	**27.5**

Table 2. Sardine abundance versus standard length for the 2013 SaKe survey.

Standard length (cm)	**Abundance (number);**
8	0
9	0
10	0
11	0
12	0
13	0
14	0
15	0
16	0
17	0
18	0
19	0
20	106181
21	113736358
22	821577566
23	687195532
24	292367516
25	81155376
26	6486959
27	0
28	0
29	0
30	0

Figure 1. Acoustic backscatter from coastal pelagic fish species (CPS; left), proportions of CPS in trawl clusters (right).



fs

Figure 2. Sardine biomass densities versus stratum (**Table 1**) estimated using the acoustic-trawl method (ATM). The numbers in blue represent the location of trawl clusters with at least 1 CPS.

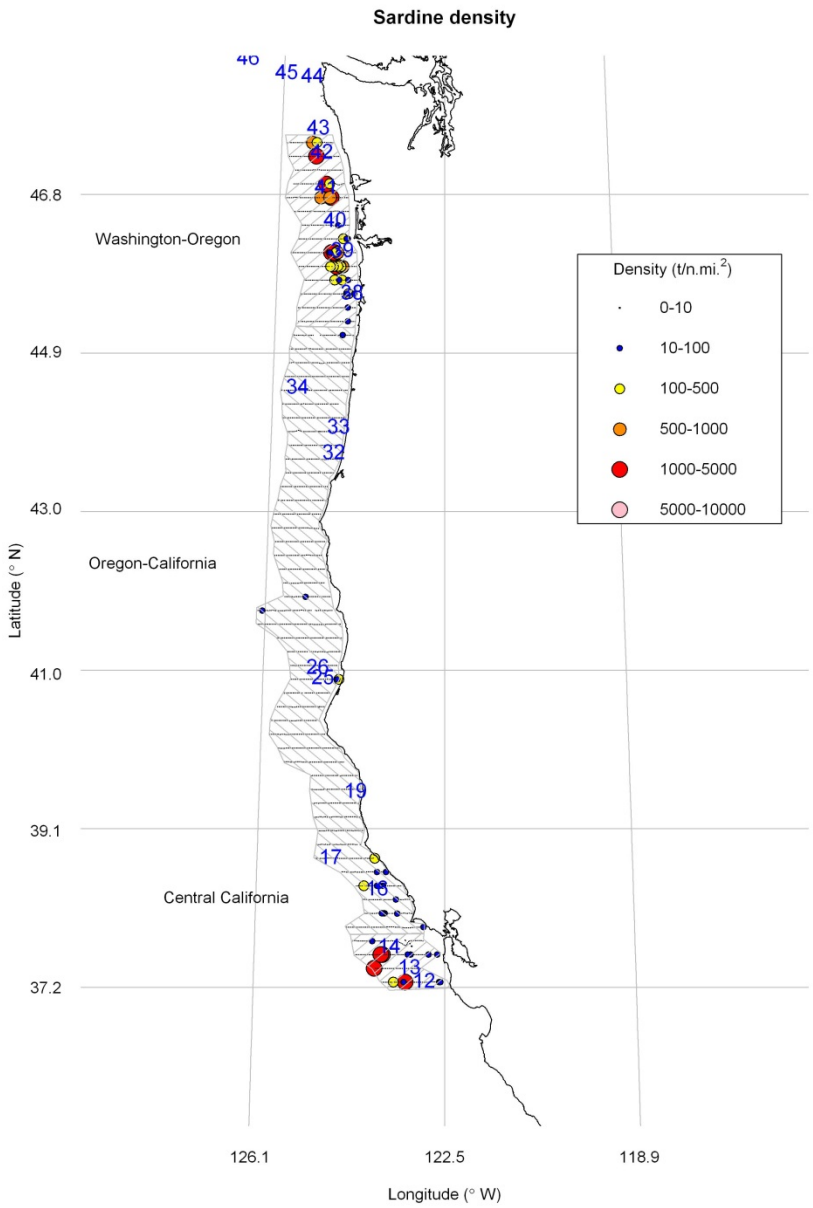


Figure 3. Distributions of sardine lengths versus trawl cluster, the total number of sardine caught in each cluster, and the proportions of the sardine abundances within each respective stratum represented by these data. The locations of the trawl clusters are shown in Fig. 2.

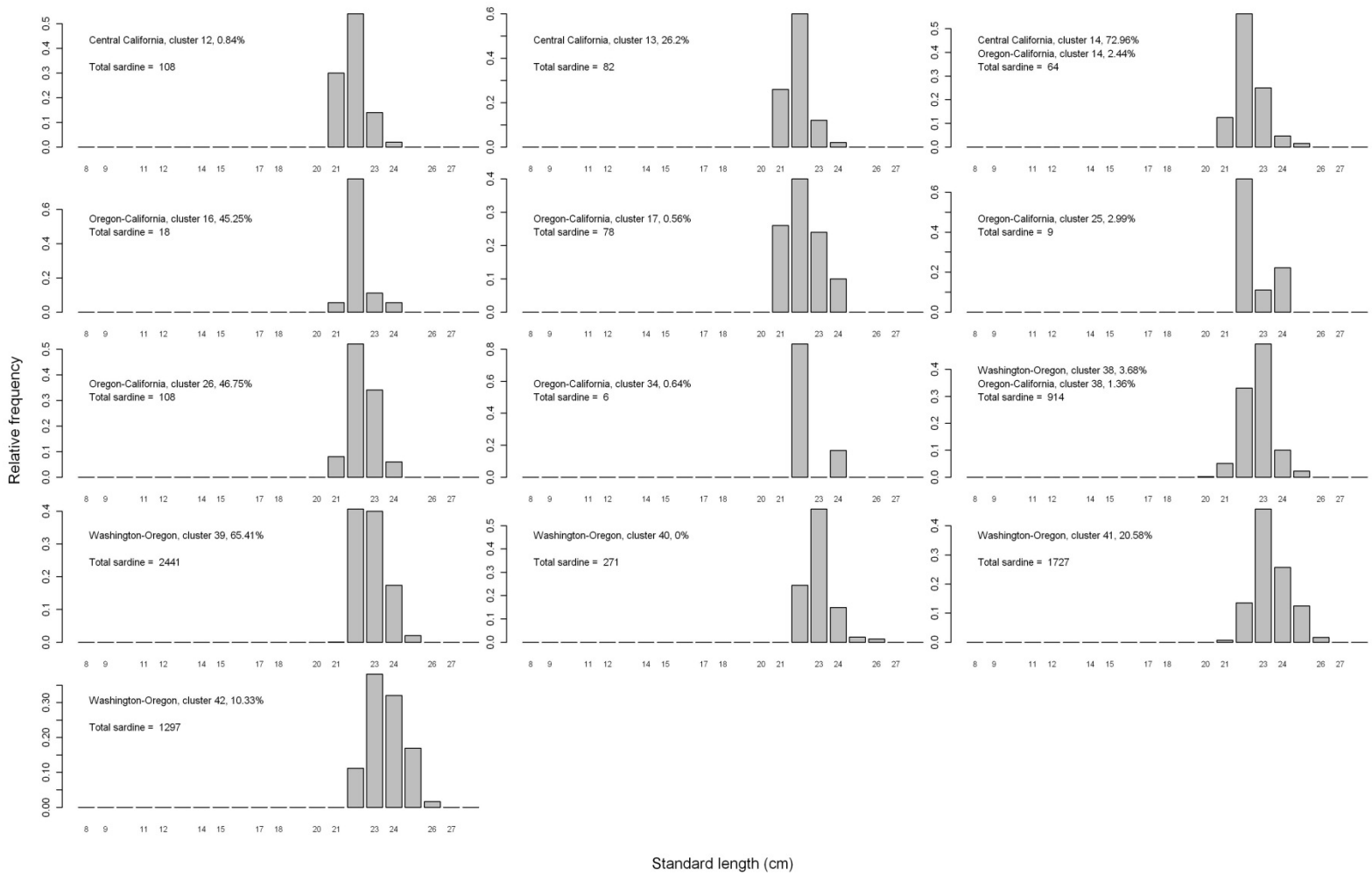
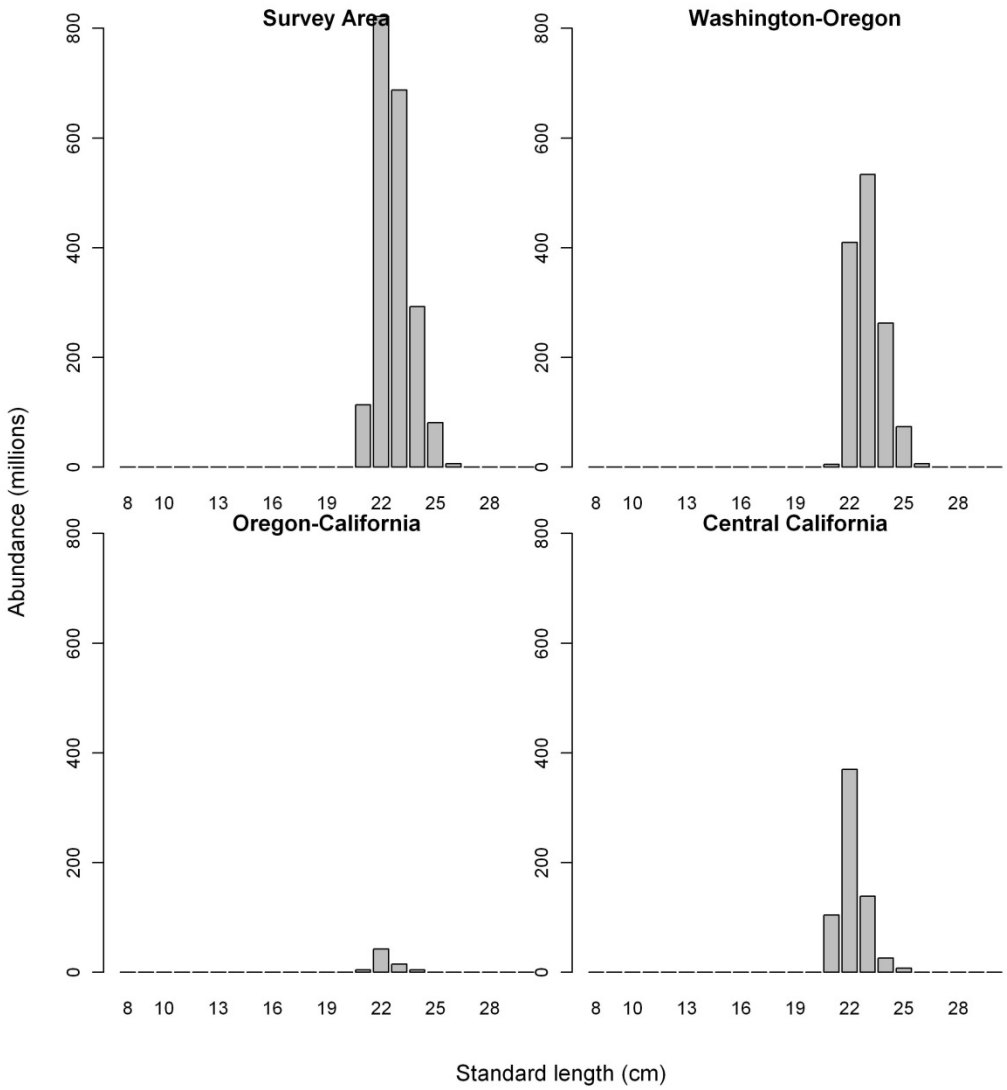


Figure 4. Sardine abundance versus standard length for the summer SaKe 2013 survey. Abundance per length class for the survey is provided in **table 2**.



Appendix C
SS Input Files for Base Model T

STARTER.SS

```
# Pacific sardine stock assessment for 2014-15
# K. T. Hill and P. R. Crone (March 2014)
# SS ver. 3.24s
T2_0.2.dat
T2_0.2.ctl
0 # 0=use init values in control file; 1=use ss3.par
1 # Run display detail (0,1,2)
2 # Detailed age-structured reports in REPORT.SSO: (0,1,2)
1 # Write detailed checkup.sso file (0,1)
3 # Write parm values to ParmTrace.sso (0=no,1=good,active; 2=good,all; 3=every_iter,all_parms; 4=every,active)
2 # Write to cumreport.sso (0=no, 1=like&timeseries, 2=add survey fits)
0 # Include prior_like for non-estimated parameters (0,1)
1 # Use soft boundaries to aid convergence: (0,1)
1 # Number of datafiles to produce: 1st is input, 2nd is estimates, 3rd and higher are bootstrap
10 # Turn off estimation for parameters entering after this phase
10 # MCeval burn interval
2 # MCeval thin interval
0 # Jitter initial parm value by this fraction
-1 # Min yr for sdreport outputs (-1 for styr)
-2 # Max yr for sdreport outputs (-1 for endyr; -2 for endyr+Nforecastyrs
0 # N individual STD years
0.00001 # Final convergence criteria (e.g., 1.0e-05)
0 # Retrospective year relative to end year (e.g. -4)
1 # Min age for calc of summary biomass
1 # Depletion basis:  denom is: 0=skip; 1=rel X*B0; 2=rel X*Bmsy; 3=rel X*B_styr
1 # Fraction (X) for depletion denominator (e.g. 0.4)
4 # SPR_report_basis: 0=skip; 1=(1-SPR)/(1-SPR_tgt); 2=(1-SPR)/(1-SPR_MSY); 3=(1-SPR)/(1-SPR_Btarget); 4=rawSPR
4 # F_report_units: 0=skip; 1=exploitation(Bio); 2=exploitation(Num); 3=sum(Frates); 4=true F for range of ages
0 13 # Min and max age over which average F will be calculated with F_reporting=4
2 # F_report_basis: 0=raw; 1=F/Fspr; 2=F/Fmsy ; 3=F/Fbtgt
999 # End of file
```

FORECAST.SS

```
# Pacific sardine stock assessment for 2014-15
# K. T. Hill and P. R. Crone (March 2014)
# SS ver. 3.24s
1 #_Benchmarks: 0=skip, 1=calc F_spr,F_btgt,F_msy
2 #_MSY: 1= set to F(SPR), 2=calc F(MSY), 3=set to F(Btgt), 4=set to F(endyr)
0.4 #_SPR target (e.g., 0.40)
0.4 #_Biomass target (e.g., 0.40)
0 0 0 0 0 0
1 # Bmark_relF_basis: 1 = use year range; 2 = set relF same as forecast below
1 # Forecast: 0=none; 1=F(SPR); 2=F(MSY) 3=F(Btgt); 4=Ave F (uses first-last relF yrs); 5=input annual F scalar
1 # N forecast years
0 # F scalar (only used for Do_Forecast==5)
# Fcast_years: beg_selex, end_selex, beg_relF, end_relF
0 0 0 0
1 # Control rule method (1=catch=f(SSB) west coast, 2=F=f(SSB) )
0.5 # Control rule Biomass level for constant F (as frac of Bzero, e.g. 0.40); (Must be > the no F level below)
0.1 # Control rule Biomass level for no F (as frac of Bzero, e.g. 0.10)
0.75 # Control rule target as fraction of Flimit (e.g. 0.75)
3 # N forecast loops
3 # First forecast loop with stochastic recruitment
0 # Forecast loop control #3 (reserved for future bells&whistles)
0 # Forecast loop control #4 (reserved for future bells&whistles)
0 # Forecast loop control #5 (reserved for future bells&whistles)
2020 # FirstYear for caps and allocations (should be after years with fixed inputs)
0 # Stddev of log(realized catch/target catch) in forecast (set value>0.0 to cause active impl_error)
0 # Do West Coast gfish rebuilder output (0/1)
0 # Rebuilder: first year catch could have been set to zero (Ydecl)(-1 to set to 1999)
0 # Rebuilder: year for current age structure (Yinit) (-1 to set to endyear+1)
1 # Fleet relative F: 1=use first-last alloc year, 2=read seas(row) x fleet(col) below
# Note: fleet allocation is used directly as average F if Do_Forecast=4
2 # Basis for forecast catch tuning and for forecast catch caps and allocation: 2=deadbio, 3=retainbio,
5=deadnum, 6=retainnum
# Max total catch by fleet (-1 to have no max): must enter value for each fleet
-1 -1 -1
# Max total catch by area (-1 to have no max): must enter value for each fleet
```

```
-1
# Fleet assignment to allocation group (enter group ID# for each fleet, 0 for not included in an alloc group)
0 0 0
# Conditional on >1 allocation group
# Allocation fraction for each of: 0 allocation groups
# No allocation groups
6 # Number of forecast catch levels to input (or else calculate catch from forecast F)
2 # Basis for input forecast catch: 2=dead catch, 3=retained catch, 99 = input Hrate(F
# Input fixed catch values
# Year Season Fleet Catch/F
2014   1      1      739
2014   2      1      0
2014   1      2      0
2014   2      2      10000
2014   1      3      5000
2014   2      3      1500
#
999 # End of file
```

CONTROL FILE 'T2_0.2.CTL'

```
# Pacific sardine stock assessment for 2014-15
# K. T. Hill and P. R. Crone (March 2014)
# SS ver. 3.24s
1 #_N_growth patterns
1 # N_Morphs within growth pattern
1 # N_recruitment assignments (overrides GP*area*season parameter values)
0 # Recruitment interaction requested
1 1 1 # GP season area for each recruitment assignment
1 # N_block patterns - selectivity
1 # N_blocks per pattern 1
1999 2013 # Block pattern 1 - MexCal_S1 and MexCal_S2
0.5 # Fraction female
0 # Natural mortality type
1 # Growth model: 1=vonBert with L1&L2, 2=Richards with L1&L2, 3=age_speciific_K, 4=not implemented
0.5 # Growth_age for_L1
999 #_Growth_age for_L2 (999=use Linf)
0 # SD add to LAA (set to 0.1 for SS2 V1.x compatibility)
0 # CV_growth pattern: (0) CV=f(LAA), (1) CV=F(A), (2) SD=F(LAA), (3) SD=F(A), (4) log(SD)=F(A)
1 # Maturity_option: 1=length logistic
0 # First mature age
1 # Fecundity option:(1) eggs=Wt*(a+b*Wt),(2) eggs=a*L^b,(3) eggs=a*Wt^b, (4) eggs=a+b*L, (5)eggs=a+b*W
0 # Hermaphroditism option: 0=none, 1=age-specific
1 # Parameter offset approach: 1=none, 2=Mortality, growth, CV_growth as offset from female-GP1, 3=like SS2 V1.x
1 # Env/block/dev adjust method: 1=standard
#
# Growth parameters
0.3 0.7 0.4 0 -1 99 -3 0 0 0 0 0 0 0 # NatM_p_1_Fem_GP_1
3 15 10 0 -1 99 3 0 0 0 0 0 0 0 # LAA_min_Fem_GP_1
20 30 25 0 -1 99 3 0 0 0 0 0 0 0 # LAA_max_Fem_GP_1
0.05 0.99 0.4 0 -1 99 3 0 0 0 0 0 0 0 # VonBert_K_Fem_GP_1
0.05 0.3 0.14 0 -1 99 3 0 0 0 0 0 0 0 # CV_young_Fem_GP_1
0.01 0.1 0.05 0 -1 99 3 0 0 0 0 0 0 0 # CV_old_Fem_GP_1
-3 3 7.5242e-006 0 -1 99 -3 0 0 0 0 0 0 0 # WtLt_1_Fem
-3 5 3.233205 0 -1 99 -3 0 0 0 0 0 0 0 # WtLt_2_Fem
9 19 15.44 0 -1 99 -3 0 0 0 0 0 0 0 # Mat50%_Fem
-20 3 -0.89252 0 -1 99 -3 0 0 0 0 0 0 0 # Mat_slope_Fem
0 10 1 0 -1 99 -3 0 0 0 0 0 0 0 # Eggs/kg_inter_Fem
-1 5 0 0 -1 99 -3 0 0 0 0 0 0 0 # Eggs/kg_slope_wt_Fem
-4 4 0 0 -1 99 -3 0 0 0 0 0 0 0 # RecrDist_GP_1
-4 4 1 0 -1 99 -3 0 0 0 0 0 0 0 # RecrDist_Area_1
-4 4 1 0 -1 99 -3 0 0 0 0 0 0 0 # RecrDist_Seas_1
-4 4 0 0 -1 99 -3 0 0 0 0 0 0 0 # RecrDist_Seas_2
1 1 1 0 -1 99 -3 0 0 0 0 0 0 0 # Cohort Growth_Dev
# Seasonal effects on biology parameter
0 0 0 0 0 0 0 0 0 0 # femwtlt1, femwtlt2, mat1, mat2, fec1, fec2, malewtlt1, malewtlt2, L1, K
# Spawner-recruit (SR) parameters
3 # SR function: 3=std_B-H
3 25 16 0 -1 99 1 # SR_R0
0.2 1 0.8 0 -1 99 -6 # SR_steepness
0 2 0.75 0 -1 99 -3 # SR_sigmaR
-5 5 0 0 -1 99 -3 # SR_env link
-15 15 0 0 -1 99 2 # SR_R1_offset
0 0 0 0 -1 99 -3 # SR_autocorr
```

```
0 # SR_env link
0 # SR_env target: 0=none, 1=devs, 2=R0, 3=steepness
1 # Do recdev:  0=none, 1=devvector, 2=simple deviations
1993 # First year of main rec_devs (early devs can preceed this era)
2012 # Last year of main rec_devs (forecast devs start in following year)
1 # Rec_dev phase
1 # Read 13 advanced options (0/1)
-6 # Rec_dev early start: 0=none (neg value makes relative to rec_dev)
2 # Rec_dev early phase
0 # Forecast rec phase (includes late rec): 0 value sets to maxphase+1
1 # Lambda for Forecast rec likelihood occurring before endyr+1
1984 # Last early_yr nobias adjustment in MPD
1993 # First yr fullbias adjustment in_MPD
2010 # Last yr fullbias adjustment in MPD
2013 # First recent_yr nobias adjustment in MPD
0.93 # Max bias adjustment in_MPD (-1 to override ramp and set bias adjustment=1.0 for all estimated rec_devs)
0 # Period of cycles in recruitment (N_parms read below)
-5 # Min rec_dev
5 # Max rec_dev
0 # Read rec_devs
# Fishing mortality (F) parameters
0.1 # F ballpark for tuning early phases
-2006 # F ballpark year (neg value to disable)
3 # F method: 1=Pope, 2=instant F, 3=hybrid
4 # Max F or harvest rate (depends on F method)
10 # N_iterations for tuning F
# Initial F parameters
0 4 0 0 -1 99 -1 # Init F_MexCal_S1
0 4 0 0 -1 99 -1 # Init F_MexCal_S2
0 4 0 0 -1 99 -1 # Init F_PacNW
# Catchability (Q) parameters
# Den-dep  Env-var  Extra_SE  Q_type
0 0 0 0 # 1 MexCal_S1
0 0 0 0 # 2 MexCal_S2
0 0 0 0 # 3 PacNW
0 0 0 2 # 4 DEPM
0 0 0 2 # 5 TEP
0 0 0 2 # 6 TEP_all
0 0 0 2 # 7 Aerial
0 0 0 2 # 8 ATM_Spring
0 0 0 -8 # 9 ATM_Summer (share q with ATM_Spring)
# Q parameters (if any)
-3 3 -1.39 0 -1 99 5 # Q_DEPM
-3 3 -0.69 0 -1 99 5 # Q_TEP
-3 3 -0.69 0 -1 99 5 # Q_TEP_full
-3 3 0 0 -1 99 5 # Q_Aerial
-3 3 0 0 -1 99 -5 # Q_Acoustic_Spring
# -3 3 0 0 -1 99 5 # Q_Acoustic_Summer
# Size selectivity types
# Pattern Discard Male Special
24 0 0 0 # 1 MexCal_S1
24 0 0 0 # 2 MexCal_S2
24 0 0 0 # 3 PacNW
30 0 0 0 # 4 DEPM
30 0 0 0 # 5 TEP
30 0 0 0 # 6 TEP_full
24 0 0 0 # 7 Aerial
24 0 0 0 # 8 Acoustic_Spring
24 0 0 0 # 9 Acoustic_Summer
# Age selectivity types
# Pattern Discard Male Special
0 0 0 0 # 1 MexCal_S1
0 0 0 0 # 2 MexCal_S2
0 0 0 0 # 3 PacNW
0 0 0 0 # 4 DEPM
0 0 0 0 # 5 TEP
0 0 0 0 # 6 TEP_full
0 0 0 0 # 7 Aerial
0 0 0 0 # 8 Acoustic_Spring
0 0 0 0 # 9 Acoustic_Summer
# Size selectivity
# MexCal_S1 (dome)
10 28 18 0 -1 99 4 0 0 0 0 0 1 2 # SizeSel_P1_MexCal_S1
-5 3 -4.985 0 -1 99 -4 0 0 0 0 0 1 2 # SizeSel_P2_MexCal_S1
-1 9 2.5 0 -1 99 4 0 0 0 0 0 1 2 # SizeSel_P3_MexCal_S1
```

```
-1 9 4 0 -1 99 4 0 0 0 0 0 1 2 # SizeSel_P4_MexCal_S1
-10 10 -10 0 -1 99 -4 0 0 0 0 0 1 2 # SizeSel_P5_MexCal_S1
-10 10 -10 0 -1 99 4 0 0 0 0 0 1 2 # SizeSel_P6_MexCal_S1
#_MexCal_S2 (dome)
10 28 18 0 -1 99 4 0 0 0 0 0 1 2 # SizeSel_P1_MexCal_S2
-5 3 -4.993 0 -1 99 -4 0 0 0 0 0 1 2 # SizeSel_P2_MexCal_S2
-1 9 2.5 0 -1 99 4 0 0 0 0 0 1 2 # SizeSel_P3_MexCal_S2
-1 9 4 0 -1 99 4 0 0 0 0 0 1 2 # SizeSel_P4_MexCal_S2
-10 10 -10 0 -1 99 -4 0 0 0 0 0 1 2 # SizeSel_P5_MexCal_S2
-10 10 -10 0 -1 99 4 0 0 0 0 0 1 2 # SizeSel_P6_MexCal_S2
# PacNW (Asymptotic)
10 28 19 0 -1 99 4 0 0 0 0 0 0 0 # SizeSel_P1_PNW
-5 10 2.5 0 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_P2_PNW
-5 10 5 0 -1 99 4 0 0 0 0 0 0 0 # SizeSel_P3_PNW
-5 10 5 0 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_P4_PNW
-10 10 -10 0 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_P5_PNW
-10 10 10 0 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_P6_PNW
# Aerial (Asymptotic)
10 28 18 0 -1 99 4 0 0 0 0 0 0 0 # SizeSel_P1__Aerial
-5 3 3 0 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_P2__Aerial
-1 9 2.5 0 -1 99 4 0 0 0 0 0 0 0 # SizeSel_P3__Aerial
-1 9 4 0 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_P4__Aerial
-10 10 -10 0 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_P5__Aerial
-10 10 10 0 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_P6__Aerial
# Acoustic_Spring (Asymptotic)
10 28 18 0 -1 99 4 0 0 0 0 0 0 0 # SizeSel_P1_Acoustic
-5 3 3 0 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_P2_Acoustic
-1 9 2.5 0 -1 99 4 0 0 0 0 0 0 0 # SizeSel_P3_Acoustic
-1 9 4 0 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_P4_Acoustic
-10 10 -10 0 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_P5_Acoustic
-10 10 10 0 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_P6_Acoustic
# Acoustic_Summer (Asymptotic)
10 28 18 0 -1 99 4 0 0 0 0 0 0 0 # SizeSel_P1_Acoustic
-5 3 3 0 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_P2_Acoustic
-1 9 2.5 0 -1 99 4 0 0 0 0 0 0 0 # SizeSel_P3_Acoustic
-1 9 4 0 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_P4_Acoustic
-10 10 -10 0 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_P5_Acoustic
-10 10 10 0 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_P6_Acoustic
1 # Custom sel-blk setup (0/1)
#_MexCal_S1 (Block 2)
10 28 18 0 -1 99 4 # SizeSel_P1_MexCal_S1_Blk2
-5 3 -4.998 0 -1 99 -4 # SizeSel_P2_MexCal_S1_Blk2
-1 9 2.5 0 -1 99 4 # SizeSel_P3_MexCal_S1_BLK2
-1 9 4 0 -1 99 4 # SizeSel_P4_MexCal_S1_Blk2
-10 10 -10 0 -1 99 -4 # SizeSel_P5_MexCal_S1_Blk2
-10 10 -10 0 -1 99 4 # SizeSel_P6_MexCal_S1_Blk2
#_MexCal_S2 (Block 2)
10 28 18 0 -1 99 4 # SizeSel_P1_MexCal_S2_Blk2
-5 3 -4.997 0 -1 99 -4 # SizeSel_P2_MexCal_S2_Blk2
-1 9 2.5 0 -1 99 4 # SizeSel_P3_MexCal_S2_Blk2
-1 9 4 0 -1 99 4 # SizeSel_P4_MexCal_S2_Blk2
-10 10 -10 0 -1 99 -4 # SizeSel_P5_MexCal_S2_Blk2
-10 10 -10 0 -1 99 4 # SizeSel_P6_MexCal_S2_Blk2
1 # Cond # Env/Block/Dev_adjustment method: 1=standard
0 # Tag custom:  0=no read, 1=read if tags exist
1 # Variance adjustments
# Fleet/Survey: 1 2 3 4 5 6 7 8 9
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     #_add_to_survey_CV
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     #_add_to_discard_stddev
0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     #_add_to_bodywt_CV
1.0     1.0     1.0     1.0     1.0     1.0     1.0     1.0     1.0     #_mult_by_lencomp_N
1.0     1.0     1.0     1.0     1.0     1.0     1.0     1.0     1.0     #_mult_by_agecomp_N
1.0     1.0     1.0     1.0     1.0     1.0     1.0     1.0     1.0     #_mult_by_size-at-age_N
1 # Max lambda phase
1 # SD_offset
25 # Number of changes to make to default Lambdas (default value=1)
# Like_comp fleet/survey  phase  value  size-freq_method
1 4 1 1 1      # DEPM
1 5 1 1 1      # TEP
1 6 1 0 1      # TEP_full
1 7 1 0 1      # Aerial
1 8 1 1 1      # Acoustic_Spring
1 9 1 1 1      # Acoustic_Summer
4 1 1 1 1      # MexCal_S1 (length)
4 2 1 1 1      # MexCal_S2 (length)
```

```
4 3 1 1 1      # PacNW (length)
4 7 1 0 1      # Aerial (length)
4 8 1 1 1      # Acoustic_Spring (length)
4 9 1 1 1      # Acoustic_Summer (length)
5 1 1 0.2 1    # MexCal_S1 (Cond AAL)
5 2 1 0.2 1    # MexCal_S2 (Cond AAL)
5 3 1 0.2 1    # PacNW (Cond AAL)
5 8 1 0 1      # Acoustic_Spring (Cond AAL)
5 9 1 0 1      # Acoustic_Summer (Cond AAL)
7 1 1 0 1      # MexCal_S1 (Mean LAA)
7 2 1 0 1      # MexCal_S2 (Mean LAA)
7 3 1 0 1      # PacNW (Mean LAA)
7 8 1 0 1      # Acoustic_Spring (Mean LAA)
7 9 1 0 1      # Acoustic_Summer (Mean LAA)
9 1 1 0 1      # Initial equilibrium catch (MexCal_S1)
9 2 1 0 1      # Initial equilibrium catch (MexCal_S2)
9 3 1 0 1      # Initial equilibrium catch (PacNW)
0 # Read specs for more SD reporting (0/1)
999 # End of file
```

DATA FILE 'T2_0.2.DAT' (NSP Data)

```
# Pacific sardine stock assessment for 2014-15
# K. T. Hill and P. R. Crone (March 2014)
# SS ver. 3.24s
#
1993 # Start year (July 1993)
2013 # End year (forecast=2014)
2 # N_seasons
6 6 # Months per season (2 semesters per fishing year)
2 # Spawning season (Spring semester)
3 # N_fleets
6 # N_surveys
1 # N_areas
MexCal_S1_NSP%MexCal_S2_NSP%PacNW%DEPM%TEP%TEP_full%Aerial%ATM_Spring%ATM_Summer
0.5 0.5 0.5 0.58 0.58 0.58 0.2 0.58 0.2 # Survey timing in season
1 1 1 1 1 1 1 1 1 # Area assignments for each fishery/survey
1 1 1 # Units of catch: 1=biomass, 2=number
0.05 0.05 0.05 # SE of log(catch), only used for initial equilibrium catch and for Fmethod=2-3
1 # N_genders
15 # N_ages
0 0 0 # Initial equilibrium catch for each fishery
42 # N_lines of catch to read
# Catch biomass(mt): columns are fisheries, year, season
822.80  0.00    0.00    1993    1
0.00    11345.83        0.00    1993    2
8838.65 0.00    0.00    1994    1
0.00    39748.42        0.00    1994    2
5993.28 0.00    22.68   1995    1
0.00    26565.72        0.00    1995    2
11917.29        0.00    0.00    1996    1
0.00    19158.65        43.54   1996    2
13018.20        0.00    27.22   1997    1
0.00    24527.60        0.82    1997    2
18925.15        0.00    488.25  1998    1
0.00    63278.38        74.39   1998    2
14996.21        0.00    725.20  1999    1
0.00    58341.39        429.59  1999    2
23693.38        0.00    15586.16        2000    1
0.00    35179.21        2336.90 2000    2
11550.53        0.00    22545.99        2001    1
0.00    41118.36        3136.84 2001    2
16562.71        0.00    35525.69        2002    1
0.00    36130.69        597.29  2002    2
10340.64        0.00    37242.26        2003    1
0.00    21300.55        2618.43 2003    2
17048.96        0.00    46730.80        2004    1
0.00    25249.92        1016.32 2004    2
13730.19        0.00    54152.62        2005    1
0.00    29752.00        101.70  2005    2
20620.28        0.00    41220.90        2006    1
0.00    39234.00        0.00    2006    2
46047.30        0.00    48237.10        2007    1
0.00    42247.81        0.00    2007    2
```

```
30147.46       0.00    39800.10       2008    1
0.00    40545.56       0.00    2008    2
13964.90       0.00    44841.15       2009    1
0.00    30240.66       1369.73 2009    2
11130.97       0.00    54085.91       2010    1
0.00    26817.27       0.09    2010    2
24700.00       0.00    39750.49       2011    1
0.00    20514.89       5805.63 2011    2
1452.24 0.00    91425.63       2012    1
0.00    7373.93 1570.78 2012    2
739.00  0.00    52961.07       2013    1
0.00    13280.00       1500.00 2013    2       #_Mexcal=9780+3500
#
51 #_N_cpue_and_surveyabundance_observations
#_Units:  0=numbers; 1=biomass; 2=F
#_Errtype:  -1=normal; 0=lognormal; >0=T
#_Fleet Units Errtype
1 1 0 # MexCal_S1
2 1 0 # MexCal_S2
3 1 0 # PacNW
4 1 0 # DEPM
5 1 0 # TEP
6 1 0 # TEP_full
7 1 0 # Aerial
8 1 0 # Acoustic_Spring
9 1 0 # Acoustic_Summer
# Year season index obs error
1993    2       4       69065   0.29    #_DEPM_9404
2003    2       4       145274  0.23    #_DEPM_0404
2004    2       4       459943  0.55    #_DEPM_0504
2006    2       4       198404  0.30    #_DEPM_0704
2007    2       4       66395   0.27    #_DEPM_0804
2008    2       4       99162   0.24    #_DEPM_0905
2009    2       4       58447   0.40    #_DEPM_1004
2010    2       4       219386  0.27    #_DEPM_1104
2011    2       4       113178  0.27    #_DEPM_1204
2012    2       4       82182   0.29    #_DEPM_1304
1995    2       5       97923   0.40    #_TEP_9604
1996    2       5       482246  0.21    #_TEP_9704
1997    2       5       369775  0.33    #_TEP_9804
1998    2       5       332177  0.34    #_TEP_9904
1999    2       5       1252539 0.39    #_TEP_0004
2000    2       5       931377  0.38    #_TEP_0104
2001    2       5       236660  0.17    #_TEP_0204
2002    2       5       556177  0.18    #_TEP_0304
2005    2       5       651994  0.25    #_TEP_0604
1993    2       6       73374   0.21    #_TEPall_9404
1995    2       6       97923   0.40    #_TEPall_9604
1996    2       6       482246  0.21    #_TEPall_9704
1997    2       6       369775  0.33    #_TEPall_9804
1998    2       6       332177  0.34    #_TEPall_9904
1999    2       6       1252539 0.39    #_TEPall_0004
2000    2       6       931377  0.38    #_TEPall_0104
2001    2       6       236660  0.17    #_TEPall_0204
2002    2       6       556177  0.18    #_TEPall_0304
2003    2       6       307795  0.24    #_TEPall_0404
2004    2       6       486950  0.40    #_TEPall_0504
2005    2       6       651994  0.25    #_TEPall_0604
2006    2       6       306297  0.26    #_TEPall_0704
2007    2       6       128118  0.21    #_TEPall_0804
2008    2       6       162188  0.22    #_TEPall_0904
2009    2       6       97838   0.39    #_TEPall_1004
2010    2       6       364798  0.26    #_TEPall_1104
2011    2       6       227632  0.27    #_TEPall_1204
2012    2       6       198472  0.29    #_TEPall_1304
2009    1       7       1236911 0.90    #_Aerial_09N
2010    1       7       173390  0.40    #_Aerial_10N
2011    1       7       201888  0.29    #_Aerial_11N
2012    1       7       696251  0.37    #_Aerial_12N
2005    2       8       1947063 0.30    #_Acoustic_0604
2007    2       8       751075  0.09    #_Acoustic_0804
2009    2       8       357006  0.41    #_Acoustic_1004
2010    2       8       493672  0.30    #_Acoustic_1104
2011    2       8       469480  0.28    #_Acoustic_1204
2012    2       8       305146  0.24    #_Acoustic_1304
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2008    1       9       801000  0.30    #_Acoustic_0807
2012    1       9       340831  0.33    #_Acoustic_1207
2013    1       9       313746  0.27    #_Acoustic_1307
0 # N_fleets with discard
0 # N_discard obs
0 # N_meanbodywt obs
100 # DF for_meanbodywt t-distribution likelihood
2 # Length bin method: 1=use databins; 2=generate from binwidth,min,max below; 3=read vector
0.5 # Bin width for population size composition
8 # Minimum size in the population (lower edge of first bin and size at age 0)
30 # Maximum size in the population (lower edge of last bin)
-0.0001 # Composition tail compression
0.0001 # Add to composition
0 # Combine males into females at or below this bin number
39 # N_length bins
9 9.5 10 10.5 11 11.5 12 12.5 13 13.5 14 14.5 15 15.5 16 16.5 17 17.5 18 18.5 19 19.5 20 20.5 21 21.5 22 22.5 23
23.5 24 24.5 25 25.5 26 26.5 27 27.5 28
79 # N_length obs
# Year Season Fleet/Survey Gender Part Nsamp Datavector(female-male)
1993    1       1       0       0       2.72    0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.01470588      0.00000000      0.14705882
        0.23529412      0.19117647      0.20588235      0.13235294      0.05882353      0.01470588      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1994    1       1       0       0       13.74   0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00192997      0.01865635
        0.04117263      0.08430434      0.07591361      0.07404029      0.08683868      0.12757807      0.09884957
        0.10926901      0.11878046      0.08880898      0.05178937      0.00695027      0.01026562      0.00365034
        0.00060123      0.00000000      0.00060123      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1995    1       1       0       0       4.80    0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00833333      0.00000000      0.00833333      0.00833333      0.01666667
        0.07500000      0.08333333      0.05833333      0.20833333      0.13333333      0.21666667      0.08333333
        0.06666667      0.01666667      0.00833333      0.00833333      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1996    1       1       0       0       59.54   0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00034806      0.00058009
        0.00219937      0.00576503      0.00957964      0.02611018      0.04050980      0.05620072      0.08282782
        0.13533238      0.15435462      0.17604004      0.13254345      0.08564194      0.05547979      0.02087313
        0.00993156      0.00286865      0.00069611      0.00023204      0.00062219      0.00000000      0.00000000
        0.00042114      0.00042114      0.00000000      0.00042114      0.00000000      0.00000000      0.00000000
1997    1       1       0       0       54.96   0.00161047      0.00000000      0.00000000      0.00000000
        0.00000000      0.00070613      0.00190931      0.00249531      0.00157254      0.00740264      0.02034422
        0.02746041      0.02356657      0.03226502      0.04920364      0.05812807      0.09131547      0.12217437
        0.17851369      0.16690609      0.10823880      0.06410378      0.02256286      0.00874199      0.00479242
        0.00070613      0.00249531      0.00176969      0.00030895      0.00070613      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1998    1       1       0       0       61.82   0.00000000      0.00013950      0.00000000      0.00054913
        0.00217145      0.00754043      0.02660605      0.06328062      0.09928446      0.12017588      0.11452861
        0.10222652      0.08662035      0.08022393      0.05559320      0.04519876      0.03979356      0.03720684
        0.02689637      0.02425384      0.01374267      0.01309129      0.01455336      0.00735521      0.00736115
        0.00379924      0.00202174      0.00182034      0.00226600      0.00169950      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1999    1       1       0       0       8.45    0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00970931      0.02427327      0.05825584      0.09709307
        0.13107564      0.18600867      0.21698374      0.07874420      0.08045604      0.05037072      0.03313752
        0.01627580      0.00727624      0.00325516      0.00229776      0.00229776      0.00153184      0.00038296
        0.00019148      0.00038296      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
2000    1       1       0       0       19.31   0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00214444      0.00687013      0.00236284      0.00816075      0.01610311
        0.02362844      0.03736871      0.07557145      0.12782502      0.17187176      0.18629126      0.17216776
        0.08516998      0.03492402      0.01434741      0.01172984      0.01007111      0.00731811      0.00463296
        0.00036867      0.00000000      0.00000000      0.00107222      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
2001    1       1       0       0       26.92   0.00299140      0.00273498      0.01506817      0.03187710
        0.04628212      0.02810027      0.01845921      0.01980049      0.02094225      0.00689629      0.00233494
        0.00009139      0.00702992      0.01724077      0.03944303      0.04010245      0.05293178      0.06963658
        0.06813359      0.03349161      0.02422864      0.01998817      0.02567865      0.04374940      0.06629584
        0.11235528      0.07962582      0.03629326      0.02802019      0.01335362      0.01339213      0.00843442
        0.00307756      0.00191866      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
2002    1       1       0       0       46.96   0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00058534      0.00000000      0.00000000      0.00427117      0.00856097      0.01383827
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	0.02882084	0.07292346	0.10667321	0.12477102	0.13591949	0.17905045	0.12960308	
	0.09350153	0.04093142	0.02615243	0.01065275	0.00566682	0.00430140	0.00526596	
	0.00146460	0.00420899	0.00225146	0.00000000	0.00000000	0.00000000	0.00058534	
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
2003	1	1	0	0	13.15	0.00000000	0.00169262	0.00451718
	0.01608292							
	0.06021648	0.12408570	0.08347189	0.05346355	0.04403720	0.02879712	0.01144579	
	0.02279141	0.01563165	0.02462320	0.02606885	0.03942352	0.05607711	0.07024577	
	0.06869371	0.06366968	0.04343752	0.04937621	0.04233675	0.02762563	0.01033400	
	0.00851117	0.00243153	0.00091182	0.00000000	0.00000000	0.00000000	0.00000000	
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
2004	1	1	0	0	32.30	0.00000000	0.00000000	0.00000000
	0.00024514							
	0.00024514	0.00073543	0.00205767	0.00283243	0.00824157	0.00988930	0.04485433	
	0.11745533	0.20110987	0.16552816	0.14517069	0.11552133	0.08888914	0.04629335	
	0.01857389	0.01104107	0.00756468	0.00443794	0.00243413	0.00239788	0.00000806	
	0.00000201	0.00000000	0.00223572	0.00000000	0.00000000	0.00223572	0.00000000	
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
2005	1	1	0	0	28.75	0.00000000	0.00000000	0.00071949
	0.00143897							
	0.00653511	0.01157153	0.01384485	0.01309843	0.02798175	0.05168794	0.07930643	
	0.09237886	0.07490876	0.08847601	0.11085534	0.15343903	0.10619562	0.07417982	
	0.03501566	0.02276698	0.01374071	0.01125064	0.00258153	0.00246207	0.00002240	
	0.00056560	0.00000000	0.00113119	0.00056560	0.00000000	0.00271410	0.00056560	
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
2006	1	1	0	0	70.00	0.00000000	0.00000000	0.00000000
	0.00000000							
	0.00000000	0.00000000	0.00000817	0.00139593	0.00370309	0.01051305	0.02830085	
	0.08812453	0.16038481	0.17472994	0.15633215	0.13757842	0.10032027	0.06327177	
	0.03845569	0.02449167	0.00528078	0.00445611	0.00132639	0.00033160	0.00033160	
	0.00033160	0.00033160	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
2007	1	1	0	0	69.87	0.00164969	0.00247453	0.00329937
	0.00264684							
	0.00076071	0.00094036	0.00106112	0.00505987	0.00726599	0.01044510	0.02075499	
	0.03448703	0.06756079	0.10788447	0.15231813	0.18353671	0.15746569	0.11193402	
	0.06189772	0.03095113	0.01131497	0.00936246	0.00448928	0.00070277	0.00070277	
	0.00049491	0.00111500	0.00082484	0.00181466	0.00164969	0.00164969	0.00115478	
	0.00032994	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
2008	1	1	0	0	27.00	0.00000000	0.00001951	0.00001951
	0.00007805							
	0.00007805	0.00025365	0.00812568	0.01322437	0.01507600	0.01012736	0.00703638	
	0.00222432	0.00815459	0.03743973	0.10519409	0.17673635	0.17069402	0.16753307	
	0.13252684	0.05969125	0.02792098	0.01779568	0.00494964	0.01433373	0.00739166	
	0.00899568	0.00066448	0.00187718	0.00005853	0.00177962	0.00000000	0.00000000	
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
2009	1	1	0	0	23.00	0.00000000	0.00000000	0.00000000
	0.00000000							
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00718480	
	0.00659772	0.02510462	0.00834218	0.03988813	0.13822895	0.30734108	0.28332180	
	0.12859970	0.04820622	0.00544034	0.00174446	0.00000000	0.00000000	0.00000000	
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
2010	1	1	0	0	13.00	0.00000000	0.00000000	0.00000000
	0.00000000							
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00307692	0.00000000	
	0.02153846	0.11076923	0.30153846	0.28615385	0.22153846	0.02153846	0.01846154	
	0.00307692	0.00307692	0.00615385	0.00307692	0.00000000	0.00000000	0.00000000	
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
2011	1	1	0	0	22.00	0.00000000	0.00000000	0.00000000
	0.00000000							
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
	0.00000000	0.00000000	0.00550160	0.02270543	0.10592845	0.30705434	0.33715847	
	0.16548304	0.03472523	0.01524281	0.00344984	0.00000000	0.00000000	0.00275080	
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
2012	1	1	0	0	22.96	0.00000000	0.00000000	0.00000000
	0.00000000							
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.02288534	
	0.01634667	0.02615468	0.01307734	0.00326933	0.00980800	0.02916482	0.07258330	
	0.10858359	0.14709358	0.12463433	0.14112953	0.13635974	0.07152817	0.05732066	
	0.01399447	0.00048164	0.00372320	0.00186160	0.00000000	0.00000000	0.00000000	
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
2013	1	1	0	0	5.00	0.00000000	0.00000000	0.00000000
	0.00000000							
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
	0.00016205	0.01991898	0.02008102	0.05975693	0.04000000	0.11967591	0.17991898	
	0.28000000	0.13060767	0.09012153	0.04979744	0.00995949	0.00000000	0.00000000	
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
1993	2	2	0	0	80.83	0.00000000	0.00000000	0.00000000
	0.00000000							
	0.00000000	0.00000000	0.00024233	0.00140226	0.00726413	0.02974873	0.06247855	
	0.09739572	0.09557449	0.07134655	0.06703480	0.08193713	0.10366195	0.11143525	
	0.10144129	0.05447251	0.03973350	0.02527592	0.01453475	0.00850628	0.00787906	

	0.00345701	0.00250677	0.00214831	0.00346978	0.00312588	0.00135054	0.00021661	
	0.00128376	0.00093526	0.00000000	0.00014086	0.00000000	0.00000000	0.00000000	
1994	2	2	0	0	206.08	0.00000000	0.00000000	0.00000000	0.00000000
	0.00145457	0.00504078	0.00606898	0.00700771	0.01410691	0.02242621	0.04034287	
	0.06906816	0.09654861	0.11238178	0.12955228	0.13501642	0.11091489	0.09320556	
	0.05899874	0.04552064	0.02495894	0.01511850	0.00540478	0.00359894	0.00066879	
	0.00092576	0.00026691	0.00000000	0.00012087	0.00000000	0.00029208	0.00069722	
	0.00000000	0.00000000	0.00000000	0.00029208	0.00000000	0.00000000	0.00000000	
1995	2	2	0	0	42.30	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00483005	0.00181639	0.00978760	0.01443863	0.02041858	0.02632739	
	0.03677194	0.05949842	0.09049866	0.10561619	0.13138787	0.11886270	0.11101527	
	0.07941884	0.07368271	0.04314995	0.03412017	0.01538229	0.01735834	0.00323563	
	0.00100235	0.00056203	0.00000000	0.00040900	0.00000000	0.00000000	0.00000000	
	0.00040900	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
1996	2	2	0	0	31.69	0.00000000	0.00000000	0.00000001	0.00000006
	0.00208698	0.00474184	0.01105977	0.01641602	0.03848093	0.04640019	0.05225376	
	0.07284165	0.06293899	0.03267289	0.02526977	0.03481597	0.04474040	0.05224002	
	0.05002577	0.07588550	0.07647282	0.09283255	0.08189359	0.05770817	0.02553826	
	0.01572120	0.00742768	0.00448802	0.00253262	0.00168842	0.00168842	0.00168842	
	0.00168842	0.00238407	0.00337683	0.00000000	0.00000000	0.00000000	0.00000000	
1997	2	2	0	0	39.04	0.00116688	0.00116688	0.01283567	0.01168079
	0.01911496	0.00995550	0.00463359	0.00836094	0.02093227	0.01412310	0.04077870	
	0.04592240	0.05486011	0.07529587	0.08758462	0.06419613	0.05883337	0.06624342	
	0.04634799	0.03228601	0.03351542	0.03099222	0.05453763	0.05713365	0.05113369	
	0.04096875	0.03221245	0.01144112	0.00765009	0.00308468	0.00057263	0.00023650	
	0.00020197	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
1998	2	2	0	0	62.89	0.00000000	0.00052375	0.00292399	0.00531268
	0.00807976	0.00892394	0.01445008	0.04007347	0.04947419	0.06018640	0.07160912	
	0.08430841	0.09930662	0.11026781	0.09545976	0.09022715	0.07892527	0.06308014	
	0.02943892	0.02494755	0.01733738	0.01275855	0.01065188	0.00689855	0.00555941	
	0.00337949	0.00283313	0.00163188	0.00071536	0.00040797	0.00030739	0.00000000	
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
1999	2	2	0	0	45.97	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00373364	0.01858885	0.06092482	0.10283009	
	0.13630227	0.17321851	0.15257482	0.12476550	0.08514671	0.05049129	0.03310700	
	0.02304860	0.01857073	0.01262764	0.00349994	0.00042741	0.00014219	0.00000000	
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
2000	2	2	0	0	42.47	0.00000000	0.00000000	0.00000000	0.00007818
	0.00031273	0.00695721	0.00948363	0.02298990	0.03958827	0.04929372	0.07791587	
	0.10364298	0.10939476	0.07624154	0.05471634	0.05940971	0.08000407	0.07736515	
	0.05906656	0.05988523	0.04314596	0.04274591	0.01443181	0.01154905	0.00083513	
	0.00000000	0.00086812	0.00007818	0.00000000	0.00000000	0.00000000	0.00000000	
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
2001	2	2	0	0	57.78	0.00000000	0.00000000	0.00114442	0.01008725
	0.02360642	0.04515338	0.06577894	0.08827063	0.10528246	0.11005028	0.08543740	
	0.06257413	0.06371308	0.05222215	0.02452615	0.02527951	0.02070571	0.02867169	
	0.04446623	0.05499618	0.03036332	0.02717653	0.01354428	0.00784013	0.00561628	
	0.00208727	0.00069576	0.00069576	0.00000000	0.00000000	0.00001467	0.00000000	
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
2002	2	2	0	0	55.61	0.00000000	0.00000000	0.00000000	0.00037996
	0.00113988	0.00189980	0.00264471	0.00378459	0.00573358	0.00469099	0.00904018	
	0.02153204	0.04856377	0.08579611	0.12189739	0.13011447	0.12668342	0.09525103	
	0.04868384	0.03776127	0.05061458	0.05005716	0.04759173	0.04675377	0.02437622	
	0.01196384	0.00688184	0.00781155	0.00573013	0.00095678	0.00080336	0.00086203	
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
2003	2	2	0	0	74.37	0.00000000	0.00000000	0.00002333	0.00737407
	0.03796815	0.06330862	0.06164288	0.08781023	0.13955871	0.16815734	0.12204441	
	0.08096378	0.04889651	0.02406924	0.01538764	0.01563158	0.01102487	0.01358790	
	0.01561320	0.02270900	0.01540512	0.01581931	0.00585443	0.00228531	0.00198207	
	0.00690423	0.00409315	0.00215683	0.00243203	0.00283737	0.00324271	0.00081068	
	0.00040534	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
2004	2	2	0	0	81.35	0.00000000	0.00000000	0.00000000	0.00000000
	0.00093783	0.00153447	0.00348067	0.00686443	0.02125242	0.03295020	0.06153444	
	0.10844211	0.11494040	0.12997977	0.12299243	0.09934347	0.09079576	0.07490959	
	0.06642619	0.03379681	0.01274994	0.00944827	0.00238726	0.00082184	0.00068687	
	0.00101954	0.00203739	0.00000000	0.00066788	0.00000000	0.00000000	0.00000000	
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
2005	2	2	0	0	69.54	0.00003323	0.00016617	0.00198183	0.00724287
	0.02546488	0.03423464	0.04343134	0.05161252	0.08921533	0.10317372	0.11440362	
	0.10395214	0.11260776	0.08466520	0.06700801	0.04312203	0.03875394	0.02639734	
	0.01505989	0.01090155	0.00709011	0.00530332	0.00273073	0.00352497	0.00253710	
	0.00095835	0.00156157	0.00078078	0.00027632	0.00048453	0.00064604	0.00035514	
	0.00032302	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	

2006	2	2	0	0	79.01	0.00000000	0.00000000	0.00000000	0.00007155
	0.00193274	0.00448013	0.00870836	0.01190914	0.02276871	0.02245554	0.05508678		
	0.08312489	0.10950482	0.11508847	0.11718795	0.09778619	0.08344183	0.07797438		
	0.05950222	0.04982304	0.02853562	0.01769640	0.00778031	0.00668425	0.00192038		
	0.00407420	0.00371857	0.00243818	0.00184306	0.00148743	0.00148743	0.00148743		
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
2007	2	2	0	0	53.13	0.00000000	0.00000000	0.00056916	0.00458294
	0.01523107	0.01624194	0.03828270	0.07429633	0.10589583	0.11936676	0.13445629		
	0.09028317	0.08948056	0.09093413	0.06813034	0.04676708	0.03148477	0.01534756		
	0.01102726	0.00991497	0.00445812	0.00594738	0.00799020	0.00561403	0.00666222		
	0.00305137	0.00193240	0.00055948	0.00018649	0.00055948	0.00018649	0.00018649		
	0.00037299	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
2008	2	2	0	0	39.53	0.00130827	0.00130827	0.00261985	0.00174435
	0.00820997	0.01240801	0.02192600	0.03724275	0.03155898	0.02949098	0.03131780		
	0.04421268	0.06406849	0.11119877	0.13321561	0.12895909	0.08889473	0.07252151		
	0.05604855	0.05270723	0.02472053	0.01390128	0.00841632	0.00910891	0.00492096		
	0.00313298	0.00174435	0.00198249	0.00043609	0.00067422	0.00000000	0.00000000		
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
2009	2	2	0	0	99.00	0.00000000	0.00000000	0.00000000	0.00033110
	0.00098937	0.00364222	0.01526663	0.04815485	0.10491762	0.15225861	0.16727933		
	0.14395945	0.12763433	0.09200956	0.07251219	0.03921100	0.01392598	0.00964499		
	0.00259569	0.00164641	0.00095708	0.00053046	0.00065827	0.00089258	0.00090368		
	0.00000000	0.00000000	0.00007860	0.00000000	0.00000000	0.00000000	0.00000000		
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
2010	2	2	0	0	32.96	0.00000000	0.00000000	0.00000000	0.00000329
	0.00000986	0.00000000	0.01533814	0.03545198	0.07505310	0.08012643	0.16082054		
	0.16409807	0.14395429	0.08121932	0.03649645	0.02499783	0.00880498	0.00803841		
	0.00505031	0.00646200	0.00190905	0.00326271	0.00879883	0.01489032	0.03181114		
	0.02910381	0.02842698	0.01759765	0.00812199	0.00744516	0.00067683	0.00135367		
	0.00067683	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
2011	2	2	0	0	56.28	0.00000000	0.00000000	0.00000000	0.00000000
	0.00042055	0.00393862	0.02649871	0.07254863	0.07899923	0.06480918	0.05727363		
	0.04957664	0.04043675	0.05008019	0.04620495	0.05065969	0.03636937	0.04610942		
	0.04153957	0.06936597	0.04808470	0.04969147	0.03341529	0.02532542	0.01673552		
	0.02905829	0.02593557	0.02224027	0.00818459	0.00324890	0.00108297	0.00216593		
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
2012	2	2	0	0	9.00	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
	0.00634863	0.00634863	0.01904590	0.03809180	0.01904590	0.08292541	0.10792675		
	0.13008930	0.15627021	0.07814954	0.12219678	0.07438000	0.05428802	0.04833258		
	0.04339435	0.00937866	0.00227252	0.00151501	0.00000000	0.00000000	0.00000000		
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
1999	1	3	0	0	3.04	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000095		
	0.00000095	0.00000285	0.00001236	0.04484245	0.07472347	0.07472918	0.13447410		
	0.15869488	0.13446554	0.05976204	0.04482153	0.02422648	0.04642701	0.03714674		
	0.03716576	0.02788359	0.03717908	0.03919457	0.00929548	0.00000666	0.00000285		
	0.01494051	0.00000000	0.00000095	0.00000000	0.00000000	0.00000000	0.00000000		
1999	2	3	0	0	4.24	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
	0.00000000	0.00000000	0.00000000	0.01886792	0.01886792	0.02830189	0.16981132		
	0.17924528	0.20754717	0.16981132	0.11320755	0.04716981	0.02830189	0.00943396		
	0.00943396	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
2000	1	3	0	0	63.93	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00003375	0.00006482	0.00000000	0.00003375	0.00000000		
	0.00003375	0.00000000	0.00000000	0.00063677	0.00308924	0.01570860	0.02898601		
	0.03823612	0.05495875	0.06093348	0.06560425	0.07664897	0.09104633	0.12502336		
	0.11358864	0.11316074	0.07608888	0.06753608	0.03163643	0.01814741	0.01018023		
	0.00428843	0.00365138	0.00060061	0.00003107	0.00003970	0.00000000	0.00001246		
2000	2	3	0	0	10.72	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000026	0.00012460	0.00000000	0.00000000		
	0.00000026	0.00000000	0.00000026	0.00000000	0.00000000	0.00000000	0.00000000		
	0.00000000	0.02350879	0.02375825	0.08315347	0.13179081	0.15417981	0.17881393		
	0.13080486	0.14894118	0.07718786	0.03579353	0.00003091	0.01189510	0.00000951		
	0.00000449	0.00000106	0.00000079	0.00000000	0.00000000	0.00000000	0.00000026		
2001	1	3	0	0	78.15	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00087005	0.00156608	0.00121806		
	0.00115894	0.00060192	0.00046425	0.00000000	0.00046425	0.00000000	0.00000002		
	0.00261835	0.01024098	0.02323570	0.07467192	0.16300429	0.17738632	0.16996193		
	0.12669923	0.09158078	0.06693893	0.04293152	0.02073142	0.01275755	0.00758599		
	0.00156533	0.00158897	0.00011092	0.00004628	0.00000000	0.00000000	0.00000002		
2001	2	3	0	0	26.76	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
	0.00000000	0.00000000	0.00000000	0.00000000	0.00048288	0.00048288	0.00000053		

	0.00000000	0.00000000	0.00000000	0.00367294	0.00879451	0.04010952	0.09046219	
	0.18199439	0.21660795	0.19187645	0.13186477	0.06604471	0.04323092	0.01074198	
	0.00880089	0.00289994	0.00048341	0.00096629	0.00048288	0.00000000	0.00000000	
2002	1	3	0	0	172.79	0.00000000	0.00000000	0.00000000	0.00000313
	0.00000626	0.00000626	0.00000626	0.00000313	0.00000938	0.00000626	0.00001363	
	0.00000313	0.00062473	0.00031198	0.00094645	0.00136169	0.00143519	0.00317196	
	0.00361648	0.00444832	0.00536365	0.00421846	0.01381946	0.03565991	0.11857744	
	0.20342331	0.21914500	0.14683906	0.11571644	0.06020604	0.03543252	0.01287390	
	0.00777273	0.00240956	0.00164771	0.00033310	0.00054432	0.00001901	0.00002414	
2002	2	3	0	0	8.44	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00312357	0.00000000	
	0.00000000	0.00624714	0.00937071	0.00937295	0.01249428	0.01249652	0.05221134	
	0.13789484	0.06785376	0.17431751	0.21008191	0.06999081	0.08758723	0.05631804	
	0.06875428	0.00938411	0.00624714	0.00312580	0.00312357	0.00000000	0.00000446	
2003	1	3	0	0	145.33	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000397	0.00000000	0.00000397	0.00000397	0.00081444	0.00403192	
	0.00514471	0.00338591	0.00141363	0.00001985	0.00029674	0.00455528	0.01661655	
	0.03216569	0.04716668	0.06356196	0.04611645	0.05368928	0.06537740	0.06742541	
	0.07208935	0.12367128	0.12474048	0.10239500	0.07361669	0.04797912	0.02147233	
	0.01095014	0.00687007	0.00305615	0.00071418	0.00062688	0.00001260	0.00001191	
2003	2	3	0	0	16.88	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
	0.00000000	0.00000000	0.00000000	0.00000000	0.00068529	0.01626167	0.03183805	
	0.07470549	0.17346083	0.15096679	0.24561041	0.16554308	0.08604058	0.03407916	
	0.01027932	0.00915877	0.00137058	0.00000000	0.00000000	0.00000000	0.00000000	
2004	1	3	0	0	93.35	0.00001567	0.00001567	0.00000000	0.00000000
	0.00056254	0.00028127	0.00056254	0.00142204	0.00609585	0.00738530	0.00901487	
	0.00780880	0.00880757	0.00314547	0.01122084	0.01449783	0.04081487	0.03735165	
	0.03390459	0.02231370	0.02555715	0.01629821	0.02816169	0.02899177	0.05840626	
	0.06057283	0.09562618	0.08453840	0.14026268	0.09805984	0.07524450	0.03709070	
	0.02707205	0.01236191	0.00425655	0.00131717	0.00055007	0.00017067	0.00024033	
2004	2	3	0	0	7.88	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
	0.00000000	0.00000000	0.00000000	0.02131378	0.05692221	0.15080485	0.27920147	
	0.24587915	0.15038613	0.02495166	0.02063744	0.00998066	0.00499033	0.00000000	
	0.00499033	0.00499033	0.00000000	0.00499033	0.00998066	0.00000000	0.00998066	
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
2005	1	3	0	0	67.68	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000553	0.00001355	0.00159531	0.00039392	0.00002710	0.00004066	0.00020755	
	0.00020258	0.00270103	0.02291847	0.05924987	0.09616749	0.20727817	0.18328761	
	0.12443673	0.05097571	0.01877167	0.01515760	0.00998755	0.00942919	0.01080600	
	0.01225695	0.01347518	0.01909393	0.02824136	0.03110144	0.04082612	0.02108261	
	0.01447999	0.00282130	0.00249264	0.00027437	0.00014659	0.00002710	0.00002710	
2006	1	3	0	0	27.00	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00385525	0.01151585	
	0.04782390	0.16295078	0.33602885	0.24986185	0.11243519	0.01737664	0.00466226	
	0.00994350	0.00193035	0.00122605	0.00686819	0.00826354	0.01135211	0.00487000	
	0.00864962	0.00000000	0.00000000	0.00038607	0.00000000	0.00000000	0.00000000	
2006	2	3	0	0	3.00	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.01333333	
	0.00000000	0.06666667	0.06666667	0.20000000	0.16000000	0.09333333	0.09333333	
	0.05333333	0.02666667	0.05333333	0.00000000	0.08000000	0.04000000	0.02666667	
	0.02666667	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	
2007	1	3	0	0	87.86	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000737	0.00000000	0.00000000	0.00000000	0.00000000	
	0.00000000	0.00000000	0.00000000	0.00001639	0.00061942	0.00255561	0.01442330	
	0.07011329	0.13161223	0.21359514	0.23707687	0.18219854	0.07245245	0.02287642	
	0.01307278	0.00799927	0.00556329	0.00684479	0.00802636	0.00410422	0.00215245	
	0.00214591	0.00115543	0.00071927	0.00011042	0.00050099	0.00001250	0.00004528	
2008	1	3	0	0	129.64	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00004054	0.00000000	0.00000000	0.00000000	0.00000000	
	0.00000000	0.00000000	0.00041928	0.00000000	0.00000000	0.00058332	0.00460794	
	0.03193930	0.06132653	0.11715864	0.14270701	0.15921219	0.11117985	0.07109068	
	0.04339494	0.04764464	0.06409722	0.06209469	0.04086420	0.02147774	0.01039633	
	0.00450936	0.00253737	0.00106315	0.00059479	0.00056213	0.00027694	0.00022122	
2009	1	3	0	0	159.41	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000722	0.00000000	0.00000000	0.00000000	0.00000000	
	0.00036834	0.00036834	0.00000722	0.00002165	0.00000722	0.00001443	0.00385185	
	0.02385351	0.05630274	0.13546005	0.16896254	0.15574778	0.09681599	0.06985591	
	0.04410210	0.07537644	0.06582272	0.05197468	0.02553117	0.01450460	0.00584005	
	0.00330284	0.00143161	0.00023704	0.00012583	0.00002508	0.00004879	0.00003229	

2009	2	3	0	0	4.33	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
	0.00000000	0.01398663	0.00000000	0.00000000	0.00000000	0.00000000	0.00640983		
	0.00764838	0.05363834	0.07792424	0.18996976	0.18962297	0.20269211	0.13261832		
	0.06086833	0.03818737	0.01244710	0.00622355	0.00776308	0.00000000	0.00000000		
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
2010	1	3	0	0	158.60	0.00000000	0.00000000	0.00000000	0.00000000
	0.00001429	0.00001429	0.00001429	0.00001429	0.00001429	0.00001429	0.00044699		
	0.00000000	0.00000121	0.00000000	0.00182244	0.00202608	0.00164970	0.00257329		
	0.00747769	0.02929572	0.09131722	0.14271426	0.15874857	0.10985279	0.08726802		
	0.06754262	0.09067348	0.07714994	0.06213060	0.03582122	0.02020100	0.00620373		
	0.00350799	0.00107204	0.00019082	0.00002417	0.00005373	0.00002859	0.00012036		
2011	1	3	0	0	209.70	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00003151	0.00000000	0.00000000	0.00001309	0.00000000		
	0.00098545	0.00003928	0.00059179	0.00017022	0.00011007	0.00198926	0.00187005		
	0.00458734	0.00621298	0.01733638	0.02663686	0.09056926	0.12766615	0.12250119		
	0.08001007	0.12016808	0.12573893	0.10839274	0.08486996	0.04554796	0.01977992		
	0.00882012	0.00339068	0.00107283	0.00055389	0.00018109	0.00013134	0.00003151		
2011	2	3	0	0	15.00	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.01595748		
	0.06102858	0.09574485	0.11202126	0.10134751	0.10393621	0.08544319	0.15735814		
	0.12312026	0.10388306	0.02943256	0.00803189	0.00269502	0.00000000	0.00000000		
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
2012	1	3	0	0	117.03	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00031117		
	0.00824020	0.03585317	0.08625069	0.13020785	0.14781588	0.13078359	0.13096350		
	0.13450060	0.09826163	0.04865465	0.03019293	0.01048763	0.00505848	0.00152875		
	0.00035161	0.00046650	0.00003843	0.00000000	0.00001799	0.00000000	0.00001476		
2012	2	3	0	0	3.00	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
	0.00000000	0.00000000	0.04000000	0.06666667	0.36000000	0.28000000	0.10666667		
	0.06666667	0.05333333	0.01333333	0.01333333	0.00000000	0.00000000	0.00000000		
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
2013	1	3	0	0	120.00	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
	0.00000000	0.00000000	0.00685106	0.04776269	0.18189361	0.26149113	0.23789051		
	0.13015577	0.07123941	0.03532203	0.01864533	0.00687701	0.00133591	0.00053554		
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
2009	1	7	0	0	33.20	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00052810	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00057622	0.00495836		
	0.03103000	0.09960013	0.16374495	0.20219759	0.22838807	0.15886180	0.07916015		
	0.02095343	0.00615335	0.00086496	0.00258641	0.00000000	0.00039648	0.00000000		
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
2010	1	7	0	0	24.00	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00080160	0.00000000	0.00000000	0.00000000	0.00051869	0.00000000		
	0.00000000	0.00000000	0.00000000	0.00000000	0.00101947	0.00144396	0.00068636		
	0.00132264	0.00518994	0.02150013	0.09853051	0.21071417	0.29173440	0.18574131		
	0.11417842	0.04092949	0.01770211	0.00669268	0.00000000	0.00129411	0.00000000		
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
2011	1	7	0	0	50.00	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00032391	0.00048844	0.00090264	0.00004834	0.00000000	0.00000000		
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00067671	0.00000000		
	0.00017503	0.00058270	0.00081600	0.00639086	0.02291477	0.10158366	0.24939403		
	0.26460441	0.20025064	0.09328675	0.03327509	0.01190588	0.00477899	0.00363973		
	0.00294363	0.00000000	0.00101779	0.00000000	0.00000000	0.00000000	0.00000000		
2012	1	7	0	0	23.00	0.00000000	0.00000000	0.00000000	0.00096182
	0.00000000	0.00000000	0.00325589	0.00292761	0.00000000	0.00000000	0.00080840		
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
	0.00000000	0.00198040	0.04085942	0.12161069	0.32194293	0.25935231	0.10149073		
	0.05042019	0.03717053	0.03715582	0.01294936	0.00496227	0.00104007	0.00111157		
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
2005	2	8	0	0	10.00	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00270862	0.00270862	0.00000000		
	0.00000000	0.01100873	0.01100873	0.12353364	0.12353364	0.06453880	0.06453880		
	0.15773170	0.15773170	0.06426980	0.06426980	0.05009669	0.05009669	0.01516183		
	0.01516183	0.00505394	0.00505394	0.00000000	0.00000000	0.00168465	0.00168465		
	0.00336930	0.00336930	0.00168465	0.00000000	0.00000000	0.00000000	0.00000000		
2007	2	8	0	0	12.00	0.00000000	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000		
	0.00000000	0.00000000	0.00000000	0.01871052	0.01871052	0.04456086	0.04456086		

```
        0.07885461      0.07885461      0.07720993      0.07720993      0.09196321      0.09196321      0.10803940
        0.10803940      0.06881783      0.06881783      0.00321240      0.00321240      0.00825866      0.00825866
        0.00037258      0.00037258      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
2009    2       8       0       0       19.00   0.00000000      0.00000000      0.00000000      0.00000000
        0.00071913      0.00071913      0.00036184      0.00036184      0.00000000      0.00000000      0.00121512
        0.00121512      0.00265337      0.00265337      0.00332081      0.00332081      0.00555546      0.00555546
        0.00224440      0.00224440      0.00833426      0.00833426      0.05506318      0.05506318      0.17107802
        0.17107802      0.16580872      0.16580872      0.06954074      0.06954074      0.01153821      0.01153821
        0.00243023      0.00243023      0.00027301      0.00000000      0.00000000      0.00000000      0.00000000
2010    2       8       0       0       18.00   0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000449      0.00000449      0.00000000      0.00000000      0.00000000
        0.00000000      0.00015121      0.00015121      0.08020558      0.08020558      0.22135962      0.22135962
        0.08918809      0.08918809      0.04535153      0.04535153      0.00957193      0.00957193      0.00287216
        0.00287216      0.01710648      0.01710648      0.02239309      0.02239309      0.00960401      0.00960401
        0.00139900      0.00139900      0.00158562      0.00000000      0.00000000      0.00000000      0.00000000
2011    2       8       0       0       12.00   0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00966230      0.00966230
        0.00000000      0.00000000      0.00874343      0.00874343      0.09109599      0.09109599      0.11348639
        0.11348639      0.05587484      0.05587484      0.10595060      0.10595060      0.08715280      0.08715280
        0.02797210      0.02797210      0.00006153      0.00006153      0.00000000      0.00000000      0.00000000
2012    2       8       0       0       18.00   0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00087027      0.00087027      0.00043514      0.00043514      0.01933857      0.01933857      0.15265050
        0.15265050      0.18642185      0.18642185      0.07407997      0.07407997      0.04749947      0.04749947
        0.00758276      0.00758276      0.01112147      0.01112147      0.00000000      0.00000000      0.00000000
2008    1       9       0       0       27.00   0.01700544      0.01700544      0.02210707      0.02210707
        0.00680218      0.00680218      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00680218      0.00680218      0.02009720      0.02009720
        0.02164783      0.02164783      0.08951514      0.08951514      0.10939327      0.10939327      0.14029251
        0.14029251      0.05385909      0.05385909      0.01118376      0.01118376      0.00129435      0.00129435
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
2012    1       9       0       0       26.00   0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00035481      0.00035481      0.00193496      0.00193496      0.13636929      0.13636929      0.21595031
        0.21595031      0.06930702      0.06930702      0.04528789      0.04528789      0.02760803      0.02760803
        0.00294741      0.00294741      0.00024028      0.00024028      0.00000000      0.00000000      0.00000000
2013    1       9       0       0       23.00   0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
        0.00000000      0.00000000      0.00000000      0.00000000      0.00002651      0.00002651      0.02839681
        0.02839681      0.20512511      0.20512511      0.17157365      0.17157365      0.07299605      0.07299605
        0.02026224      0.02026224      0.00161961      0.00161961      0.00000000      0.00000000      0.00000000

10 # N_age bins
0 1 2 3 4 5 6 7 8 11
6  # N_ageerror definitions
#
0.5     1.5     2.5     3.5     4.5     5.5     6.5     7.5     8.5     9.5     10.5    11.5    12.5    13.5    14.5
        15.5    #_1_CA_1981-06
0.2832  0.2832  0.289   0.8009  0.8038  0.9597  1.1156  1.2715  1.4274  1.5833  1.7392  1.8951  2.051   2.2069  2.3627
        2.5186  #_1_CA_1981-06
0.5     1.5     2.5     3.5     4.5     5.5     6.5     7.5     8.5     9.5     10.5    11.5    12.5    13.5    14.5
        15.5    #_2_CA_2007
0.2539  0.2539  0.3434  0.9205  0.9653  1.1743  1.3832  1.5922  1.8011  2.0101  2.219   2.428   2.6369  2.8459  3.0548
        3.2638  #_2_CA_2007
0.5     1.5     2.5     3.5     4.5     5.5     6.5     7.5     8.5     9.5     10.5    11.5    12.5    13.5    14.5
        15.5    #_3_CA_2008-09
0.4032  0.4032  0.4995  0.58    0.6902  0.8246  0.9727  1.0165  1.1144  1.2123  1.3102  1.4082  1.5061  1.604   1.702
        1.7999  #_3_CA_2008-09
0.5     1.5     2.5     3.5     4.5     5.5     6.5     7.5     8.5     9.5     10.5    11.5    12.5    13.5    14.5
        15.5    #_4_CA_2010-13
0.2825  0.2825  0.2955  0.3125  0.3347  0.3637  0.4017  0.4046  0.4245  0.4445  0.4645  0.4844  0.5044  0.5243  0.5443
        0.5643  #_4_CA_2010-13
0.5     1.5     2.5     3.5     4.5     5.5     6.5     7.5     8.5     9.5     10.5    11.5    12.5    13.5    14.5
        15.5    #_5_ORWA_all
0.26655 0.30145 0.3149  0.3615  0.3847  0.3961  0.4018  0.4047  0.4061  0.4352  0.4487  0.4622  0.4756  0.4891  0.5026
        0.516   #_5_ORWA_all
0.5     1.5     2.5     3.5     4.5     5.5     6.5     7.5     8.5     9.5     10.5    11.5    12.5    13.5    14.5
        15.5    #_6_CalCOFI_C
0.5386  0.5386  0.7547  0.8341  0.8634  0.8741  0.8781  0.8796  0.8801  0.8801  0.8801  0.8801  0.8801  0.8801  0.8801
        0.8801  #_6_CalCOFI_C
#
```

```
800 # N_age composition obs
3 # Length bin method: 1=poplenbins, 2=datalenbins, 3=lengths
-1 # Combine males into females at or below this bin number
# Year Season Fleet/Survey Gender Part Ageerr Lbin_lo Lbin_hi Nsamp datavector(female-male)
1993   1       1       0       0       1       16      16.5    0.04    0.00000000      0.00000000      0.00000000
       1.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1993   1       1       0       0       1       17      17.5    0.40    0.00000000      0.00000000      0.40000000
       0.60000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1993   1       1       0       0       1       18      18.5    1.16    0.00000000      0.00000000      0.13793103
       0.79310345      0.06896552      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1993   1       1       0       0       1       19      19.5    0.92    0.00000000      0.00000000      0.00000000
       0.73913043      0.21739130      0.04347826      0.00000000      0.00000000      0.00000000      0.00000000
1993   1       1       0       0       1       20      20.5    0.20    0.00000000      0.00000000      0.00000000
       1.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1994   1       1       0       0       1       15      15.5    0.64    0.06555503      0.80333490      0.13111007
       0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1994   1       1       0       0       1       16      16.5    1.56    0.02720121      0.82987390      0.14292490
       0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1994   1       1       0       0       1       17      17.5    3.92    0.01800542      0.66544962      0.23382015
       0.06471939      0.01800542      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1994   1       1       0       0       1       18      18.5    3.20    0.02584465      0.24477748      0.51450358
       0.21051706      0.00435722      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1994   1       1       0       0       1       19      19.5    2.04    0.00651038      0.05119051      0.39133174
       0.44858636      0.10238102      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1994   1       1       0       0       1       20      20.5    0.28    0.00000000      0.00000000      0.37554250
       0.37554250      0.24891501      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1994   1       1       0       0       1       21      21.5    0.08    0.00000000      0.00000000      1.00000000
       0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1994   1       1       0       0       1       22      22.5    0.04    0.00000000      0.00000000      1.00000000
       0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1995   1       1       0       0       1       12      12.5    0.04    1.00000000      0.00000000      0.00000000
       0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1995   1       1       0       0       1       13      13.5    0.08    0.00000000      1.00000000      0.00000000
       0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1995   1       1       0       0       1       14      14.5    0.44    0.63636364      0.27272727      0.09090909
       0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1995   1       1       0       0       1       15      15.5    0.64    0.18750000      0.43750000      0.31250000
       0.06250000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1995   1       1       0       0       1       16      16.5    1.64    0.04878049      0.73170732      0.19512195
       0.02439024      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1995   1       1       0       0       1       17      17.5    1.44    0.02777778      0.63888889      0.30555556
       0.02777778      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1995   1       1       0       0       1       18      18.5    0.40    0.00000000      0.20000000      0.40000000
       0.40000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1995   1       1       0       0       1       19      19.5    0.08    0.00000000      0.00000000      0.50000000
       0.50000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1996   1       1       0       0       1       14      14.5    0.12    0.00000000      1.00000000      0.00000000
       0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1996   1       1       0       0       1       15      15.5    1.28    0.00000000      0.44897248      0.55102752
       0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1996   1       1       0       0       1       16      16.5    6.24    0.00000000      0.20902801      0.75030358
       0.04066841      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1996   1       1       0       0       1       17      17.5    14.96   0.00000000      0.10419308      0.69554700
       0.18400205      0.01500520      0.00125267      0.00000000      0.00000000      0.00000000      0.00000000
1996   1       1       0       0       1       18      18.5    28.44   0.00000000      0.04005148      0.64987230
       0.28378437      0.02424253      0.00204932      0.00000000      0.00000000      0.00000000      0.00000000
1996   1       1       0       0       1       19      19.5    26.68   0.00000000      0.01621994      0.50808503
       0.42049373      0.05031671      0.00488459      0.00000000      0.00000000      0.00000000      0.00000000
1996   1       1       0       0       1       20      20.5    9.92    0.00000000      0.01435739      0.40880868
       0.48247061      0.07970037      0.01466295      0.00000000      0.00000000      0.00000000      0.00000000
1996   1       1       0       0       1       21      21.5    1.40    0.00000000      0.00000000      0.23003121
       0.45723664      0.31273215      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1996   1       1       0       0       1       22      22.5    0.08    0.00000000      0.00000000      0.50000000
       0.50000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1996   1       1       0       0       1       23      23.5    0.04    0.00000000      0.00000000      0.00000000
       1.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1996   1       1       0       0       1       25      25.5    0.08    0.00000000      0.00000000      0.00000000
       0.00000000      0.50000000      0.50000000      0.00000000      0.00000000      0.00000000      0.00000000
1996   1       1       0       0       1       26      26.5    0.04    0.00000000      0.00000000      0.00000000
       0.00000000      0.00000000      0.00000000      0.00000000      1.00000000      0.00000000      0.00000000
1997   1       1       0       0       1       9       9.5     0.04    1.00000000      0.00000000      0.00000000
       0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
1997   1       1       0       0       1       11      11.5    0.04    1.00000000      0.00000000      0.00000000
       0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000
```

1997	1	1	0	0	1	12	12.5	0.16	0.00000000	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1997	1	1	0	0	1	13	13.5	0.72	0.00000000	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1997	1	1	0	0	1	14	14.5	4.04	0.00000000	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1997	1	1	0	0	1	15	15.5	4.56	0.00000000	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1997	1	1	0	0	1	16	16.5	7.36	0.00000000	0.92361566	0.07638434
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1997	1	1	0	0	1	17	17.5	13.84	0.00000000	0.56076615	0.43632757
	0.00290628	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1997	1	1	0	0	1	18	18.5	15.36	0.00000000	0.20645551	0.74805856
	0.04548592	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1997	1	1	0	0	1	19	19.5	6.88	0.00934460	0.04764680	0.63951375
	0.30349485	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1997	1	1	0	0	1	20	20.5	1.44	0.00000000	0.00000000	0.31385049
	0.54512566	0.14102386	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1997	1	1	0	0	1	21	21.5	0.24	0.00000000	0.00000000	0.29289001
	0.41776573	0.12842148	0.16092278	0.00000000	0.00000000	0.00000000	0.00000000				
1997	1	1	0	0	1	22	22.5	0.16	0.00000000	0.00000000	0.00000000
	0.37760183	0.41493211	0.20746606	0.00000000	0.00000000	0.00000000	0.00000000				
1997	1	1	0	0	1	23	23.5	0.08	0.00000000	0.00000000	0.00000000
	0.30435611	0.69564389	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1998	1	1	0	0	1	9	9.5	0.04	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1998	1	1	0	0	1	10	10.5	0.08	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1998	1	1	0	0	1	11	11.5	0.72	0.77179412	0.22820588	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1998	1	1	0	0	1	12	12.5	4.56	0.52354126	0.47645874	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1998	1	1	0	0	1	13	13.5	14.04	0.12472173	0.83932736	0.03595091
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1998	1	1	0	0	1	14	14.5	19.88	0.00755918	0.95562857	0.03681224
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1998	1	1	0	0	1	15	15.5	15.92	0.00189458	0.81696133	0.18114409
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1998	1	1	0	0	1	16	16.5	7.84	0.00000000	0.51773405	0.48226595
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1998	1	1	0	0	1	17	17.5	5.72	0.00000000	0.12190583	0.84714166
	0.03095251	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1998	1	1	0	0	1	18	18.5	3.20	0.00000000	0.00000000	0.75348715
	0.19827166	0.04824119	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1998	1	1	0	0	1	19	19.5	1.28	0.00000000	0.00000000	0.48477799
	0.31566788	0.19955413	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1998	1	1	0	0	1	20	20.5	0.88	0.00000000	0.00000000	0.02174408
	0.33200944	0.52769706	0.11854942	0.00000000	0.00000000	0.00000000	0.00000000				
1998	1	1	0	0	1	21	21.5	0.64	0.00000000	0.00000000	0.00000000
	0.39164730	0.47995442	0.12839828	0.00000000	0.00000000	0.00000000	0.00000000				
1998	1	1	0	0	1	22	22.5	0.24	0.00000000	0.00000000	0.00000000
	0.00000000	0.66666667	0.16666667	0.16666667	0.00000000	0.00000000	0.00000000				
1998	1	1	0	0	1	23	23.5	0.28	0.00000000	0.00000000	0.00000000
	0.28571429	0.28571429	0.42857143	0.00000000	0.00000000	0.00000000	0.00000000				
1999	1	1	0	0	1	12	12.5	0.08	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1999	1	1	0	0	1	13	13.5	0.68	0.76470588	0.17647059	0.05882353
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1999	1	1	0	0	1	14	14.5	1.88	0.12765957	0.70212766	0.17021277
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1999	1	1	0	0	1	15	15.5	3.24	0.00000000	0.54320988	0.45679012
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1999	1	1	0	0	1	16	16.5	0.84	0.00000000	0.42857143	0.57142857
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1999	1	1	0	0	1	17	17.5	0.24	0.00000000	0.16666667	0.66666667
	0.16666667	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2000	1	1	0	0	1	12	12.5	0.24	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2000	1	1	0	0	1	13	13.5	0.20	0.77547183	0.22452817	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2000	1	1	0	0	1	14	14.5	0.76	0.73513244	0.05947023	0.20539733
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2000	1	1	0	0	1	15	15.5	2.48	0.04184241	0.34985918	0.38220788
	0.22609053	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				

2000	1	1	0	0	1	16	16.5	7.32	0.00789018	0.23451758	0.50324882
	0.24287279	0.01147062	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2000	1	1	0	0	1	17	17.5	8.52	0.00000000	0.22372714	0.52623066
	0.23738678	0.01265541	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2000	1	1	0	0	1	18	18.5	2.52	0.00000000	0.10780866	0.49898474
	0.35130144	0.04190515	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2000	1	1	0	0	1	19	19.5	0.28	0.00000000	0.00000000	0.57142857
	0.42857143	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2000	1	1	0	0	1	20	20.5	0.20	0.00000000	0.00000000	0.64477748
	0.35522252	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2000	1	1	0	0	1	21	21.5	0.08	0.00000000	0.00000000	0.00000000
	0.00000000	0.50000000	0.50000000	0.00000000	0.00000000	0.00000000	0.00000000				
2000	1	1	0	0	1	23	23.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2001	1	1	0	0	1	9	9.5	0.28	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2001	1	1	0	0	1	10	10.5	2.00	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2001	1	1	0	0	1	11	11.5	3.44	0.98962726	0.01037274	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2001	1	1	0	0	1	12	12.5	1.52	0.95694052	0.04305948	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2001	1	1	0	0	1	13	13.5	1.12	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2001	1	1	0	0	1	14	14.5	0.12	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2001	1	1	0	0	1	15	15.5	0.72	0.00000000	0.94144234	0.05855766
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2001	1	1	0	0	1	16	16.5	2.52	0.00000000	0.93072865	0.04908709
	0.01009213	0.01009213	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2001	1	1	0	0	1	17	17.5	4.32	0.00000000	0.65761214	0.28043072
	0.04490983	0.01704730	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2001	1	1	0	0	1	18	18.5	3.48	0.00000000	0.52059262	0.35201836
	0.11348088	0.01390813	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2001	1	1	0	0	1	19	19.5	1.32	0.00000000	0.09566902	0.28511142
	0.57373618	0.04548338	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2001	1	1	0	0	1	20	20.5	2.20	0.00000000	0.08098452	0.09414834
	0.69451401	0.11021743	0.02013571	0.00000000	0.00000000	0.00000000	0.00000000				
2001	1	1	0	0	1	21	21.5	6.68	0.00000000	0.01097761	0.04893767
	0.69266867	0.21654653	0.03086952	0.00000000	0.00000000	0.00000000	0.00000000				
2001	1	1	0	0	1	22	22.5	4.56	0.00000000	0.01013073	0.06708930
	0.56915583	0.26557073	0.06115037	0.01677232	0.01013073	0.00000000	0.00000000				
2001	1	1	0	0	1	23	23.5	1.80	0.00000000	0.00000000	0.02801048
	0.19328092	0.36134382	0.26859609	0.12075821	0.02801048	0.00000000	0.00000000				
2001	1	1	0	0	1	24	24.5	0.96	0.00000000	0.00000000	0.00000000
	0.08790503	0.40295158	0.47433427	0.03480912	0.00000000	0.00000000	0.00000000				
2001	1	1	0	0	1	25	25.5	0.20	0.00000000	0.00000000	0.00000000
	0.00000000	0.15206736	0.46391019	0.15206736	0.23195510	0.00000000	0.00000000				
2002	1	1	0	0	1	11	11.5	0.04	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2002	1	1	0	0	1	13	13.5	0.64	0.34819315	0.65180685	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2002	1	1	0	0	1	14	14.5	2.16	0.19080057	0.74295168	0.06624776
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2002	1	1	0	0	1	15	15.5	6.08	0.18228648	0.74492089	0.07279263
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2002	1	1	0	0	1	16	16.5	8.64	0.26111752	0.60128336	0.11432186
	0.02327725	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2002	1	1	0	0	1	17	17.5	7.48	0.12851185	0.43163453	0.41302223
	0.02683138	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2002	1	1	0	0	1	18	18.5	3.24	0.10308813	0.30784160	0.40739980
	0.16097894	0.02069153	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2002	1	1	0	0	1	19	19.5	1.12	0.00000000	0.22094657	0.54446895
	0.10340392	0.13118056	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2002	1	1	0	0	1	20	20.5	0.44	0.00000000	0.24521992	0.42641430
	0.16884672	0.15951906	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2002	1	1	0	0	1	21	21.5	0.20	0.00000000	0.41949119	0.11978151
	0.29970968	0.16101762	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2002	1	1	0	0	1	22	22.5	0.24	0.00000000	0.00000000	0.10316942
	0.13868663	0.61945732	0.13868663	0.00000000	0.00000000	0.00000000	0.00000000				
2002	1	1	0	0	1	24	24.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2003	1	1	0	0	1	9	9.5	0.08	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				

2003	1	1	0	0	1	10	10.5	0.84	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2003	1	1	0	0	1	11	11.5	3.72	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2003	1	1	0	0	1	12	12.5	2.52	0.98245740	0.01754260	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2003	1	1	0	0	1	13	13.5	1.24	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2003	1	1	0	0	1	14	14.5	0.44	0.48294759	0.51705241	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2003	1	1	0	0	1	15	15.5	0.52	0.00000000	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2003	1	1	0	0	1	16	16.5	1.52	0.00000000	0.88536046	0.11463954
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2003	1	1	0	0	1	17	17.5	3.36	0.00000000	0.54652359	0.45347641
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2003	1	1	0	0	1	18	18.5	2.40	0.00000000	0.31560192	0.66200264
	0.02239544	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2003	1	1	0	0	1	19	19.5	0.72	0.00000000	0.00000000	0.97348824
	0.02651176	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2003	1	1	0	0	1	20	20.5	0.36	0.00000000	0.09488687	0.28466061
	0.43351017	0.18694235	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2003	1	1	0	0	1	21	21.5	0.04	0.00000000	0.00000000	0.00000000
	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2004	1	1	0	0	1	10	10.5	0.04	0.00000000	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2004	1	1	0	0	1	11	11.5	0.12	0.00000000	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2004	1	1	0	0	1	12	12.5	0.32	0.26982236	0.73017764	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2004	1	1	0	0	1	13	13.5	0.60	0.00000000	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2004	1	1	0	0	1	14	14.5	6.08	0.00188560	0.99391267	0.00420173
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2004	1	1	0	0	1	15	15.5	13.64	0.00000000	0.97925637	0.01732336
	0.00000000	0.00342027	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2004	1	1	0	0	1	16	16.5	8.20	0.00505216	0.86811527	0.11755742
	0.00927515	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2004	1	1	0	0	1	17	17.5	3.32	0.00000000	0.85656519	0.11887042
	0.00558631	0.01897807	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2004	1	1	0	0	1	18	18.5	0.76	0.00000000	0.39684213	0.49701007
	0.00000000	0.10614780	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2004	1	1	0	0	1	19	19.5	0.28	0.00000000	0.38960446	0.25214348
	0.35825205	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2004	1	1	0	0	1	20	20.5	0.08	0.00000000	0.00000000	0.00000000
	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2004	1	1	0	0	1	22	22.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000			
2004	1	1	0	0	1	24	24.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000			
2005	1	1	0	0	1	10	10.5	0.08	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2005	1	1	0	0	1	11	11.5	1.00	0.60000000	0.40000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2005	1	1	0	0	1	12	12.5	1.48	0.66372335	0.33627665	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2005	1	1	0	0	1	13	13.5	4.92	0.23073098	0.62970257	0.13956644
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2005	1	1	0	0	1	14	14.5	8.84	0.18573131	0.63240199	0.18186670
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2005	1	1	0	0	1	15	15.5	5.60	0.04064125	0.33093795	0.62373605
	0.00468476	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2005	1	1	0	0	1	16	16.5	6.80	0.00000000	0.06282689	0.91934231
	0.01783080	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2005	1	1	0	0	1	17	17.5	4.32	0.00000000	0.05576095	0.83201279
	0.11222627	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2005	1	1	0	0	1	18	18.5	1.12	0.00000000	0.00000000	0.82757016
	0.17242984	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2005	1	1	0	0	1	19	19.5	0.72	0.00000000	0.00000000	0.74964298
	0.22394597	0.02641105	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2005	1	1	0	0	1	20	20.5	0.08	0.00000000	0.00000000	0.00000000
	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2005	1	1	0	0	1	21	21.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			

2005	1	1	0	0	1	22	22.5	0.08	0.00000000	0.00000000	0.00000000
	0.00000000	0.50000000	0.50000000	0.00000000	0.00000000	0.00000000	0.00000000			
2005	1	1	0	0	1	23	23.5	0.04	0.00000000	0.00000000	0.00000000
	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2005	1	1	0	0	1	24	24.5	0.12	0.00000000	0.00000000	0.00000000
	0.00000000	0.65509203	0.17245399	0.17245399	0.00000000	0.00000000	0.00000000			
2006	1	1	0	0	1	12	12.5	0.64	0.00969274	0.82381022	0.16649704
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2006	1	1	0	0	1	13	13.5	2.12	0.12950784	0.85495467	0.01553749
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2006	1	1	0	0	1	14	14.5	11.92	0.01372349	0.94883032	0.03744619
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2006	1	1	0	0	1	15	15.5	24.12	0.00827923	0.88315188	0.10720699
	0.00136190	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2006	1	1	0	0	1	16	16.5	17.08	0.00617434	0.64052788	0.33200330
	0.02129448	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2006	1	1	0	0	1	17	17.5	9.12	0.00634360	0.22254651	0.68627996
	0.08482992	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2006	1	1	0	0	1	18	18.5	3.56	0.00000000	0.01820135	0.73249892
	0.24929974	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2006	1	1	0	0	1	19	19.5	0.88	0.00000000	0.00000000	0.59828848
	0.40171152	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2006	1	1	0	0	1	20	20.5	0.20	0.00000000	0.00000000	0.00000000
	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2006	1	1	0	0	1	21	21.5	0.08	0.00000000	0.00000000	0.50000000
	0.50000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2006	1	1	0	0	1	22	22.5	0.04	0.00000000	0.00000000	0.00000000
	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2007	1	1	0	0	2	10	10.5	0.08	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2007	1	1	0	0	2	11	11.5	0.56	0.85714286	0.14285714	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2007	1	1	0	0	2	12	12.5	0.80	0.87626801	0.12373199	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2007	1	1	0	0	2	13	13.5	2.68	0.40483739	0.55358268	0.04157993
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2007	1	1	0	0	2	14	14.5	5.68	0.01803592	0.75380995	0.20726697
	0.02088716	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2007	1	1	0	0	2	15	15.5	14.56	0.00387012	0.34648381	0.62501079
	0.02463528	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2007	1	1	0	0	2	16	16.5	28.80	0.00028385	0.09330496	0.77807930
	0.12710868	0.00122320	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2007	1	1	0	0	2	17	17.5	23.16	0.00281026	0.04058452	0.66877144
	0.26920715	0.01862662	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2007	1	1	0	0	2	18	18.5	7.36	0.00000000	0.01236885	0.59949472
	0.35606275	0.03207368	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2007	1	1	0	0	2	19	19.5	1.84	0.00000000	0.00000000	0.18710923
	0.78336207	0.02952870	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2007	1	1	0	0	2	20	20.5	0.40	0.00000000	0.00000000	0.24239178
	0.66239470	0.09521352	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2007	1	1	0	0	2	21	21.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2007	1	1	0	0	2	22	22.5	0.04	0.00000000	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2008	1	1	0	0	3	12	12.5	0.56	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2008	1	1	0	0	3	13	13.5	0.52	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2008	1	1	0	0	3	14	14.5	0.12	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2008	1	1	0	0	3	15	15.5	1.60	0.00000000	0.72257965	0.27742035
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2008	1	1	0	0	3	16	16.5	10.08	0.01437160	0.40213365	0.57334683
	0.01014792	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2008	1	1	0	0	3	17	17.5	10.40	0.01495756	0.20893843	0.71709879
	0.05900522	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2008	1	1	0	0	3	18	18.5	5.12	0.01158259	0.19549447	0.70461698
	0.08830597	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2008	1	1	0	0	3	19	19.5	1.36	0.00000000	0.19981464	0.49211465
	0.25835350	0.04971721	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2008	1	1	0	0	3	20	20.5	0.60	0.00000000	0.00000000	0.21969054
	0.58469349	0.19561597	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2008	1	1	0	0	3	21	21.5	0.36	0.00000000	0.00000000	0.11111111
	0.55555556	0.33333333	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			

2008	1	1	0	0	3	22	22.5	0.08	0.00000000	0.00000000	0.19646010
	0.00000000	0.80353990	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2008	1	1	0	0	3	23	23.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2009	1	1	0	0	3	14	14.5	0.56	0.00000000	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2009	1	1	0	0	3	15	15.5	1.08	0.05215629	0.84353112	0.10431259
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2009	1	1	0	0	3	16	16.5	4.44	0.00000000	0.47928776	0.50836509
	0.01234715	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2009	1	1	0	0	3	17	17.5	12.64	0.00296329	0.13276991	0.72454418
	0.12490618	0.01481644	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2009	1	1	0	0	3	18	18.5	4.00	0.00000000	0.02948402	0.60770512
	0.33461294	0.02819793	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2009	1	1	0	0	3	19	19.5	0.16	0.00000000	0.00000000	0.25073428
	0.74926572	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2010	1	1	0	0	4	13	13.5	0.04	0.00000000	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2010	1	1	0	0	4	14	14.5	0.28	0.14285714	0.85714286	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2010	1	1	0	0	4	15	15.5	5.28	0.01515152	0.86363636	0.12121212
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2010	1	1	0	0	4	16	16.5	6.36	0.01257862	0.77358491	0.19496855
	0.01886792	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2010	1	1	0	0	4	17	17.5	0.52	0.00000000	0.53846154	0.38461538
	0.07692308	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2010	1	1	0	0	4	18	18.5	0.08	0.00000000	0.00000000	0.50000000
	0.50000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2010	1	1	0	0	4	19	19.5	0.12	0.00000000	0.00000000	0.00000000
	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2011	1	1	0	0	4	15	15.5	0.08	0.00000000	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2011	1	1	0	0	4	16	16.5	1.96	0.00000000	0.55600263	0.32620509
	0.11779228	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2011	1	1	0	0	4	17	17.5	12.36	0.00000000	0.33958915	0.50120495
	0.15920590	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2011	1	1	0	0	4	18	18.5	6.60	0.00000000	0.12877487	0.50542429
	0.35157075	0.01423009	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2011	1	1	0	0	4	19	19.5	0.60	0.00000000	0.00000000	0.33656921
	0.62603421	0.03739658	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2011	1	1	0	0	4	21	21.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2012	1	1	0	0	4	14	14.5	0.48	0.08333333	0.91666667	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2012	1	1	0	0	4	15	15.5	0.48	0.00000000	0.83333333	0.16666667
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2012	1	1	0	0	4	16	16.5	0.16	0.00000000	0.50000000	0.50000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2012	1	1	0	0	4	17	17.5	1.76	0.00000000	0.12388536	0.70653509
	0.16957955	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2012	1	1	0	0	4	18	18.5	5.92	0.00000000	0.03878870	0.67166629
	0.27666426	0.01288075	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2012	1	1	0	0	4	19	19.5	6.60	0.00000000	0.00093824	0.53772555
	0.44589212	0.01544409	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2012	1	1	0	0	4	20	20.5	4.92	0.00000000	0.00000000	0.20675044
	0.59305156	0.16229851	0.03789949	0.00000000	0.00000000	0.00000000	0.00000000				
2012	1	1	0	0	4	21	21.5	1.80	0.00000000	0.00000000	0.02764022
	0.66790505	0.22153409	0.00000000	0.08292065	0.00000000	0.00000000	0.00000000				
2012	1	1	0	0	4	22	22.5	0.16	0.00000000	0.00000000	0.00000000
	0.00000000	0.55727171	0.44272829	0.00000000	0.00000000	0.00000000	0.00000000				
2012	1	1	0	0	4	23	23.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1993	2	2	0	0	1	13	13.5	0.20	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1993	2	2	0	0	1	14	14.5	1.36	0.97070472	0.02929528	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1993	2	2	0	0	1	15	15.5	2.12	0.87662406	0.12337594	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1993	2	2	0	0	1	16	16.5	5.36	0.38724536	0.51316166	0.09959298
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1993	2	2	0	0	1	17	17.5	9.44	0.07213542	0.61158283	0.29388355
	0.01953423	0.00286397	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1993	2	2	0	0	1	18	18.5	6.28	0.01233362	0.40889523	0.55275049
	0.02602066	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				

1993	2	2	0	0	1	19	19.5	2.64	0.00000000	0.10547058	0.68579430
	0.14425622	0.02149297	0.02149297	0.02149297	0.00000000	0.00000000	0.00000000				
1993	2	2	0	0	1	20	20.5	1.04	0.00000000	0.06147662	0.42885278
	0.41036671	0.05459334	0.04471056	0.00000000	0.00000000	0.00000000	0.00000000				
1993	2	2	0	0	1	21	21.5	0.56	0.00000000	0.00000000	0.24819545
	0.54255200	0.20925255	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1993	2	2	0	0	1	22	22.5	0.52	0.00000000	0.00000000	0.19223104
	0.33136029	0.26109730	0.07177046	0.14354091	0.00000000	0.00000000	0.00000000				
1993	2	2	0	0	1	23	23.5	0.52	0.00000000	0.00000000	0.12733396
	0.27876739	0.42428329	0.16961536	0.00000000	0.00000000	0.00000000	0.00000000				
1993	2	2	0	0	1	24	24.5	0.16	0.00000000	0.00000000	0.00000000
	0.40563177	0.59436823	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1993	2	2	0	0	1	25	25.5	0.20	0.00000000	0.00000000	0.00000000
	0.26700525	0.00000000	0.46598950	0.26700525	0.00000000	0.00000000	0.00000000				
1993	2	2	0	0	1	26	26.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1994	2	2	0	0	1	11	11.5	0.72	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1994	2	2	0	0	1	12	12.5	1.88	0.98302973	0.01697027	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1994	2	2	0	0	1	13	13.5	6.64	0.86880561	0.12761125	0.00358315
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1994	2	2	0	0	1	14	14.5	15.00	0.87264589	0.12512599	0.00222812
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1994	2	2	0	0	1	15	15.5	23.80	0.64265504	0.33692582	0.01875050
	0.00166863	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1994	2	2	0	0	1	16	16.5	31.56	0.23602009	0.70894433	0.04969618
	0.00367082	0.00000000	0.00166858	0.00000000	0.00000000	0.00000000	0.00000000				
1994	2	2	0	0	1	17	17.5	23.40	0.08662464	0.67844162	0.16526082
	0.06184184	0.00783109	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1994	2	2	0	0	1	18	18.5	11.84	0.04546867	0.40515272	0.33567341
	0.19105666	0.02083700	0.00181155	0.00000000	0.00000000	0.00000000	0.00000000				
1994	2	2	0	0	1	19	19.5	4.60	0.01420067	0.14104731	0.44919582
	0.32473849	0.06329571	0.00752201	0.00000000	0.00000000	0.00000000	0.00000000				
1994	2	2	0	0	1	20	20.5	1.08	0.00000000	0.11300204	0.44817926
	0.43881870	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1994	2	2	0	0	1	21	21.5	0.36	0.00000000	0.16665558	0.23680924
	0.41616224	0.07015366	0.00000000	0.11021929	0.00000000	0.00000000	0.00000000				
1994	2	2	0	0	1	23	23.5	0.04	0.00000000	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1994	2	2	0	0	1	24	24.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1995	2	2	0	0	1	12	12.5	0.44	0.71231509	0.28768491	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1995	2	2	0	0	1	13	13.5	2.68	0.59996788	0.37064073	0.02939139
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1995	2	2	0	0	1	14	14.5	4.80	0.73717939	0.24782276	0.01499785
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1995	2	2	0	0	1	15	15.5	10.08	0.50967566	0.31351836	0.17303392
	0.00377205	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1995	2	2	0	0	1	16	16.5	16.44	0.23707804	0.48564470	0.25976314
	0.01751411	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1995	2	2	0	0	1	17	17.5	14.76	0.04581167	0.53108806	0.39150329
	0.03044360	0.00000000	0.00115339	0.00000000	0.00000000	0.00000000	0.00000000				
1995	2	2	0	0	1	18	18.5	7.20	0.01242179	0.52624193	0.41951324
	0.04182304	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1995	2	2	0	0	1	19	19.5	1.76	0.00000000	0.46335195	0.48609034
	0.03570396	0.01485375	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1995	2	2	0	0	1	20	20.5	0.32	0.00000000	0.08174470	0.66468272
	0.00000000	0.25357259	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1995	2	2	0	0	1	21	21.5	0.24	0.00000000	0.00000000	0.29285599
	0.51848817	0.18865585	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1995	2	2	0	0	1	22	22.5	0.04	0.00000000	0.00000000	0.00000000
	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1995	2	2	0	0	1	23	23.5	0.04	0.00000000	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1995	2	2	0	0	1	25	25.5	0.04	0.00000000	0.00000000	0.00000000
	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1996	2	2	0	0	1	10	10.5	0.40	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1996	2	2	0	0	1	11	11.5	0.60	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1996	2	2	0	0	1	12	12.5	1.60	0.80975028	0.16683245	0.02341728
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				

1996	2	2	0	0	1	13	13.5	5.96	0.73478866	0.24312398	0.02208736
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1996	2	2	0	0	1	14	14.5	8.12	0.46518847	0.51089433	0.02391719
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1996	2	2	0	0	1	15	15.5	6.24	0.41849666	0.54255775	0.03894559
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1996	2	2	0	0	1	16	16.5	3.76	0.08756362	0.56516625	0.31965063
	0.02761951	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1996	2	2	0	0	1	17	17.5	5.36	0.00000000	0.50925012	0.41255772
	0.07819215	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1996	2	2	0	0	1	18	18.5	5.60	0.00000000	0.18027972	0.73786000
	0.08186028	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1996	2	2	0	0	1	19	19.5	5.56	0.00797248	0.09130891	0.65341448
	0.21119852	0.00797248	0.02813313	0.00000000	0.00000000	0.00000000	0.00000000				
1996	2	2	0	0	1	20	20.5	1.88	0.00000000	0.04190018	0.78996467
	0.14355012	0.00000000	0.02458503	0.00000000	0.00000000	0.00000000	0.00000000				
1996	2	2	0	0	1	21	21.5	0.56	0.00000000	0.06665516	0.66672422
	0.19996547	0.06665516	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1996	2	2	0	0	1	22	22.5	0.24	0.00000000	0.20026673	0.31989331
	0.31989331	0.15994665	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1996	2	2	0	0	1	25	25.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1997	2	2	0	0	1	9	9.5	0.08	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1997	2	2	0	0	1	10	10.5	0.88	0.95240426	0.04759574	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1997	2	2	0	0	1	11	11.5	1.40	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1997	2	2	0	0	1	12	12.5	1.08	0.91020233	0.08979767	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1997	2	2	0	0	1	13	13.5	2.48	0.76619269	0.23380731	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1997	2	2	0	0	1	14	14.5	2.80	0.51770442	0.46377638	0.01851919
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1997	2	2	0	0	1	15	15.5	4.40	0.11696030	0.83583819	0.04620143
	0.00100008	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1997	2	2	0	0	1	16	16.5	5.40	0.00086050	0.87069252	0.12844699
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1997	2	2	0	0	1	17	17.5	4.48	0.02019942	0.75406485	0.19363098
	0.02872855	0.00337619	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1997	2	2	0	0	1	18	18.5	3.88	0.05477172	0.47661077	0.43935640
	0.02926111	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1997	2	2	0	0	1	19	19.5	3.48	0.02384269	0.09743413	0.41598185
	0.33822133	0.11611399	0.00840601	0.00000000	0.00000000	0.00000000	0.00000000				
1997	2	2	0	0	1	20	20.5	6.56	0.00000000	0.01314396	0.37161014
	0.43608829	0.17341751	0.00574010	0.00000000	0.00000000	0.00000000	0.00000000				
1997	2	2	0	0	1	21	21.5	6.20	0.00000000	0.01452790	0.19985641
	0.56258895	0.18587032	0.03715641	0.00000000	0.00000000	0.00000000	0.00000000				
1997	2	2	0	0	1	22	22.5	3.36	0.00000000	0.02844437	0.22226700
	0.42427703	0.23657884	0.05998839	0.02844437	0.00000000	0.00000000	0.00000000				
1997	2	2	0	0	1	23	23.5	0.80	0.00000000	0.00000000	0.00000000
	0.29555010	0.55667486	0.02630317	0.12147188	0.00000000	0.00000000	0.00000000				
1997	2	2	0	0	1	24	24.5	0.12	0.00000000	0.00000000	0.00000000
	0.00000000	0.89581040	0.00000000	0.10418960	0.00000000	0.00000000	0.00000000				
1997	2	2	0	0	1	25	25.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000				
1998	2	2	0	0	1	9	9.5	0.08	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1998	2	2	0	0	1	10	10.5	1.00	0.93302808	0.06697192	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1998	2	2	0	0	1	11	11.5	2.76	0.93937164	0.06062836	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1998	2	2	0	0	1	12	12.5	7.20	0.70798306	0.27701796	0.01499898
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1998	2	2	0	0	1	13	13.5	11.32	0.45328775	0.48748534	0.05922691
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1998	2	2	0	0	1	14	14.5	14.92	0.25039999	0.70896504	0.04063497
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1998	2	2	0	0	1	15	15.5	12.56	0.10807270	0.74316709	0.14876021
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1998	2	2	0	0	1	16	16.5	8.56	0.03179538	0.53952165	0.41540227
	0.01328071	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1998	2	2	0	0	1	17	17.5	6.92	0.02123072	0.29925113	0.67254621
	0.00697193	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				

1998	2	2	0	0	1	18	18.5	3.08	0.03216085	0.18604913	0.69226176
	0.08952826	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1998	2	2	0	0	1	19	19.5	2.56	0.01770014	0.15680268	0.53573909
	0.21011342	0.06194454	0.01770014	0.00000000	0.00000000	0.00000000	0.00000000				
1998	2	2	0	0	1	20	20.5	0.76	0.00000000	0.12209916	0.12209916
	0.55328948	0.15824033	0.04427187	0.00000000	0.00000000	0.00000000	0.00000000				
1998	2	2	0	0	1	21	21.5	0.56	0.00000000	0.18419311	0.00000000
	0.32230705	0.36957328	0.12392657	0.00000000	0.00000000	0.00000000	0.00000000				
1998	2	2	0	0	1	22	22.5	0.12	0.00000000	0.34126400	0.31747200
	0.00000000	0.34126400	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1998	2	2	0	0	1	23	23.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1998	2	2	0	0	1	24	24.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1999	2	2	0	0	1	12	12.5	0.20	0.40000000	0.60000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1999	2	2	0	0	1	13	13.5	4.96	0.32014309	0.59185826	0.07961241
	0.00838624	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1999	2	2	0	0	1	14	14.5	14.76	0.38169092	0.53787963	0.05824497
	0.01109225	0.00792438	0.00316786	0.00000000	0.00000000	0.00000000	0.00000000				
1999	2	2	0	0	1	15	15.5	20.56	0.29216020	0.50155986	0.18149188
	0.01622977	0.00855830	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1999	2	2	0	0	1	16	16.5	11.52	0.09831156	0.50838282	0.36209246
	0.02387339	0.00733978	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1999	2	2	0	0	1	17	17.5	2.32	0.01043611	0.49352601	0.39132747
	0.09949235	0.00521806	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1999	2	2	0	0	1	18	18.5	0.76	0.00000000	0.26746419	0.71685887
	0.01567694	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1999	2	2	0	0	1	19	19.5	0.16	0.00000000	0.07997843	0.92002157
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1999	2	2	0	0	1	20	20.5	0.08	0.00000000	0.00000000	0.75037064
	0.00000000	0.00000000	0.00000000	0.24962936	0.00000000	0.00000000	0.00000000				
2000	2	2	0	0	1	11	11.5	0.72	0.74752075	0.25247925	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2000	2	2	0	0	1	12	12.5	2.28	0.69582437	0.27982735	0.00000000
	0.02434828	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2000	2	2	0	0	1	13	13.5	5.76	0.54811614	0.38124029	0.06174778
	0.00889578	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2000	2	2	0	0	1	14	14.5	11.24	0.40848094	0.55352931	0.03355320
	0.00443655	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2000	2	2	0	0	1	15	15.5	9.52	0.42979540	0.45185267	0.10229483
	0.01605710	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2000	2	2	0	0	1	16	16.5	5.08	0.01642085	0.19905252	0.60775348
	0.13866829	0.03810485	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2000	2	2	0	0	1	17	17.5	7.80	0.00000000	0.27828201	0.59017585
	0.11411492	0.01742722	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2000	2	2	0	0	1	18	18.5	4.36	0.00000000	0.28601716	0.57222152
	0.11953874	0.02222258	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2000	2	2	0	0	1	19	19.5	0.92	0.00000000	0.14449116	0.48172259
	0.31375949	0.06002676	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2000	2	2	0	0	1	20	20.5	0.24	0.00000000	0.00000000	0.08261869
	0.91738131	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2000	2	2	0	0	1	22	22.5	0.12	0.00000000	0.00000000	0.00000000
	0.91738131	0.00000000	0.00000000	0.00000000	0.08261869	0.00000000	0.00000000				
2001	2	2	0	0	1	10	10.5	2.00	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2001	2	2	0	0	1	11	11.5	7.60	0.97427376	0.02572624	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2001	2	2	0	0	1	12	12.5	14.40	0.92240780	0.07443303	0.00000000
	0.00315917	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2001	2	2	0	0	1	13	13.5	16.48	0.90627331	0.08890553	0.00482116
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2001	2	2	0	0	1	14	14.5	10.28	0.70552085	0.25611000	0.03357300
	0.00479614	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2001	2	2	0	0	1	15	15.5	8.20	0.39784787	0.47685263	0.12242888
	0.00287063	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2001	2	2	0	0	1	16	16.5	3.28	0.13467477	0.63572470	0.22298713
	0.00661341	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2001	2	2	0	0	1	17	17.5	2.72	0.01132070	0.51465616	0.37410852
	0.07508872	0.02482590	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2001	2	2	0	0	1	18	18.5	2.96	0.00000000	0.29324400	0.54354648
	0.13118093	0.03202859	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2001	2	2	0	0	1	19	19.5	1.24	0.00000000	0.09918852	0.59034994
	0.31046154	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				

2001	2	2	0	0	1	20	20.5	1.24	0.00000000	0.00000000	0.51528889
	0.37935414	0.07775853	0.02759844	0.00000000	0.00000000	0.00000000	0.00000000				
2001	2	2	0	0	1	21	21.5	0.52	0.00000000	0.00000000	0.09031628
	0.63873488	0.09031628	0.18063256	0.00000000	0.00000000	0.00000000	0.00000000				
2001	2	2	0	0	1	22	22.5	0.08	0.00000000	0.00000000	0.00000000
	0.50000000	0.50000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2001	2	2	0	0	1	24	24.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2002	2	2	0	0	1	10	10.5	0.04	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2002	2	2	0	0	1	11	11.5	0.32	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2002	2	2	0	0	1	12	12.5	0.60	0.94090193	0.05909807	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2002	2	2	0	0	1	13	13.5	1.16	0.88345627	0.11654373	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2002	2	2	0	0	1	14	14.5	2.88	0.48918927	0.44747715	0.06333357
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2002	2	2	0	0	1	15	15.5	13.12	0.31065759	0.63716391	0.04841090
	0.00376759	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2002	2	2	0	0	1	16	16.5	23.64	0.16463876	0.70856009	0.12022830
	0.00632938	0.00000000	0.00000000	0.00000000	0.00000000	0.00024347	0.00000000				
2002	2	2	0	0	1	17	17.5	21.24	0.11234893	0.62532418	0.22200514
	0.03331450	0.00700723	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2002	2	2	0	0	1	18	18.5	6.84	0.05496442	0.48012677	0.34689512
	0.10915720	0.00885649	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2002	2	2	0	0	1	19	19.5	3.96	0.00000000	0.21147060	0.47842753
	0.26219346	0.04790841	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2002	2	2	0	0	1	20	20.5	1.80	0.00000000	0.03922441	0.48545390
	0.36552610	0.10979558	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2002	2	2	0	0	1	21	21.5	0.40	0.00000000	0.00000000	0.49698361
	0.18994586	0.17934508	0.13372545	0.00000000	0.00000000	0.00000000	0.00000000				
2002	2	2	0	0	1	22	22.5	0.24	0.00000000	0.00000000	0.00000000
	0.27921688	0.22613844	0.49464468	0.00000000	0.00000000	0.00000000	0.00000000				
2002	2	2	0	0	1	23	23.5	0.20	0.00000000	0.00000000	0.00000000
	0.05517708	0.05517708	0.88964584	0.00000000	0.00000000	0.00000000	0.00000000				
2002	2	2	0	0	1	24	24.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000				
2003	2	2	0	0	1	10	10.5	0.52	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2003	2	2	0	0	1	11	11.5	7.40	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2003	2	2	0	0	1	12	12.5	11.16	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2003	2	2	0	0	1	13	13.5	26.04	0.99216013	0.00783987	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2003	2	2	0	0	1	14	14.5	15.40	0.97074099	0.02925901	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2003	2	2	0	0	1	15	15.5	3.96	0.76533365	0.21262370	0.02204265
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2003	2	2	0	0	1	16	16.5	1.24	0.08207484	0.51377819	0.40414697
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2003	2	2	0	0	1	17	17.5	1.24	0.03396623	0.34689388	0.57761967
	0.04152022	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2003	2	2	0	0	1	18	18.5	2.64	0.00000000	0.00000000	0.74075755
	0.23570895	0.02353350	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2003	2	2	0	0	1	19	19.5	2.20	0.00000000	0.05383938	0.46209001
	0.42658630	0.04311323	0.01437108	0.00000000	0.00000000	0.00000000	0.00000000				
2003	2	2	0	0	1	20	20.5	0.64	0.00000000	0.00000000	0.28011714
	0.46931240	0.19601734	0.05455312	0.00000000	0.00000000	0.00000000	0.00000000				
2003	2	2	0	0	1	21	21.5	0.64	0.06615850	0.00000000	0.18886008
	0.42216843	0.27713679	0.04567620	0.00000000	0.00000000	0.00000000	0.00000000				
2003	2	2	0	0	1	22	22.5	0.60	0.00000000	0.00000000	0.00000000
	0.25966959	0.36244571	0.31296731	0.06491740	0.00000000	0.00000000	0.00000000				
2003	2	2	0	0	1	23	23.5	0.52	0.00000000	0.00000000	0.00000000
	0.00000000	0.69230769	0.07692308	0.15384615	0.07692308	0.00000000	0.00000000				
2003	2	2	0	0	1	24	24.5	0.40	0.00000000	0.00000000	0.00000000
	0.10000000	0.30000000	0.00000000	0.50000000	0.10000000	0.00000000	0.00000000				
2003	2	2	0	0	1	25	25.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2004	2	2	0	0	1	11	11.5	0.20	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2004	2	2	0	0	1	12	12.5	0.84	0.67276468	0.32723532	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				

2004	2	2	0	0	1	13	13.5	4.20	0.17333774	0.82666226	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2004	2	2	0	0	1	14	14.5	14.12	0.01354159	0.98015485	0.00630357
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2004	2	2	0	0	1	15	15.5	18.92	0.02407765	0.96462996	0.01129239
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2004	2	2	0	0	1	16	16.5	13.52	0.02694741	0.88209742	0.09095517
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2004	2	2	0	0	1	17	17.5	4.36	0.00662725	0.78340253	0.18912430
	0.02084592	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2004	2	2	0	0	1	18	18.5	1.84	0.00000000	0.22342592	0.66408266
	0.11249141	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2004	2	2	0	0	1	19	19.5	0.72	0.00000000	0.00000000	0.76369562
	0.23630438	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2004	2	2	0	0	1	20	20.5	0.16	0.00000000	0.00000000	0.62830617
	0.37169383	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2004	2	2	0	0	1	21	21.5	0.12	0.00000000	0.00000000	0.28697889
	0.00000000	0.71302111	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2004	2	2	0	0	1	22	22.5	0.12	0.00000000	0.00000000	0.00000000
	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2004	2	2	0	0	1	23	23.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2005	2	2	0	0	1	9	9.5	0.24	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2005	2	2	0	0	1	10	10.5	2.72	0.94665661	0.05334339	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2005	2	2	0	0	1	11	11.5	10.68	0.96530636	0.03469364	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2005	2	2	0	0	1	12	12.5	10.36	0.81270629	0.18729371	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2005	2	2	0	0	1	13	13.5	17.28	0.59682376	0.38056749	0.02260874
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2005	2	2	0	0	1	14	14.5	17.12	0.41831331	0.53139427	0.05029242
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2005	2	2	0	0	1	15	15.5	14.80	0.39763833	0.44064831	0.16171335
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2005	2	2	0	0	1	16	16.5	6.76	0.20647100	0.39320685	0.38209007
	0.01823208	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2005	2	2	0	0	1	17	17.5	4.00	0.00145799	0.22876657	0.64096402
	0.10121078	0.02760064	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2005	2	2	0	0	1	18	18.5	2.28	0.00000000	0.13419048	0.65656358
	0.12972242	0.07952352	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2005	2	2	0	0	1	19	19.5	1.72	0.00000000	0.19742790	0.58505873
	0.21751337	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2005	2	2	0	0	1	20	20.5	0.40	0.00000000	0.15374970	0.18538703
	0.35336388	0.15374970	0.15374970	0.00000000	0.00000000	0.00000000	0.00000000				
2005	2	2	0	0	1	21	21.5	0.12	0.00000000	0.00000000	0.15765441
	0.84234559	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2005	2	2	0	0	1	23	23.5	0.16	0.00000000	0.00000000	0.00000000
	0.00000000	0.03208177	0.32263941	0.32263941	0.00000000	0.32263941	0.00000000				
2005	2	2	0	0	1	24	24.5	0.32	0.00000000	0.00000000	0.16131970
	0.00000000	0.00000000	0.16131970	0.19340148	0.32263941	0.16131970	0.00000000				
2005	2	2	0	0	1	25	25.5	0.08	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.50000000	0.50000000	0.00000000	0.00000000	0.00000000				
2006	2	2	0	0	1	10	10.5	0.04	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2006	2	2	0	0	1	11	11.5	0.96	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2006	2	2	0	0	1	12	12.5	2.88	0.99618629	0.00381371	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2006	2	2	0	0	1	13	13.5	6.12	0.77428590	0.22571410	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2006	2	2	0	0	1	14	14.5	16.36	0.36825533	0.63118455	0.00056011
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2006	2	2	0	0	1	15	15.5	25.96	0.10019307	0.88164250	0.01816443
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2006	2	2	0	0	1	16	16.5	20.96	0.06804923	0.84951026	0.08244051
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2006	2	2	0	0	1	17	17.5	13.92	0.01400216	0.43528504	0.53121210
	0.01950069	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2006	2	2	0	0	1	18	18.5	9.92	0.00000000	0.10728396	0.77280768
	0.11990836	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2006	2	2	0	0	1	19	19.5	5.56	0.00000000	0.06548736	0.77827275
	0.15623989	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				

2006	2	2	0	0	1	20	20.5	2.12	0.00000000	0.01675003	0.59447114
	0.33123547	0.05754335	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2006	2	2	0	0	1	21	21.5	0.20	0.00000000	0.00000000	0.58224916
	0.41775084	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2006	2	2	0	0	1	22	22.5	0.08	0.00000000	0.00000000	0.00000000
	0.50000000	0.50000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2006	2	2	0	0	1	23	23.5	0.08	0.00000000	0.00000000	0.00000000
	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2007	2	2	0	0	2	10	10.5	0.52	0.81161422	0.18838578	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2007	2	2	0	0	2	11	11.5	3.56	0.81748933	0.16948738	0.01302330
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2007	2	2	0	0	2	12	12.5	7.96	0.80789846	0.18543433	0.00666722
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2007	2	2	0	0	2	13	13.5	13.60	0.58443765	0.40077974	0.01478262
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2007	2	2	0	0	2	14	14.5	12.40	0.35239361	0.57909543	0.06851095
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2007	2	2	0	0	2	15	15.5	8.40	0.13962133	0.67446158	0.18591708
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2007	2	2	0	0	2	16	16.5	5.72	0.04265578	0.60969432	0.34455928
	0.00309062	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2007	2	2	0	0	2	17	17.5	4.52	0.13907978	0.44035193	0.35454781
	0.06602048	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2007	2	2	0	0	2	18	18.5	3.24	0.00000000	0.25882826	0.41917676
	0.32199498	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2007	2	2	0	0	2	19	19.5	1.72	0.13230410	0.04936132	0.24787050
	0.54753177	0.02293231	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2007	2	2	0	0	2	20	20.5	2.76	0.10336144	0.05906368	0.25102064
	0.48319280	0.10336144	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2007	2	2	0	0	2	21	21.5	2.16	0.01919929	0.09599643	0.17973905
	0.56372476	0.11519571	0.02614477	0.00000000	0.00000000	0.00000000	0.00000000				
2007	2	2	0	0	2	22	22.5	0.56	0.07484045	0.07484045	0.10191455
	0.44904273	0.22452136	0.07484045	0.00000000	0.00000000	0.00000000	0.00000000				
2007	2	2	0	0	2	23	23.5	0.16	0.00000000	0.00000000	0.00000000
	0.75000000	0.25000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2007	2	2	0	0	2	24	24.5	0.08	0.50000000	0.00000000	0.00000000
	0.00000000	0.50000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2007	2	2	0	0	2	25	25.5	0.08	0.00000000	0.00000000	0.00000000
	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2008	2	2	0	0	3	10	10.5	0.04	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2008	2	2	0	0	3	11	11.5	0.84	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2008	2	2	0	0	3	12	12.5	2.80	0.98557929	0.01442071	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2008	2	2	0	0	3	13	13.5	2.80	0.85459472	0.14540528	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2008	2	2	0	0	3	14	14.5	1.92	0.21852994	0.75404580	0.02742427
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2008	2	2	0	0	3	15	15.5	7.56	0.02649326	0.84675852	0.12433842
	0.00240980	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2008	2	2	0	0	3	16	16.5	11.56	0.03125844	0.83304051	0.12357623
	0.01212482	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2008	2	2	0	0	3	17	17.5	5.56	0.01343018	0.47528389	0.49238317
	0.01890276	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2008	2	2	0	0	3	18	18.5	4.44	0.00380832	0.15793925	0.63661667
	0.20163576	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2008	2	2	0	0	3	19	19.5	1.24	0.00000000	0.22595676	0.28517288
	0.48887036	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2008	2	2	0	0	3	20	20.5	0.60	0.00000000	0.09286446	0.27321611
	0.60214765	0.03177178	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2008	2	2	0	0	3	21	21.5	0.32	0.00000000	0.24674396	0.08441868
	0.50000000	0.16883736	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2008	2	2	0	0	3	22	22.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2008	2	2	0	0	3	23	23.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2009	2	2	0	0	3	10	10.5	0.04	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2009	2	2	0	0	3	11	11.5	0.40	0.83691728	0.16308272	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2009	2	2	0	0	3	12	12.5	5.72	0.68145305	0.30663268	0.01191427
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				

2009	2	2	0	0	3	13	13.5	22.80	0.68617830	0.30180153	0.01202017	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2009	2	2	0	0	3	14	14.5	31.00	0.50072394	0.41119099	0.08808506	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2009	2	2	0	0	3	15	15.5	24.56	0.24486876	0.58373796	0.17103486	0.00035843	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2009	2	2	0	0	3	16	16.5	10.52	0.06872480	0.66651811	0.25241790	0.01233919	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2009	2	2	0	0	3	17	17.5	2.20	0.01588792	0.50372935	0.45454300	0.02583974	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2009	2	2	0	0	3	18	18.5	0.48	0.00000000	0.15610386	0.64984043	0.19405571	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2009	2	2	0	0	3	19	19.5	0.16	0.00000000	0.00000000	0.35660263	0.05284122	0.59055614	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2009	2	2	0	0	3	20	20.5	0.12	0.00000000	0.00000000	0.47296513	0.42445713	0.10257774	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2009	2	2	0	0	3	21	21.5	0.04	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2009	2	2	0	0	3	22	22.5	0.04	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	4	10	10.5	0.04	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	4	11	11.5	0.08	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	4	12	12.5	1.36	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	4	13	13.5	4.12	0.97937873	0.02062127	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	4	14	14.5	7.52	0.67153245	0.32846755	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	4	15	15.5	6.28	0.34882731	0.65117269	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	4	16	16.5	1.80	0.07426376	0.88304453	0.04269171	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	4	17	17.5	0.64	0.00000000	0.66556773	0.24839031	0.08604197	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	4	18	18.5	0.48	0.00000000	0.36659141	0.51582438	0.11758421	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	4	19	19.5	0.28	0.00000000	0.14661550	0.14661550	0.41353799	0.14661550	0.14661550	0.00000000	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	4	20	20.5	1.40	0.00000000	0.00000000	0.08571429	0.37142857	0.42857143	0.08571429	0.02857143	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	4	21	21.5	3.60	0.00000000	0.00000000	0.03333333	0.15555556	0.40000000	0.40000000	0.01111111	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	4	22	22.5	2.72	0.00000000	0.00000000	0.00000000	0.04411765	0.33823529	0.58823529	0.02941176	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	4	23	23.5	0.92	0.00000000	0.00000000	0.00000000	0.00000000	0.08695652	0.65217391	0.21739130	0.00000000	0.04347826	0.00000000
2010	2	2	0	0	4	24	24.5	0.12	0.00000000	0.00000000	0.00000000	0.33333333	0.00000000	0.00000000	0.66666667	0.00000000	0.00000000	0.00000000
2010	2	2	0	0	4	25	25.5	0.04	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000
2011	2	2	0	0	4	11	11.5	0.16	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2011	2	2	0	0	4	12	12.5	3.48	0.87151784	0.12848216	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2011	2	2	0	0	4	13	13.5	6.12	0.58895794	0.41104206	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2011	2	2	0	0	4	14	14.5	5.72	0.31002959	0.66498769	0.02498273	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2011	2	2	0	0	4	15	15.5	4.40	0.07834036	0.82494300	0.09671665	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2011	2	2	0	0	4	16	16.5	5.36	0.01103939	0.53018555	0.43864331	0.02013174	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2011	2	2	0	0	4	17	17.5	6.16	0.01002697	0.40719167	0.56696774	0.01581362	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2011	2	2	0	0	4	18	18.5	8.72	0.00000000	0.30312009	0.57538979	0.11721027	0.00427985	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
2011	2	2	0	0	4	19	19.5	6.24	0.00000000	0.15416024	0.43440474	0.35481783	0.05159881	0.00501838	0.00000000	0.00000000	0.00000000	0.00000000
2011	2	2	0	0	4	20	20.5	3.20	0.00000000	0.00225041	0.19916413	0.29504166	0.36341325	0.10256523	0.03756533	0.00000000	0.00000000	0.00000000
2011	2	2	0	0	4	21	21.5	2.36	0.00000000	0.00000000	0.02370815	0.15957820	0.11678121	0.34331561	0.32697276	0.02964408	0.00000000	0.00000000

2011	2	2	0	0	4	22	22.5	2.28	0.00000000	0.00000000	0.00000000
	0.23982904	0.15442350	0.27219333	0.17317178	0.14299539	0.01738697	0.00000000				
2011	2	2	0	0	4	23	23.5	0.56	0.00000000	0.00000000	0.00000000
	0.02066462	0.34328736	0.06199386	0.26923320	0.21010218	0.09471878	0.00000000				
2011	2	2	0	0	4	24	24.5	0.12	0.00000000	0.00000000	0.00000000
	0.00000000	0.66666667	0.00000000	0.33333333	0.00000000	0.00000000	0.00000000				
2012	2	2	0	0	4	14	14.5	0.04	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2012	2	2	0	0	4	15	15.5	0.16	0.00000000	0.75000000	0.25000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2012	2	2	0	0	4	16	16.5	0.36	0.11111111	0.55555556	0.33333333
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2012	2	2	0	0	4	17	17.5	1.20	0.00000000	0.24086491	0.72472581
	0.03440927	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2012	2	2	0	0	4	18	18.5	2.40	0.00000000	0.18265179	0.63037559
	0.18697263	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2012	2	2	0	0	4	19	19.5	1.60	0.00000000	0.09506487	0.73668091
	0.13460337	0.03365084	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2012	2	2	0	0	4	20	20.5	1.48	0.00000000	0.11634427	0.34903280
	0.52873563	0.00588730	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2012	2	2	0	0	4	21	21.5	1.28	0.00000000	0.00887236	0.31640548
	0.44277321	0.23194894	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2012	2	2	0	0	4	22	22.5	0.32	0.00000000	0.00000000	0.06501548
	0.32507740	0.54489164	0.06501548	0.00000000	0.00000000	0.00000000	0.00000000				
2012	2	2	0	0	4	23	23.5	0.08	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.50000000	0.50000000	0.00000000	0.00000000	0.00000000				
1999	1	3	0	0	5	16	16.5	0.32	0.00000000	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1999	1	3	0	0	5	17	17.5	0.56	0.00000000	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1999	1	3	0	0	5	18	18.5	0.76	0.00000000	0.00000000	0.78519341
	0.21480659	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1999	1	3	0	0	5	19	19.5	0.28	0.00000000	0.00000000	0.28571429
	0.71428571	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1999	1	3	0	0	5	20	20.5	0.24	0.00000000	0.00000000	0.00000000
	0.69739439	0.30260561	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1999	1	3	0	0	5	21	21.5	0.32	0.00000000	0.00000000	0.00000000
	0.25000000	0.37500000	0.37500000	0.00000000	0.00000000	0.00000000	0.00000000				
1999	1	3	0	0	5	22	22.5	0.28	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1999	1	3	0	0	5	23	23.5	0.16	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.69162500	0.30837500	0.00000000	0.00000000	0.00000000				
1999	1	3	0	0	5	25	25.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000				
2000	1	3	0	0	5	16	16.5	0.24	0.00000000	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2000	1	3	0	0	5	17	17.5	3.16	0.00000000	0.02971019	0.81568211
	0.15460770	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2000	1	3	0	0	5	18	18.5	6.20	0.00000000	0.01663748	0.69778813
	0.22384006	0.05787131	0.00000000	0.00386302	0.00000000	0.00000000	0.00000000				
2000	1	3	0	0	5	19	19.5	7.80	0.00000000	0.01005256	0.26678825
	0.58022529	0.11436740	0.02079638	0.00777013	0.00000000	0.00000000	0.00000000				
2000	1	3	0	0	5	20	20.5	12.20	0.00000000	0.00000000	0.12132936
	0.62061646	0.19578829	0.04921868	0.01167967	0.00000000	0.00136755	0.00000000				
2000	1	3	0	0	5	21	21.5	18.48	0.00000000	0.00000000	0.07284473
	0.43584726	0.29043133	0.13631424	0.05024663	0.00393816	0.01037764	0.00000000				
2000	1	3	0	0	5	22	22.5	13.32	0.00000000	0.00376028	0.04421478
	0.24078300	0.31639225	0.25016788	0.09655734	0.03249653	0.01562794	0.00000000				
2000	1	3	0	0	5	23	23.5	4.48	0.00000000	0.00996131	0.02853334
	0.11903465	0.33924029	0.19843023	0.21097310	0.08115465	0.01267242	0.00000000				
2000	1	3	0	0	5	24	24.5	0.60	0.00000000	0.08604282	0.00000000
	0.09553265	0.03549035	0.35597674	0.35597674	0.07098070	0.00000000	0.00000000				
2000	1	3	0	0	5	25	25.5	0.16	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.44069022	0.21415281	0.00000000	0.34515697	0.00000000				
2001	1	3	0	0	5	13	13.5	0.56	0.00000000	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2001	1	3	0	0	5	14	14.5	0.36	0.00000000	0.78526625	0.21473375
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2001	1	3	0	0	5	15	15.5	0.16	0.00000000	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2001	1	3	0	0	5	16	16.5	0.04	0.00000000	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2001	1	3	0	0	5	18	18.5	1.12	0.00000000	0.18051209	0.33614455
	0.37483373	0.03610242	0.04280481	0.02960240	0.00000000	0.00000000	0.00000000				

2001	1	3	0	0	5	19	19.5	8.44	0.00000000	0.01925963	0.21266479
	0.54224992	0.19662330	0.02920235	0.00000000	0.00000000	0.00000000	0.00000000				
2001	1	3	0	0	5	20	20.5	29.64	0.00000000	0.00422791	0.14436947
	0.54004602	0.27399952	0.03365278	0.00370430	0.00000000	0.00000000	0.00000000				
2001	1	3	0	0	5	21	21.5	23.96	0.00000000	0.00526833	0.05438869
	0.44296758	0.35803980	0.09663834	0.02718394	0.01385955	0.00165377	0.00000000				
2001	1	3	0	0	5	22	22.5	11.28	0.00000000	0.00000000	0.02739324
	0.27709108	0.31245259	0.20449538	0.14091520	0.03370418	0.00394833	0.00000000				
2001	1	3	0	0	5	23	23.5	4.16	0.00000000	0.00000000	0.00000000
	0.09938270	0.26174016	0.29696200	0.25522179	0.06547067	0.02122267	0.00000000				
2001	1	3	0	0	5	24	24.5	1.36	0.00000000	0.00000000	0.00000000
	0.00000000	0.11400278	0.29653276	0.41151161	0.11324999	0.06470286	0.00000000				
2001	1	3	0	0	5	25	25.5	0.20	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.42632700	0.57367300	0.00000000	0.00000000	0.00000000				
2002	1	3	0	0	5	16	16.5	0.08	0.00000000	0.61079433	0.00000000
	0.00000000	0.38920567	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2002	1	3	0	0	5	17	17.5	0.20	0.00000000	0.05397122	0.33719811
	0.60883067	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2002	1	3	0	0	5	18	18.5	0.96	0.00000000	0.36692199	0.47794134
	0.13307801	0.01102933	0.01102933	0.00000000	0.00000000	0.00000000	0.00000000				
2002	1	3	0	0	5	19	19.5	1.48	0.00000000	0.08124207	0.44744620
	0.37831800	0.00351850	0.06096807	0.00000000	0.02850716	0.00000000	0.00000000				
2002	1	3	0	0	5	20	20.5	5.72	0.00000000	0.00096806	0.16028495
	0.29077515	0.43336995	0.08898633	0.00974430	0.01587127	0.00000000	0.00000000				
2002	1	3	0	0	5	21	21.5	36.20	0.00000000	0.00138445	0.03422952
	0.20205619	0.45716363	0.23106171	0.05486628	0.01522131	0.00401691	0.00000000				
2002	1	3	0	0	5	22	22.5	40.68	0.00000000	0.00120007	0.00769523
	0.10957576	0.40541534	0.26660646	0.13228271	0.05251317	0.02390997	0.00080130				
2002	1	3	0	0	5	23	23.5	18.56	0.00000000	0.00027504	0.00304354
	0.07014138	0.23002191	0.30895891	0.22516891	0.11658483	0.04580547	0.00000000				
2002	1	3	0	0	5	24	24.5	5.08	0.00000000	0.00000000	0.00000000
	0.03031816	0.15396709	0.22605776	0.19593474	0.18364555	0.20308000	0.00699671				
2002	1	3	0	0	5	25	25.5	1.08	0.00000000	0.00000000	0.00000000
	0.00000000	0.03411823	0.03411823	0.29486547	0.38081541	0.22892806	0.02715461				
2002	1	3	0	0	5	26	26.5	0.28	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.40176012	0.59823988	0.00000000				
2003	1	3	0	0	5	13	13.5	0.04	0.00000000	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2003	1	3	0	0	5	14	14.5	0.64	0.00000000	0.29858794	0.70141206
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2003	1	3	0	0	5	15	15.5	0.32	0.00000000	0.62500000	0.25000000
	0.12500000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2003	1	3	0	0	5	16	16.5	0.04	0.00000000	0.00000000	0.00000000
	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2003	1	3	0	0	5	17	17.5	1.72	0.00000000	0.02889942	0.59388085
	0.29995467	0.07726506	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2003	1	3	0	0	5	18	18.5	6.04	0.00000000	0.04616067	0.48016399
	0.39541506	0.05770611	0.02055418	0.00000000	0.00000000	0.00000000	0.00000000				
2003	1	3	0	0	5	19	19.5	8.72	0.00000000	0.04256105	0.42806829
	0.36049142	0.09471140	0.04309680	0.02116158	0.00990946	0.00000000	0.00000000				
2003	1	3	0	0	5	20	20.5	10.76	0.00000000	0.01717435	0.29797333
	0.31388290	0.13396080	0.11909415	0.05801165	0.05330316	0.00659966	0.00000000				
2003	1	3	0	0	5	21	21.5	13.28	0.00000000	0.00954035	0.17388138
	0.21066376	0.16657500	0.20443594	0.15382384	0.05487022	0.02620950	0.00000000				
2003	1	3	0	0	5	22	22.5	24.52	0.00000000	0.00433987	0.02139465
	0.05261511	0.10155919	0.29939187	0.26100100	0.14053818	0.11045425	0.00870587				
2003	1	3	0	0	5	23	23.5	17.40	0.00000000	0.00000000	0.00580201
	0.03805724	0.09739760	0.22253494	0.22808285	0.19974443	0.18466718	0.02371374				
2003	1	3	0	0	5	24	24.5	6.56	0.00000000	0.00900865	0.00193705
	0.00576173	0.04555107	0.15018181	0.20368581	0.12017707	0.38184532	0.08185148				
2003	1	3	0	0	5	25	25.5	1.92	0.00000000	0.00000000	0.00000000
	0.03311641	0.05115135	0.14950034	0.27774722	0.13268709	0.34825686	0.00754073				
2003	1	3	0	0	5	26	26.5	0.32	0.00000000	0.00000000	0.00000000
	0.04130292	0.00000000	0.00000000	0.00000000	0.08260584	0.87609124	0.00000000				
2003	1	3	0	0	5	27	27.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2004	1	3	0	0	5	11	11.5	0.04	0.00000000	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2004	1	3	0	0	5	12	12.5	0.24	0.00000000	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2004	1	3	0	0	5	13	13.5	1.48	0.00000000	0.86640401	0.13359599
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2004	1	3	0	0	5	14	14.5	2.64	0.00000000	0.81022906	0.16028563
	0.02948531	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				

2004	1	3	0	0	5	15	15.5	2.44	0.00000000	0.81693870	0.15224300
	0.02701525	0.00380304	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2004	1	3	0	0	5	16	16.5	2.44	0.00000000	0.91506888	0.08493112
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2004	1	3	0	0	5	17	17.5	7.08	0.00000000	0.82911979	0.13811037
	0.03276984	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2004	1	3	0	0	5	18	18.5	4.64	0.00000000	0.70590326	0.18379993
	0.11029681	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2004	1	3	0	0	5	19	19.5	3.28	0.00000000	0.12849706	0.38179877
	0.42007401	0.06963017	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2004	1	3	0	0	5	20	20.5	3.60	0.00000000	0.06764562	0.22718819
	0.43632745	0.20513650	0.02123408	0.04246816	0.00000000	0.00000000	0.00000000				
2004	1	3	0	0	5	21	21.5	7.12	0.00000000	0.02507256	0.14317139
	0.40119569	0.27665293	0.08143410	0.04737353	0.00000000	0.02509980	0.00000000				
2004	1	3	0	0	5	22	22.5	10.88	0.00000000	0.01339372	0.07334027
	0.13251533	0.12700182	0.29782043	0.20631143	0.09216441	0.05026100	0.00719159				
2004	1	3	0	0	5	23	23.5	13.56	0.00000000	0.00000000	0.01271574
	0.04461322	0.10214081	0.22098845	0.27593474	0.15398881	0.15826834	0.03134988				
2004	1	3	0	0	5	24	24.5	5.76	0.00000000	0.00000000	0.01698676
	0.01580170	0.05125012	0.18765518	0.40400194	0.08129150	0.18450322	0.05850957				
2004	1	3	0	0	5	25	25.5	1.28	0.00000000	0.00000000	0.00000000
	0.02532908	0.13645475	0.14911929	0.25845116	0.20716081	0.15798550	0.06549941				
2004	1	3	0	0	5	26	26.5	0.08	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.36623068	0.00000000	0.00000000	0.63376932	0.00000000				
2005	1	3	0	0	5	12	12.5	0.08	0.00000000	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2005	1	3	0	0	5	15	15.5	0.84	0.00000000	0.00000000	0.91882170
	0.00000000	0.08117830	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2005	1	3	0	0	5	16	16.5	5.32	0.00000000	0.02117241	0.81569472
	0.15807194	0.00506093	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2005	1	3	0	0	5	17	17.5	14.84	0.00000000	0.00643022	0.78357060
	0.16751096	0.03437875	0.00732624	0.00078323	0.00000000	0.00000000	0.00000000				
2005	1	3	0	0	5	18	18.5	7.20	0.00000000	0.02142792	0.74255130
	0.18572045	0.03920476	0.00770222	0.00134353	0.00000000	0.00204982	0.00000000				
2005	1	3	0	0	5	19	19.5	1.36	0.00000000	0.01819245	0.64158675
	0.08655097	0.16711887	0.08655097	0.00000000	0.00000000	0.00000000	0.00000000				
2005	1	3	0	0	5	20	20.5	0.72	0.00000000	0.00000000	0.18644387
	0.21159555	0.37478461	0.11262507	0.07764151	0.00000000	0.03690940	0.00000000				
2005	1	3	0	0	5	21	21.5	1.00	0.00000000	0.00000000	0.11058216
	0.08033075	0.58483462	0.14392172	0.08033075	0.00000000	0.00000000	0.00000000				
2005	1	3	0	0	5	22	22.5	1.56	0.00000000	0.00000000	0.00000000
	0.04232762	0.46888188	0.14965618	0.13515448	0.12377543	0.06188772	0.01831669				
2005	1	3	0	0	5	23	23.5	3.40	0.00000000	0.00000000	0.02270702
	0.01580238	0.01941793	0.16224316	0.18771401	0.09741119	0.37852811	0.11617621				
2005	1	3	0	0	5	24	24.5	3.56	0.00000000	0.00000000	0.00000000
	0.00000000	0.01297664	0.06131838	0.11939381	0.25404643	0.37055304	0.18171170				
2005	1	3	0	0	5	25	25.5	0.88	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.05049915	0.00000000	0.20199661	0.52275381	0.22475042				
2005	1	3	0	0	5	26	26.5	0.08	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000				
2006	1	3	0	0	5	17	17.5	0.24	0.00000000	0.00000000	0.00000000
	0.51704397	0.48295603	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2006	1	3	0	0	5	18	18.5	4.76	0.00000000	0.00000000	0.04347242
	0.63966086	0.16481578	0.07602547	0.04062132	0.00000000	0.01770207	0.01770207				
2006	1	3	0	0	5	19	19.5	14.92	0.00000000	0.00000000	0.00727865
	0.64061532	0.20355835	0.08308284	0.04645900	0.00000000	0.01900585	0.00000000				
2006	1	3	0	0	5	20	20.5	4.56	0.00000000	0.00000000	0.01204775
	0.62924849	0.24556590	0.07757939	0.00612325	0.02943522	0.00000000	0.00000000				
2006	1	3	0	0	5	21	21.5	0.72	0.00000000	0.00000000	0.00000000
	0.28199047	0.05286559	0.15688084	0.50826311	0.00000000	0.00000000	0.00000000				
2006	1	3	0	0	5	22	22.5	0.32	0.00000000	0.00000000	0.00000000
	0.14380492	0.61156791	0.00000000	0.00000000	0.12231358	0.12231358	0.00000000				
2006	1	3	0	0	5	23	23.5	0.52	0.00000000	0.00000000	0.00000000
	0.05102799	0.32632300	0.05102799	0.27081202	0.24529802	0.05551098	0.00000000				
2006	1	3	0	0	5	24	24.5	0.64	0.00000000	0.00000000	0.00000000
	0.22881018	0.04759812	0.07557884	0.02379906	0.09519624	0.52901755	0.00000000				
2006	1	3	0	0	5	25	25.5	0.20	0.00000000	0.00000000	0.00000000
	0.00000000	0.85825403	0.04463446	0.04463446	0.05247705	0.00000000	0.00000000				
2006	1	3	0	0	5	26	26.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2007	1	3	0	0	5	16	16.5	0.04	0.00000000	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2007	1	3	0	0	5	17	17.5	2.16	0.00000000	0.00000000	0.23740467
	0.45780179	0.27618093	0.02861261	0.00000000	0.00000000	0.00000000	0.00000000				

2007	1	3	0	0	5	18	18.5	18.56	0.00000000	0.00000000	0.07683540
	0.57588439	0.31802187	0.02626425	0.00299409	0.00000000	0.00000000	0.00000000				
2007	1	3	0	0	5	19	19.5	41.00	0.00000000	0.00000000	0.03081318
	0.50919315	0.39309440	0.05765305	0.00637106	0.00287516	0.00000000	0.00000000				
2007	1	3	0	0	5	20	20.5	23.36	0.00000000	0.00000000	0.00437021
	0.32889907	0.48632183	0.14330941	0.02698247	0.00772495	0.00239205	0.00000000				
2007	1	3	0	0	5	21	21.5	2.84	0.00000000	0.00000000	0.01790312
	0.06248941	0.60674578	0.22974585	0.08311583	0.00000000	0.00000000	0.00000000				
2007	1	3	0	0	5	22	22.5	0.36	0.00000000	0.00000000	0.00000000
	0.21943393	0.48478081	0.10971697	0.18606829	0.00000000	0.00000000	0.00000000				
2007	1	3	0	0	5	23	23.5	0.64	0.00000000	0.00000000	0.00000000
	0.00000000	0.09044068	0.34236015	0.31113120	0.12166964	0.13439832	0.00000000				
2007	1	3	0	0	5	24	24.5	0.28	0.00000000	0.00000000	0.00000000
	0.00000000	0.23026346	0.26146231	0.00000000	0.09267026	0.41560397	0.00000000				
2007	1	3	0	0	5	25	25.5	0.12	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.37093453	0.62906547				
2007	1	3	0	0	5	27	27.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000				
2008	1	3	0	0	5	17	17.5	0.88	0.00000000	0.00000000	0.08076731
	0.45003422	0.35683235	0.11236612	0.00000000	0.00000000	0.00000000	0.00000000				
2008	1	3	0	0	5	18	18.5	13.12	0.00000000	0.00000000	0.01184838
	0.32043582	0.46529163	0.19547765	0.00694651	0.00000000	0.00000000	0.00000000				
2008	1	3	0	0	5	19	19.5	32.08	0.00000000	0.00000000	0.00088424
	0.15493135	0.57736237	0.24563050	0.01859373	0.00259781	0.00000000	0.00000000				
2008	1	3	0	0	5	20	20.5	32.48	0.00000000	0.00000000	0.00000000
	0.05859962	0.53023043	0.34778716	0.05769815	0.00246186	0.00322279	0.00000000				
2008	1	3	0	0	5	21	21.5	10.88	0.00000000	0.00000000	0.00000000
	0.01475106	0.36452259	0.47038098	0.10796971	0.02632704	0.01604862	0.00000000				
2008	1	3	0	0	5	22	22.5	2.80	0.00000000	0.00000000	0.00000000
	0.03766021	0.19998154	0.35594165	0.24583760	0.12291880	0.03766021	0.00000000				
2008	1	3	0	0	5	23	23.5	1.28	0.00000000	0.00000000	0.00000000
	0.00000000	0.19731636	0.34757381	0.22868898	0.19401355	0.03240729	0.00000000				
2008	1	3	0	0	5	24	24.5	0.40	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.07480361	0.14173213	0.17913393	0.60433033	0.00000000				
2008	1	3	0	0	5	25	25.5	0.08	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.79120760	0.00000000	0.20879240	0.00000000				
2009	1	3	0	0	5	15	15.5	0.04	0.00000000	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2009	1	3	0	0	5	17	17.5	0.68	0.00000000	0.00000000	0.00000000
	0.42804400	0.48314281	0.03371438	0.00000000	0.05509881	0.00000000	0.00000000				
2009	1	3	0	0	5	18	18.5	11.68	0.00000000	0.00000000	0.02050733
	0.12037526	0.46365604	0.31060975	0.08018280	0.00466882	0.00000000	0.00000000				
2009	1	3	0	0	5	19	19.5	41.76	0.00000000	0.00000000	0.00226916
	0.03590519	0.36741479	0.37324927	0.18827612	0.02953106	0.00335441	0.00000000				
2009	1	3	0	0	5	20	20.5	31.56	0.00000000	0.00000000	0.00219593
	0.01342498	0.21422056	0.43913111	0.25999418	0.06078386	0.01024938	0.00000000				
2009	1	3	0	0	5	21	21.5	6.80	0.00000000	0.00000000	0.00212453
	0.00568681	0.10318651	0.44777766	0.31985777	0.10280451	0.01856221	0.00000000				
2009	1	3	0	0	5	22	22.5	0.56	0.00000000	0.00000000	0.00000000
	0.00000000	0.04893710	0.22695408	0.46075579	0.08550180	0.17785124	0.00000000				
2009	1	3	0	0	5	23	23.5	0.12	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.83888941	0.00000000	0.16111059	0.00000000	0.00000000				
2009	1	3	0	0	5	24	24.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000				
2010	1	3	0	0	5	16	16.5	0.20	0.00000000	0.00000000	0.76934528
	0.23065472	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2010	1	3	0	0	5	17	17.5	0.20	0.00000000	0.00000000	0.00000000
	0.38467264	0.46130945	0.15401791	0.00000000	0.00000000	0.00000000	0.00000000				
2010	1	3	0	0	5	18	18.5	1.84	0.00000000	0.00000000	0.00000000
	0.16788478	0.16797029	0.46967550	0.17677483	0.01769459	0.00000000	0.00000000				
2010	1	3	0	0	5	19	19.5	12.44	0.00000000	0.00000000	0.00000000
	0.04896287	0.27875690	0.38697070	0.18333172	0.08992043	0.01205738	0.00000000				
2010	1	3	0	0	5	20	20.5	14.44	0.00000000	0.00000000	0.00000000
	0.01016532	0.16180590	0.40427576	0.30760341	0.09572334	0.02042628	0.00000000				
2010	1	3	0	0	5	21	21.5	4.28	0.00000000	0.00000000	0.00000000
	0.00000000	0.17346526	0.35308184	0.28013074	0.16224575	0.03107640	0.00000000				
2010	1	3	0	0	5	22	22.5	0.32	0.00000000	0.00000000	0.00000000
	0.00000000	0.20110753	0.39240600	0.07009449	0.26629749	0.07009449	0.00000000				
2010	1	3	0	0	5	23	23.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000				
2011	1	3	0	0	5	14	14.5	0.04	0.00000000	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2011	1	3	0	0	5	15	15.5	0.04	0.00000000	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				

2011	1	3	0	0	5	17	17.5	0.36	0.00000000	0.51810763	0.21835447
	0.00000000	0.00000000	0.08820160	0.17533631	0.00000000	0.00000000	0.00000000				
2011	1	3	0	0	5	18	18.5	0.88	0.00000000	0.00000000	0.50596905
	0.21929168	0.19223208	0.06856094	0.00000000	0.00000000	0.01394624	0.00000000				
2011	1	3	0	0	5	19	19.5	3.40	0.00000000	0.00000000	0.15072866
	0.26068154	0.13777478	0.16189115	0.23719457	0.03802670	0.01370261	0.00000000				
2011	1	3	0	0	5	20	20.5	18.40	0.00000000	0.00000000	0.00859330
	0.03904601	0.13922408	0.33680258	0.27486556	0.15650820	0.04496027	0.00000000				
2011	1	3	0	0	5	21	21.5	16.08	0.00000000	0.00000000	0.00422339
	0.01197875	0.10077749	0.31338103	0.33280820	0.20914405	0.02768709	0.00000000				
2011	1	3	0	0	5	22	22.5	3.12	0.00000000	0.00000000	0.00000000
	0.00000000	0.14846829	0.30437049	0.28564527	0.18671576	0.07480019	0.00000000				
2011	1	3	0	0	5	23	23.5	0.56	0.00000000	0.00000000	0.00000000
	0.00000000	0.03268375	0.34533842	0.27886041	0.34311741	0.00000000	0.00000000				
2012	1	3	0	0	5	17	17.5	0.04	0.00000000	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2012	1	3	0	0	5	18	18.5	5.48	0.00000000	0.00000000	0.74304840
	0.23730442	0.01964719	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2012	1	3	0	0	5	19	19.5	30.96	0.00000000	0.00094202	0.66082840
	0.26778733	0.03782638	0.00983471	0.00554848	0.00428623	0.01294645	0.00000000				
2012	1	3	0	0	5	20	20.5	35.76	0.00000000	0.00116550	0.38557432
	0.33735691	0.11024423	0.04944098	0.03141783	0.04173074	0.04306948	0.00000000				
2012	1	3	0	0	5	21	21.5	26.64	0.00000000	0.00000000	0.03900776
	0.12680052	0.08678037	0.08175227	0.18143254	0.19322295	0.28507335	0.00593025				
2012	1	3	0	0	5	22	22.5	16.44	0.00000000	0.00000000	0.01068538
	0.00799751	0.04921246	0.06488152	0.15952159	0.27504714	0.41065066	0.02200375				
2012	1	3	0	0	5	23	23.5	2.84	0.00000000	0.00000000	0.00000000
	0.00000000	0.02087101	0.05696684	0.12747367	0.23738363	0.51556283	0.04174203				
2012	1	3	0	0	5	24	24.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000				
2012	1	3	0	0	5	25	25.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	1.00000000	0.00000000				
2005	2	8	0	0	6	11	11.5	0.04	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2005	2	8	0	0	6	13	13.5	0.04	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2005	2	8	0	0	6	15	15.5	0.12	0.00000000	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2005	2	8	0	0	6	16	16.5	1.60	0.35000000	0.65000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2005	2	8	0	0	6	17	17.5	1.80	0.08888889	0.62222222	0.24444444
	0.04444444	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2005	2	8	0	0	6	18	18.5	2.40	0.00000000	0.68333333	0.31666667
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2005	2	8	0	0	6	19	19.5	3.24	0.00000000	0.56790123	0.40740741
	0.02469136	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2005	2	8	0	0	6	20	20.5	1.92	0.02083333	0.45833333	0.47916667
	0.02083333	0.02083333	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2005	2	8	0	0	6	21	21.5	0.56	0.00000000	0.50000000	0.42857143
	0.00000000	0.07142857	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2005	2	8	0	0	6	22	22.5	0.12	0.00000000	0.66666667	0.33333333
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2005	2	8	0	0	6	24	24.5	0.08	0.00000000	0.00000000	0.50000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.50000000	0.00000000				
2005	2	8	0	0	6	25	25.5	0.16	0.00000000	0.25000000	0.00000000
	0.25000000	0.50000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2005	2	8	0	0	6	26	26.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2007	2	8	0	0	6	16	16.5	0.12	0.00000000	0.33333333	0.66666667
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2007	2	8	0	0	6	17	17.5	0.40	0.00000000	0.00000000	0.80000000
	0.20000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2007	2	8	0	0	6	18	18.5	0.96	0.00000000	0.08333333	0.70833333
	0.20833333	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2007	2	8	0	0	6	19	19.5	1.00	0.00000000	0.00000000	0.36000000
	0.52000000	0.08000000	0.04000000	0.00000000	0.00000000	0.00000000	0.00000000				
2007	2	8	0	0	6	20	20.5	2.84	0.00000000	0.00000000	0.16901408
	0.66197183	0.14084507	0.02816901	0.00000000	0.00000000	0.00000000	0.00000000				
2007	2	8	0	0	6	21	21.5	4.96	0.00000000	0.00000000	0.08870968
	0.73387097	0.16935484	0.00806452	0.00000000	0.00000000	0.00000000	0.00000000				
2007	2	8	0	0	6	22	22.5	3.40	0.00000000	0.00000000	0.00000000
	0.77647059	0.21176471	0.01176471	0.00000000	0.00000000	0.00000000	0.00000000				
2007	2	8	0	0	6	23	23.5	0.80	0.00000000	0.00000000	0.00000000
	0.75000000	0.20000000	0.05000000	0.00000000	0.00000000	0.00000000	0.00000000				

2007	2	8	0	0	6	24	24.5	0.24	0.00000000	0.00000000	0.00000000
	0.50000000	0.50000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2007	2	8	0	0	6	25	25.5	0.08	0.00000000	0.00000000	0.00000000
	0.00000000	0.50000000	0.50000000	0.00000000	0.00000000	0.00000000	0.00000000			
2009	2	8	0	0	6	12	12.5	0.04	0.00000000	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2009	2	8	0	0	6	14	14.5	0.04	0.00000000	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2009	2	8	0	0	6	15	15.5	0.12	0.00000000	0.66666667	0.33333333
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2009	2	8	0	0	6	16	16.5	0.24	0.16666667	0.50000000	0.33333333
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2009	2	8	0	0	6	17	17.5	0.32	0.00000000	0.62500000	0.37500000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2009	2	8	0	0	6	18	18.5	0.16	0.00000000	0.00000000	0.50000000
	0.50000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2009	2	8	0	0	6	19	19.5	0.36	0.00000000	0.11111111	0.11111111
	0.44444444	0.11111111	0.22222222	0.00000000	0.00000000	0.00000000	0.00000000			
2009	2	8	0	0	6	20	20.5	2.72	0.00000000	0.00000000	0.01470588
	0.39705882	0.42647059	0.16176471	0.00000000	0.00000000	0.00000000	0.00000000			
2009	2	8	0	0	6	21	21.5	8.12	0.00000000	0.00000000	0.01970443
	0.25123153	0.44827586	0.25123153	0.02955665	0.00000000	0.00000000	0.00000000			
2009	2	8	0	0	6	22	22.5	9.72	0.00000000	0.00411523	0.01646091
	0.18518519	0.45679012	0.25514403	0.07818930	0.00411523	0.00000000	0.00000000			
2009	2	8	0	0	6	23	23.5	4.16	0.00000000	0.00000000	0.00000000
	0.17307692	0.46153846	0.30769231	0.05769231	0.00000000	0.00000000	0.00000000			
2009	2	8	0	0	6	24	24.5	0.96	0.00000000	0.00000000	0.00000000
	0.12500000	0.37500000	0.41666667	0.04166667	0.04166667	0.00000000	0.00000000			
2009	2	8	0	0	6	25	25.5	0.08	0.00000000	0.00000000	0.00000000
	0.50000000	0.00000000	0.50000000	0.00000000	0.00000000	0.00000000	0.00000000			
2009	2	8	0	0	6	26	26.5	0.16	0.00000000	0.00000000	0.00000000
	0.00000000	0.50000000	0.00000000	0.25000000	0.25000000	0.00000000	0.00000000			
2010	2	8	0	0	6	14	14.5	0.08	0.00000000	0.50000000	0.50000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2010	2	8	0	0	6	15	15.5	0.12	0.33333333	0.33333333	0.33333333
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2010	2	8	0	0	6	16	16.5	1.28	0.00000000	0.65625000	0.31250000
	0.03125000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2010	2	8	0	0	6	17	17.5	3.76	0.01063830	0.51063830	0.42553191
	0.04255319	0.01063830	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2010	2	8	0	0	6	18	18.5	5.60	0.02142857	0.37142857	0.50000000
	0.10000000	0.00714286	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2010	2	8	0	0	6	19	19.5	2.24	0.00000000	0.23214286	0.50000000
	0.25000000	0.01785714	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2010	2	8	0	0	6	20	20.5	0.48	0.00000000	0.00000000	0.75000000
	0.25000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2010	2	8	0	0	6	21	21.5	1.56	0.00000000	0.00000000	0.05128205
	0.25641026	0.33333333	0.28205128	0.07692308	0.00000000	0.00000000	0.00000000			
2010	2	8	0	0	6	22	22.5	4.92	0.00000000	0.00000000	0.04878049
	0.15447154	0.36585366	0.27642276	0.12195122	0.03252033	0.00000000	0.00000000			
2010	2	8	0	0	6	23	23.5	4.16	0.00000000	0.00961538	0.03846154
	0.17307692	0.33653846	0.32692308	0.09615385	0.01923077	0.00000000	0.00000000			
2010	2	8	0	0	6	24	24.5	0.84	0.00000000	0.00000000	0.00000000
	0.04761905	0.52380952	0.23809524	0.19047619	0.00000000	0.00000000	0.00000000			
2010	2	8	0	0	6	25	25.5	0.28	0.00000000	0.00000000	0.00000000
	0.00000000	0.28571429	0.42857143	0.28571429	0.00000000	0.00000000	0.00000000			
2010	2	8	0	0	6	26	26.5	0.16	0.00000000	0.00000000	0.00000000
	0.00000000	0.75000000	0.00000000	0.25000000	0.00000000	0.00000000	0.00000000			
2011	2	8	0	0	6	17	17.5	0.04	0.00000000	1.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2011	2	8	0	0	6	18	18.5	0.08	0.00000000	0.50000000	0.50000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2011	2	8	0	0	6	19	19.5	1.84	0.00000000	0.17391304	0.58695652
	0.19565217	0.04347826	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000			
2011	2	8	0	0	6	20	20.5	3.20	0.00000000	0.13750000	0.62500000
	0.15000000	0.07500000	0.00000000	0.01250000	0.00000000	0.00000000	0.00000000			
2011	2	8	0	0	6	21	21.5	2.00	0.00000000	0.16000000	0.40000000
	0.26000000	0.14000000	0.00000000	0.04000000	0.00000000	0.00000000	0.00000000			
2011	2	8	0	0	6	22	22.5	1.60	0.00000000	0.00000000	0.27500000
	0.17500000	0.12500000	0.20000000	0.20000000	0.02500000	0.00000000	0.00000000			
2011	2	8	0	0	6	23	23.5	3.72	0.00000000	0.00000000	0.03225806
	0.15053763	0.32258065	0.29032258	0.15053763	0.05376344	0.00000000	0.00000000			
2011	2	8	0	0	6	24	24.5	1.56	0.00000000	0.00000000	0.02564103
	0.10256410	0.35897436	0.33333333	0.17948718	0.00000000	0.00000000	0.00000000			

2011	2	8	0	0	6	25	25.5	0.24	0.00000000	0.00000000	0.16666667
	0.16666667	0.33333333	0.00000000	0.33333333	0.00000000	0.00000000	0.00000000				
2011	2	8	0	0	6	26	26.5	0.04	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	1.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2012	2	8	0	0	6	18	18.5	0.12	0.00000000	0.33333333	0.33333333
	0.33333333	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2012	2	8	0	0	6	20	20.5	0.84	0.00000000	0.00000000	0.47619048
	0.42857143	0.04761905	0.04761905	0.00000000	0.00000000	0.00000000	0.00000000				
2012	2	8	0	0	6	21	21.5	3.12	0.00000000	0.00000000	0.20512821
	0.53846154	0.19230769	0.01282051	0.05128205	0.00000000	0.00000000	0.00000000				
2012	2	8	0	0	6	22	22.5	2.64	0.00000000	0.00000000	0.25757576
	0.54545455	0.10606061	0.03030303	0.03030303	0.01515152	0.01515152	0.00000000				
2012	2	8	0	0	6	23	23.5	1.04	0.00000000	0.00000000	0.03846154
	0.19230769	0.11538462	0.15384615	0.30769231	0.03846154	0.15384615	0.00000000				
2012	2	8	0	0	6	24	24.5	0.76	0.00000000	0.00000000	0.00000000
	0.05263158	0.15789474	0.26315789	0.10526316	0.26315789	0.15789474	0.00000000				
2012	2	8	0	0	6	25	25.5	0.12	0.00000000	0.00000000	0.00000000
	0.00000000	0.33333333	0.00000000	0.00000000	0.66666667	0.00000000	0.00000000				
2008	1	9	0	0	6	9	9.5	0.40	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2008	1	9	0	0	6	10	10.5	0.52	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2008	1	9	0	0	6	11	11.5	0.16	1.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2008	1	9	0	0	6	16	16.5	0.16	0.00000000	0.00000000	0.75000000
	0.25000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2008	1	9	0	0	6	17	17.5	0.48	0.00000000	0.00000000	0.41666667
	0.58333333	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2008	1	9	0	0	6	18	18.5	0.88	0.00000000	0.00000000	0.27272727
	0.59090909	0.13636364	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2008	1	9	0	0	6	19	19.5	4.76	0.00000000	0.00840336	0.25210084
	0.51260504	0.21848739	0.00840336	0.00000000	0.00000000	0.00000000	0.00000000				
2008	1	9	0	0	6	20	20.5	7.60	0.00000000	0.00526316	0.11578947
	0.45263158	0.40526316	0.02105263	0.00000000	0.00000000	0.00000000	0.00000000				
2008	1	9	0	0	6	21	21.5	9.32	0.00000000	0.00000000	0.05150215
	0.43347639	0.49356223	0.02145923	0.00000000	0.00000000	0.00000000	0.00000000				
2008	1	9	0	0	6	22	22.5	3.52	0.00000000	0.00000000	0.03409091
	0.40909091	0.51136364	0.04545455	0.00000000	0.00000000	0.00000000	0.00000000				
2008	1	9	0	0	6	23	23.5	0.68	0.00000000	0.00000000	0.00000000
	0.35294118	0.58823529	0.05882353	0.00000000	0.00000000	0.00000000	0.00000000				
2008	1	9	0	0	6	24	24.5	0.32	0.00000000	0.00000000	0.12500000
	0.37500000	0.50000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2008	1	9	0	0	6	25	25.5	0.08	0.00000000	0.00000000	0.00000000
	0.50000000	0.50000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2012	1	9	0	0	6	17	17.5	0.04	0.00000000	0.00000000	1.00000000
	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2012	1	9	0	0	6	19	19.5	0.80	0.00000000	0.10000000	0.45000000
	0.40000000	0.05000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2012	1	9	0	0	6	20	20.5	6.80	0.00000000	0.03529412	0.44705882
	0.35882353	0.12941176	0.02941176	0.00000000	0.00000000	0.00000000	0.00000000				
2012	1	9	0	0	6	21	21.5	8.12	0.00000000	0.00492611	0.28571429
	0.39901478	0.18719212	0.06896552	0.02463054	0.02955665	0.00000000	0.00000000				
2012	1	9	0	0	6	22	22.5	3.04	0.00000000	0.00000000	0.07894737
	0.28947368	0.18421053	0.22368421	0.09210526	0.10526316	0.02631579	0.00000000				
2012	1	9	0	0	6	23	23.5	2.40	0.00000000	0.00000000	0.00000000
	0.03333333	0.10000000	0.26666667	0.26666667	0.23333333	0.10000000	0.00000000				
2012	1	9	0	0	6	24	24.5	1.28	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.21875000	0.31250000	0.21875000	0.25000000	0.00000000				
2012	1	9	0	0	6	25	25.5	0.40	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.10000000	0.10000000	0.50000000	0.30000000	0.00000000				
2013	1	9	0	0	6	20	20.5	0.16	0.00000000	0.00000000	0.00000000
	0.75000000	0.25000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2013	1	9	0	0	6	21	21.5	3.40	0.00000000	0.00000000	0.35294118
	0.51764706	0.11764706	0.00000000	0.01176471	0.00000000	0.00000000	0.00000000				
2013	1	9	0	0	6	22	22.5	6.00	0.00000000	0.00000000	0.32666667
	0.52000000	0.12666667	0.01333333	0.00666667	0.00666667	0.00000000	0.00000000				
2013	1	9	0	0	6	23	23.5	3.24	0.00000000	0.00000000	0.22222222
	0.43209877	0.11111111	0.14814815	0.04938272	0.01234568	0.02469136	0.00000000				
2013	1	9	0	0	6	24	24.5	1.08	0.00000000	0.00000000	0.00000000
	0.07407407	0.03703704	0.37037037	0.37037037	0.03703704	0.11111111	0.00000000				
2013	1	9	0	0	6	25	25.5	0.28	0.00000000	0.00000000	0.00000000
	0.00000000	0.00000000	0.14285714	0.57142857	0.14285714	0.14285714	0.00000000				
1993	1	-1	0	0	1	9	28	2.72	0.00000000	0.00000000	0.11764706
	0.76470588	0.10294118	0.01470588	0.00000000	0.00000000	0.00000000	0.00000000				

1994	1	-1	0	0	1	9	28	11.76	0.02233392	0.46921325	0.31997955
	0.15950127	0.02897201	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1995	1	-1	0	0	1	9	28	4.76	0.11764706	0.56302521	0.25210084
	0.06722689	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
1996	1	-1	0	0	1	9	28	89.28	0.00000000	0.05567822	0.57869148
	0.31936116	0.04119642	0.00460375	0.00000000	0.00046897	0.00000000	0.00000000				
1997	1	-1	0	0	1	9	28	54.92	0.00393055	0.41526377	0.48143507
	0.08999595	0.00760341	0.00177125	0.00000000	0.00000000	0.00000000	0.00000000				
1998	1	-1	0	0	1	9	28	75.32	0.08752419	0.65178011	0.20556040
	0.02738368	0.02185746	0.00530475	0.00058942	0.00000000	0.00000000	0.00000000				
1999	1	-1	0	0	1	9	28	6.96	0.12068966	0.51724138	0.35632184
	0.00574713	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2000	1	-1	0	0	1	9	28	22.64	0.05612282	0.21594669	0.47409550
	0.23739199	0.01419224	0.00225076	0.00000000	0.00000000	0.00000000	0.00000000				
2001	1	-1	0	0	1	9	28	37.24	0.19498424	0.24032396	0.10821490
	0.29193947	0.11194383	0.03989310	0.00899338	0.00370711	0.00000000	0.00000000				
2002	1	-1	0	0	1	9	28	30.32	0.17079894	0.53308456	0.23318285
	0.04302452	0.01864624	0.00126289	0.00000000	0.00000000	0.00000000	0.00000000				
2003	1	-1	0	0	1	9	28	17.76	0.56513500	0.22899483	0.18990839
	0.01273176	0.00323001	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2004	1	-1	0	0	1	9	28	33.52	0.00300111	0.90375628	0.06959324
	0.00743078	0.01147566	0.00000000	0.00474293	0.00000000	0.00000000	0.00000000				
2005	1	-1	0	0	1	9	28	35.24	0.09102697	0.26552164	0.59466314
	0.04284618	0.00412282	0.00121284	0.00060642	0.00000000	0.00000000	0.00000000				
2006	1	-1	0	0	1	9	28	69.76	0.00908783	0.64539166	0.30295669
	0.04256381	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2007	1	-1	0	0	2	9	28	86.00	0.01357889	0.16055166	0.64593872
	0.17061145	0.00931929	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2008	1	-1	0	0	3	9	28	30.84	0.06153622	0.26350954	0.58776778
	0.07218948	0.01499698	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2009	1	-1	0	0	3	9	28	22.88	0.00349661	0.21120316	0.63114846
	0.14041369	0.01373808	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2010	1	-1	0	0	4	9	28	12.68	0.01577287	0.79179811	0.16719243
	0.02523659	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2011	1	-1	0	0	4	9	28	21.64	0.00000000	0.32278273	0.47187076
	0.19905465	0.00629186	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2012	1	-1	0	0	4	9	28	22.32	0.00335775	0.10053293	0.44773547
	0.37325638	0.05790999	0.01147166	0.00573583	0.00000000	0.00000000	0.00000000				
1993	2	-2	0	0	1	9	28	30.44	0.21106902	0.38434172	0.30704382
	0.06010656	0.02088125	0.01089044	0.00566720	0.00000000	0.00000000	0.00000000				
1994	2	-2	0	0	1	9	28	120.96	0.36945499	0.45924059	0.11019804
	0.05280057	0.00706495	0.00093579	0.00030505	0.00000000	0.00000000	0.00000000				
1995	2	-2	0	0	1	9	28	58.84	0.24589769	0.44769841	0.28115147
	0.02299743	0.00194198	0.00031302	0.00000000	0.00000000	0.00000000	0.00000000				
1996	2	-2	0	0	1	9	28	45.92	0.29892120	0.35526509	0.28407353
	0.05385728	0.00380762	0.00407529	0.00000000	0.00000000	0.00000000	0.00000000				
1997	2	-2	0	0	1	9	28	47.44	0.16769604	0.44927048	0.17462436
	0.14077280	0.05754727	0.00731508	0.00277398	0.00000000	0.00000000	0.00000000				
1998	2	-2	0	0	1	9	28	72.48	0.26761762	0.47815789	0.21604073
	0.02580353	0.00936489	0.00301533	0.00000000	0.00000000	0.00000000	0.00000000				
1999	2	-2	0	0	1	9	28	55.32	0.27314763	0.51943459	0.18108008
	0.01831521	0.00686090	0.00095133	0.00021026	0.00000000	0.00000000	0.00000000				
2000	2	-2	0	0	1	9	28	48.04	0.27341328	0.37293108	0.27881477
	0.06382949	0.01091465	0.00000000	0.00000000	0.00009674	0.00000000	0.00000000				
2001	2	-2	0	0	1	9	28	71.04	0.67276346	0.18270578	0.09872123
	0.03669650	0.00653717	0.00257586	0.00000000	0.00000000	0.00000000	0.00000000				
2002	2	-2	0	0	1	9	28	76.48	0.18899176	0.59397851	0.16841782
	0.03741263	0.00773647	0.00329546	0.00008367	0.00000000	0.00008367	0.00000000				
2003	2	-2	0	0	1	9	28	74.64	0.83351604	0.04116990	0.06930792
	0.03300254	0.01468797	0.00389736	0.00353461	0.00088365	0.00000000	0.00000000				
2004	2	-2	0	0	1	9	28	59.16	0.04238489	0.87005119	0.07242785
	0.01265237	0.00145970	0.00102400	0.00000000	0.00000000	0.00000000	0.00000000				
2005	2	-2	0	0	1	9	28	89.04	0.53994582	0.36702223	0.08416083
	0.00500806	0.00132284	0.00090732	0.00072560	0.00045366	0.00045366	0.00000000				
2006	2	-2	0	0	1	9	28	105.16	0.20172661	0.63015996	0.15000726
	0.01740041	0.00070577	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2007	2	-2	0	0	2	9	28	67.44	0.42021952	0.43386305	0.10589809
	0.03396340	0.00544372	0.00061223	0.00000000	0.00000000	0.00000000	0.00000000				
2008	2	-2	0	0	3	9	28	39.76	0.19862191	0.52834154	0.21532639
	0.05558720	0.00212296	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2009	2	-2	0	0	3	9	28	98.08	0.44090117	0.44149224	0.11209083
	0.00372405	0.00179171	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000				
2010	2	-2	0	0	4	9	28	31.40	0.50304830	0.32470002	0.01757707
	0.02625377	0.05345083	0.06594583	0.00763583	0.00069417	0.00069417	0.00000000				

```
2011    2       -2      0       0       4       9       28      54.88   0.20910019      0.35249163      0.22419952
        0.08833225      0.04648802      0.03648118      0.03009719      0.01083858      0.00197145      0.00000000
2012    2       -2      0       0       4       9       28      8.92    0.01286056      0.18465132      0.56709595
        0.19900628      0.03408414      0.00153450      0.00076725      0.00000000      0.00000000      0.00000000
1999    1       -3      0       0       5       9       28      2.96    0.00000000      0.00000000      0.59151581
        0.20074375      0.04758623      0.12952271      0.03063150      0.00000000      0.00000000      0.00000000
2000    1       -3      0       0       5       9       28      66.64   0.00000000      0.00661920      0.20664268
        0.39154056      0.21333728      0.10964756      0.05159158      0.01292370      0.00769745      0.00000000
2001    1       -3      0       0       5       9       28      81.28   0.00000000      0.01319829      0.09882524
        0.43321579      0.28807345      0.09650734      0.05247704      0.01444472      0.00325813      0.00000000
2002    1       -3      0       0       5       9       28      110.32  0.00000000      0.00376606      0.02888569
        0.14173143      0.37497785      0.24597782      0.11747427      0.05690067      0.02950284      0.00078337
2003    1       -3      0       0       5       9       28      92.32   0.00000000      0.02102307      0.16425121
        0.15811910      0.10310171      0.18273199      0.16023280      0.09892235      0.09975931      0.01185845
2004    1       -3      0       0       5       9       28      66.56   0.00000000      0.18029041      0.09935404
        0.14911095      0.11148963      0.14727065      0.15776410      0.06809703      0.07147469      0.01514850
2005    1       -3      0       0       5       9       28      40.84   0.00000000      0.01355483      0.68729690
        0.14494663      0.04909713      0.02077143      0.01635392      0.01781254      0.03540648      0.01476013
2006    1       -3      0       0       5       9       28      26.92   0.00000000      0.00000000      0.01497099
        0.60873284      0.20905176      0.07984672      0.04903877      0.00985519      0.02477402      0.00372971
2007    1       -3      0       0       5       9       28      89.40   0.00000000      0.00000000      0.03684181
        0.45391632      0.40243125      0.08105161      0.01657055      0.00464352      0.00366742      0.00087752
2008    1       -3      0       0       5       9       28      94.00   0.00000000      0.00000000      0.00238411
        0.12188750      0.50241139      0.30400027      0.05113905      0.01114247      0.00703520      0.00000000
2009    1       -3      0       0       5       9       28      93.24   0.00000000      0.00000000      0.00497725
        0.03834955      0.30673956      0.39095629      0.20858215      0.04278986      0.00760533      0.00000000
2010    1       -3      0       0       5       9       28      33.76   0.00000000      0.00000000      0.00486375
        0.03556323      0.20782114      0.39064640      0.24531203      0.09814472      0.01764872      0.00000000
2011    1       -3      0       0       5       9       28      42.88   0.00000000      0.00357123      0.03311394
        0.04935194      0.12486830      0.30299646      0.28571874      0.16388915      0.03649023      0.00000000
2012    1       -3      0       0       5       9       28      118.24  0.00000000      0.00058319      0.34026869
        0.21053451      0.06934004      0.04548403      0.07671303      0.10090398      0.15072623      0.00544631
2005    2       -8      0       0       6       9       28      12.12   0.06930693      0.58085809      0.31023102
        0.01980198      0.01320132      0.00330033      0.00000000      0.00000000      0.00330033      0.00000000
2007    2       -8      0       0       6       9       28      14.80   0.00000000      0.00810811      0.15945946
        0.65405405      0.15945946      0.01891892      0.00000000      0.00000000      0.00000000      0.00000000
2009    2       -8      0       0       6       9       28      27.20   0.00147059      0.02058824      0.02647059
        0.22205882      0.42794118      0.24852941      0.04852941      0.00441176      0.00000000      0.00000000
2010    2       -8      0       0       6       9       28      25.48   0.00784929      0.21507064      0.26844584
        0.13186813      0.17582418      0.13657771      0.05494505      0.00941915      0.00000000      0.00000000
2011    2       -8      0       0       6       9       28      14.32   0.00000000      0.08100559      0.31843575
        0.16759777      0.18435754      0.13687151      0.09497207      0.01675978      0.00000000      0.00000000
2012    2       -8      0       0       6       9       28      8.64    0.00000000      0.00462963      0.20833333
        0.43518519      0.13888889      0.06018519      0.07407407      0.04166667      0.03703704      0.00000000
2008    1       -9      0       0       6       9       28      28.88   0.03739612      0.00277008      0.11357341
        0.43628809      0.38919668      0.02077562      0.00000000      0.00000000      0.00000000      0.00000000
2012    1       -9      0       0       6       9       28      22.88   0.00000000      0.01573427      0.26223776
        0.30419580      0.14160839      0.10489510      0.06818182      0.06993007      0.03321678      0.00000000
2013    1       -9      0       0       6       9       28      14.16   0.00000000      0.00000000      0.27401130
        0.45762712      0.11299435      0.07062147      0.05649718      0.01129944      0.01694915      0.00000000
#
63 # N_mean size-at-age_obs
# Year Season Fleet/Survey Gender Part Ageerr Nsamp datavector(female-male) Nfish (female-male)
1993    1       1       0       0       1       2.72    -1.0    -1.0    18.0    18.8    19.3    -1.0    -1.0    -1.0
        -1.0    -1.0    0.00    0.00    0.32    2.08    0.28    0.00    0.00    0.00    0.00    0.00
1994    1       1       0       0       1       11.76   17.8    -1.0    18.4    18.9    19.0    -1.0    -1.0    -1.0
        -1.0    -1.0    0.32    0.00    3.80    2.00    0.32    0.00    0.00    0.00    0.00    0.00
1995    1       1       0       0       1       4.76    15.0    16.5    16.9    17.7    -1.0    -1.0    -1.0    -1.0
        -1.0    -1.0    0.56    2.68    1.20    0.32    0.00    0.00    0.00    0.00    0.00    0.00
1996    1       1       0       0       1       89.28   -1.0    17.5    18.5    19.2    19.6    20.2    -1.0    26.6
        -1.0    -1.0    0.00    5.12    52.28   27.72   3.68    0.44    0.00    0.04    0.00    0.00
1997    1       1       0       0       1       54.92   13.5    16.4    18.3    19.6    21.6    22.0    -1.0    -1.0
        -1.0    -1.0    0.12    25.80   24.68   3.92    0.32    0.08    0.00    0.00    0.00    0.00
1998    1       1       0       0       1       75.32   12.7    14.5    17.0    19.6    20.8    21.9    22.4    -1.0
        -1.0    -1.0    3.56    53.52   14.84   1.76    1.24    0.36    0.04    0.00    0.00    0.00
1999    1       1       0       0       1       6.96    13.7    15.1    15.7    17.9    -1.0    -1.0    -1.0    -1.0
        -1.0    -1.0    0.84    3.60    2.48    0.04    0.00    0.00    0.00    0.00    0.00    0.00
2000    1       1       0       0       1       22.64   14.1    16.7    17.1    17.1    18.1    22.2    -1.0    -1.0
        -1.0    -1.0    1.08    3.92    10.64   6.56    0.36    0.08    0.00    0.00    0.00    0.00
2001    1       1       0       0       1       37.24   11.6    17.3    18.8    21.3    22.1    23.3    23.5    23.8
        -1.0    -1.0    8.36    7.68    4.28    10.68   4.24    1.52    0.36    0.12    0.00    0.00
2002    1       1       0       0       1       30.32   16.1    16.3    17.6    18.4    20.8    22.8    -1.0    -1.0
        -1.0    -1.0    5.36    16.48   6.84    1.16    0.44    0.04    0.00    0.00    0.00    0.00
2003    1       1       0       0       1       17.76   12.0    16.9    18.2    20.0    20.7    -1.0    -1.0    -1.0
        -1.0    -1.0    8.56    4.48    4.36    0.32    0.04    0.00    0.00    0.00    0.00    0.00
```

2004	1	1	0	0	1	33.52	13.9	15.6	16.9	18.5	18.5	-1.0	23.7	-1.0
	-1.0	-1.0	0.16	30.12	2.72	0.20	0.24	0.00	0.08	0.00	0.00	0.00		
2005	1	1	0	0	1	35.24	13.4	14.3	16.4	18.3	21.8	23.3	24.5	-1.0
	-1.0	-1.0	4.72	12.56	16.48	1.20	0.16	0.00	0.00	0.00	0.00	0.00		
2006	1	1	0	0	1	69.76	14.5	15.4	16.9	18.2	-1.0	-1.0	-1.0	-1.0
	-1.0	-1.0	0.92	47.36	18.60	2.88	0.00	0.00	0.00	0.00	0.00	0.00		
2007	1	1	0	0	2	86.00	12.9	15.2	16.7	17.6	18.1	-1.0	-1.0	-1.0
	-1.0	-1.0	2.24	16.16	52.00	14.80	0.80	0.00	0.00	0.00	0.00	0.00		
2008	1	1	0	0	3	30.84	14.1	16.9	17.4	18.9	21.2	-1.0	-1.0	-1.0
	-1.0	-1.0	1.60	8.56	18.08	2.24	0.36	0.00	0.00	0.00	0.00	0.00		
2009	1	1	0	0	3	22.88	16.1	16.4	17.4	17.9	-1.0	-1.0	-1.0	-1.0
	-1.0	-1.0	0.08	5.40	13.20	3.92	0.00	0.00	0.00	0.00	0.00	0.00		
2010	1	1	0	0	4	12.68	15.8	16.0	16.3	17.8	-1.0	-1.0	-1.0	-1.0
	-1.0	-1.0	0.20	10.04	2.12	0.32	0.00	0.00	0.00	0.00	0.00	0.00		
2011	1	1	0	0	4	21.64	-1.0	17.4	17.7	17.9	19.4	-1.0	-1.0	-1.0
	-1.0	-1.0	0.00	5.64	10.76	5.12	0.12	0.00	0.00	0.00	0.00	0.00		
2012	1	1	0	0	4	22.32	14.3	16.4	18.9	19.9	20.7	21.3	21.3	-1.0
	-1.0	-1.0	0.04	1.60	10.44	8.52	1.36	0.24	0.12	0.00	0.00	0.00		
1993	2	2	0	0	1	30.44	15.8	17.5	18.4	20.6	22.1	23.6	-1.0	-1.0
	-1.0	-1.0	6.44	11.52	9.24	1.96	0.72	0.40	0.00	0.00	0.00	0.00		
1994	2	2	0	0	1	120.96	15.0	16.7	18.0	18.6	19.1	-1.0	21.0	-1.0
	-1.0	-1.0	47.44	54.28	12.08	6.24	0.76	0.00	0.04	0.00	0.00	0.00		
1995	2	2	0	0	1	58.84	15.5	16.6	17.3	18.1	20.5	-1.0	-1.0	-1.0
	-1.0	-1.0	13.20	29.12	14.96	1.36	0.16	0.00	0.00	0.00	0.00	0.00		
1996	2	2	0	0	1	45.92	13.9	15.9	18.5	19.2	22.2	-1.0	-1.0	-1.0
	-1.0	-1.0	14.00	15.16	13.80	2.60	0.16	0.00	0.00	0.00	0.00	0.00		
1997	2	2	0	0	1	47.44	13.2	16.6	19.5	21.0	21.5	21.8	23.8	-1.0
	-1.0	-1.0	8.36	15.04	9.64	9.84	3.76	0.64	0.16	0.00	0.00	0.00		
1998	2	2	0	0	1	72.48	13.4	15.1	17.1	19.6	20.8	21.2	-1.0	-1.0
	-1.0	-1.0	23.24	33.12	13.80	1.52	0.60	0.20	0.00	0.00	0.00	0.00		
1999	2	2	0	0	1	55.32	15.0	15.3	16.0	16.1	-1.0	-1.0	20.5	-1.0
	-1.0	-1.0	16.72	26.68	10.44	1.04	0.00	0.00	0.04	0.00	0.00	0.00		
2000	2	2	0	0	1	48.04	14.1	15.2	17.2	17.6	17.7	-1.0	-1.0	22.6
	-1.0	-1.0	13.04	19.12	12.76	2.60	0.48	0.00	0.00	0.04	0.00	0.00		
2001	2	2	0	0	1	71.04	13.1	15.4	17.7	19.3	20.3	21.1	-1.0	-1.0
	-1.0	-1.0	49.60	13.44	5.28	2.20	0.40	0.12	0.00	0.00	0.00	0.00		
2002	2	2	0	0	1	76.48	15.5	16.7	17.8	18.9	20.0	22.8	24.8	-1.0
	-1.0	-1.0	12.88	43.52	14.92	3.92	0.92	0.24	0.04	0.00	0.04	0.00		
2003	2	2	0	0	1	74.64	13.4	15.7	18.5	19.8	22.1	-1.0	23.9	-1.0
	-1.0	-1.0	63.08	2.76	4.60	2.16	1.24	0.00	0.32	0.00	0.00	0.00		
2004	2	2	0	0	1	59.16	14.2	15.4	17.6	19.7	21.7	23.4	-1.0	-1.0
	-1.0	-1.0	3.32	50.76	4.36	0.60	0.08	0.04	0.00	0.00	0.00	0.00		
2005	2	2	0	0	1	89.04	13.0	14.8	16.9	19.2	20.0	23.4	24.6	-1.0
	-1.0	-1.0	44.68	31.32	11.56	0.80	0.16	0.16	0.20	0.00	0.00	0.00		
2006	2	2	0	0	1	105.16	14.0	15.8	18.2	19.3	21.2	-1.0	-1.0	-1.0
	-1.0	-1.0	17.08	61.52	23.04	3.40	0.12	0.00	0.00	0.00	0.00	0.00		
2007	2	2	0	0	2	67.44	13.4	14.8	17.3	20.1	21.7	-1.0	-1.0	-1.0
	-1.0	-1.0	22.96	27.76	10.64	5.12	0.84	0.00	0.00	0.00	0.00	0.00		
2008	2	2	0	0	3	39.76	13.1	16.2	17.6	19.0	21.8	-1.0	-1.0	-1.0
	-1.0	-1.0	7.16	21.88	8.44	2.08	0.20	0.00	0.00	0.00	0.00	0.00		
2009	2	2	0	0	3	98.08	14.2	15.0	15.6	18.0	20.1	-1.0	-1.0	-1.0
	-1.0	-1.0	49.52	37.36	10.56	0.48	0.16	0.00	0.00	0.00	0.00	0.00		
2010	2	2	0	0	4	31.40	14.2	15.5	19.1	20.8	21.5	22.1	23.0	25.1
	-1.0	-1.0	13.84	7.96	0.68	1.52	3.08	3.80	0.44	0.04	0.00	0.00		
2011	2	2	0	0	4	54.88	13.4	15.9	18.2	19.8	21.0	21.7	22.0	22.5
	23.0	-1.0	9.40	18.92	14.96	5.24	2.44	2.08	1.28	0.48	0.08	0.00		
2012	2	2	0	0	4	8.92	15.5	18.2	19.1	20.1	20.9	22.8	23.1	-1.0
	-1.0	-1.0	0.08	1.36	4.72	2.32	0.32	0.08	0.04	0.00	0.00	0.00		
1999	1	3	0	0	5	2.96	-1.0	-1.0	17.8	19.7	21.0	22.5	24.2	-1.0
	-1.0	-1.0	0.00	0.00	1.56	0.60	0.20	0.52	0.08	0.00	0.00	0.00		
2000	1	3	0	0	5	66.64	-1.0	19.9	19.1	20.7	21.5	22.1	22.3	22.7
	-1.0	-1.0	0.00	0.44	12.40	25.16	14.76	8.16	4.00	1.12	0.00	0.00		
2001	1	3	0	0	5	81.28	-1.0	16.3	20.4	20.8	21.2	22.1	22.8	-1.0
	23.4	-1.0	0.00	1.76	8.68	34.96	22.88	7.56	4.08	0.00	0.00	0.00		
2002	1	3	0	0	5	110.32	-1.0	19.5	20.7	21.7	22.0	22.3	22.8	23.2
	23.5	24.1	0.00	0.96	4.28	15.36	39.76	26.68	12.80	6.64	3.72	0.12		
2003	1	3	0	0	5	92.32	-1.0	18.9	19.6	20.4	21.8	22.5	22.7	22.9
	23.5	23.8	0.00	1.80	15.12	14.40	10.40	17.80	14.88	8.08	8.72	1.12		
2004	1	3	0	0	5	66.56	-1.0	16.9	19.7	21.2	22.5	23.1	23.4	23.5
	23.6	23.8	0.00	18.80	8.80	9.76	6.44	7.64	8.04	3.12	3.32	0.64		
2005	1	3	0	0	5	40.84	-1.0	17.0	17.5	17.9	19.6	21.9	22.9	24.0
	24.0	24.3	0.00	0.96	22.12	5.48	2.72	1.76	1.52	1.64	3.20	1.44		
2006	1	3	0	0	5	26.92	-1.0	-1.0	19.1	19.5	19.8	20.4	20.7	23.5
	-1.0	-1.0	0.00	0.00	0.48	17.64	5.40	1.80	0.76	0.32	0.48	0.04		

```
2007    1       3       0       0       5       89.40   -1.0    -1.0    18.6    19.3    19.7    20.1    20.8    21.1
        24.1    25.5    0.00    0.00    3.00    38.36   37.80   7.76    1.68    0.40    0.32    0.08
2008    1       3       0       0       5       94.00   -1.0    -1.0    18.5    19.2    19.9    20.3    21.0    21.8
        22.8    -1.0    0.00    0.00    0.24    11.76   45.96   29.12   5.24    1.08    0.60    0.00
2009    1       3       0       0       5       93.24   -1.0    -1.0    19.1    19.1    19.5    19.9    20.1    20.4
        20.9    -1.0    0.00    0.00    0.64    4.16    28.68   35.48   19.56   4.00    0.72    0.00
2010    1       3       0       0       5       33.76   -1.0    -1.0    16.4    19.0    19.9    20.0    20.2    20.3
        20.4    -1.0    0.00    0.00    0.16    1.12    6.88    13.04   8.40    3.48    0.68    0.00
2011    1       3       0       0       5       42.88   -1.0    17.4    19.0    20.0    20.7    20.9    21.0    21.1
        21.0    -1.0    0.00    0.12    1.24    2.12    5.16    13.08   12.60   7.04    1.52    0.00
2012    1       3       0       0       5       118.24  -1.0    19.9    19.8    20.1    20.8    21.4    21.7    21.8
        21.9    22.4    0.00    0.12    41.72   25.04   8.12    5.44    8.92    11.76   16.52   0.60
2005    2       8       0       0       6       12.12   16.4    18.6    19.4    20.1    23.3    26.8    -1.0    -1.0
        -1.0    -1.0    0.84    7.04    3.76    0.24    0.16    0.04    0.00    0.00    0.04    0.00
2007    2       8       0       0       6       14.80   -1.0    17.7    19.4    21.4    21.8    22.0    -1.0    -1.0
        -1.0    -1.0    0.00    0.12    2.36    9.68    2.36    0.28    0.00    0.00    0.00    0.00
2009    2       8       0       0       6       27.20   16.6    16.9    19.7    21.8    22.1    22.3    22.7    24.3
        -1.0    -1.0    0.04    0.56    0.72    6.04    11.64   6.76    1.32    0.12    0.00    0.00
2010    2       8       0       0       6       25.48   17.7    17.9    18.6    21.0    22.9    23.0    23.1    -1.0
        -1.0    -1.0    0.20    5.48    6.84    3.36    4.48    3.48    1.40    0.24    0.00    0.00
2011    2       8       0       0       6       14.32   -1.0    20.3    20.7    21.9    23.0    -1.0    23.3    23.3
        -1.0    -1.0    0.00    1.16    4.56    2.40    2.64    0.00    1.36    0.00    0.00    0.00
2012    2       8       0       0       6       8.64    -1.0    18.1    21.5    21.8    22.2    23.3    -1.0    24.3
        -1.0    -1.0    0.00    0.04    1.80    3.76    1.20    0.52    0.00    0.36    0.32    0.00
2008    1       9       0       0       6       28.88   10.2    19.7    19.9    20.7    21.2    21.5    -1.0    -1.0
        -1.0    -1.0    1.08    0.08    3.28    12.60   11.24   0.60    0.00    0.00    0.00    0.00
2012    1       9       0       0       6       22.88   -1.0    20.4    20.8    21.1    21.5    22.6    23.3    23.3
        24.0    -1.0    0.00    0.36    6.00    6.96    3.24    2.40    1.56    1.60    0.76    0.00
2013    1       9       0       0       6       14.16   -1.0    -1.0    22.3    22.4    22.4    23.7    -1.0    -1.0
        24.1    -1.0    0.00    0.00    3.88    6.48    1.60    1.00    0.00    0.00    0.24    0.00
0 # N_environment variables
0 # N_environment obs
0 # N_sizefreq methods to read in
0 # No tag data
0 # No morph composition data
999 # End of file
```

Appendix D
PFMC Scientific Peer Reviews and Advisory Body Reports.

Agenda Item H.1.a
Attachment 3
April 2014

Pacific Sardine
STAR Panel Meeting Report

NOAA / Southwest Fisheries Science Center
La Jolla, California
March 3-5, 2014

STAR Panel Members:
André Punt (Chair), Scientific and Statistical Committee (SSC), University of Washington
Meisha Key, SSC, California Department of Fish and Wildlife
José De Oliveira, Center for Independent Experts (CIE)
John Simmonds, Center for Independent Experts (CIE)

Pacific Fishery Management Council (Council) Representatives:
Kerry Griffin, Council Staff
Diane Pleschner-Steele, CPSAS Advisor to STAR Panel
Chelsea Protasio, CPSMT Advisor to STAR Panel

Pacific Sardine Stock Assessment Team:
Kevin Hill, NOAA / SWFSC
Paul Crone, NOAA / SWFSC
Dave Demer, NOAA / SWFSC
Juan Zwolinski, NOAA / SWFSC
Emmanis Dorval, NOAA / SWFSC
Beverly Macewicz, NOAA / SWFSC

1) Overview

The Pacific Sardine Stock Assessment and Review (STAR) Panel (Panel) met at the Southwest Fisheries Science Center, La Jolla, CA from March 3-5, 2014 to review a draft assessment by the Stock Assessment Team (STAT) for Pacific Sardine. Introductions were made (see list of attendees, Appendix 1), and the agenda was adopted. A draft assessment document and background materials were provided to the Panel in advance of the meeting on a SWFSC FTP site.

Paul Crone and Kevin Hill presented the assessment methodology and the results from a draft assessment utilizing the Stock Synthesis Assessment Tool, Version 3.24s (SS model) to the Panel. The assessment report included many model runs. However, two "blended" models (G and H) were the focus for Panel discussion. Model G included the following features: (a) the data were updated through 2013, (b) the catches for the MexCal fleet were derived from the environmental-based method, (c) the weight-length and maturity-at-length relationships were updated, (d) the data for the aerial survey were omitted from the assessment, (e) the acoustic-trawl (ATM) survey was split into spring and summer surveys (with separate catchability and selectivity parameters), with catchability parameters (*q*s) no longer fixed, (f) no additional data weighting for survey abundance data beyond input coefficients of variation (CVs) (i.e., lambda=1), (g) no additional data weighting for the length composition data for fisheries/surveys beyond the input effective sample sizes (lambda=1), (h) weighting for the conditional age-at-length data in addition to the input effective sample sizes (lambda=0.5), (i) the value for σ_R was rounded and fixed to 0.75, and (j) recruitment was related to spawning stock size according to a Beverton-Holt stock-recruitment relationship with pre-specified steepness (set to 0.8). Model H differed from Model G by assuming age- rather than length-specific selectivity patterns, by fitting to age-composition data rather than length-composition and conditional age-at-length data, and by fixing the parameters of the growth curve. Model H included no additional data weighting to the abundance or composition data.

David Demer presented the environmental-based method for identifying the catches from the northern subpopulation (NSP). This method led to excluding some of the data (catches and associated composition data) for the Ensenada and San Pedro fisheries from the assessment as those catches were predicted to have come from the southern subpopulation. The Panel welcomed this new approach, noting that past Panels had recommended that developing and applying a method for a more appropriate splitting of catches between the northern and southern subpopulations was a high research priority. The Panel noted that adopting this new catch series meant that there would be no assessment for the population (southern) part of which is subject to being caught during the fall off southern California. The CPS representative commented during the Panel that a pragmatic way to address issues of stock structure might be to conduct an assessment based on catches from US waters only, since the proportions of the southern and northern stocks landed at San Pedro and Ensenada respectively were approximately equal.

David Demer and Emmanis Dorval presented aspects of the methodology and results for the ATM and Daily Egg Production Method (DEPM) respectively. No representative of the Northwest Aerial Survey was available to present the results from the 2013 aerial survey, but Tom Jagielo provided a summary of the results by email on February 27, just

prior to the review (Appendix 2). Chris Francis (NIWA, retired) provided a presentation regarding data weighting and the use of conditional age-at-length data in assessments. The Panel noted, and was particularly appreciative of, the efforts made by the STAT to respond to the recommendations from past panels and the SSC. The draft assessment report did not include a summary of progress relative to the recommendations from the ATM survey methdology panel that was held in 2011. Appendix 3 was produced by the end of the Panel meeting, which summarizes this progress. This document was not reviewed by the Panel, but is included in this report for completeness.

The review and subsequent explorations of the assessment through sensitivity analyses were motivated primarily by the need to determine the weightings assigned to the compositional data, particularly given the obvious sensitivity of the results of the assessment to how the conditional age-at-length data are weighted. The Panel also explored various configurations for how selectivity and catchability are parameterized for the ATM survey.

The STAR Panel thanked the STAT for their hard work and willingness to respond to Panel requests, and the staff at the SWFSC La Jolla laboratory for their usual exceptional support and provisioning during the STAR meeting.

2) Day 1 requests made to the STAT during the meeting – Monday, March 3rd
[Note: Request numbers do not necessarily correspond with the model numbers given in Table 1.]

A. ***Request***: Compare the yearly length-composition data for the Ensenada fishery that are included in the MexCal data set for the NSP scenario with the corresponding southern California length compositions. Also, compare the yearly length-composition data for the Oregon-Washington catches with those for the British Columbia fishery.
Rationale: There are no age-length data for the Ensenada fishery or for the British Columbia fishery available for use in the assessment at this time, but model H implicitly assumes that the length frequencies for the Ensenada fishery are the same as those for the southern California fishery and that the length-frequencies for the British Columbia fishery are the same as those for the Oregon-Washington fishery.
Response: This request was not required because the Panel focused on model G (length-based) that was presented as the potential base case model and not model H (age-based). Model H was not a focus for the Panel review because it was not as fully tested as model G, and because the construction of the catch age-composition data ignored the length data for Mexico and British Columbia. However, this request has been put forward as a research recommendation.

B. ***Request***: Compute age-compositions for the ATM survey by multiplying the survey length-frequencies by the associated age-length keys. Compare the mean age-at-length time-series north and south of 40°10’ from the ATM survey.
Rationale: The age data for the ATM survey presented in the draft report were unweighted.

Response: This request was not required because the Panel focused on model G (length-based) that was presented as potential base case model and not model H (age-based). However, this request has been put forward as a research recommendation.

C. ***Request***: Construct catch time series using a one month shorter and longer monthly duration for when the San Pedro and Ensenada fisheries are catching southern subpopulation fish.
Rationale: To evaluate the sensitivity of the catches to the cutoff (50%) that is used to assign catches to the NSP.
Response: Figure 1 shows that the results are likely to be somewhat sensitive to the cut-off chosen to define catches from the northern subpopulation. A research recommendation was raised to examine this issue further.

D. ***Request***: Overlay the habitat map with the spring survey results for the 2013 ATM survey.
Rationale: The survey did not go north of San Francisco. The Panel was interested to know whether the areas north of San Francisco would have been expected to have been suitable habitat for Pacific sardine.
Response: The plots showed no evidence of substantial suitable habitat north of San Francisco in the two weeks around the time the survey was conducted, which suggests that the survey should have provided an adequate sample of the population.

E. ***Request***: Provide additional information regarding the apparent discrepancy between the biomass estimates from the ATM survey in the Washington / Oregon area and the landings in this area, based on the information from 2012.
Rationale: The Panel wished to have more information on this apparent discrepancy.
Response: Juan Zwolinski noted that the ATM survey sampled the region between 44° 47.2'N and 48°18'N and from the 50m to the 1500m depth isobaths from 07/31/2012 to 08/10/2012. The resulting point estimate of sardine biomass was 13,333 mt. The sampling variance was high, resulting in a 95% confidence interval of [3,918, 27,559] mt. During the same time period, the commercial fishery off Oregon and Washington caught 9,747 mt. The ATM surveyed the area to the north, including northern Washington and western Vancouver Island, B.C. There, the sardine biomass was estimated at 18,675 mt, with a 95% confidence interval of [2,661, 54,017] mt. It was likely that by 08/10/2012, 32,008 mt of sardine, with 95% confidence interval [12,439, 68,945] mt, would have been available for the Oregon and Washington fisheries, assuming that all the sardine observed off western Vancouver Island migrated from the south.

F. ***Request***: With model G (from initial draft), reweight the fishery and survey length-composition and conditional age-at-length data by applying the Francis (2011) weighting method (Equation TA1.8). The weighting factors should be implemented as changes to the lambdas in the SS model.
Rationale: The compositional data may not be appropriately weighted.
Response: The upper panel of Table 2 lists the factors to weight the input sample sizes (which are lower than the actual number of fish sized and aged), for each length-composition and conditional age-at-length data component that needs to be weighted. The

response to this request (and requests L, M, and N) was based on model 'K' in which the conditional age-at-length data are not downweighted by 0.5 (see Table 1 for the specifications for the models investigated during the Panel requests). The Francis method suggested that the length-compositions needed to be downweighted substantially. In contrast, this method also suggested that the conditional age-at-length data for the MexCal fleets and the ATM survey need to be upweighted. Implementing these weighting factors (model F) led to a markedly lower biomass trajectory and substantially changed selectivity patterns for the two MexCal fisheries. The results from this request led to requests L, M, N and O.

G. *Request*: With model G (from initial draft), include the NWSS aerial survey data. Summarize the results in terms of residual patterns and the information given in Table 8 of the draft document.
Rationale: The Panel wished to understand whether the aerial survey data would be influential if they were included in the assessment.
Response: The biomass trajectory was lower than for model G when the NWSS aerial survey was included in the assessment, but otherwise the results were not substantially different. The Panel did not see evidence to disagree with the STAT's recommendation to leave this survey out of the assessment.

H. *Request*: With model G (from initial draft), examine scenarios in which catchability is the same for the spring and summer ATM surveys. Consider values for ATM survey catchability from 0.7 to 1.1 in steps of 0.2. Summarize the results in terms of residual patterns and the information given in Table 8.
Rationale: The Panel noted that the ATM survey scientists expressed the view that the spring and summer surveys were directly comparable and wished to understand whether this view is supported by the data included in the assessment.
Response: There is no evidence to support having separate q's for the spring and summer ATM surveys in terms of the change to the value of the objective function. The single q is closer to that from the spring surveys, which is expected given the relative number of ATM survey data points for spring (6) and summer (3). The spring survey selectivity pattern switches to being less knife-edged for the higher qs, but the change for this and the biomass trajectory did not occur in a systematic way as the ATM survey catchability was changed from 0.7 to 1.1. This request led to an additional request (P).

I. *Request*: With model G (from initial draft), replace the Beverton-Holt stock-recruitment relationship with the Ricker form of this relationship. Estimate steepness rather than assuming it equals 0.8.
Rationale: Several past assessments were based on the Ricker form of the stock-recruitment relationship, with steepness estimated. The Panel wished to explore the sensitivity to this change from prior assessments.
Response: The scale of biomass is slightly lower with the Ricker stock-recruitment relationship, with no difference in likelihoods between the two model runs. Steepness was estimated at 2.05.

J. *Request*: With model G (from initial draft), set $M = 0.5\text{yr}^{-1}$.

Rationale: The analysis of Zwolinski and Demer (2013) suggests that *M* is higher ($0.52yr^{-1}$) than the model G assumption of $0.4yr^{-1}$.
Response: As expected, the scale of the biomass was higher, and the ATM survey *q*'s were lower (spring=0.58, summer=0.63). The change in likelihood was 3 units with the higher *M*, but given the concerns with the weights assigned to the length and conditional age-at-length data, this is not considered to be a substantial change.

<u>Day 2 requests made to the STAT during the meeting – Tuesday, March 4th</u>

K: ***Request***: Conduct an assessment where all the weighting factors (lambdas) are set to 1 and compare the results for this model to those for model G (from the initial draft assessment).
Rationale: The selection of the factors to weight the length-composition and conditional age-at-length data was based on this model.
Response: The STAT provided model K which showed increasing the weights on the conditional age-at-length data from 0.5 to 1 substantially lowered the biomass trajectory.

L. ***Request***: Based on model K, apply the Francis method to estimate weighting factors for the length-composition and conditional age-at-length data, pooling the two MexCal fleets, pooling the spring and summer ATM survey data and analyzing the PacNW separately.
Rationale: Some of the weighting factors are based on very few compositions and consequently the weighting factors are uncertain (Table 2, upper).
Response: This was model L. The weighting factors for the pooled fleets are as expected, but the confidence intervals, particularly for the ATM survey, are narrower (Table 2, lower). The Panel considered it appropriate to pool across fleets when computing the weights for the length-composition and conditional age-at-length data.

M. ***Request***: Based on model K, change only the weights assigned to the length-composition data using the weighting factors from Request F.
Rationale: The Panel wished to understand whether the length-frequency or conditional age-at-length data were most influential.
Response: This was model M. The biomass estimates for the early years were sensitive to changing the weights assigned to the length-frequency data. However, the trend in abundance over recent years was unchanged, and the biomass scale was largely unchanged. The Panel concluded that how the conditional age-at-length data are weighted was the major cause of the change in results observed for request F.

N. ***Request***: Based on model K, change only the weighting factors assigned to the conditional age-at-length data using the weighting factors from Request F.
Rationale: The Panel wished to understand whether the length-frequency or conditional age-at-length data were most influential.
Response: The biomass trajectory for model N was markedly lower (and survey *q* markedly higher) when the conditional age-at-length data were changed.

O. ***Request***: Same as for request N, except that the weighting factor for the conditional age-at-length data sets for the PacNW fishery is assumed to equal 1.

Rationale: The weighting factor for the conditional age-at-length data for the PacNW fleet was less than one, in contrast to the weighting factors for the MexCal fleets and the ATM survey.
Response: The results for model O were essentially identical to those for request N.

P. *Request*: Same as for model G, except that catchability and selectivity for the spring and summer ATM surveys are assumed to be the same.
Rationale: The Panel wished to understand whether there is support for separating the two surveys.
Response: The fits to the survey length-frequency data for model P were not as good as for model G, even after accounting for there being three fewer parameters. The biomass trajectory was lower than for model G, and the ATM survey catchability was 2.38, a value considered implausible. The single ATM survey selectivity was less knife-edged and to the right of those for the spring and summer ATM survey selectivities from model G, which was unexpected. The model appeared to increase the selection at smaller lengths to account for the summer survey which had appreciable catches at these lengths. The consequence was to then reduce selection at the greater lengths that were previously fully selected when the surveys were fitted with separate selection patterns.

Q. *Request*: Same as for model P, except that the weight assigned to ATM survey length-frequency data was increased from 1 to 20.
Rationale: The Panel wished to understand whether it is possible to fit the length-frequency data for the ATM survey, at least in principle.
Response: The fits to the ATM length-frequency data for model Q were better, but the model was still unable to adequately mimic all of the length-frequencies.

R. *Request*: Conduct models R, S, T, W and U.
Rationale: The Panel wished to understand the trade-offs in results among various treatments of ATM survey catchability and selectivity. Some of these models ignore the ATM survey conditional age-at-length data because these data were not computed accounting for the sampling scheme for the survey.
Response: Figure 2 summarizes the biomass trajectories from these models. Models R and S, in which selectivity for the spring and summer ATM surveys was assumed to be the same, led to higher estimates of biomass compared to model G, whereas model T which estimated separate selectivity patterns for the spring and summer ATM surveys, led to lower estimates of biomass; in contrast model W, which is the same as model T but estimates separate catchabilities for the ATM surveys, led to higher estimates of biomass than even model S. Model U in which the conditional age-at-length data for the MexCal and PacNW fisheries were markedly downweighted led to much lower biomass estimates and unrealistically high estimates of survey catchability.

S. *Request*: Repeat request Q, but omit the ATM survey length-frequency data for spring 2012.
Rationale: This length-frequency was considered unreliable by the ATM survey team.
Response: This model (V) was not able to adequately fit the remaining ATM survey length-frequencies.

T. Request: Conduct analyses for a range of values for the extent which the conditional age-at-length data are downweighted. The analyses should be conducted for model specifications G-2, W-2, W-3, and T-2 (See Table 1).
Rationale: The Panel wished to understand the impact of different weighting factors on the results of the model.
Response: The outputs for models based on configuration W-3 all led to values for the ATM survey catchability coefficients which were considered unrealistically low (~0.25). The biomass trajectories for recent years were more robust for the models based on configuration T-2, but there was considerable sensitivity of biomass estimates for the early years (Figure 3). The biomass trajectories for recent years fell into two groups (one group based on weighting factors on the conditional age-at-length data of 0.1, 0.2 and 0.4; another group based on weighting factors of 0.3, and 0.5 and larger). The biomass trajectories were more stable for model runs based on configuration W-2 than configuration W-3. The weighting factor is 0.035 for configuration W-2 if it is chosen so that the average ATM (spring and summer) survey catchability is 1. Alternatively, this weighting factor is ~0.7 if the analysis is based on configuration G-2. Downweighting is more severe for model configuration W-2 because this model configuration ignores the ATM conditional age-at-length data which tends to support lower biomass estimates. However, the STAT noted that choosing a weighting factor to achieve a given average ATM survey catchability coefficient may not be a robust way to provide management advice. The Panel concurred with this view.

Day 3 requests made to the STAT during the meeting – Wednesday, March 5th

At this point in the meeting, the STAT and Panel agreed to proceed with models which are variants of configuration T-2, i.e. the weighting factors for the length-frequency data are set to 1, catchability is set to 1 for both the spring and summer ATM surveys, separate selectivity patterns are estimated for the spring and summer ATM surveys, and the ATM survey conditional age-at-length data are ignored. The STAT and Panel agreed to focus on two models: T-2_0.2 and T-2_0.7. The difference between these two models is the weight assigned to the fishery conditional age-at-length data. These choices for weighting factors were selected because they are representative of the two groups in Figure 3.

U. Request: Apply models T-2_0.2 and T-2_0.7 when the length-frequencies for the 2011 and 2012 spring ATM surveys are ignored.
Rationale: It was speculated that some of the model sensitivity was due to attempts to fit these two length-frequencies (the fits to these length-frequencies are always poor).
Response: The results when the weighting factor for the conditional age-at-length data was set to 0.7 were similar to those when the weighting factor was set to 0.2 (Figure 4), suggesting that at least one reason for the two groups of results in Figure 3 are conflicts when fitting to the length-frequencies for the 2011 and 2012 spring ATM surveys.

V. Request: Apply models T-2_0.2 and T-2_0.7 when the data for the last four years are ignored.

Rationale: The Panel wished to understand whether a retrospective analysis might help to distinguish between these two models.
Response: The results from both models changed markedly when the data for last four years were ignored (Figure 5).

The STAT and Panel agreed that model T-2_0.2 would be the base model given the relative lack of sensitivity to omitting data (see request U).

3) Technical Merits and/or Deficiencies of the Assessment
Recruitment estimation and environmental variables
The estimate of the most recent recruitment (age 1 in 2013) is uncertain and estimated to be close to the expected value from the stock-recruitment function (Figure 6). Deviations of sardine recruitment from a fitted stock-recruitment model of either Ricker or Beverton-Holt form are observed to be correlated in time, such that there appear to be periods of 'high' recruitment and separate periods of 'low' recruitment. Investigations of the potential for environmental factors to be informative have been conducted by Zwolinski and Demer (in press). They showed that the variability in sardine recruitment in the California Current during the last three decades mimics aspects of the environment in the North Pacific indicated by the Pacific Decadal Oscillation (PDO) index. Research indicated that the average number of recruits per biomass during "warm" periods was more than threefold higher than during "cold" periods. In addition to the environmental conditions experienced by sardine larvae, variability in sardine recruitment is also partially explained by both the environmental conditions several months before the spawning season and the adult's condition factor prior to spawning.

Management of the stock uses information on the biomass of age 1+ sardine when applying the Overfishing Level and Acceptable Biological Catch control rules. Recruitment in the last few years has been lower than expected from the stock-recruitment relationship used in the assessment model. Improved estimation (or prediction) of age-1 recruitment for the most recent year would improve management of the stock given that the assessment model currently leads to a rather imprecise estimate of this quantity (Figure 6). There are a number of potential approaches to do this.

1. A prediction model based on recent recruitment and observed autocorrelation could be used to provide more likely estimates of recruits in the final year without assigning any specific underlying reason for the recruitment.
2. A recruitment prediction index such as that proposed by Zwolinski and Demer (in press), could be used outside the assessment model to replace the assessed value with an alternative value based on a weighted mean of the assessed and index-derived values. One method of determining appropriate weights is given by Shepherd (1997).
3. Inclusion of informative environmental indices in stock-recruitment estimation within the assessment model.

When investigating environmental drivers to explain recruitment, a number of issues need to be considered:

1. The spawning biomass and recruitment pairs estimated in an assessment are subject to uncertainty, and this needs to be accounted for when estimating the prediction intervals for any potential index.
2. Development of environmental indices (for recruitment) through regression analysis needs to be undertaken with care. There are often many explanatory environmental variables. The approach is often to examine many variables to establish the most significant explanatory set. However, to understand the significance of the conclusions, it is important to recognise that exclusion of unsuitable variables is effectively setting the coefficient for the relationship to zero. This needs to be accounted for correctly in tests for overall significance by, for example, removing one degree of freedom for every variable (or variable at lag) rejected. This can be done easily for variables formally tested, but may be more difficult to include when variables are rejected at an early stage based on simple graphical investigation. Currently there are 20 stock-recruitment pairs for Pacific sardine; rejection of 18 potential variables (and or lags) while a relationship is being developed should result in a perception of no significant fit. Failure to consider this can lead to an over-optimistic conclusion of the utility of explanatory functions; see for example Gröger *et al*. (2010) who examined many potential indices and a wide variety of lags, and concluded they had found significant drivers for recruitment.

DEPM Survey

The analysis of the egg survey has some minor issues, mostly to do with the raising of density to survey area. The survey design is intended to sample the region of higher density, because, ideally, the survey obtains lower values around the periphery. A high density stratum is then drawn around a group of observations that contain the higher values, by creating a 'simple' (relatively smooth) boundary using the location of the points. The main idea behind this approach is that the survey objective is to map a peak density in space. There is therefore an assumption that the survey will have higher values towards the centre of the area and lower values around the edges. This is then analysed using a two stratum analysis approach that has two minor issues:

1. the current method for placing the boundary between the high and low density areas by placing the boundary on the observation locations means the higher density area is smaller than the region represented by those observations, and conversely the low density area is a little larger, resulting in a small underestimate. The method should be changed so that the correct area allocation is used for each point in each of the two strata. The effect is likely small on the index value used in the assessment because the current procedure is applied for all years.
2. The post stratification and CV calculations may not be correctly calculating the CV used to weight the survey index values in the assessment. The use of post stratification may result in underestimation due to the separation into strata based on the observed values. The use of a simple variance based on the within-stratum observations in the two strata may result in overestimation given there is expected to be some spatial trend within each stratum. A method that accounts for transect-based sampling, and correlated observations, and reflects the presence of a spawning aggregation would be an improvement.

Construction of conditional age-at-length for the ATM survey

Currently fish aged during the ATM survey are combined into an unweighted age-length key, and subsequently used to construct the conditional age-at-length data for each complete ATM survey. This treatment is not considered to be optimal given the possibility for age- and size-specific distribution of sardine. The use of separate age-length keys for the MexCal and PacNW fleets suggests that there may be differences in age-length keys from these regions. The implication of the current method for the ATM surveys is that this is not occurring. The alternatives are to develop separate age-length keys for the different regions covered by the ATM survey, or to use appropriate biomass-based weighting for each part of the survey area.

Sensitivity of biomass estimates

During its deliberations (see Section 2 of this report) the Panel found, as have several previous Panels, that the trend in abundance for Pacific sardine is generally well-determined by the available data. However, the absolute scale of the population is not well-determined by the data and seemingly small changes to the specifications of the assessment (e.g. the relative weighting of the composition data) can lead to marked changes to the scale of the population. The sensitivity to scale is most obvious in the early years of the assessment period, for which the only index data are the (relatively uninformative) DEPM and Total Egg Production (TEP) estimates. The 2011 assessment addressed this "stability" issue by fixing the q for one of the surveys. The 2011 Panel noted that this is not an ideal approach, and it recommended that this assessment include the development of informative priors for the q parameters for the DEPM, aerial and ATM surveys. However, it also noted that development of informative priors is a non-trivial task and should involve people in addition to the STAT, in particular the survey teams. The last assessment imposed the assumption q=1 for the ATM survey because (a) there are more estimates of abundance for this series than for the aerial survey, (b) the ATM survey is more synoptic (in terms of area coverage) than the aerial survey, (c) the estimates are generally more precise than those for the aerial survey, and (d) the assumption q=1 for the DEPM survey leads to unrealistic values of q for the aerial and ATM surveys (>1.8).

The current assessment team and Panel examined sensitivity to weighting factors (lambdas), and the ATM survey q and selectivity options, and concluded the following:

1. *Sensitivity to the weighting of the ATM conditional age-at-length data*: Estimates of biomass were particularly sensitive to this factor (see models G, K, F, L, N), and the time series were not appropriately assembled (see "Construction of conditional age-at-length for the ATM survey" above). Due to both of these considerations, the ATM conditional age-at-length data were excluded from the final model.
2. *Sensitivity to the weighting of the ATM length-composition data*: When compared to weighting by haul (model K), model results for recent years were insensitive to alternative weighting of the ATM length-composition data, including the use of Francis weights (model M) and arbitrary up-weighting (by a factor of 20; models Q and V).

3. *Sensitivity to weighting of the fishery conditional age-at-length*: A range of weighting factors less than 1 were explored (see models G-2, W-2, W-3, T-2). The sensitivity observed depended on whether the ATM *q* was estimated or fixed (*q*=1). Model outputs were more stable when *q* was fixed (model T-2).
4. *Sensitivity to weighting of the fishery length-composition data*: Two options were investigated: weighting by haul and using the Francis data weighting method. When *q* is estimated (W-3), the use of Francis weights resulted in unrealistically low estimates of *q* (0.2-0.3). For haul-based weights (G-2, W-2), estimates of *q* included the value of 1 over the range of weights considered.
5. *Sensitivity to estimation of ATM q*: Three options were explored: (a) separate estimated *q*s for the spring and summer surveys, (b) a single estimated *q* for both surveys, and (c) a fixed *q*=1 for both surveys. The sensitivity to how the fishery conditional age-at-length data are weighted was considerably reduced for recent years when fixing *q*=1 (e.g. compare models W-2 and T-2). Given the rather arbitrary conditional age-at-length weights being applied for Model G, and that the sensitivity to these could be considerably reduced by fixing *q*=1, it was decided to choose this option in the final model, thereby reducing the sensitivity of the model results to weighting. Generally similar reasoning was used in past assessment reviews (e.g., PFMC, 2011).
6. *Sensitivity to selectivity options for ATM survey*: Two options were explored: (a) a single selectivity pattern for both ATM surveys (spring and summer) or (b) separate selectivity patterns for each survey. When estimated separately, selectivity for the spring survey was nearly knife-edged at around 16cm, and in comparison, that for the summer survey shifted to higher lengths (e.g., model G). When estimated as a single selection pattern, the result was a much shallower curve, starting in a similar place to that estimated for the spring survey and extending to even greater lengths than that estimated for the summer survey (e.g. model P). This probably results from a requirement to include fish between 15 and 18cm in the spring survey, while giving reduced selection at around 20cm for the summer survey and thereby implying a reduction in selectivity for a range of lengths greater than 22cm that were fully selected with separate selection patterns.

The final base model incorporates the following specifications:

- catches for the MexCal fleet computed using the environmentally-based method;
- two seasons (semesters, Jul-Dec=S1 and Jan-Jun=S2) for each assessment year from 1993 to 2013;
- sexes were combined;
- two fisheries (MexCal and PacNW fleets), with an annual selectivity pattern for the PacNW fleet and seasonal selectivity patterns (S1 and S2) for the MexCal fleet;
  - MexCal fleet:
    - dome-shaped length-based selectivity with two periods of time blocking (1993-1998, 1999-2013);
  - PacNW fleet:
    - asymptotic length-based selectivity for a single time period;
  - length compositions with effective sample sizes calculated by dividing the number of fish sampled by 25 (externally) and lambda weighting=1 (internally);

- conditional age-at-length compositions with effective sample sizes calculated by dividing the number of fish sampled by 25 (externally) and lambda weighting=0.2 (internally);
- Beverton-Holt stock-recruitment relationship "steepness" was fixed (0.8);
- *M* was fixed (0.4 yr^{-1});
- recruitment deviations estimated from 1987-2012;
- virgin (R_0), and initial recruitment offset (R_1) were estimated, and σ_R fixed (0.75);
- initial *F*s set to 0 for all fleets (non-equilibrium model following the initial age composition method in SS);
- DEPM and TEP indices of spawning biomass with *q* estimated for both surveys;
- ATM survey biomass 2006-2013, partitioned into two (spring and summer) surveys, with *q*=1 for each survey;
  - length compositions with effective sample sizes set to 1 per haul (externally) and lambda weighting=1 (internally);
  - asymptotic length-based selectivity for spring and summer surveys;
  - conditional age-at-length data from the ATM surveys excluded;
- NWSS aerial survey index of abundance (biomass) and associated length compositions excluded.

The Panel agrees that the final base model represents the best available science regarding the status of the northern subpopulation of Pacific sardine. The Panel wishes to highlight that the level of variation in terminal biomass evident from the retrospective pattern (on the order of 100,000s of tons from one year to the next; Figure 7 of this report) is not unexpected and has been seen in previous assessments (e.g., PFMC, 2011). Changes in terminal age-1+ biomass estimates used for management of this magnitude may occur when the 2015 assessment update takes place.

On the final day of the review, the STAT provided the Panel with a model in which ATM survey catchability was assumed to be 1 or estimated, separate selectivity patterns were estimated for the spring and summer ATM surveys, the weighting factors for all the length-frequency data were set to 1, and for the conditional age-at-length data were set to 1 for the fishery data and to zero for the ATM surveys, and there were three time blocks for selectivity for the PacNW fishery. There was insufficient time to fully evaluate these models, but the Panel agreed that it would be a valuable model configuration to consider for a future full assessment. That is, model configurations that include time-varying selectivity for suspect fishery/survey composition data that potentially influence absolute abundance estimation is an alternative to downweighting data sources as was largely conducted during this review.

Figure 8 shows time-trajectories of biomass based on applying the final base model (T-2_0.2) in which the catch series is constructed by assuming that all catches in the MexCal fleet are from the northern subpopulation. This model could be used to form the basis for management advice if the model using the environmentally-based catch series cannot be used for management purposes.

4) Areas of Disagreement

There were no major areas of disagreement between the STAT and Panel, nor among members of the Panel.

5) Unresolved Problems and Major Uncertainties

1. The ongoing uncertainties, in particular regarding absolute biomass, are likely to persist until the information content of the data increases substantially, and perhaps not even then.
2. The Panel wishes to highlight that the level of variation in terminal biomass evident from the retrospective analysis (on the order of 100,000s of tons from one year to the next; Figure 7 of this report) is not unexpected, and changes in terminal age 1+ biomass estimates of this extent may occur when the 2015 assessment update takes place.
3. The indices of abundance do not exhibit consistent trends even after allowing for the differences in their respective selectivities, and remain in conflict even when the age and length data are greatly down-weighted.
4. The data set is able to estimate general trends in abundance fairly robustly, but the likelihood is flat over a wide range of current biomass levels, which means that relatively small changes to the data sets or assumptions can lead to marked changes in current abundance.

6) Issues raised by the CPSMT and CPSAS representatives during the meeting

a) CPSMT issues

The CPSMT representative commends the STAT for their efforts accomplished prior to and during the meeting. The CPSMT representative notes that the Panel thoroughly reviewed the stock assessment and the survey data informing the stock assessment. The CPSMT representative appreciates the STAT's effort in addressing data weighting, specifically related to the conditional age-at-lengths from the ATM survey and fisheries. The CPSMT representative agrees with the Panel's attempt to dampen the sensitivity of weighting the data.

The Panel recognized the scaling in the model is not defined given the available data and has been a recurring concern for Pacific sardine and mackerel assessments. Given this instability often seen in the model, the CPSMT representative urges careful consideration when establishing sardine harvest management measures. Ultimately, it is only through further data collection and refinement of data collected that these uncertainties may be resolved. An increase in trawl sampling during the ATM survey could help to increase the amount of size/age data in the model and to potentially reduce conflict between the survey and fishery data.

b) CPSAS issues

The CPSAS representative commends the Panel and STAT for their significant body of work throughout the 2014 sardine STAR panel. Unfortunately, the 2014 sardine assessment encountered the same basic difficulty with scaling issues observed in the 2011 assessment. The SS model is very sensitive to weighting of the input length and conditional age-at-length data from the ATM surveys. Most of the work at the meeting was spent making further analyses to resolve the source of these problems, which

included very high variability in the biomass estimates for the first half of the time series. It became apparent from sensitivity runs that data weighting matters. The STAT and Panel attempted to find a solution that made results less sensitive by down-weighting certain conditional age-at-length data.

The sardine assessment model was improved by a more realistic separation of the landings from the northern and southern stocks (excluding the landings of southern stock sardine from Ensenada and Southern California). This reduces the biomass estimates and largely resolves problems associated with the distribution parameter in the harvest guideline.

The final base model ultimately fixed catchability (Q) at 1 for the ATM surveys, as in prior years, attempting to achieve model stability. The CPSAS has voiced concern in the past that acoustic surveys as currently deployed have been unable to measure the full biomass, particularly in the Pacific Northwest. The point is that fishermen observed and caught significantly more fish in the area than the point estimate of the ATM cruise – which measured only one spot in time but contributed to a low overall sardine biomass estimate.

The CPSAS also voices concern that stock assessments seem to be gravitating toward one independent index based on ATM surveys. We encourage a continuation of multiple surveys as each survey type has similar constraints. We acknowledge and applaud the acquisition of the RV Reuben Lasker and its capability to survey with forward and side-scanning sonar. We can support the ATM with the use of sonar to augment acoustic search of water columns that the downsounder does not effectively measure (i.e. the top 10 meters of the water column).

On behalf of the CPSAS and industry at large, the CPSAS representative also expresses disappointment that the aerial survey has been dropped from consideration in this and presumably future stock assessments. Ultimately, industry wants to see a sustainable resource (to the degree that environmental conditions will allow) that is in no danger of being overfished. Current sardine stock assessments and harvest policy are very precautionary. We sincerely hope that going forward we can develop a truly collaborative research program for the CPS complex.

Appendix 4 elaborates on the above concerns and provides recommendations for future stock assessments.

7) Research Recommendations

High priority

A. The assessment would benefit not only from data from Mexico and Canada, but also from joint assessment activities, which would include assessment team members from both countries during assessment development.
B. Modify Stock Synthesis so that the standard errors of the logarithms of age-1+ biomass can be reported. These biomasses are used when computing the Overfishing Level, the Acceptable Biological catch, and the Harvest Level, but

the CV used when applying the ABC control rule is currently that associated with spawning biomass and not age-1+ biomass.

C. Explore models that consider a much longer time-period (e.g. 1931 onwards) to determine whether it is possible to model the entire period and determine whether this leads to a more informative assessment as well as provide a broader context for evaluating changes in productivity.
D. Investigate sensitivity of the assessment to the threshold used in the environmental-based method (currently 50% favourable habitat) to further delineate the southern and northern subpopulations of Pacific sardine. The exploration of sensitivity in the present assessment was limited given time available, but indicated potential sensitivity to this cut-off.
E. Compute age-composition data for the ATM survey by multiplying weighted length-frequencies by appropriately constructed age-length keys (i.e. taking account of where the samples were taken).
F. Investigate alternative approaches for dealing with highly uncertain estimates of recruitment that have an impact on the most recent estimate of age-1+ biomass that is important for management. Possible approaches are outlined in Section 3 of this report.
G. Validation of the environmentally-based stock splitting method should be carried out if management is to be based on separating the northern and southern subpopulations using the habitat model. It may be possible to develop simple discriminant factors to differentiate the two sub-populations by comparing metrics from areas where mixing does not occur. Once statistically significant discriminant metrics (e.g. morphometric, otolith morphology, otolith micro-structure, and possibly using more recent developments in genetic methods) have been chosen, these should be applied to samples from areas where mixing may be occurring or where habitat is close to the environmentally-based boundary. This can be used to help set either a threshold or to allocate proportions if mixing is occurring.
H. Continue to investigate the merits/drawbacks of model configurations that include age compositions (e.g., model H) rather than length-composition and conditional age-at-length data, given some evidence for time- and spatially-varying growth.

Medium priority

I. Continue to explore possible additional fishery-independent data sources. However, inclusion of a substantial new data source would likely require review, which would not be easily accomplished during a standard STAR Panel meeting and would likely need to be reviewed during a Council-sponsored Methodology Review.
J. The reasons for the discrepancy between the observed and expected proportions of old fish in the length and age compositions should be explored further. Possible factors to consider in this investigation include ageing error / ageing bias and the way dome-shaped selectivity has been modelled.
K. The Panel continues to support expansion of coast-wide sampling of adult fish for use when estimating parameters in the DEPM method (and when computing

biomass from the ATM surveys). It also encourages sampling in waters off Mexico and Canada.

L. Consider spatial models for Pacific sardine that can be used to explore the implications of regional recruitment patterns and region-specific biological parameters. These models could be used to identify critical biological data gaps as well as better represent the latitudinal variation in size-at-age.
M. Consider a model that explicitly models the sex-structure of the population and the catch. An analysis of length-at-age samples did not indicate sexual dimorphism for this stock (see Figure 4a in Hill et al. 2014), so all models presented were combined-sex configurations. Nevertheless, it was felt that a sex-specific model was needed minimally as a sensitivity test to investigate the possibility that accounting for sex will have an impact on stock-assessment results for this resource.
N. Consider a model that has separate fleets for Mexico, California, Oregon-Washington and Canada.
O. Compare annual length-composition data for the Ensenada fishery that are included in the MexCal data sets for the NSP scenario with the corresponding southern California length compositions. Also, compare the annual length-composition data for the Oregon-Washington catches with those from the British Columbia fishery. This is particularly important if a future age data/age-based selectivity model scenario is further developed and presented for review.
P. Further explore methods to reduce between-reader ageing bias. In particular, consider comparisons among laboratories and assess whether the age-reading protocol can be improved to reduce among-ager variation.
Q. Change the method for allocating area in the DEPM method so that the appropriate area allocation for each point is included in the relevant stratum. Also, apply a method that better accounts for transect-based sampling and correlated observations that reflects the presence of a spawning aggregation.
R. Consider future research on natural mortality. Note that changes to the assumed value for natural mortality may lead to a need for further changes to harvest control rules.

Low Priority

S. Develop a relationship between egg production and fish age that accounts for the duration of spawning, batch fecundity, etc. by age. Using this information in the assessment would require that the stock-recruitment relationship in SS be modified appropriately.

Finally, the Panel notes that value of the *Small Pelagic Ageing Research Cooperative*, which should improve consistency in age-reading methods generally, and in particular for Pacific sardine. Lack of consistency in age estimates was the reason for not using age data for British Columbia.

8) References

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9) Tables and Figures

Table 1. Summary of the models requested of the STAT during the review. "F" indicates that the weights assigned to the composition type were based on the Francis (2011) TA1.8 method, "F-pool" indicates that factor to weight the composition concerned pooled information across fleets / seasons, "split" under the "ATM Q" and "ATM sel" (selectivity) columns indicates that separate parameters were estimated for the spring / summer surveys, "equal" under the "ATM Q" and "ATM sel" columns indicates that the parameters concerned were assumed to be the same for the spring / summer surveys, "1" indicates that survey catchability was assumed to be 1. "profile" in the last three lines implies that the STAT were requested to profile over the weighting factor concerned.

	Lambda: Length composition			Lambda: Conditional age-at-length			ATM	ATM
	MexCal (1+2)	PacNW	ATM	MexCal (1+2)	PacNW	ATM	Q	Sel
G	1	1	1	0.5	0.5	0.5	split	split
K	1	1	1	1	1	1	split	split
F	F	F	F	F	F	F	split	split
L	F-pool	F	F-pool	F-pool	F	F-pool	split	split
M	F	F	F	1	1	1	split	split
N	1	1	1	F	F	F	split	split
O	1	1	1	F	1	F	split	split
P	1	1	1	0.5	0.5	0.5	equal	equal
Q	1	1	20	0.5	0.5	0.5	equal	equal
R	1	1	1	0.5	0.5	0	equal	equal
S	1	1	1	0.5	0.5	0	1	equal
T	1	1	1	0.5	0.5	0	1	split
U	1	1	1	0.01	0.01	0.5	split	split
V	1	1	20, excl spr12	0.5	0.5	0.5	equal	equal
W	1	1	1	0.5	0.5	0	split	split
G-2	1	1	1	profile	profile	profile	split	split
W-2	1	1	1	profile	profile	0	split	split
W-3	F-pool	F	F-pool	profile	profile	0	split	split
T-2	1	1	1	profile	profile	0	1	split

Table 2. Weighting factors and 95% confidence intervals. Results are shown when the Francis (2011) method TA1.8 is applied separately by fleet,and when it is applied to data pooled over fleets or surveys.

Fishery/Survey	Weighting factors Length	Conditional age-at-length
Single data source		
MexCal_S1	**0.17** (0.11-0.43)	**1.79** (1.43-2.33)
MexCal_S2	**0.15** (0.10-0.31)	**1.69** (1.40-2.11)
PacNW	**0.11** (0.08-0.22)	**0.39** (0.30-0.54)
Aerial	NA	NA
ATM_Spr	**0.15** (0.09-1.13)	**2.11** (1.52-3.49)
ATM_Sum	**0.04** (0.03-Inf)	**1.61** (1.0-3.64)
Pooled data source		
MexCal_S1-S2	**0.17** (0.12-0.28)	**1.66** (1.40-1.98)
PacNW	**0.11** (0.08-0.22)	**0.39** (0.30-0.53)
ATM_Spr-Sum	**0.09** (0.06-0.42)	**1.87** (1.37-2.85)

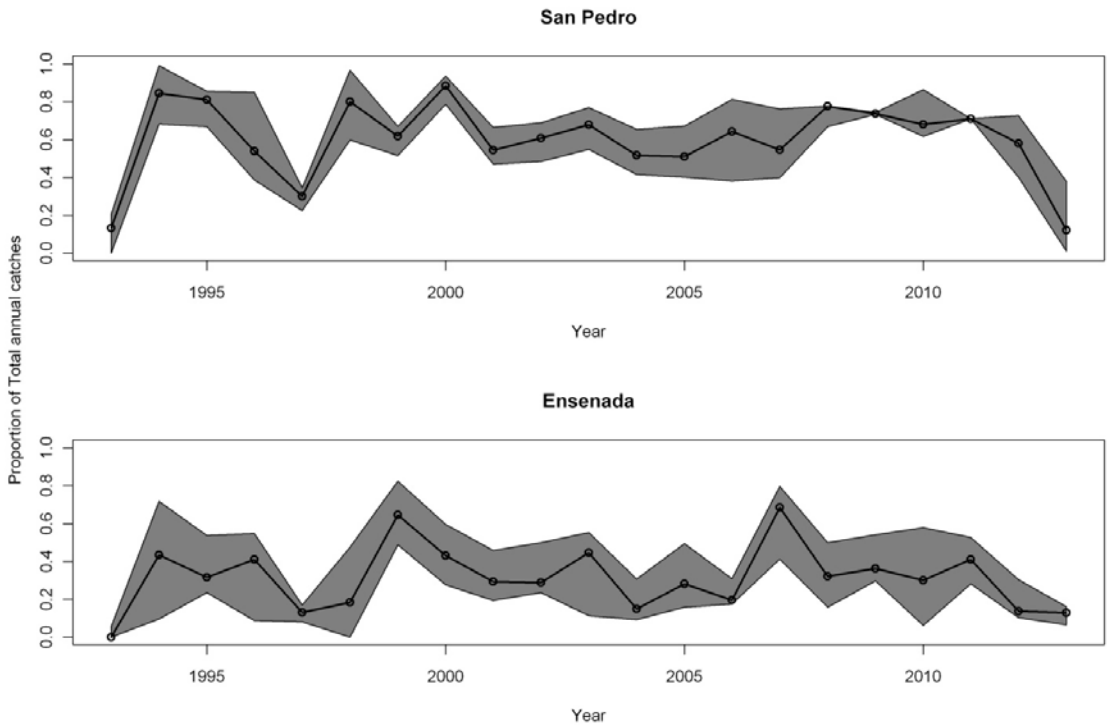

Figure 1. Sensitivity of the proportion of the total catch off San Pedro and Ensenada that is estimated to be from the northern subpopulation to basing the apportionment method on one additional and one fewer month.

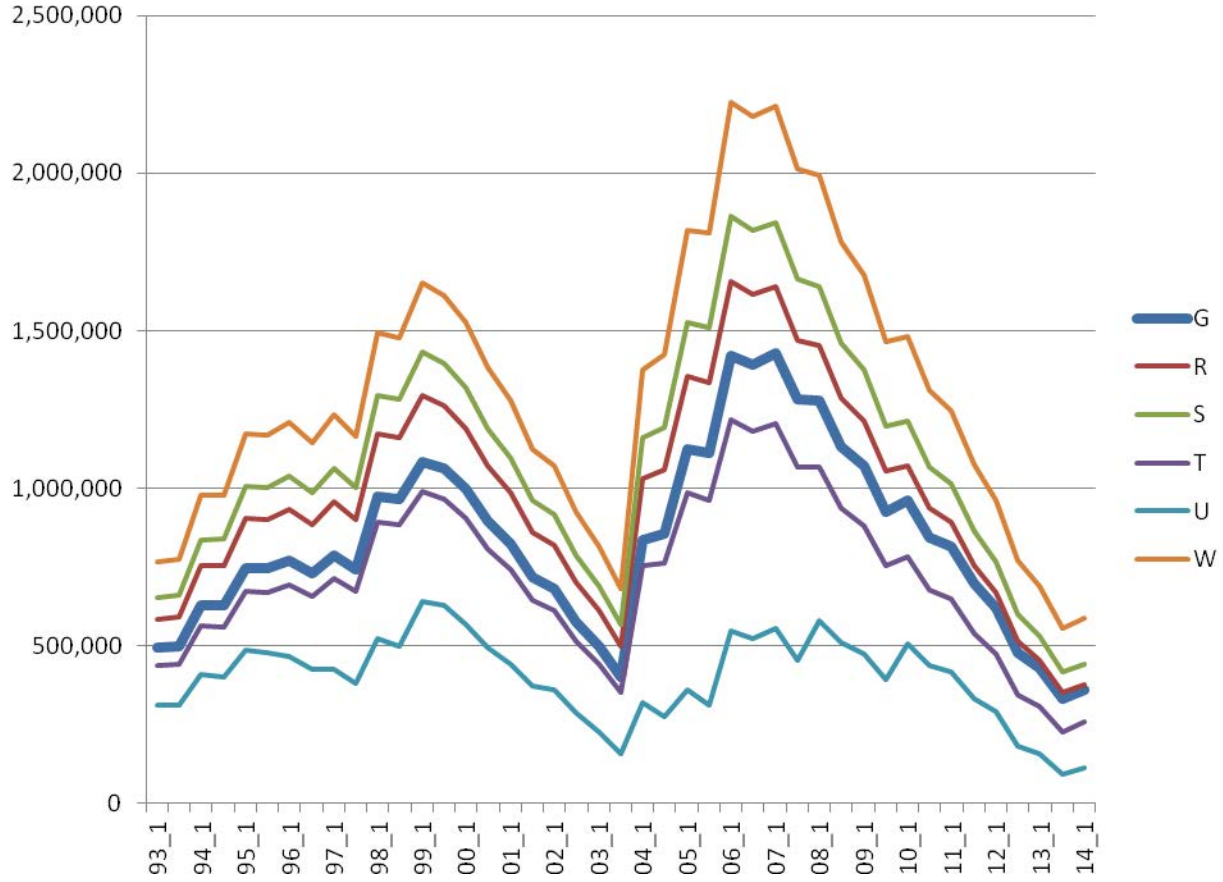

Figure 2. Sensitivity of the results of model G to varying the treatment of the ATM survey selectivity and catchability.

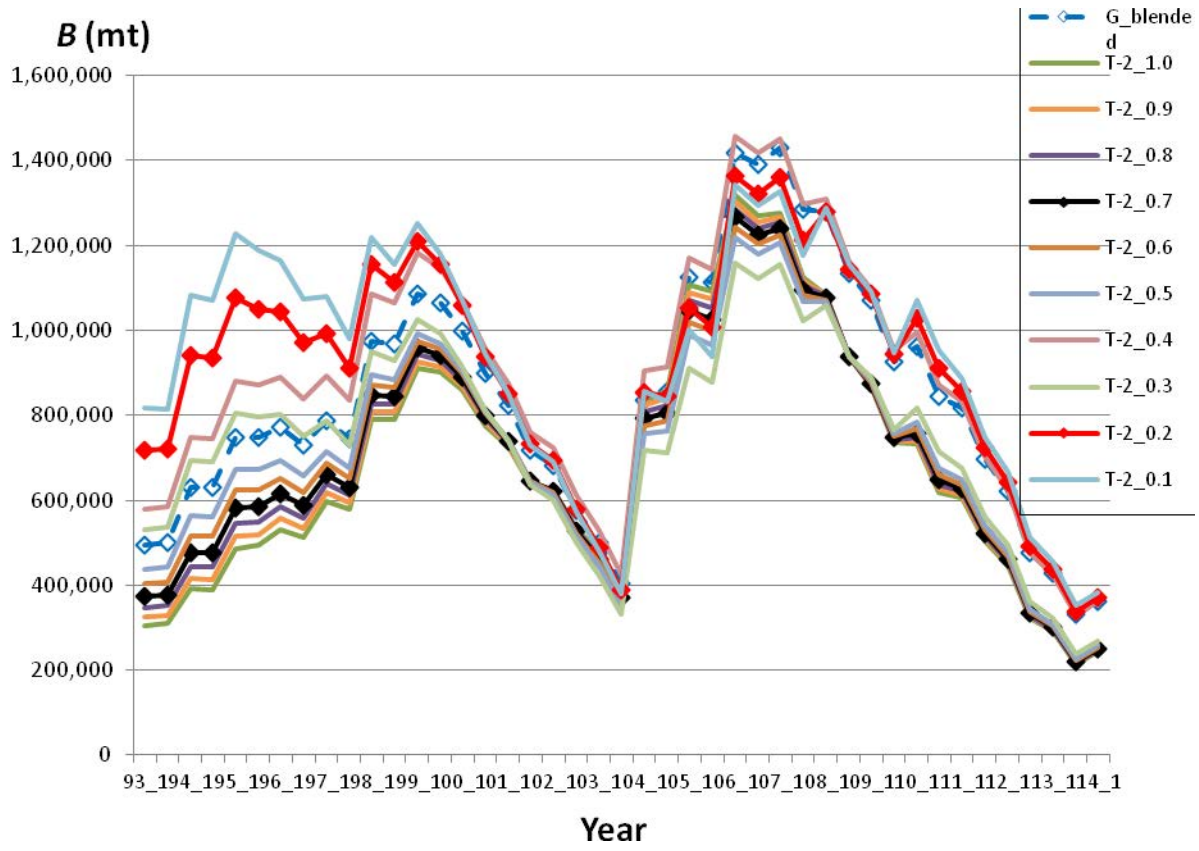

Figure 3. Biomass trajectories for variants of model configuration T-2 constructed by changing the weighting factor for the conditional age-at-length data for the MexCal and PacNW fisheries.

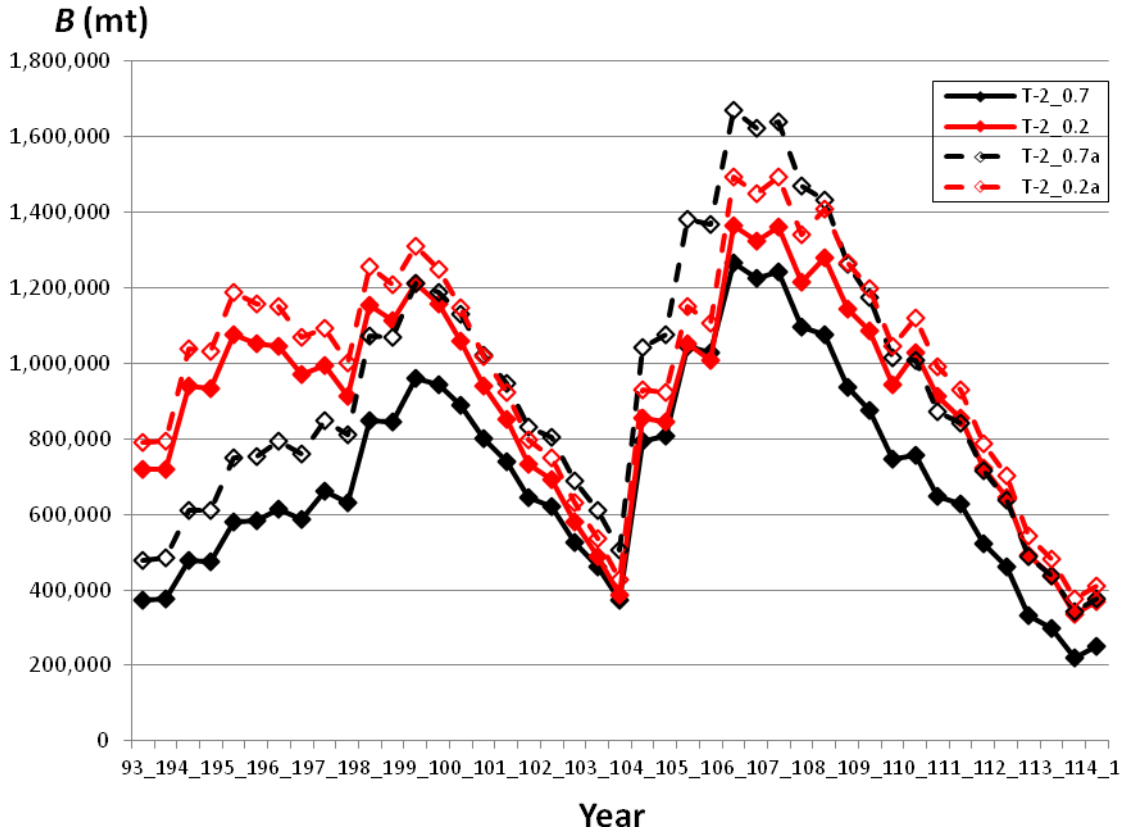

Figure 4. Biomass trajectories for models T-2_0.2 and T-2_0.7 and variants thereof that ignore the length-frequencies for the 2011 and 2012 spring ATM surveys.

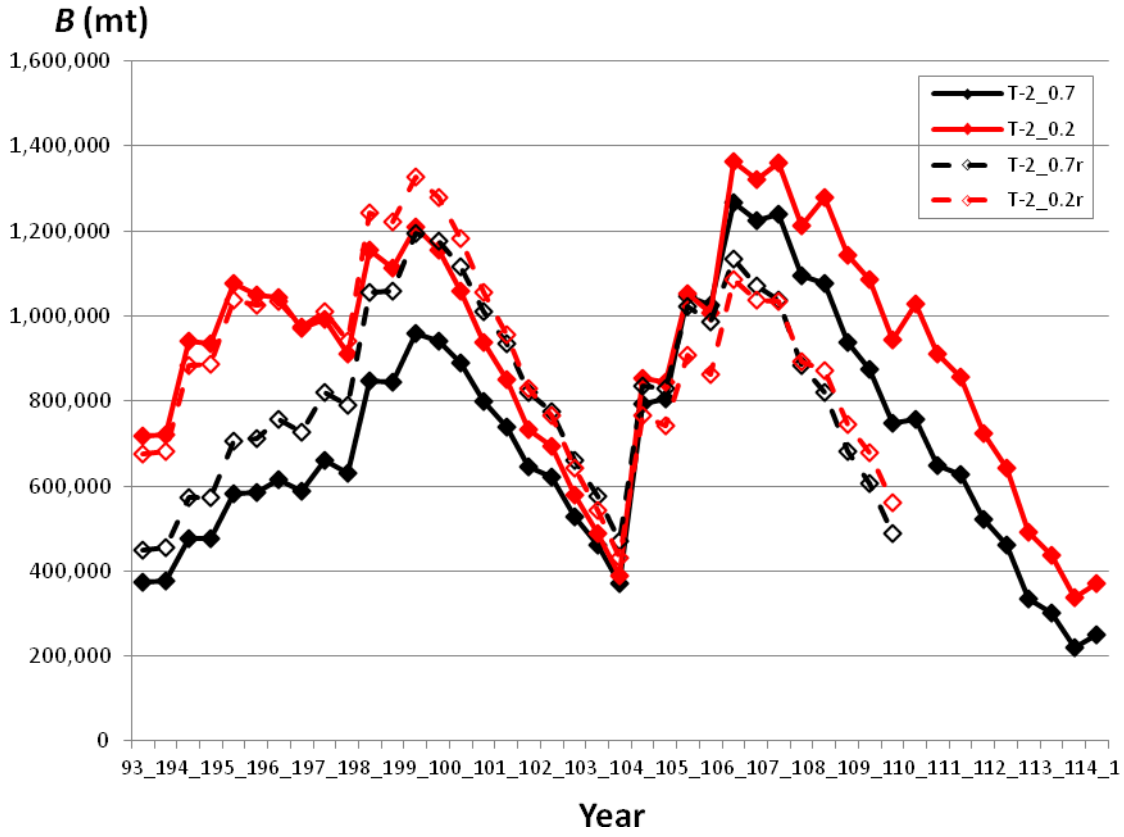

Figure 5. Biomass trajectories for models T-2_0.2 and T-2_0.7 and variants thereof that ignore data for the last four years.

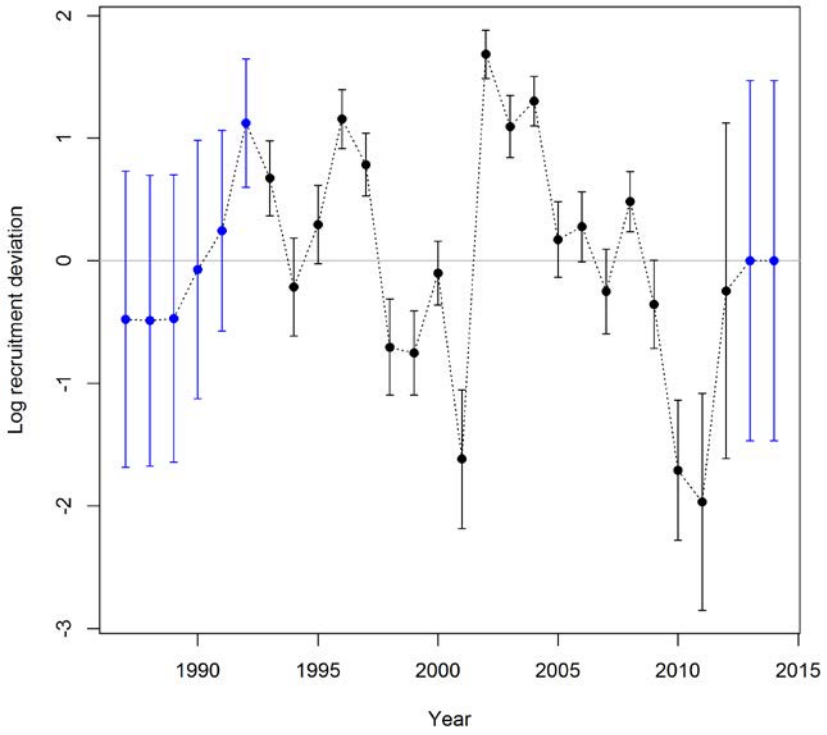

Figure 6. Estimates of the recruitment deviations for model G with their asymptotic standard errors.

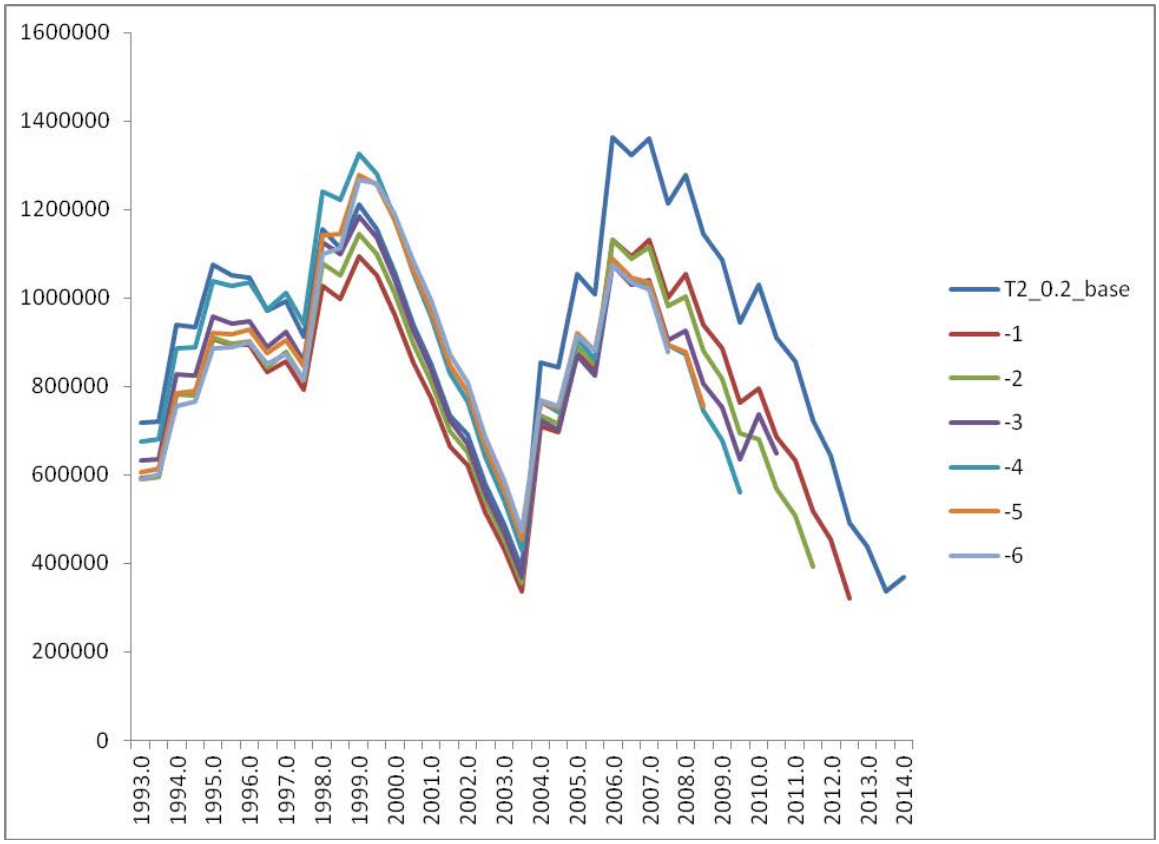

Figure 7. Results of a retrospective analysis based on the final base model T-2_0.2.

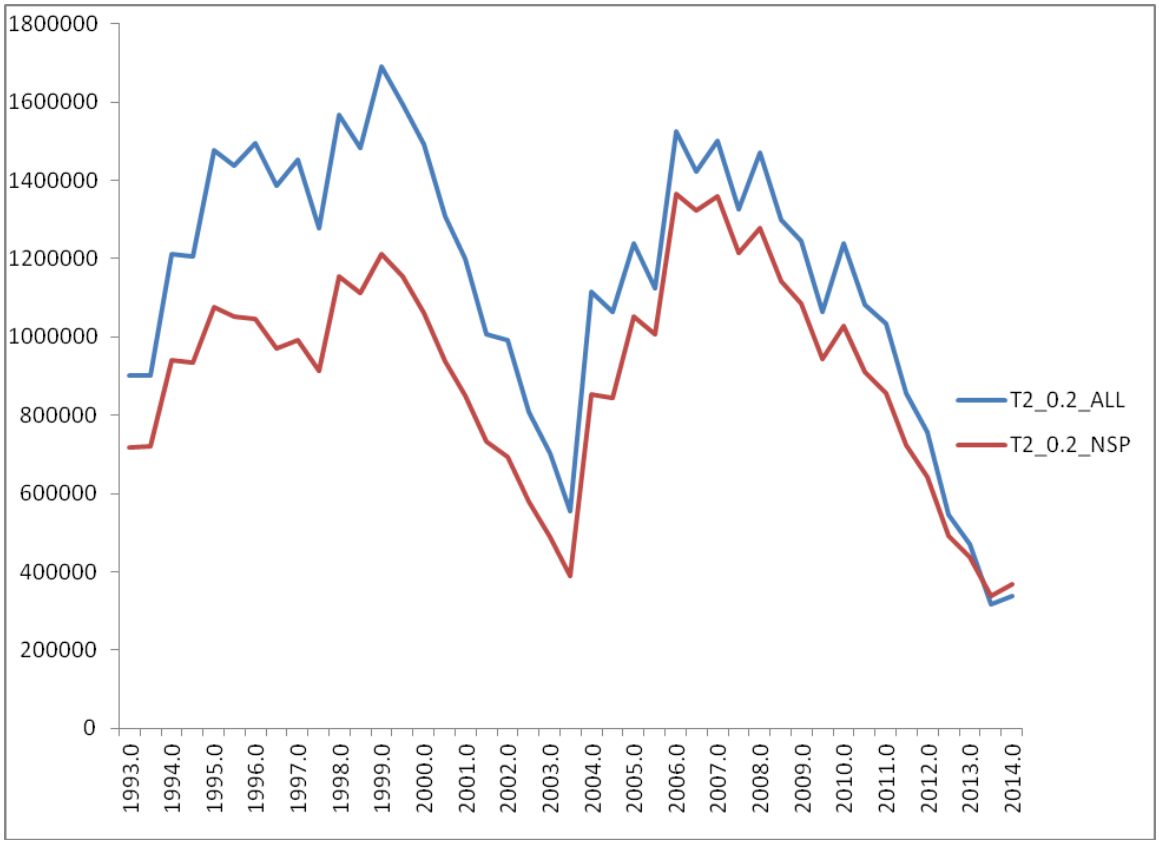

Figure 8. Comparison of the biomass trajectory for model T-2_0.2 when it is applied to the NSP only (differentiating catches) and the total catch time series.

Appendix 1
2014 Pacific Sardine STAR Panel Meeting Attendees

STAR Panel Members
André Punt (Chair), SSC, University of Washington
Meisha Key, SSC, CDFW
José De Oliveira, CIE Reviewer, CEFAS
John Simmonds, CIE Reviewer, ICES

Pacific Fishery Management Council Represenatives
Diane Pleschner-Steele, CPSAS Advisor to STAR Panel
Chelsea Protasio, CPSMT Advisor to STAR Panel
Kerry Griffin, PFMC

STAT Members
Kevin Hill, SWFSC
Paul Crone, SWFSC
Dave Demer, NOAA / SWFSC
Juan Zwolinski, NOAA / SWFSC
Emmanis Dorval, NOAA / SWFSC
Beverly Macewicz, NOAA / SWFSC

Other Attendees
Jenny McDaniel, SWFSC
Kirk Lynn, CDFG
Dale Sweetnam, SWFSC
Erin Reed, SWFSC
Ed Weber, SWFSC
Josh Lindsay, NMFS WCR
Russ Vetter, SWFSC
Al Carter, Ocean Companies
Richard Carroll, Jessie's Ilwaco Fish Company
Elizabeth Helmers, CDFW
Nancy Lo, SWFSC
Sam McClatchie, SWFSC
Richard Parrish, NMFS Emeritus
Yukong Gu, SWFSC
Jeff Laake, AFSC
Kevin Piner, SWFSC
William Watson, SWFSC
Elaine Acuňa, SWFSC
Anna Holder, CDFW
Joel Van Nord, CWPA
Noelle Bowlin, SWFSC
Mike Okoniewski, Pacific Seafood
Cisco Werner, SWFSC

Sarah Shoffler, SWFSC
Kristen Koch, SWFSC
Chris Francis, NIWA
Emily Gardner, SWFSC
Alex Da Silva, IATTC
Steven Teo, SWFSC
George Cutter, SWFSC
Mark Maunder, IATTC

AFSC – Alaska Fisheries Science Center
CDFW – California Department of Fish and Wildlife
CEFAS - Centre for Environment, Fisheries & Aquaculture Science
CPSAS - Coastal Pelagic Species Advisory Subpanel
CIE – Council on Independent Experts
CPSMT - Coastal Pelagic Species Management Team
CWPA – California Wetfish Producers Association
IATTC – Inter-American Tropical Tuna Commission
ICES – International Council for the Exploration of the Sea
NIWA - National Institute of Water and Atmospheric Research
NMFS - National Marine Fisheries Service
SSC - Scientific and Statistical Committee (of the Pacific Fishery Management Council)
SWFSC - Southwest Fisheries Science Center (National Oceanic and Atmospheric Administration)
WCR – West Coast Region

Appendix 2
Email from Tom Jagielo regarding the 2013 aerial survey

Hi Kevin,

I just completed crunching the numbers for the 2013 aerial sardine survey. We are now in the process of preparing a survey report with all the details about the 2013 sampling season, but I wanted to forward the "bottom line" to you in advance of finishing that.

The survey occurred on 8-12-2013 and 8-13-2013 and covered a latitudinal distance of about 48 miles, ranging from The Columbia River to the area offshore of Garibaldi, OR. A total of 21 transects were used for the analysis.

Biomass = 160,763
CV = 0.3488

As noted previously, no new point sets were conducted in 2013. Thus, the biomass estimate was derived using the same point set data as last year (n=123 collected from 2008-2012).

Also noted previously, no bio-data were collected in 2013. Thus, I have no new length composition data for you. In previous years, we saw very good agreement between length comps from the fishery and the point sets sampled. In general, both operate in the same area using the same gear. This suggests that fishery length comps could serve as a proxy for estimating selectivity for the survey, depending on what you may have from the fishery in 2013.

Please do not hesitate to call me with any questions.

Thank you for your consideration,

Tom

Appendix 3
Progress related to the recommendations from ATM survey review
Juan Zwolinski and David Demer

1. Immediate (prior to the next stock assessments)

a. Analyses be conducted using auxiliary information (e.g. trends in density along transects, information from ichythoplankton surveys south of the survey area, and catch information) to provide best estimates for the biomass outside of the survey area, as well as the range of possible biomass levels.

Response: During spring surveys (i.e., April and early May), the northern stock of Pacific sardine resides ~30-70 m deep and spawn offshore of central and southern California. During summer surveys, (i.e., June through August), the same stock resides shallower and closer to the shore off central California, Oregon, Washington, and Vancouver Island. The sardine biomass estimates from the spring and summer ATM surveys during 2008 (Demer et al., 2012), 2012 (Zwolinski et al. in Hill et al. 2012), and 2013 (Zwolinski et al. in Hill et al. 2013) were not statistically different, indicating that any biomass outside of the survey areas are small compared to the stock biomass and the survey precision.

b. The CVs for the estimates need to be modified to fully account for the uncertainty of the trawl data.

Response: In the case that the trawl information was used to characterize independently the length and species composition of each transect (i.e., by having at least one transect per trawl), bootstrapping of the transect means would provide an unbiased of the sampling CV (Demer et al., 2012). Since 2011, efforts were made to obtain a larger number of trawls in order to get closer to the full independence of the transects.

2. Short-term

a. Investigate potential species selectivity effects by comparing the ratios of catch rates and acoustically-estimated densities in areas where single species dominate.

Response: There are strong limitations on the use of the surface, night-time trawls as quantitative measurements of fish density that preclude us to compare them to the measurements of daytime, depth-integrated fish densities from acoustics. The three main ones are: 1) There is strong vertical variability on the opening of the net by trawling at the surface, especially under bad weather; 2) It is difficult to determine with accuracy the horizontal dimension of the net to be used in the calculation of the swept area. Some studies suggest that the herding of fish begins at the doors, which have a distance much larger than that of the horizontal dimension of the net; 3) For the data already collected, there is no way to determine if all the fish that were vertically integrated by the echosounder are contained in the depth interval spanning the surface and the foot rope.

b. Compare total CPS backscatter along transects to trawl catch rates using statistical techniques.

Response: Positive trawls were associated with acoustic samples with significantly higher than average backscatter (Zwolinski et al., 2012).

c. Conduct sensitivity tests in which stations are pooled and allocated to acoustic values over a larger area.
   Response: The trawl catches from each night are pooled. Species and size composition data from these "trawl clusters" are associated to the most proximate acoustic samples (see Appendices A and B in Hill et al., 2012).
d. Consult experts in trawl design to evaluate the current trawl design in relation to the survey objectives.
   Response: Trawl experts have been consulted.
e. Develop methods that categorize the acoustic record and thus support automatic species identification and continue to work on definition and precision of the VMR process
   Response: Due to the overlap in size of the various schooling CPS, acoustic classification of species is inherently difficult when the number of samples within a school is small (for example, when using a large interval between pings when recording acoustic data over 750 m depth while conducting at a survey 10 kts). The first approach to ameliorate the quality of the data was the development the EK60 Adaptive Logging software (EAL). This software allows the reduction of the interval between acoustic pings when the bottom is shallower than 750 meters, effectively increasing the sampling intensity of schools observed over the continental shelf and slope.
   The VMR is part of a larger algorithm aiming to identify and eliminate the backscatter of non-CPS targets from echograms. The algorithm is tested on a survey basis to ensure that the retained backscatter of the echoes identified as CPS is at least 95% of the original backscatter.
f. Evaluate the potential use of the echosounder in a non-vertical position.
   Response: Multibeam observations have been made of CPS schools since the initial ATM survey in 2006. These data have been used to evaluate potential avoidance of CPS to the survey ship (see report of the PFMC/CIE review of the ATM). The new FSV Reuben Lasker is equipped with Simrad EK60, ME70, MS70, and SX90 echosounders/sonars, which will facilitate improved characterizations of fish behaviours and abundances.
g. Check the filtering algorithm every year to ensure that it is still suitable under changing conditions.
   Response: The filtering results are checked on a subset of fish schools during every survey to ensure that at least 95% of the acoustic backscatter of CPS schools is retained in the filtered echograms.
h. Study trends in frequency response over depth strata in schools.
   Response: We observed that the CPS echoes of tightly schooling fish in areas with positive trawls for anchovy, mackerels, and sardine had very little depth contrasts due to their association with the mixed layer. There, there were no obvious patterns of variability in the frequency response of the schools.
i. Compare results from the 18-kHz and other transducers to examine possible avoidance reactions.
   Response: The recommendation is unclear.
j. Continue to consider the advantages and disadvantages of conducting ATM surveys at different times of the year.

Response: This was addressed in the January 2014 CIE review of the summer sardine-hake survey (SaKe).

k. Evaluate the potential to give age-based abundance or biomass estimates for sardine and consider their utility in the SS3 assessment, given the lack of contrast in length-at-age at older ages and the ability to directly estimate total mortality from the survey result.

   Response: Age-based abundances can be estimated from the ATM using age-to-length keys derived from sardine collected on the survey themselves, or from a composite age-to-length key from the fisheries.

   The ATM survey showed the persistence of dominant cohorts over time, allowing the estimation of total and natural mortality (Zwolinski and Demer, 2013).

l. Conduct standard (ICES) vessel noise measurements for all vessels.

   Response: Vessel noise measurements are made for all NOAA FSVs. Noise measurements have not been made for RV Ocean Starr, formerly RV David Starr Jordan.

3. Long-term

a. Evaluate if different trawling practices or gears, or both would be beneficial.
b. Use the current variance estimation procedure to investigate the trade-offs in terms of variance of different time allocations between acoustic transect and trawl data collection.
c. Use a trawl/vessel configuration that can support directed trawl sampling.
d. Conduct repeated trawl sampling experiments to obtain a better understanding of small-scale variability.

   Response: The current sampling technique involves three trawls per night with inter-trawl distance of less than 10-nmi.

e. Test the efficiency and selectivity of the trawl by comparing samples from same area taken with the survey trawl and purse seine.
f. Apply state-of-the-art acoustic and optic technology to investigate fish behavior and escapement at various critical positions of the trawl.

   Response: Cameras attached to the trawl in front of the cod end have been developed and used extensively in the spring and summer 2013 surveys to observe and quantify fish behaviour and MMED performance.

g. Conduct validation tows on various kinds of backscatter to assure that the filtering algorithm is performing as intended to apportion backscatter to CPS.
h. Make efforts to obtain TS measurements for *in situ* CPS in the California Current Ecosystem.
i. Focus on utilizing more advanced instrumentation and resource-demanding research for studying vessel impacts.

   Response: The state-of-the-art instrumentation aboard the FSV Reuben Lasker (EK60s, ME70, MS70, SX90) should facilitate studies of fish behaviour that could potentially impact the estimations of abundances.

References

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Zwolinski, J. P., Demer, D. A., Byers, K. A., Cutter, G. R., Renfree, J. S., Sessions, S. T., and Macewicz, B. J. 2012. Distributions and abundances of Pacific sardine (*Sardinops sagax*) and other pelagic fishes in the California Current ecosystem during spring 2006, 2008, and 2010, estimated from acoustic-trawl surveys. Fishery Bulletin, 110: 110-122.

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

Appendix 4
Full CPSAS representative comments
Diane Pleschner-Steele

The CPSAS representative commends the Panel and STAT for their significant body of work throughout the 2014 sardine STAR panel. Unfortunately, the 2014 sardine assessment encountered the same basic difficulty with scaling issues observed in the 2011 assessment. The SS model is very sensitive to weighting of the input length and conditional age at length (CAAL) compositions from the ATM surveys. Most of the work at the meeting was spent making further analyses to resolve the source of these problems; which included very high variability in the biomass estimates for the first half of the time series. It became apparent from sensitivity runs that data weighting matters. The STAT and Panel attempted to find a solution that made results less sensitive by down-weighting certain conditional age-at-length data.

The sardine assessment model was improved by a more realistic separation of the landings from the northern and southern stocks (excluding the landings of southern stock sardine from Ensenada or Southern California). This reduces the biomass estimate and largely resolves problems associated with the distribution parameter in the harvest guideline.

The final base model ultimately fixed catchability (Q) at 1 for the ATM surveys, as in prior years, attempting to achieve model stability. The CPSAS has voiced concern in the past that acoustic surveys as currently deployed have been unable to measure the full biomass, particularly in the Pacific Northwest. For example, in 2012 the ATM survey went through waters from Newport to the Canadian border in 11 days and estimated the total biomass for that area at 13,000mt. We understand that the CV for that survey leg was estimated at 0.63. In the same 11 days the fishery landed 9,747mt. Previous to the arrival of the NOAA vessel the harvest in that area was 35,531mt. After the NOAA vessel left those waters the harvest was 32,781mt for the remainder of the season. The point is that fishermen observed and caught significantly more fish in the area than the point estimate of the ATM cruise – which measured only one spot in time but contributed to a low overall sardine biomass estimate. In contrast, the NWSS-sponsored aerial survey for that summer (which was later down-weighted due to too few point sets) estimated more than 900,000mt in the PNW. The inconsistency in the two data points remains unresolved.

On behalf of the CPSAS and industry at large, the CPSAS representative also expresses disappointment that the aerial survey has been dropped from consideration in this and presumably future stock assessments. It should be noted that the rationale for eliminating the aerial survey, "*vulnerability of this survey method to prevailing ocean conditions potentially affecting q over short and long time frames (water clarity, sea state, water column stratification, and associated changes in vertical distribution,…" c*ould be applied to other fishery independent indices as well. Moreover, the aerial survey assumption that daylight-photographed schools represented sardines was questioned by comparing species composition from night-time ATM trawls. The CPSAS notes that

schooling patterns day vs. night differ and should not be compared.

The CPSAS also voices concern that stock assessments seem to be gravitating toward one independent index based on ATM surveys. We encourage a continuation of multiple surveys, recognizing that each survey type has issues with varying ocean conditions and assumptions. Although the CPSAS and industry express serious reservations about use of only one index for sardines developed solely around the ATM survey, we acknowledge and applaud the acquisition of the RV Reuben Lasker and its capability to survey with forward and side-scanning sonar. We can support the ATM with the use of sonar to augment acoustic search of water columns that the downsounder does not effectively measure (i.e. the top 10 meters of the water column). Further, sonar can offer clues to school behavior. As stated by a sitting Council member who has had many years of experience fishing for sardines: First choice: sonar: second choice spotter plane: third choice downsounder.

Ultimately, industry wants to see a sustainable resource (to the degree that environmental conditions will allow) that is in no danger of being overfished. Current sardine stock assessments and harvest policy are very precautionary. We sincerely hope that going forward we can develop a truly collaborative research program for the CPS complex.

Recommendations:

- Continue to involve industry in collaborative research.
- Recognize that the 2014 assessment is “déjà vu all over again” and most of the unresolved problems and major uncertainties listed in the 2011 STAR panel report still exist
- Also, many of the research recommendations in 2011 also are applicable in 2014, i.e.
    - Explore models which consider a much longer time-period (e.g. 1931 onwards) to determine whether it is possible to model the entire period
    - Consider model configurations which use age-composition rather than length-composition and conditional age-at-length data given evidence for time- and spatially-varying growth.

Center for Independent Experts (CIE) Independent Peer Review Report of:

STAR Panel Review of the 2014-2015 Pacific Sardine Stock Assessment

La Jolla
California
March 3-5, 2014

E J Simmonds

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1. Executive summary

The meeting to review the Pacific Sardine (*Sardinops sagax caerulea*) Stock Assessment took place in the Southwest Fisheries Science Center in La Jolla, California from 3-5 February 2014. The reports and presentations provided an excellent basis to evaluate the performance of the assessments. Following an extensive model exploration, the Panel agreed on a single model formulation that is accepted for estimating 1+biomass that is suitable for biomass estimation for management. The main differences between the initial model and the final model were different data weighting for survey conditional age at length and use of a common q for both spring and summer ATM surveys. The science reviewed was of a high standard and could be classed as 'of the best scientific information available'.

2. Background

The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Technical Representative (COTR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance with the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Appendix 1**. This SoW describes the work tasks and deliverables of the CIE reviewers for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

3. Description of the review and role in the review activities.

The STAR Panel Review met in the Southwest Fisheries Science Center in La Jolla California from 3-5 February 2014 to review Pacific sardine (*Sardinops sagax caerulea*) stock assessment. The review committee was composed of André Punt, SSC, University of Washington (Chair), Meisha Key, SSC, California Department of

Fish and Wildlife, José de Oliveira, CIE Reviewer, CEFAS - Centre for Environment, Fisheries & Aquaculture Science, UK, and John Simmonds, CIE Reviewer, ICES – International Council for the Exploration of the Sea, Denmark.

At the beginning of the meeting introductions were made (see list of attendees, Appendix 3), and the agenda was adopted (Appendix 3). A draft assessment document and background materials had been provided to the Panel in advance of the meeting on a SWFSC FTP site (Hill and Crone 2014). Paul Crone introduced the draft assessment report. Then David Demer, SWFSC, presented the Acoustic Trawl Survey (ATM) results. Emmanis Dorval, SWFSC, presented the Egg survey results (DEPM). Juan Zwolinski, SWFSC, presented the information on split of the fishery data into subpopulations. Paul Crone and Kevin Hill presented the assessment methodology and the results from a draft assessment utilizing the Stock Synthesis Assessment Tool, Version 3.24s to the Panel. The assessment report included many model options but concentrated on two main models (designated G and H in the draft report). The review examined the underlying assumptions of these two models, selected G as the methodologically most appropriate and then concentrated on exploring model G and a number of potential modified versions (see Section 4.4 below).

I participated in all aspects of the review, paying particular attention to input survey data, and its use in the assessment, which consisted of a) Acoustic Trawl Method (ATM) in spring and summer, b) egg surveys utilizing; total egg production method (TEPM), and daily egg and daily egg production method (DEPM), and c) combined aerial photogrammetric and fishing surveys of biomass. In addition, I also participated in the Panel review and exploration of the Pacific sardine stock assessment and the sensitivity analyses presented in the draft report and developed during the meeting.

Comments given throughout this report should not be read as direct criticism of what has been done, rather ideas of areas for development. In retrospect, one can always find room for improvement and, as such, minor suggestions have been made throughout this report. These should not be considered prescriptive or limiting but rather as aspects for careful consideration.

4. Findings by ToR

4.1. Introduction

The complete ToR for the Pacific Sardine review are given in the statement of work (Appendix 2), the main aspects are repeated here.

1. Reviewing draft stock assessment and other pertinent information (e.g.; previous assessments and STAR Panel reports);
2. Working with STAT Teams to ensure assessments are reviewed as needed;

3. Documenting meeting discussions;
4. Reviewing summaries of stock status (prepared by STAT Teams) for inclusion in the Stock Assessment and Fishery Evaluation (SAFE) document;
5. Recommending alternative methods and/or modifications of proposed methods, as appropriate during the STAR Panel meeting, and;
6. The STAR Panel's terms of reference concern technical aspects of stock assessment work. The STAR Panel should strive for a risk neutral approach in its reports and deliberations.

Items 1 and 4 form the main body of the review, which is discussed in detail in this Section below. Items 2 and 3 and 6 were the process of the review, which are dealt with under proceedings of the review, Section 5 of this report. Item 5 is dealt with under recommendations and conclusions in Section 6.

4.2. Survey data available for the assessment

4.2.1. Acoustic survey

Use of the survey in the model: Two series of acoustic trawl surveys (ATM) are currently available for the assessment. The acoustic survey is carried out to a high standard. The procedures and performance of the ATM has been documented in the methodological review (2011), which concluded that it was possible to consider the ATM as an absolute estimate, but also considered that it would be necessary to check if the resulting residuals in the assessment were compatible with that assumption. As a general principle surveys with short time series that have q close to unity can be considered absolute initially; however, as the number of observations in the survey time series increases over time, it may in the end be possible to detect bias and fit the survey with an estimated q. The 2013 assessment used the ATM survey as absolute, Model G (See Section 4.4) presented in the draft assessment report, used both the spring and summer ATM as relative indices with separately estimated qs. The confidence intervals on these fitted qs included q=1 (ATM absolute) within the estimated range (Figure 4.1).

Survey procedures: Overall the survey is carried out to a high standard particularly in terms of the acoustic aspects, but there are a few aspects that should be examined to see if improvements can be made. The ATM survey takes night trawl samples and uses these to apportion observed daytime biomass between species and additionally uses the samples of Pacific sardine to estimate length and conditional age at length. In many cases catches are a high proportion of one species, so allocation to species is often quite precise. However, the local biomass estimates can be rather variable, so while the samples appear to be sufficient to obtain local estimates of species proportions to allocate to the acoustically derived biomass estimates, the procedure of using night time trawls to assign daytime biomass proportions is not ideal, as it assumes that the species encountered acoustically during the day are then available in the same proportions to night time fishing. Catch rates appear relatively low which is not encouraging. Also the catch rates

and age sampling can end up giving only marginally sufficient information on length and conditional age at length. This issue is discussed in detail further under section 4.4.

Development of techniques either to allocate acoustic records directly to species or to obtain direct samples of daytime aggregations would greatly improve the confidence in the age and length structure, as well as for areas where mixtures are encountered the species proportions (see Section 6).

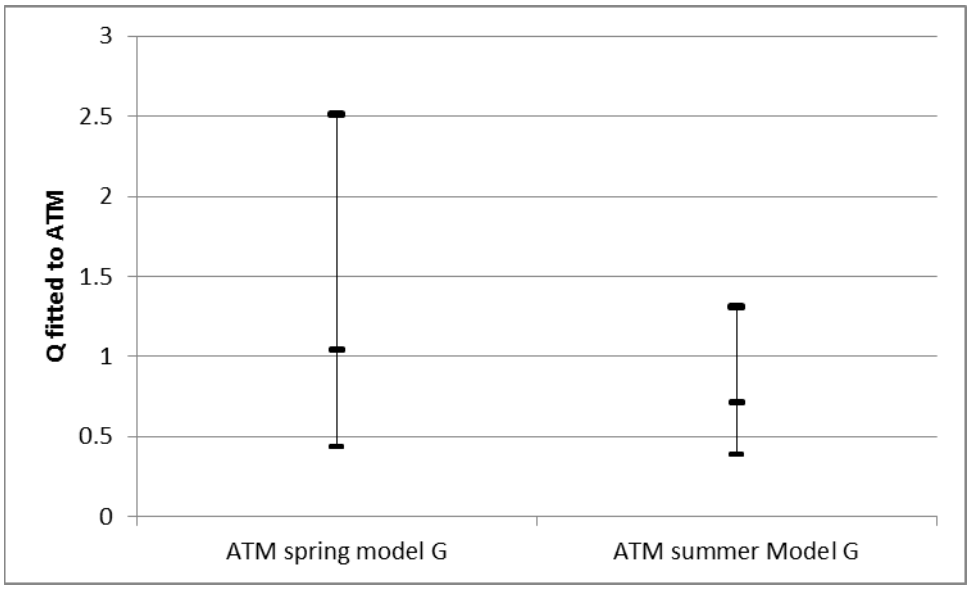

Figure 4.1 Estimated Q with 95% intervals from Model Q, assessment report.

Construction of conditional age-at-length for the ATM survey

Currently fish aged during the ATM survey are combined into an unweighted age-length key, and this is used to construct the conditional age-at-length data for each complete ATM survey. This treatment is not considered to be optimal given the possibility for age- and size-specific distribution of sardine. The use of separate conditional age-length keys for the MexCal and PacNW fleets suggests that there may be differences in age-length keys from these regions. The current method for estimating conditional age at length from the ATM surveys assumes that this is not occurring. The alternatives are to develop separate age-length keys for the different regions covered by the ATM survey, or to use appropriate biomass-based weighting for each part of the survey area.

4.2.2. Egg Survey

The long running combined CALCOFI and DEPM survey provides the longest time series of relative abundance estimates for use in the assessment of Pacific sardine. The survey is well developed and the DEPM method is organized to give biomass estimates which are used to give relative estimates of sardine stock abundance. Because of the long

time period over which this survey has been developed, the survey index has considerable utility in the assessment and provides biomass related information that is useful for the kind of model used.

Examination of the data collected and analytical methods highlights a number of areas which may benefit from improvement. Whilst these issues have been identified it seems unlikely that they result in sufficient uncertainty to warrant exclusion of series from the assessment. Thus it is appropriate that the survey is used in the assessment. The identified issues fall into two areas, sampling of adult sardine to obtain biological parameters, and analytical methods to obtain abundance indices.

Sampling of adult sardine on the egg surveys

The numbers of adult sardine samples to give fecundity (at age), proportion spawning on the sampling day and two previous days are only sufficient to provide at best global means. Sardine are known to distribute by size or age and currently the numbers obtained are very few and do not allow investigation of the dependence of the DEPM on any other factors. A better fish sampling scheme might allow the biological samples to be used to verify that the proportions at length or age that appear to be contributing to the egg abundance do or do not conform to the estimated population, this would help understand the underlying assumptions of the DEPM method.

Analytical methods to derive DEPM estimates from the egg surveys

The analysis of the egg survey has some minor issues, mostly to do with the raising of density to survey area. The survey design is intended to sample the region of higher density, because, ideally, the survey obtains lower values around the periphery. A high density stratum is then drawn around a group of observations that contain the higher values, by creating a ‘simple’ (relatively smooth) boundary using the location of the points. The main idea behind this approach recognizes that the survey objective is to map a peak density in space. There is therefore an assumption that the survey will have higher values towards the center of the area and lower values around the edges. This is then analyzed using a two stratum analysis approach which has two minor issues:

a) The current method for placing the boundary between high and low density areas by placing the boundary on the observation locations means the higher density area is smaller than the region represented by those observations, and conversely the low density area is a little larger resulting in a small underestimate of DEPM abundance. The method should be changed so that the area is allocated to include the correct area allocation for each sampling point included in each of the two strata. The effect is likely small on the index value used in the assessment because the current procedure is applied for all years and the DEPM is used as a relative index.

b) The post stratification and CV calculations may not be correctly calculating the CV used to weight the survey index values in the assessment. The post

stratification may result in underestimation of the CV due to the process of separating into strata based not on some independent measure but on the observed values themselves. Such a post stratification procedure is known to be negatively biased. Conversely the use of simple variance based on the within-stratum observations in the two strata may result in overestimation as there is expected to be some spatial trend within each strata. As the two effects are in opposite directions, the end result may not be a major problem. An improved method which accounts for transect-based sampling and correlated observations that reflect the presence of a spawning aggregation would be an improvement.

4.2.3. Aerial Survey

Previously this index had been used in the assessment. No new data from the Aerial Survey were presented at the meeting, though a copy of an Email indicating some work had been done was provided to the meeting and is attached to the main STAR Panel report. Historic Survey estimates were available and although it was indicated that new data was being prepared, no new data was provided to the group so it was not possible to extend the series. The previous values from this survey exhibit considerably more variability than other abundance indices (ATM and DEPM) over the same period (See Figure 20 in the draft assessment report (Hill and Crone 2014)).

The survey potentially provides a good method for estimating the number of near surface fish schools in the area. Though this may be degraded if the schools are too deep or visibility (due to weather) affects the coverage. However, counting schools alone may not give a very precise estimate of biomass. Marchal and Petigas (1993) partitioned variance between school counting and mean school size and school density estimation for a sardine survey. Estimating the number of schools through school counting was shown to be responsible for only a small part of the variance of the abundance estimate, whereas estimating within school density dominated the precision. The indications from the information on the aerial survey provided to the review panel was that while some limited school count data were collected this year and last year, school size information was spatially very limited and missing in some years. It is possible that shortage of good school identification, and possibly more importantly good school density information, is limiting the precision of the aerial survey.

4.3. Fishery data

The assessment presented was based on a substantial subset of the fishery data. The sardine catches were partitioned into three major groupings, a) Canadian, Washington and Oregon fisheries, b) Mexican and Californian fisheries on the northern component of the Pacific sardine, treated as seasonally dependent groupings, and c) southern component. The primary assessment was based on parts a and b, and classed as the NSP component, though an additional assessment based on all three parts using reported catches from Ensenada in Mexico, USA, and Canada was also presented.

Splitting the catch among components

A habitat based separation method was used to define regions in space and time that were allocated to northern and southern components of the Pacific Sardine. The method was based on 100% allocation to each component on a monthly basis derived from a 50% habitat threshold. The sensitivity to the choice of 50% decision threshold was investigated, and because generally the rate of change of this parameter was rapid in time, the resulting allocation was rather insensitive to the choice of threshold value. The consequences of the assumed temporal stability of the habitat choice were investigated during the review by extending or contracting the allocation period by a month. It was shown overall that the total catch was not substantially sensitive to the split. However, no information was presented on direct validation of component allocation by habitat by checking the correct population assignment of catches. An investigation of the environmentally-based stock splitting method should be carried out if management is to be based on separating the northern and southern subpopulations using the habitat model. It may be possible to develop simple discriminant factors to differentiate the two sub-populations by comparing metrics from areas where mixing does not occur. Once statistically significant discriminant metrics have been chosen these should be applied to samples from areas where mixing may be occurring or where habitat is close to the environmentally-based boundary. This can be used to help to set either a threshold or to allocate proportions if mixing is occurring. If mixed catches are occurring, the accuracy of 100% allocation among the alternate components will be sensitive to population size and may not be the best approach. A number of methods have been found useful to identify pelagic fish to stock component, body morphometrics, otolith morphology, otolith micro-structure, otolith micro chemistry, and possibly using more recent developments in genetic methods. In the case of herring stocks the low tech methods of morphology outperformed the more complex methods of genetics and otolith-microchemistry (see WESTHER project information http://www.clupea.net/westher/).

In addition to the split catch which was used in the main stock assessment model, the total catch was also made available and a second assessment run on the total available catch estimates from all catch Ensenada northwards. The assessment appears to perform equally well for the NSP or the total catch, so the sensitivity for managers only relates to the correct allocation of total catch.

Length and age data in the catch

While sampling at length appears to provide a good description of the landings in all the areas included in the assessment, sampling for age was sparse. In particular both northern and southern extremes of the region were missing age information. In general age data is being treated with a lower priority. Although substantial length information is being collected, there are indications that the modeling assumptions of consistent growth over the years may be responsible for part of the uncertainty in the overall scaling that is the major issue with the assessment. In the absence of good age data it is difficult to determine if migration and the resulting selection are more correctly modeled by age or

by length (see discussion in Section 4.4).

4.4. Stock Assessment

Paul Crone and Kevin Hill presented the assessment methodology and the results from a draft assessment (Hill and Crone 2014) to the Panel. The assessment utilized the Stock Synthesis Assessment Tool, Version 3.24s. The assessment report included results from many model runs and some sensitivity analyses. However, two specific model formulations were selected as the main models for consideration (Models G and H). The full model outputs for these runs were provided on the FTP prior to the review and the focus for Panel discussion concentrated on these models and Model G included the following features:

(a) The data were updated to 2013,
(b) The catches for the MexCal fleet were split from the total catch by the environmental-based method,
(c) The weight-length and maturity-at-length relationships were updated,
(d) The data for the aerial survey were omitted from the assessment,
(e) The ATM survey was split into spring and summer surveys (with separate catchability and selectivity parameters), with catchability parameters estimated,
(f) No additional data weighting for survey abundance data beyond input CVs (i.e. lambda=1),
(g) No additional data weighting for length composition data for fishery/surveys beyond input effective sample sizes (lambda=1),
(h) Weighting for conditional age-at-length data in addition to input effective sample sizes (lambda=0.5),
(i) The value for σ_R was rounded and fixed to 0.75, and
(j) Recruitment was related to spawning stock size according to a Beverton-Holt stock-recruitment relationship with pre-specified steepness (set to 0.8).

Model H differed from Model G by assuming age- rather than length-specific selectivity patterns, by fitting to age-composition data rather than length-composition and conditional age-at-length data, and by fixing the parameters of the growth curve.

Table 1. Summary of the models requested of the STAT during the review. "F" indicates that the weights assigned to the composition type concerned were based on the Francis (2011) method, "F-pool" indicates that factor to weight the composition concerned pooled information across fleets / seasons, "split" under the "ATM Q" and "ATM selectivity" columns indicates that parameters were estimated for the spring / summer surveys separately, "equal" under the "ATM Q" and "ATM selectivity" columns indicates that the parameter concerned were assumed to be the same for the spring / summer surveys, "1" indicates that survey catchability was assumed to be 1. The "profile" in the last three lines implies than the STAT were requested to profile over the weighting factor concerned.

	Lambda: Length composition			Lambda: Conditional age-at-length			ATM	
	MexCal (1+2)	PacNW	ATM	MexCal (1+2)	PacNW	ATM	Q	Sel
G	1	1	1	0.5	0.5	0.5	split	split
K	1	1	1	1	1	1	split	split
F	F	F	F	F	F	F	split	split
L	F-pool	F	F-pool	F-pool	F	F-pool	split	split
M	F	F	F	1	1	1	split	split
N	1	1	1	F	F	F	split	split
O	1	1	1	F	1	F	split	split
P	1	1	1	0.5	0.5	0.5	equal	equal
Q	1	1	20	0.5	0.5	0.5	equal	equal
R	1	1	1	0.5	0.5	0	equal	equal
S	1	1	1	0.5	0.5	0	1	equal
T	1	1	1	0.5	0.5	0	1	split
U	1	1	1	0.01	0.01	0.5	split	split
V	1	1	20, excl spr12	0.5	0.5	0.5	equal	equal
W	1	1	1	0.5	0.5	0	split	split
W-2	1	1	1	profile	profile	0	split	split
W-3	F-pool	F	F-pool	profile	profile	0	split	split
T-2	1	1	1	profile	profile	0	1	split

The stock assessment team had also explored an extensive number of model options within this framework to illustrate model sensitivity, but the results as presented were not conclusive and raised concerns regarding the sensitivity of the assessment, particularly to the data weighting. The weighting method presented was essentially *ad hoc* so it was difficult to justify without further exploration. Therefore further sensitivity analysis was conducted throughout the review, this sensitivity analysis concentrated mostly on weighting of different sources of length frequency and conditional age at length information, but also on the interaction of a few model assumptions such as the ATM

survey q and ATM selectivity with the size and age data weighting. The main features explored during the review are given in Table 1 as a list of different model parameterizations. In addition to these main model formulations model T-2 (Table 1) was explored further with the sensitivity to two years of ATM length composition data (2011 and 2012) which were omitted from the ATM spring survey data series to resolve a specific switch in population state under different weighting assumption for the ATM length data.

Based on the set of sensitivity analyses given in Table 1 the following general conclusions were drawn:

1. Sensitivity to the weighting of the ATM conditional age at length data: Estimates of biomass were particularly sensitive to this weighting factor, and the information was not appropriately assembled (see Section 4.2.1 above). Due to both these considerations, the ATM conditional age at length data were excluded from the final model.
2. Sensitivity to the weighting of the ATM length composition data: Model results were insensitive to the use of a) Francis weights (see TA1.8 in Appendix A of Francis, 2011), b) weighting by haul, and c) arbitrary up-weighting (by a factor of 20). In conclusion weighting of ATM length composition was regarded as a minor issue. However, close examination of year 2011 and 2012 data from the ATM indicates potential incompatibility between the observed length frequencies and the model assumptions of invariant growth over years. The disparity resulted in the potential for two different states which depended on the data weighting. Sensitivity to these two years length composition data was tested (by omission of length from those years), and the weighting chosen that minimized the influence of these data. Overall it is unclear if the observations are correct and the growth assumptions in the assessment model are too simplistic or the precision of the local estimates used to raise local length compositions in the ATM survey are too large. (See research recommendations).
3. Sensitivity to weighting of the fishery conditional age at length data: A range of weighting factors less than 1 were explored. The sensitivity observed depended on whether ATM q was estimated or fixed (q=1). Model outputs were more stable when q was fixed.
4. Sensitivity to weighting of the fishery length composition data: Two options were investigated: weighting by haul and using the Francis (2011) method. When q is estimated, the use of Francis weights resulted in unrealistically low estimates of q (0.2-0.3). For haul-based weights, estimates of ATM q included the value of 1 within the range of weights considered.
5. Sensitivity to estimation of ATM q: Three options were explored: (a) separate estimated qs for the spring and summer surveys, (b) a single estimated q for both surveys, and (c) a fixed q=1 for both surveys. The sensitivity of the model output to how the fishery conditional age at length data are weighted was considerable. Given the rather arbitrary conditional age at length weights being applied for Model G, and that the sensitivity to these could be considerably reduced by fixing

q=1, it was decided to choose this option in the final model, thereby reducing the sensitivity of the model results to weighting which could not be easily justified.

6. Sensitivity to selectivity options for ATM survey: Two options were explored: a single selectivity pattern for both ATM surveys or separate selectivity patterns by survey. When estimated separately, selectivity for the spring survey was near-knife edge at around 16cm, and that for the summer survey shifted to higher lengths in comparison. When estimated as a single selection pattern, the result was a much longer shallower curve, starting in a similar place to that estimated for the spring survey and extending to even greater lengths than that estimated for the summer survey. This change probably results from a requirement to include fish between 15 and 18cm in the spring survey, while giving reduced selection at around 20cm for the summer survey. This results in a reduction in selectivity for a range of lengths greater than 22cm that were not observed for either of the surveys when used with the separate selection patterns. This change to catchability of larger sardine was considered an inappropriate model response resulting from an unreasonable limitation of a single selection pattern. Based on these considerations two separate selections patterns were used in the final model.

It was clear from the sensitivity exploration (Table 1) that solutions that gave plausible q close to unity for the ATM were preferred. This could be obtained by setting data weights to achieve this or explicitly including this requirement in the model. Given that the assessment would be used for at least one more year before further review data weighting, that might be sensitive to new data values, was considered a poor option and setting q=1 for the ATM was the preferred option.

The final base model incorporates the following specifications:

- two seasons (Jul-Dec and Jan-Jun) (assessment years 1993 to 2013);
- sex is combined;
- two fishery fleets (MexCal, PacNW), with an annual selectivity pattern for the PacNW fleet, and seasonal selectivity patterns (S1 and S2) for the MexCal fleet;
  - MexCal fleet:
    - double-normal (i.e. dome-shaped) length-selectivity with two periods of time-blocking (1993-1998, 1999-2012)
  - PacNW fleet:
    - asymptotic length-selectivity for the a single period
  - Length compositions with effective sample size set to 1 per haul and lambda weighting =1
  - Conditional age at length with effective sample size set to 1 per haul and lambda weighting = 0.2
- Beverton-Holt stock-recruitment relationship “steepness” set to 0.8;
- M = 0.4 yr^{-1}; σ_R = 0.75 (fixed value);
- recruitment residuals estimated for 1987-2013;
- length-frequency and conditional age-at-length data for all fisheries;
- virgin (R_0) and initial recruitment offset (R_1) were estimated;
- initial *F*s set to 0 for all fleets;
- DEPM and TEP indices of spawning biomass; *q* estimated;

- acoustic-trawl (ATM) survey biomass 2006-2013, *q*=1;
  - Length compositions with effective sample sizes set by dividing the number of fish sampled by 25 and lambda weighting =1
  - asymptotic length-selectivity separately for spring and summer surveys
  - Conditional age at length from the ATM surveys excluded
- NWSS aerial photogrammetric surveys of biomass excluded
  (The Panel agrees that the final base model represents the best available science regarding the status of the northern subpopulation of Pacific sardine. The Panel wishes to highlight that the level of variation in terminal biomass evident from the retrospective pattern (on the order of 100,000s of tons from one year to the next; Figure 7 of this report) is not unexpected and has been seen in previous assessments (PFMC, 2011). Changes in terminal 1+ biomass estimates used for management of this magnitude may occur when the 2015 assessment update take place.)

On the final day of the review, the STAT provided the Panel with additional model variants with three time blocks for selectivity for the Pacific Northwest fishery. The other settings were: ATM survey catchability was assumed to be 1 or estimated, separate selectivity patterns were estimated for the spring and summer ATM surveys, the weighting factors for the length-frequency, and the conditional age-at-length data were set to 1 for the fishery data and to zero for the ATM surveys. There was insufficient time to fully evaluate these options, but it is considered that it would be a valuable model configuration to consider along with sensitivity to data weighting for a future full assessment.

A further 'bases case' assessment based on applying the final base model (see above) in which the catch series is constructed by assuming that all catches off Ensenada and north are from the northern subpopulation (See Section 4.7). It is considered that this model could be used to form the basis for management advice if the model using the environmentally-based catch series cannot be used for management purposes.

Some additional aspects were considered relevant.

- There is some misalignment between the modeled and observed length. The time step in the model is 6 months, whereas the ATM survey is completed in around one month. Growth occurs through the six month period so the width (sigma) on the catch length distribution needs to be wider than the distribution at length observed by the survey. This can be seen in either bubble plots of residuals at length for the survey or observed and modeled length distributions. Such conflict which relates to the model formulation / time step might be resolved if age based data were used or the ATM survey given a different sigma for spread of length.
- While the ATM survey appears, at first glance, to pick up cohorts correctly, there is some mismatch between spring survey estimates at length in 2010 and 2011. This mismatch does appear to lead to some instability in the model estimates of abundance.
- There are indications that the overall growth assumptions do not align with the conditional age at length information. This is one reason for observed model

instability and the decision to remove the conditional age at length data for the ATM and to down-weight the conditional age at length data for the catch though the first of these was not necessarily assembled correctly and the latter is partial, missing Mexican and Canadian age at length data. Nevertheless it is unclear if fixing these deficiencies will solve the problems.

- If there is a desire to look for ways to stabilize the model, other than the assumption of ATM q=1, collection of more complete age at length data, on both ATM surveys and fisheries, may be one way to resolve whether the issues are that, fishery selection is changing due to different spatial distributions at length by season, or whether growth is more variable than the current model implies. As selection in the fisheries is dominated by the spatial interaction of the migrating stock and different locations of each of the regional fisheries, unlike selection based on gear characteristics it is not possible to determine a priori the form of the selection (by age or by length). Alternatives to the collection of more complete and better quality age data would be: a) to invest more in the aerial survey, both in terms of spatial coverage and more rigorous sampling for species identification and size, and more accurate school density estimation; and b) to investigate further what would be needed to improve the accuracy of the DEPM. However, both of these are likely to be much more expensive than improving the collection of age data.

4.5. Estimates of 1+ biomass in the advice year

The assessment provided estimates of 1+ biomass which are required to give catch advice for Pacific sardine. However, the modeling environment does not provide estimates of precision of the 1+ biomass. It is understood that it is intended to extend the model output to include precision of this quantity, and this development should be encouraged. However, it needs to be kept in mind that a substantial part of the uncertainty regarding 1+ biomass comes from the model specification, not just from precision of the estimates given the model and the data. To fully include useful estimates of precision requires methodology that accounts for multiple models with precision, to at least account for some of the model uncertainty.

Recruitment estimation and environmental variables

The estimate of the most recent recruitment in the assessment model (age 1 in 2013) is rather uncertain and is estimated by the model to be close to the expected value from the stock-recruitment function. Deviations of sardine recruitment from a fitted stock-recruitment model of either Ricker or Beverton-Holt form is observed to be correlated in time, such that there appear to be periods of ‘high’ recruitment and separate periods of ‘low’ recruitment. Investigations of the potential for environmental factors to be informative have been conducted by Zwolinski and Demer (2014 in press). They showed that the variability in sardine recruitment in the California Current during the last three decades mimics aspects of the environment in the North Pacific indicated by the Pacific Decadal Oscillation (PDO) index. They report that the average number of recruits per

biomass during “warm” periods was more than threefold higher than that during “cold” periods. In addition to the environmental conditions experienced by sardine larvae, variability in sardine recruitment is also partially explained by both the environmental conditions many months before the spawning season and the adult condition factor.

Management of the stock uses information on the biomass of age 1+ sardine when applying the Overfishing Level and Acceptable Biological Catch control rules.

Estimated recruitment in the last few years has been lower than expected from the stock-recruitment relationship used in the assessment model. Improved estimation (or prediction) of age 1 recruitment for the most recent year would improve management advice for the Pacific sardine stock as the assessment model currently leads to a rather imprecise and, because of the correlation, potentially biased estimate of this quantity. There are a number of potential approaches to improve on this:

1. Use of a prediction model based on recent recruitment and observed autocorrelation could be used to give potentially more likely estimates of recruits in the final year without assigning any specific underlying reason for the recruitment.
2. Development of a recruitment prediction index such as that proposed by Zwolinski and Demer (2014 in press) could be used outside the assessment to replace the assessed value with an alternative value based on a weighted mean of the assessed and index-derived values. One method of determining appropriate weights might be taken from Shepherd (1997).
3. Inclusion of informative environmental indices within the assessment.

When investigating environmental drivers to explain recruitment, a number of issues need to be considered:

- The spawning biomass and recruitment pairs estimated in an assessment are subject to uncertainty, and this needs to be accounted for when estimating the prediction intervals for any potential index.
- Development of environmental indices (for recruitment) through regression analysis needs to be undertaken with care. There are often many explanatory environmental variables available to be tested. The approach is often to examine many potential variables to establish the most powerful explanatory set. However, to understand the significance of the conclusions it is important to recognise that exclusion of unsuitable variables is effectively setting the coefficient for the relationship for that variable to zero. This needs to be accounted for correctly in tests for overall significance by, for example, removing one degree of freedom for every variable (or variable at lag) rejected. This can be done easily for variables formally tested, but may be more difficult to include where variables are rejected at an early stage based on simple graphical investigation. Currently there are 20 stock-recruitment pairs for Pacific sardine; rejection of 18 potential variables (and or lags) while a relationship is being developed should result in a perception of no significant fit. Failure to consider this can lead to an over-optimistic perception of the utility of explanatory functions;

see for example Gröger *et al*. (2010) who examined many potential indices and a wide variety of lags and considered they had found significant drivers for recruitment.

The stock assessment was based on NSP catch data only (See Section 4.3). The model can also be fitted to all catches from US, Canada and Ensenada, A comparison of the biomass trajectory for final model when it is applied to the NSP and total catch series shows a simple relationship and either estimate can be used for management of the fisheries depending on the stock definition requirements of managers.

4.6. Research Recommendations

Research recommendations have been provided in the STAR Panel report. Many, but not all, are repeated here as they result from this specific review.

High priority

1. The assessment would benefit not only from data from Mexico and Canada, but also from joint assessment, which includes assessment team members from these countries.
2. Modify Stock Synthesis so that the standard errors of the logarithms of 1+ biomass can be reported. These biomasses are used when computing the Overfishing Level, the Acceptable Biological catch, and the Harvest Level, but the CV used when applying the ABC control rule is currently that associated with spawning biomass and not 1+ biomass.
3. Investigate sensitivity of the assessment to the threshold used in the environmental-based method (currently 50% favorable habitat) to delineate the southern and northern subpopulations of Pacific sardine; the exploration of sensitivity in the present assessment was limited given time available, but suggested there would be some sensitivity to this cut-off.
4. Compute age-composition data for the ATM survey by multiplying weighted length-frequencies by appropriately constructed age-length keys (i.e. taking account of where the samples were taken).
5. Explore the disparity between ATM estimates at length and conditional age at length. Consider increased sampling at age to obtain clear understanding if differences at length are also the result of differences in age or just differences in growth.
6. Investigate alternative approaches for dealing with highly uncertain estimates of recruitment that have an impact on the most recent estimate of 1+biomass that is important for management. Possible approaches are outlined in Section 4.5 of this report.
7. Validation of the environmentally-based stock splitting method should be carried out if management is to be based on separating the northern and southern subpopulations using the habitat model. It may be possible to develop simple discriminant factors to differentiate the two sub-populations by comparing metrics from areas where mixing does not occur. Once statistically significant discriminant metrics (e.g. morphometric, otolith morphology, otolith micro-structure and possibly using more recent

developments in genetic methods) have been chosen, these should be applied to samples from areas where mixing may be occurring or where habitat is close to the environmentally-based boundary. This can be used to help to set either a threshold or to allocate proportions if mixing is occurring.

Medium priority

1. Continue to explore possible additional fishery-independent data sources.
2. The Panel continues to support expansion of coast-wide sampling of adult fish for use when estimating parameters in the DEPM method and when computing biomass from the acoustic-trawl surveys. Direct comparison between individual samples in survey and fishery should be used to inform model choices. Also encourage sampling in Mexican and Canadian waters.
3. Consider spatial models for Pacific sardine, which can be used to explore the implications of regional recruitment patterns and region-specific biological parameters. These models could be used to identify critical biological data gaps as well as better represent the latitudinal variation in size-at-age.
4. Consider a model which has separate fleets for Mexico, California, Oregon-Washington and Canada.
5. Consider model configurations which use age-composition rather than length-composition and conditional age-at-length data given evidence for time- and spatially-varying growth.
6. Compare annual length-composition data for the Ensenada fishery that are not omitted from MexCal data set for the NSP scenario with the corresponding southern California length compositions. Also, compare the annual length-composition data for the Oregon-Washington catches with those for the British Columbia fishery. This is particularly important if a future age-based model is to be applied.
7. Further explore methods to reduce between-reader ageing bias. In particular, consider comparisons among laboratories and assess whether the age-reading protocol can be improved to reduce among-ager variation.
8. Change the method for allocating area in the DEPM method so that the appropriate area allocation for each point is included in the relevant stratum. Also, apply a method that better accounts for transect-based sampling and correlated observations that reflect the presence of a spawning aggregation.
9. Consider future research on natural mortality. Note that changes to the assumed value for natural mortality may lead to a need for further changes to harvest control rules.

5. Panel review proceedings

Item 3 of the ToR involved documenting meeting discussion with reference to technical aspects of stock assessment work. Item 6 related to the requirement for the STAR Panel to provide ‘a risk neutral approach’ in its reports and deliberations.

I was impressed overall with the quality of this review and all who participated in it, I would like to thank all involved for their efforts. In particular I would like to thank the presenters for their hard work in prepared presentations and the chair for his work guiding the review and for the work assembling and editing the review group report. In particular I would like to thank Paul Crone and Kevin Hill for their willingness to carry out additional model runs to help clarify the model sensitivity and Andre Punt for this hard work as chair of the Panel.

All the data and assessment reports were provided on time. The presentations covered most issues well. A small improvement would be to ask presenters to refocus the presentation of the assessment results more to sensitivities than primarily the model results. The current approach was a description of the approach and the stages along the way, which provides an insight to the process rather than the results. The important aspects are the differences between the new model and previously agreed assessments, the changes resulting from new data and then the sensitivity to critical assumptions. Nevertheless these aspects are minor and I consider that overall the final review was of a high standard.

The final draft of the Star Panel report was completed on time.

6. Conclusion and Recommendations

The reports and presentations and additional model runs provided an excellent basis to evaluate the performance of the assessment. It is agreed that the assessments are effective in delineating stock status, they are particularly good at projecting probable short-term trends in stock biomass, fishing mortality, and catches. The science reviewed was of a high standard and could be classed as ‘of the best scientific information available’. Comments given throughout this report should not be read as direct criticism of what has been done, rather ideas of areas for development. In retrospect one can always find room for improvement, and as such minor suggestions have been made throughout this report which should not be considered prescriptive or limiting but rather as aspects for careful consideration. A number of research recommendations are included in Section 4.6.

I fully endorse the panel agreement that the final base model represents the best available science regarding the status of the northern subpopulation of Pacific sardine. It is also important to reiterate that the level of variation in terminal biomass evident from the retrospective pattern (on the order of 100,000s of tons from one year to the next) is not unexpected and has been seen in previous assessments (PFMC, 2011). It is likely that changes in terminal 1+ biomass estimates used for management of this magnitude may occur when the 2015 assessment update takes place.

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Appendix 2: Statement of Work

External Independent Peer Review by the Center for Independent Experts

STAR Panel Review of the 2014-2015 Pacific Sardine Stock Assessment

March 3-5, 2014

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Technical Representative (COTR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Appendix 1**. This SoW describes the work tasks and deliverables of the CIE reviewers for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description: The CIE reviewers will serve on a Stock Assessment Review (STAR) Panel and will be expected to participate in the review of Pacific sardine stock assessment. The Pacific sardine stock is assessed regularly (currently, every 1-2 years) by SWFSC scientists, and the Pacific Fishery Management Council (PFMC) uses the resulting biomass estimate to establish an annual harvest guideline (quota). The stock assessment data and model are formally reviewed by a Stock Assessment Review (STAR) Panel once every three years, with a coastal pelagic species subcommittee of the SSC reviewing updates in interim years. Independent peer review is required by the PFMC review process. The STAR Panel will review draft stock assessment documents and any other pertinent information for Pacific sardine, work with the stock assessment teams to make necessary revisions, and produce a STAR Panel report for use by the PFMC and other interested persons for developing management recommendations for the fishery. The PFMC's Terms of Reference (ToRs) for the STAR Panel review are attached in **Appendix 2**. The tentative agenda of the Panel review meeting is attached in **Appendix 3**. Finally, a Panel summary report template is attached as **Appendix 4**.

Requirements for CIE Reviewers: Two CIE reviewers shall participate during a panel review meeting in La Jolla, California during 3-5 March, and shall conduct an impartial and independent peer review accordance with the SoW and ToRs herein. The CIE

reviewers shall have the expertise as listed in the following descending order of importance:

- The CIE reviewer shall have expertise in the application of fish stock assessment methods, particularly, length/age-structured modeling approaches, e.g., 'forward-simulation' models (such as Stock Synthesis, SS) and it is desirable to have familiarity in 'backward-simulation' models (such as Virtual Population Analysis, VPA).
- The CIE reviewer shall have expertise in the life history strategies and population dynamics of coastal pelagic fishes.
- It is desirable for the CIE reviewer to be familiar with the design and execution of fishery-independent surveys for coastal pelagic fishes.
- It is desirable for the CIE reviewer to be familiar with the design and application of fisheries underwater acoustic technology to estimate fish abundance for stock assessment.
- It is desirable for the CIE reviewer to be familiar with the design and application of aerial surveys to estimate fish abundance for stock assessment.

The CIE reviewer's duties shall not exceed a maximum of 14 days to complete all work tasks of the peer review process.

Location/Date of Peer Review: The CIE reviewers shall conduct an independent peer review during the STAR Panel review meeting at NOAA Fisheries, Southwest Fisheries Science Center, 8901 La Jolla Shores, La Jolla, California from March 3-5, 2014.

Statement of Tasks: The CIE reviewers shall complete the following tasks in accordance with the SoW, ToRs and Schedule of Milestones and Deliverables specified herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selections by the CIE Steering committee, the CIE shall provide the CIE reviewers information (name, affiliation, and contact details) to the COTR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents, reports, foreign national security clearance, and information concerning other pertinent meeting arrangements. The NMFS Project Contact is also responsible for providing the Chair a copy of the SoW in advance of the panel review meeting. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

Foreign National Security Clearance: When CIE reviewers participate during a panel review meeting at a government facility, the NMFS Project Contact is responsible for obtaining the Foreign National Security Clearance approval for CIE reviewers who are non-US citizens. For this reason, the CIE reviewers shall provide requested information (e.g., first and last name, contact information, gender, birth date, passport number,

country of passport, travel dates, country of citizenship, country of current residence, and home country) to the NMFS Project Contact for the purpose of their security clearance, and this information shall be submitted at least 30 days before the peer review in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations available at the Deemed Exports NAO website: http://deemedexports.noaa.gov/compliance_access_control_procedures/noaa-foreign-national-registration-system.html

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send by electronic mail or make available at an FTP site to the CIE reviewers all necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE on where to send documents. The CIE reviewers shall read all documents in preparation for the peer review, for example:

- Recent stock assessment documents since 2013;
- STAR Panel- and SSC-related documents pertaining to reviews of past assessments;
- CIE-related summary reports pertaining to past assessments; and
- Miscellaneous documents, such as ToR, logistical considerations.

Pre-review documents will be provided up to two weeks before the peer review. Any delays in submission of pre-review documents for the CIE peer review will result in delays with the CIE peer review process, including a SoW modification to the schedule of milestones and deliverables. Furthermore, the CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein.

Panel Review Meeting: The CIE reviewers shall conduct the independent peer review in accordance with the SoW and ToRs. **Modifications to the SoW and ToR cannot be made during the peer review, and any SoW or ToR modification prior to the peer review shall be approved by the COTR and CIE Lead Coordinator.** The CIE reviewers shall actively participate in a professional and respectful manner as a member of the meeting review panel, and their peer review tasks shall be focused on the ToRs as specified in the contract SoW.

Respective roles of the CIE reviewers and STAR Panel chair are described in Appendix 2 (see p. 6-8). The CIE reviewers will serve a role that is equivalent to the other panelists, differing only in the fact that he/she are considered an 'external' member (i.e., outside the Pacific Fishery Management Council family and not involved in management or assessment of West Coast CPS). The CIE reviewers will serve at the behest of the STAR Panel Chair, adhering to all aspects of the PFMC's ToR as described in Appendix 2. The STAR Panel chair is responsible for: 1) developing an agenda, 2) ensuring that STAR Panel members (including the CIE reviewers), and STAT Teams follow the Terms of Reference, 3) participating in the review of the assessment (along with the CIE

reviewers), 4) guiding the STAR Panel (including the CIE Reviewers) and STAT Team to mutually agreeable solutions.

The NMFS Project Contact is responsible for any facility arrangements (e.g., conference room for panel review meetings or teleconference arrangements). The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements, including the meeting facility arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: The CIE reviewers shall complete an independent peer review report in accordance with the SoW. The CIE reviewers shall complete the independent peer review according to required format and content as described in Appendix 1. The CIE reviewers shall complete the independent peer review addressing each ToR as described in Appendix 2.

Other Tasks – Contribution to Summary Report: The CIE reviewers will assist the Chair of the panel review meeting with contributions to the Summary Report. The CIE reviewers are not required to reach a consensus, and should instead provide a brief summary of their views on the summary of findings and conclusions reached by the review panel in accordance with the ToRs.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by the CIE reviewers in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review;
2) Participate during the panel review meeting in La Jolla, California during March 3-5, 2014 as called for in the SoW, and conduct an independent peer review in accordance with the ToRs (Appendix 2);
3) No later than March 24, 2014, the CIE reviewers shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and Dr. David Die., CIE Regional Coordinator, via email to ddie@rsmas.miami.edu. The CIE report shall be written using the format and content requirements specified in Appendix 1, and address each ToR in Appendix 2.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

January 20, 2014	CIE sends reviewers contact information to the COTR, who then sends this to the NMFS Project Contact

February 14, 2014	NMFS Project Contact sends the CIE Reviewers the pre-review documents
March 3-5, 2014	The reviewers participate and conduct an independent peer review during the panel review meeting
March 24, 2014	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
April 14, 2014	CIE submits CIE independent peer review reports to the COTR
April 22, 2014	The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: Requests to modify this SoW must be made through the Contracting Officer's Technical Representative (COTR) who submits the modification for approval to the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the CIE within 10 working days after receipt of all required information of the decision on substitutions. The COTR can approve changes to the milestone dates, list of pre-review documents, and Terms of Reference (ToR) of the SoW as long as the role and ability of the CIE Reviewers to complete the SoW deliverable in accordance with the ToRs and deliverable schedule are not adversely impacted. The SoW and ToRs cannot be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (the CIE independent peer review reports) to the COTR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COTR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards: (1) the CIE report shall have the format and content in accordance with Appendix 1, (2) the CIE report shall address each ToR as specified in Appendix 2, (3) the CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon notification of acceptance by the COTR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to

the COTR. The COTR will distribute the approved CIE reports to the NMFS Project Contact and regional Center Director.

Support Personnel:

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Appendix 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations.

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR, and Conclusions and Recommendations in accordance with the ToRs.

   a. Reviewer should describe in their own words the review activities completed during the panel review meeting, including providing a detailed summary of findings, conclusions, and recommendations.

   b. Reviewer should discuss their independent views on each ToR even if these were consistent with those of other panelists, and especially where there were divergent views.

   c. Reviewer should elaborate on any points raised in the Summary Report that they feel might require further clarification.

   d. Reviewer shall provide a critique of the NMFS review process, including suggestions for improvements of both process and products.

   e. The CIE independent report shall be a stand-alone document for others to understand the proceedings and findings of the meeting, regardless of whether or not they read the summary report. The CIE independent report shall be an independent peer review of each ToRs, and shall not simply repeat the contents of the summary report.

3. The reviewer report shall include as separate appendices as follows:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Statement of Work
   Appendix 3: Panel Membership or other pertinent information from the panel review meeting.

Appendix 2: Terms of Reference for the Peer Review of the Pacific sardine stock assessment

The CIE reviewers are one of the four equal members of the STAR panel. The principal responsibilities of the STAR Panel are to review stock assessment data inputs, analytical models, and to provide complete STAR Panel reports.

Along with the entire STAR Panel, the CIE Reviewer's duties include:
1. Reviewing draft stock assessment and other pertinent information (e.g.; previous assessments and STAR Panel reports);
2. Working with STAT Teams to ensure assessments are reviewed as needed;
3. Documenting meeting discussions;
4. Reviewing summaries of stock status (prepared by STAT Teams) for inclusion in the Stock Assessment and Fishery Evaluation (SAFE) document;
5. Recommending alternative methods and/or modifications of proposed methods, as appropriate during the STAR Panel meeting, and;
6. The STAR Panel's terms of reference concern technical aspects of stock assessment work. The STAR Panel should strive for a risk neutral approach in its reports and deliberations.

The STAR Panel, including the CIE Reviewers, are responsible for determining if a stock assessment or technical analysis is sufficiently complete. It is their responsibility to identify assessments that cannot be reviewed or completed for any reason. The decision that an assessment is complete should be made by Panel consensus. If agreement cannot be reached, then the nature of the disagreement must be described in the Panels' and CIE Reviewer's reports.

The review solely concerns technical aspects of stock assessment. It is therefore important that the Panel strive for a risk neutral perspective in its reports and deliberations. Assessment results based on model scenarios that have a flawed technical basis, or are questionable on other grounds, should be identified by the Panel and excluded from the set upon which management advice is to be developed. The STAR Panel should comment on the degree to which the accepted model scenarios describe and quantify the major sources of uncertainty Confidence intervals of indices and model outputs, as well as other measures of uncertainty that could affect management decisions, should be provided in completed stock assessments and the reports prepared by STAR Panels.

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

Appendix 3: Review Group Agenda CPS STAR PANEL and Participants

Monday 3 March

08h30	Call to Order and Administrative Matters	
	Introductions	Punt/Key
	Facilites, e-mail, network, etc.	Sweetnam
	Work plan and Terms of Reference	Griffin
	Report Outline and Appointment of Rapporteurs	Punt/Key
09h00	Pacific Sardine assessment presentation	Hill/Crone
10h00	Break	
10h30	Pacific Sardine assessment presentation	Hill/Crone
11h30	Acoustic and trawl survey	Zwolinski
12h00	Bayesian estimates of spawning fraction	Dorval
12h30	Lunch	
13h30	Pacific Sardine assessment presentation (continue)	Hill/Crone
14h30	Panel discussion and analysis requests	Panel
15h00	Break	
15h30	Public comments and general issues	
17h00	Adjourn	

Tuesday 4 March

08h00.	Assessment Team Responses	Hill/Crone
10h30	Break	
11h00.	Discussion and STAR Panel requests	Panel
12h30	Lunch	
13h30	Report drafting	Panel
15h00	Break	
15h30	Assessment Team Responses	Hill/Crone
16h30	Discussion and STAR Panel requests	
17h00	Adjourn	

Wednesday 5 March

08h00.	Assessment Team Responses	Hill/Crone
10h30	Break	
11h00.	Discussion and STAR Panel requests	Panel
12h30	Lunch	
13h30	Finalize STAR Panel Report	Panel
15h00	Break	
15h30	Finalize STAR Panel Report	Panel
17h00	Adjourn	

Participants 2014 Pacific Sardine STAR Panel

STAR Panel Members

André Punt (Chair), SSC, University of Washington
Meisha Key, SSC, CDFW – California Department of Fish and Wildlife
José de Oliveira, CIE Reviewer, CEFAS - Centre for Environment, Fisheries & Aquaculture Science, UK
John Simmonds, CIE Reviewer, ICES – International Council for the Exploration of the Sea, Denmark
Diane Pleschner-Steele, CPSAS - Coastal Pelagic Species Advisory Sub panel Advisor to STAR Panel
Chelsea Protasio, CPSMT - Coastal Pelagic Species Management Team Advisor to STAR Panel

STAT Report

Kevin Hill, SWFSC - Southwest Fisheries Science Center
Paul Crone, SWFSC - SOUTHWEST FISHERIES SCIENCE CENTER

Other STAT presenters

David Demer, SWFSC - SOUTHWEST FISHERIES SCIENCE CENTER
Emmanis Dorval, SWFSC - SOUTHWEST FISHERIES SCIENCE CENTER
Juan Zwolinski, SWFSC - SOUTHWEST FISHERIES SCIENCE CENTER

Other Attendees

Jenny McDaniel, SWFSC - SOUTHWEST FISHERIES SCIENCE CENTER
Beverly Macewicz, SWFSC - SOUTHWEST FISHERIES SCIENCE CENTER
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Individual CIE Report

STAR Panel Review of 2014-2015 Pacific Sardine Stock Assessment

Southwest Fisheries Science Center, La Jolla, California, 3-5 March 2014

Prepared for the Center for Independent Experts

By

Dr José A. A. De Oliveira

April 2014

Cefas Contract C5386

COMMERCIAL IN CONFIDENCE

Executive Summary

A STAR Panel review of the 2014-2015 stock assessment of the northern subpopulation of Pacific sardine (*Sardinops sagax*) was held during 3-5 March 2014 in La Jolla, California. The review activities included reviewing the draft stock assessment and other pertinent information provided in advance of the review meeting, working with the STAT team to ensure input data and assessment models are reviewed as necessary, and recommending alternative methods and/or modifications to proposed methods, as appropriate. This report describes the material and methods provided for the review, and focuses on the review activities leading up to the selection of the final model for the 2014-2015 stock assessment, providing a summary of findings and recommendations. Review activities focussed primarily on alternative weighting for compositional data and found that, although abundance trends were generally well-determined by the available data, the absolute scale of the population was highly uncertain, with small changes to the model leading to large changes in scale. The assumption of catchability equal to 1 for both the ATM spring and summer surveys was key to reducing sensitivity to scale, although biomass estimates for the early years of the assessment remained volatile. The Panel could find no reason to disagree with the STAT's decision to omit the NWSS aerial survey from the assessment, and also supported the omission of the ATM conditional age-at-length data from the assessment, because the age-length keys that they relied on were inappropriately assembled, and model results were highly sensitive to alternative weightings for these data. The final model continued to show a high level of variation in terminal biomass (reflected by a strong retrospective pattern), but this has been seen in the past for this stock and will likely continue to be the case in future assessments. The Panel report provides results for the final model for both options for assigning catch to the northern subpopulation, the first using an environmentally-based method to remove southern subpopulation fish from the Mexican-southern Californian fleet data, and the second assuming all catches taken by the Mexican-southern Californian fleet belong to the northern subpopulation. The Panel concluded that the final model represented the best available science regarding the current status of the northern subpopulation of Pacific sardine. The CIE reviewer fully supports and endorses the Panel's findings and recommendations, as reflected in their report.

Background

The review concerns the 2014-2015 stock assessment for the northern subpopulation of Pacific sardine (*Sardinops sagax*). The majority of review material (including detailed output for two proposed models, and the draft assessment report) was made available through the FTP site (http://swfscftp.noaa.gov/) between 19-21 February 2014 – the review material made available before, during and after the STAR Panel review meeting is given in Annex 1. The actual STAR Panel review took place at the Southwest Fisheries Science Center in La Jolla, California over 3-5 March 2014. Details of this meeting, including Terms of Reference and Agenda, can be found in Annex 2 and its Appendices, and a list of participants in Annex 3.

The STAR Panel comprised four equal members, two of which were CIE reviewers (see Annex 3). The main responsibilities of the STAR Panel were as follows:

(a) Review stock assessment data inputs.
(b) Review the analytical models presented.
(c) Provide complete STAR Panel reports.

In particular, the STAR Panel are responsible for determining if a stock assessment or technical analysis is sufficiently complete, with any decision on this having to be made by Panel consensus.

Along with the entire STAR Panel, the CIE Reviewer's duties included the following:

1. Reviewing the draft stock assessment and other pertinent information (e.g. previous assessments and STAR Panel reports).
   This was done by reviewing material provided prior to and during the meeting (Annex 1).
2. Working with STAT Team to ensure assessments are reviewed as needed.
   A number of requests were made to explore model sensitivity to alternative parameterisations and data weighting scenarios, including the exclusion of some data (Annex 4).
3. Documenting meeting discussions.
   These are reflected in the STAR Panel report and below.
4. Reviewing summaries of stock status (prepared by STAT Team) for inclusion in the Stock Assessment and Fishery Evaluation (SAFE) document.
   These were provided during the meeting in the form of detailed model outputs for the final model (T-2_0.2; see Annex 5 for description), uploaded to the FTP site.
5. Recommending alternative methods and/or modifications of proposed methods, as appropriate, during the STAR Panel meeting.
   These were reflected in the number of requests the STAR Panel made to the STAT (Annex 4) as well as the research recommendations (see STAR Panel report and below).
6. The STAR Panel's terms of references concern technical aspects of stock assessment work. The STAR Panel should strive for a risk neutral approach in its reports and deliberations.
   The STAR Panel indeed kept to technical aspects of the stock assessment and its input data.

Following the meeting, a careful review of the STAR Panel report was conducted and suggestions made for improvements, making sure that all statements and conclusions were

backed up and justified by model outputs and results. The STAT was requested to add key model outputs to the FTP site that were needed for the purposes of corroboration.

Review activities and findings

The Agenda for the meeting is given in Appendix 3 of Annex 2, and detailed descriptions with accompanying rationale and outcomes for all review requests provided in Annex 4. This section attempts to summarise these activities and their findings.

Presentations

Presentations included a description of the seasonal distributions of the northern subpopulation, with associated fishing areas and modelled fleets; a description of the fishery data (landings and length and age compositions for the MexCal fleet by semester, and for the PacNW fleet by year); a description of the general survey areas for the spring and summer ATM surveys, the spring DEPM/TEP survey, and the summer NWSS aerial survey; a description of the survey time series available for each of these surveys, as well as the associated length and age compositions for the ATM surveys, and the length compositions for the NWSS aerial survey. In-depth presentations were made on methodology for the DEPM surveys and estimation procedure, and the ATM spring and summer surveys, including the environmental method used to differentiate between the northern and southern subpopulations of Pacific sardine. There was no specific presentation on the NWSS aerial survey, but a summary was provided by email and included in the Panel report. Key aspects of blended models G and H (results of which had been made available prior to the meeting on the FTP site and in the draft assessment document, along with a range of sensitivity analyses) were presented and compared with each other and with previous assessment results. The key difference between models G and H was that the former assumed length-specific selection by fitting to length-composition data, and estimated growth by fitting to conditional age-at-length data (which was down-weighting further relative to input weights), while the latter assumed age-specific selection by fitting the age-composition data and setting growth parameters to pre-specified values. The Stock Synthesis version used for the 2014-2015 assessment models was Version 3.24s. A presentation on issues affecting the use of composition data, including data weighting (a key concern for the Pacific sardine assessment) was given.

Exploring input data

Differentiating the northern subpopulation

A key concern for the assessment (and one highlighted by past Panels as a high research priority) was that catches should be appropriately allocated to the northern and southern subpopulations of Pacific sardine; to this end, an environmentally-based method was developed and used to exclude some of the data (catches and associated composition data) belonging to the southern subpopulation (taken in the San Pedro and Ensenada fisheries, the southern portion of the MexCal fleet) from the assessment. The Panel and STAT were in favour of this new approach, but foresaw difficulties for management related to setting catch levels for a portion of a population (the southern subpopulation) for which there is no assessment. A decision was therefore made to conduct all sensitivity analyses using the environmentally-based method for deriving the northern subpopulation fishery data, but then to present the final model as two versions, one where the environmentally-based method is

used to remove southern subpopulation fish from the MexCal fleet data, and the other assuming that all catches taken in the MexCal fleet belong to the northern subpopulation. Request C (Annex 4) found that the environmentally-based method was potentially sensitive to the threshold used to switch between whether an area was more suitable for the northern or for the southern subpopulation; if further analysis continues to find the method sensitive for plausible alternative threshold values, it may require further refinement.

DEPM survey

The Panel highlighted two minor issues with the DEPM estimation procedures that, although they may not lead to large changes in the estimates, nevertheless need to be corrected. These related to the appropriate area allocation for each point in each of two strata (high and low density), and appropriately accounting for transect-based sampling and correlated observations.

ATM surveys

During spring 2013, it was noticed that the ATM survey did not venture north of San Francisco, and concern was expressed that suitable habitat for sardine at the time may have been missed (Request D, Annex 4). However, an overlay of a habitat map with the survey results did not show evidence of this being the case, suggesting that the survey did indeed provide an adequate sample of the population. Furthermore, the ATM survey team considered the spring 2012 ATM survey length frequency as unreliable, and sensitivity tests explored the omission of this data (Request S, Annex 4) as well as the omission of the spring 2011 ATM survey length frequency data (Request U, Annex 4), since model fits to both these length frequencies were always poor. The latter request (U) helped in the selection of appropriate weighting for compositional data in the final model; however, the final model included both these length frequencies. The ATM survey team were also asked to investigate the apparent discrepancy between the biomass estimates from the ATM survey in the Oregon-Washington area during summer 2012 and the contemporaneous landings in the area (Request E, Annex 4); they found that point estimates from the survey comfortably exceeded the landings, and that assuming fish had migrated from the south, the landings were below the lower 95% confidence bound for combined survey estimate for the same period and area, and for the area to the north of it surveyed immediately afterwards.

Conditional age-at-length for the ATM surveys

When constructing ALKs for fish aged during ATM surveys, no weighting was used (aged fish were simply combined into a single ALK), despite possible differences between regions (e.g. separate ALKs were used for the MexCal and PacNW fleets). This treatment is not optimal, given the possibility for age- and size-specific distribution of sardine. This was one of the reasons the Panel supported the removal of conditional age-at-length data for the ATM surveys from the final model. Panel Request B (Annex 4) was intended to investigate this more closely, but was not pursued during the meeting because blended model H (age-based) was ignored; however, a research recommendation was raised.

NWSS aerial survey

Apart from a sensitivity analysis (Request G, Annex 4), the aerial survey was omitted from blended models G and H and all subsequent models developed during the meeting, including the final model. The Panel did not see evidence to disagree with the STAT's recommendation to omit the aerial survey.

Sensitivity analyses

[Note, in an attempt to follow a narrative (grouping similar areas of investigation together), the order that requests are discussed below is not necessarily chronological or the same as followed in the Panel report.]

It was decided early on to focus on blended model G (length-based) because blended model H (age-based) was not as fully tested, and because the fishery age composition data ignored the length compositions for the fisheries at the extremes of the northern subpopulation distribution (i.e. in Canada and Mexico), thereby implicitly assuming that these length compositions were the same as those from adjacent fisheries (i.e. Oregon-Washington and southern California respectively). The first two of the Panel requests (Requests A and B, Annex 4) were therefore not considered, and instead put forward as research recommendations. This issue (assuming length compositions at the extremes are the same as adjacent areas for the purpose of compiling age data) remains a concern for the conditional age-at-length data used in the final model, although the additional weighting (λ=0.2) in the final model does further down-weight this data (see Annex 5).

The primary concern for the review was that appropriate weights were established and justified for the compositional data, particularly given the high sensitivity of stock assessment results to alternative weighting of the conditional age-at-length data. Sensitivity analyses focussed primarily on this aspect, but also looked at sensitivity to combining/splitting the spring and summer ATM survey *q*s (catchability) and selectivities, estimating/fixing the ATM survey *q*s, and omitting certain ATM spring survey length frequencies. Sensitivity to an alternative stock-recruit formulation (Request I, Annex 4) and to an alternative value for M (Request J, Annex 4) was also checked, but results were found to be either relatively insensitive (former) or predictable (latter).

Applications of "Francis weights" to compositional data

Blended model G applied rather arbitrary weights to the compositional data (λ=1 for all length composition data, and λ=0.5 for all conditional age-at-length data; Table A4.2, Annex 4). These weights were in addition to the input weights which accounted for effective sample sizes (note: when referring to weighting below, it is always in this context – i.e. in addition to input weights). One of the first tasks related to the stock assessment model itself was to investigate the effect of applying one of the weighting methods proposed by Francis (2011; method TA1.8) to the compositional data, referred to here and in the Panel report as "Francis weights". In order to derive these Francis weights, the STAT team first developed model K by setting all weights to 1 (λ=1 for all compositional data), then estimated the Francis weights using model K. The Panel supported this approach. Compared to model G, model K, which gave more weight to the conditional age-at-length data, substantially lowered estimates of biomass, and changed the spring ATM selection to be less knife-edge and more like the summer ATM selection pattern.

Francis weights derived from model K (and implemented as changes to λ) were applied to all compositional data (model F) which resulted in a severe down-weighting of all length composition data and up-weighting of all conditional age-at-length data apart from that for the PacNW fleet. However, some of the weights were poorly determined (e.g. for the ATM summer survey), so the Panel requested pooling of similar data sources (the summer and spring ATM surveys were pooled, and the first and second semester MexCal fleets were pooled), which led to improved estimates for weights (model L). Models F and L showed similar behaviour to each other; however, compared to G they gave substantially lower

estimates of biomass (like K), and substantially different selection patterns for the two MexCal fleets (whereas K had shown changed selection for the spring ATM survey). These results led to further requests in order to isolate what was causing the differences.

In order to investigate whether it was the length composition data or the conditional age-at-length data that were most influential, model M assigned Francis weights only to the length composition data, while model N assigned Francis weights only to the conditional age-at-length data; in both cases, the compositional data that were not assigned Francis weights were allocated λ=1. Although biomass estimates for the earlier years for model M were affected, the scale and trend in biomass in recent years were relatively insensitive, whereas biomass estimates for model N were markedly lower throughout the times series, leading to the conclusion that weighting of the conditional age-at-length caused the most sensitivity. When allocating Francis weights to conditional age-at-length data for models F, L and N, it was noticed that weights greater than 1 were allocated to all but the PacNW fleet (λ well below 1), so model O was the same as model N but forced λ=1 for the conditional age-at-length data of the PacNW fleet. Results for model O were almost identical to model N.

Although they did not apply Francis weights, models U and W looked further into the question of which of the different sources of conditional age-at-length data were most influential. Considering the weighting for conditional age-at-length data only and compared to model G (for which λ=0.5 was used throughout for these data), model U kept λ=0.5 for the ATM survey but down-weighted all the fishery data (λ=0.01), while model W set λ=0 for the ATM survey (i.e. omitted the ATM survey conditional age-at-length data) but kept λ=0.5 for all the fishery data (see Annex 4, Table A4.2). The contrast between models U and W was quite marked, with U leading to much lower biomass levels than model G (and consequently unrealistically high estimates of survey *q*), and W much higher ones. Given these results and the Panel's unease with the way in which the conditional age-at-length data were constructed for the ATM surveys (see "Exploring input data" above), some of the later sensitivity tests and the final model ignored the conditional age-at-length data from the ATM surveys.

ATM survey q and selection

In order to investigate whether assessment data supported a single *q* for ATM surveys, one of the first assessment model requests (Request H, Annex 4) was to force *q* to be the same for the ATM spring and summer surveys, and instead of estimating the single *q*, scanning over a range of values for it (0.7 to 1.1 was run in steps of 0.1). From a likelihood point of view, there was no support for separate *q*s; furthermore, the biomass trajectory re-scales with changing *q*, and the selection pattern for the ATM spring survey flips from being almost knife-edged to being closer to the ATM summer survey selection as *q* increases. The lack of these changes occurring in a systematic way (as pointed out in the Panel report) is likely to do with the model not having obtained a global minimum in some cases. This behaviour (ATM spring survey selection markedly changing) was also noted for model K when conditional age-at-length data were up-weighted (λ changed from 0.5 to 1).

These results led to further requests (Requests P, Q and V, Annex 4) to investigate whether there was any support for treating the ATM spring and summer surveys as a single survey time series (i.e. with a common *q* and selection pattern for both spring and summer surveys). For model P the ATM spring and summer survey *q* and selection were forced the same, and when compared to model G resulted in a poorer fit to the ATM survey length frequency data, lower biomass estimates and consequently an unrealistically high survey *q*. Furthermore, for fish lengths below ~15cm and above ~20cm, the single ATM survey selection was

respectively above and well below both the ATM spring and summer selection curves estimated under model G – the use of a single ATM selection curve with only two parameters to estimate for model P means there is less flexibility to deal with differences in the length frequencies (after accounting for growth and mortality) in the spring and summer surveys, and so a "compromise" selection curve is obtained, with the inevitable poorer fits to some length frequency data. Model Q was the same as P, but gave a much higher weighting (λ=20) to the ATM survey length frequency data in an attempt to improve the fits to these data. Although there were some improvements, the model was still unable to fit all the length frequencies adequately. Model V was an attempt to improve the fit to the ATM length frequencies by removing one of the ATM survey length frequencies (spring survey held in 2012) that the ATM survey team considered unreliable; the model (same as model Q but with the 2012 ATM spring survey compositional data omitted) was still unable to fit the remaining ATM survey length frequencies adequately.

Models R, S and T were an attempt to further understand the trade-offs involved depending on how the estimation of the ATM survey *q*s and selectivities were treated; in all these cases, the conditional age-at-length data for the ATM surveys were ignored (λ=0) for the reasons explained in the final paragraph of "Applications of 'Francis weights' to compositional data" above, and in the section "Exploring input data" also above. Models R and S assume the same *q* and selection pattern for the ATM spring and summer surveys, but the former estimates the single *q* while the latter sets it to 1; both cases result in higher estimates of biomass than model G (S being more optimistic than R). Model T sets the single *q* to 1, but estimates separate selectivities for the ATM spring and summer surveys; this results in lower estimates of biomass than model G and contrasts with model W (described earlier), which estimates separate ATM spring and summer *q*s (this is the only difference to model T) that results in even higher biomass estimates than model S. Given the difficulties encountered when assuming a single selection pattern for the ATM spring and summer surveys (previous paragraph), the Panel was leaning towards estimating separate selection patterns for the ATM spring and summer surveys.

Profiling over weights for the conditional age-at-length data

The Panel continued to have difficulty with the *ad-hoc* weighting assumed for the conditional age-at-length data (λ=0.5). Further requests therefore focussed on profiling over the λ weights for these data for a selection of models in order to better justify a value for λ. The models were: G (the base model), W (estimating separate ATM spring and summer survey *q*s) and T (a single ATM survey *q* fixed at 1), and the profiling models were labelled G-2, W-2 and T-2 respectively. A further version of model W was considered, where Francis weights were used for the length composition data, pooled for the MexCal fishery and for the ATM surveys (as was done for these data in model L), and this was labelled W-3. All these models estimated separate ATM spring and summer survey selection patterns. The initial approach, particularly for G-2, W-2 and W-3, was to specify a λ value that would result in the average of the ATM spring and summer survey *q*s being around 1. This was achieved for $\lambda \approx 0.7$ for G-2 and for $\lambda \approx 0.035$ for W-2, but was not achievable for W-3, the latter resulting in unrealistically low values for *q* for all λ values tried. Inclusion of the ATM survey conditional age-at-length data, and increasing λ on these data had the tendency of reducing biomass estimates (e.g. models G and K), so omission of these data led to higher biomass estimates (model W) which then required a much lower value of λ in order to reduce these biomass estimates to achieve an average ATM survey *q* of 1.

At this point the STAT and Panel agreed that selecting a weighting factor in order to achieve some average value of a survey *q* (in this case 1) was not a robust and sensible way to provide management advice, so focus shifted instead to model T-2, which explicitly assumed *q*=1 for both ATM surveys. Setting *q*=1 also helped reduce model sensitivity to weighting. Although profiling over the λ applied to the fishery conditional age-at-length data showed model T-2 to be quite sensitive to changes in this λ for the early years of the biomass trajectory, it was fairly robust for recent years; nevertheless, biomass trajectories for recent years fell into two groups, one where λ was 0.1, 0.2 and 0.4, and the other where it was 0.3, 0.5 and higher, which seemed to depend on which sort of data the model "latched onto" (similar "flipping" behaviour was described earlier under "ATM survey *q* and selection"; as before, the lack of this happening in a systematic way is likely due to the model not reaching its global minimum in some cases). This led the Panel to explore a means for selecting which group was most appropriate, so the λ values at the midpoint of each group were selected for further exploration, leading to models T-2_0.2 and T-2_0.7 (the numbers after the underscore reflecting the midpoint λ values).

Two approaches were used to try to isolate which of models T-2_0.2 and T-2_0.7 was the most appropriate to serve as a final model. The first approach (Request U, Annex 4) refitted each model without two ATM spring survey length frequencies (2011 and 2012), assuming that the observed "flipping" behaviour was due to trying to fit these two length frequencies (which were always poorly fitted); furthermore, the 2012 ATM spring survey length frequency was considered unreliable by the ATM survey team. The models using the first approach were re-labelled T-2_0.2a and T-2_0.7a respectively. The second approach (Request V, Annex 4) conducted a retrospective analysis (comparing the models with and without the most recent four years of data). The second approach did not provide a decisive means to distinguish between the two candidates (both models changing markedly), but the first approach did: models T-2_0.2a and T-2_0.7a both fell into the same group as T-2_0.2, indicating that the grouping behaviour discussed in the preceding paragraph was at least partially being caused by conflicts when fitting the two ATM survey length frequencies. Model T-2_0.2 was selected as the final model because it showed less sensitivity to the omission of 2011 and 2012 ATM spring survey length frequencies (but note that the final model did include these length frequencies). The specifications of the final model are provided in Annex 5.

Additional STAT runs

The STAT presented additional model runs on the final day that included time-varying selectivity (models X and X-1 in Table A4.2 of Annex 4), but there wasn't sufficient time to fully evaluate these models. However the Panel agreed that they would be valuable options to consider for future assessments.

Conclusions and recommendations

The STAT, with input from the Panel during the review, conducted a thorough investigation of input data and model settings leading up to selection of the final model (T-2_0.2) to be used for the 2014-2015 Pacific sardine stock assessment (Annex 5). These investigations focussed particularly on alternative weighting for compositional data. Although the trend in abundance is generally well determined by the available data, the absolute scale of the population continues to be uncertain (as found in previous years), with small changes to the model (e.g. relative weights assigned to compositional data) leading to large changes in model results (including population scale). The assumptions of *q*=1 for both ATM surveys

was important to reduce model sensitivity, particularly to scale, but despite this, the scale of early years continued to be relatively sensitive. Previous assessments had investigated setting *q*=1 for the DEPM survey, but found that this lead to unrealistic *q*s for the ATM surveys.

The Panel could not find reason to disagree with the STAT's view that the NWSS aerial survey should be omitted from the assessment, so the final model excludes this data source. The final model also excludes the ATM spring and summer conditional age-at-length data because it was felt that the ALKs used were not appropriately assembled and because model results were particularly sensitive to alternative weights assigned to these data. In contrast, model results were relatively insensitive to alternative weights assigned to the length composition data (compare the following models: K to M, N to F, and P to Q and V). However, this conclusion (relative insensitivity to alternative weights for length composition data) only held while the ATM conditional age-at-length data were included (Figure 1). As soon as ATM conditional age-at-length data were omitted, model results became very sensitive to alternative weights assigned to the length composition data (compare W-2_0.3 and W-3_0.3 in Figure 1, where the "_0.3" refers to the value for λ assigned to the fishery conditional age-at-length data; this λ value was used because it was the only common value for which results were available on the FTP site for both models W-2 and W-3). This result supports the choice of *q*=1 for the ATM surveys in the final model (because it acts to stabilise the scale), but also raises the possibility that it may be worth including once again in future assessments the conditional age-at-length data for ATM surveys once the ALKs on which they are based have been appropriately assembled.

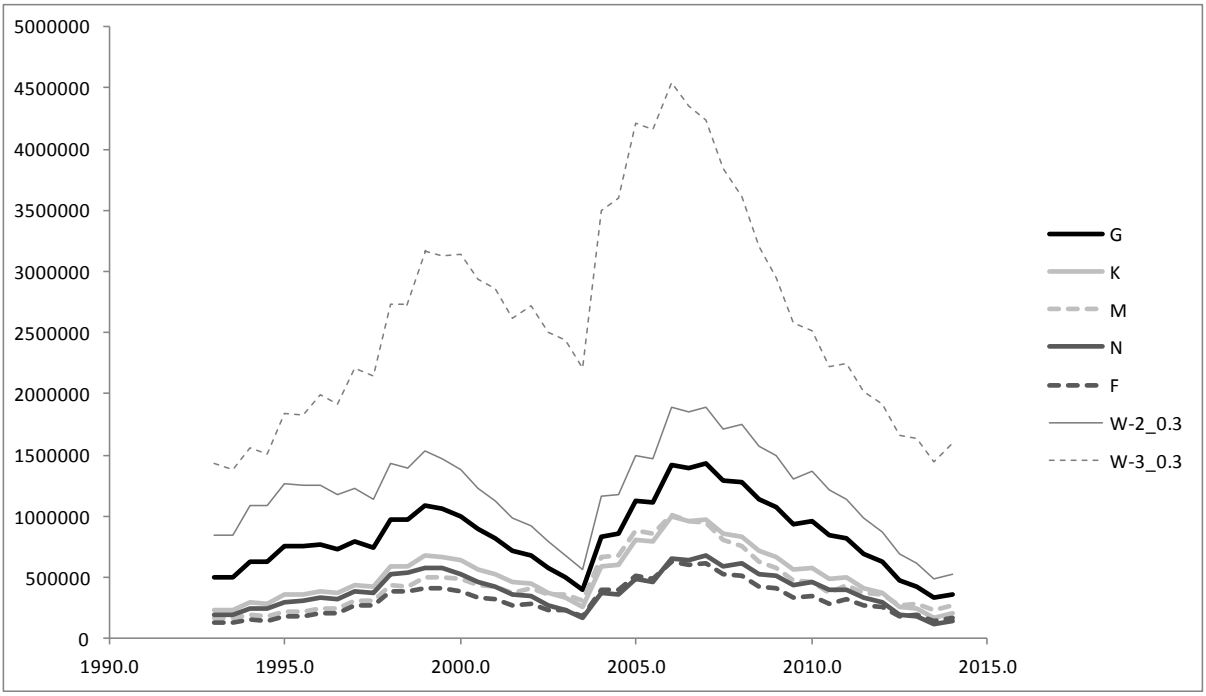

Figure 1. A comparison of models that assign Francis weights to the length composition data (broken lines), given a particular model configuration (solid line in the same colour). Model G is included for comparison. For a description of model differences, see Table A4.2 in Annex 4.

The final model uses separate selection patterns for the ATM spring and summer surveys, given the additional difficulties encountered when forcing these patterns to be the same (poorer fits to survey length frequency data and unrealistically high survey *q*s). The Panel concluded that the final model represented the best available science regarding the current

status of the northern subpopulation of Pacific sardine, and that the level of variation in terminal biomass, reflected by a strong retrospective pattern, was both expected and seen in previous assessments, and will likely occur again in future assessments. The Panel report provides results for the final model for both options for assigning catch to the northern subpopulation, the first using the environmentally-based method to remove southern subpopulation fish from the MexCal fleet data, and the second assuming all catches taken in the MexCal fleet belong to the northern subpopulation.

A number of recommendations arose from the review, and these were classified as high (H), medium (M) or low (L) priority. Most of them were "rolled over" from previous STAR Panel reviews and related to the benefits of greater international cooperation (H), needed changes to the Stock Synthesis package (H), the need to consider models with a longer period of data for a broader context of changes in productivity (H), exploring additional fishery-independent data sources (H), exploring reasons for discrepancies in the observed and expected proportions of older fish in length and age compositions (M), continued support for the expansion of coast-wide sampling of adult fish (M), the need to consider spatial models in order to better capture regional variations in population dynamics (M), the need to explicitly consider sex-structure in models (despite the lack of sexual dimorphism in length-at-age samples demonstrated during this review) because of sensitivity to this seen in the past (M), the need to model fleets separately (Mexico, California, Oregon-Washington, Canada) (M), continued investigation of the pros and cons of age-based models rather than age-length ones given evidence for time- and spatially-varying growth (despite being presented as an option, age-based models were not really given any attention during this review) (M), further exploration of methods to reduce between-reader ageing bias (M), and developing a relationship between egg production and fish age that accounts for processes by age (e.g. duration of spawning and batch fecundity) (L).

Recommendations that specifically arose from this review were the following:

- Investigate the sensitivity of the assessment model to the threshold used in the environmentally-based method to delineate the northern and southern subpopulations of Pacific sardine. An initial investigation conducted during the review did not consider changing the threshold itself (this would require more time than available), but instead used a rough proxy for this and found that proportion allocated to each subpopulation was potentially sensitive to the threshold used. [H]
- Carry out validation of the environmentally-based method used to split catches between the northern and southern subpopulation of Pacific sardine. The development of simple discriminant factors from areas where mixing doesn't occur (e.g. morphometrics, otolith morphology and microstructure, latest developments in genetics) to be applied where mixing does occur or to areas close to the separation boundary was suggested. [H]
- Compute age compositions for the ATM surveys by applying weighted length frequencies to appropriately derived ALKs (i.e. taking into account where sampling occurred). This was one of the main reasons for ignoring the conditional age-at-length information for the ATM surveys. [H]
- Investigate alternative ways to deal with the most recent estimates of those that tend to be among the most uncertain and have a large impact on the estimation of 1+ biomass used for management. In the absence of information, the most recent recruitment estimates rely heavily on stock-recruit assumptions. The Panel report highlights several options for

dealing with these estimates of recruitment, including: a prediction model based solely on recent recruitment and observed autocorrelation; a recruitment prediction index developed outside the assessment model, such as proposed by Zwolinski and Demer (in press), and then combined with the assessment model estimate of recruitment in the form of a weighted mean, with weights derived by, for example, the method proposed by Shepherd (1997); direct inclusion of environmental indices within the assessment model that are informative about recruitment. The Panel report also highlights the challenges involved when investigating environmental drivers to explain recruitment – in particular that assessment uncertainty should not be ignored when using stock-recruit pairs, and that the degrees of freedom effect (leading to over-fitting data) should also not be ignored when considering a range of environmental indices (see e.g. De Oliveira and Butterworth 2005). [H]

- For the MexCal data, compare annual length compositions from Ensenada to those from California, and for the PacNW data, compare annual length compositions from British Columbia with those from Oregon-Washington. The length compositions from Ensenada and British Columbia were ignored in the age-based model (blended model H), because no age data was made available for these regions, and age compositions for adjacent areas were assumed to apply to these regions (i.e. implicitly assuming length compositions were the same as in adjacent areas). This recommendation is seen as important if age-based models are pursued in future, but it is also important because conditional age-at-length data (used in the age-length models presented for review) will have the same problem. [M]
- For the DEPM estimation methodology, change the method used to allocate area for each point included in each stratum, and apply a method that better accounts for transect-based sampling and correlated observations. These suggested changes have a potentially minor effect on estimates, but are nevertheless regarded as more appropriate. [M]
- Consider future research on natural mortality. The assessment models currently assume a time- and age-invariant value of 0.4. [M]

Comments on Terms of Reference

The terms of reference are given in “Background” above and in Appendix 2 of Annex 2. As a CIE reviewer, I participated fully in the activities of the STAR Panel, and provide full support to, and endorse the Panel’s findings and recommendations, as reflected in their report. Comments on the individual terms of reference are already provided in italics in the “Background” section.

Comments on NMFS review process

The review process was thorough, but also fast-moving. Although understanding of the difficulty of doing it (lack of time and personnel, and volume of material), the one thing I did find frustrating was that model results produced during the meeting were not automatically made fully available on the FTP site, either during the meeting or afterwards (apart from those specifically requested for corroboration of report statements). I found that this did

hamper slightly the review process for me, particularly when compiling this report (as I wanted to give careful consideration to all the model results covered during the meeting). If the volume of material was a concern, then even just making available the Report.sso files for all model runs would have been helpful. As a caveat to this, I must add that when I did ask for information, it was always provided. Apart from this, I found the review to be well-run, professionally handled and very informative, and I was appreciative of the efforts of the STAT to provide everything needed for the review, and of the organisers for their background work to ensure a smoothly run meeting.

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Annex 1

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Methot, R.D. Jr. 2013. User manual for Stock Synthesis. Model Version 3.24s. Updated November 21, 2013: 152pp.

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Hill, K.T. 2013. Pacific sardine biomass projection in 2013 for U.S. management during the first half of 2014 (Executive Summary). Agenda item E.5.b, Supplemental Attachment 2, November 2013: 7pp.

Hill, K.T., Crone, P.R., Lo, N.C.H., Macewicz, B.J., Dorval, E., McDaniel, J.D. and Y. Gu. 2011. Assessment of the Pacific sardine resource in 2011 for U.S. management in 2012. November 2011. NOAA-TM-NMFS-SWFSC-487: 264pp.

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SSC. 2011. Scientific and Statistical Committee report on Pacific sardine assessment and coastal pelagic species management measures for 2012. Agenda item F.2.c, Supplemental SSC Report, November 2011: 2pp.

SSC. 2012. Scientific and Statistical Committee report on the Pacific sardine stock assessment and management for 2013, including preliminary EFP proposals and tribal set-aside. Agenda item G.3.c, Supplemental SSC Report, November 2012: 2pp.

SSC. 2013. Scientific and Statistical report on 2013 Pacific sardine stock assessment and management, including tribal set-aside. Agenda item E.5.c, Supplemental SSC Report, November 2013: 1p.

STAR Panel. 2011. Pacific sardine STAR Panel meeting report. Agenda item F.2.b, Attachment 5, November 2011: 24pp.

Model report and outputs on the FTP site (swfscftp.noaa.gov)

Prior to the meeting

Anon. 2014. Differentiating sardine landings (for highlighted section on page 10 of the assessment report – see Hill *et al*. 2014). 1p.

Dorval, E., Macewicz, B.J., Griffith, D.A., Lo, N.C.H. and Y. Gu. 2014. Spawning biomass of Pacific sardine (*Sardinops sagax*) off U.S. in 2013. Draft document: 42pp.

Hill, K.T., Crone, P.R. *et al*. (TBD). 2014. Assessment of the Pacific sardine resource in 2014 for U.S.A. management in 2014-15. Preliminary Draft for STAR Panel Review 3-5 March 2014: 137pp.

Comprehensive model outputs (all files and plots) for models G and H.

During the meeting

Selected model outputs for models H, I, J, P, Q, R, S, T, U, W, G-2 and W-2
Comprehensive model outputs for T-2_0.2_NSP (including retrospective patterns) and T-2_0.2_all (i.e. where environmental-based splitting of fishery data is not applied).

After the meeting

Comprehensive model outputs for models F, G, I, K, M, N, Q, V, W
Selected model outputs for W-3_0.3 and W-3_0.8

Presentations (during the meeting)

Assessment overview

Paul Crone

Assessment data

Background, sub-stocks, biology, fisheries, surveys, management – Kevin Hill
Stock structure and environment-based index (catch/composition) –Juan Zwolinski
Acoustic-trawl method (ATM) survey – David Demer
Daily egg production model (DEPM)/Total egg production (TEP) surveys – Emmanis Dorval
Overlaying spring 2013 survey with favourable habitat – Juan Zwolinski

Assessment results

Blended model (G and H) overview – Paul Crone
Data weighting considerations (composition vs. abundance time series) – Chris Francis
Sensitivity analysis and model G and H results – Paul Crone

Interactive assessment results during the meeting

Paul Crone and Kevin Hill

Annex 2

Copy of CIE Statement of Work

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Technical Representative (COTR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Appendix 1**. This SoW describes the work tasks and deliverables of the CIE reviewers for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description: The CIE reviewers will serve on a Stock Assessment Review (STAR) Panel and will be expected to participate in the review of Pacific sardine stock assessment. The Pacific sardine stock is assessed regularly (currently, every 1-2 years) by SWFSC scientists, and the Pacific Fishery Management Council (PFMC) uses the resulting biomass estimate to establish an annual harvest guideline (quota). The stock assessment data and model are formally reviewed by a Stock Assessment Review (STAR) Panel once every three years, with a coastal pelagic species subcommittee of the SSC reviewing updates in interim years. Independent peer review is required by the PFMC review process. The STAR Panel will review draft stock assessment documents and any other pertinent information for Pacific sardine, work with the stock assessment teams to make necessary revisions, and produce a STAR Panel report for use by the PFMC and other interested persons for developing management recommendations for the fishery. The PFMC's Terms of Reference (ToRs) for the STAR Panel review are attached in **Appendix 2**. The tentative agenda of the Panel review meeting is attached in **Appendix 3**. Finally, a Panel summary report template is attached as **Appendix 4**.

Requirements for CIE Reviewers: Two CIE reviewers shall participate during a panel review meeting in La Jolla, California during 3-5 March, and shall conduct an impartial and independent peer review accordance with the SoW and ToRs herein. The CIE reviewers shall have the expertise as listed in the following descending order of importance:

- The CIE reviewer shall have expertise in the application of fish stock assessment methods, particularly, length/age-structured modeling approaches, e.g., 'forward-simulation' models (such as Stock Synthesis, SS) and it is desirable to have familiarity in 'backward-simulation' models (such as Virtual Population Analysis, VPA).
- The CIE reviewer shall have expertise in the life history strategies and population dynamics of coastal pelagic fishes.
- It is desirable for the CIE reviewer to be familiar with the design and execution of fishery-independent surveys for coastal pelagic fishes.

- It is desirable for the CIE reviewer to be familiar with the design and application of fisheries underwater acoustic technology to estimate fish abundance for stock assessment.
- It is desirable for the CIE reviewer to be familiar with the design and application of aerial surveys to estimate fish abundance for stock assessment.

The CIE reviewer's duties shall not exceed a maximum of 14 days to complete all work tasks of the peer review process.

Location/Date of Peer Review: The CIE reviewers shall conduct an independent peer review during the STAR Panel review meeting at NOAA Fisheries, Southwest Fisheries Science Center, 8901 La Jolla Shores, La Jolla, California from March 3-5, 2014.

Statement of Tasks: The CIE reviewers shall complete the following tasks in accordance with the SoW, ToRs and Schedule of Milestones and Deliverables specified herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selections by the CIE Steering committee, the CIE shall provide the CIE reviewers information (name, affiliation, and contact details) to the COTR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents, reports, foreign national security clearance, and information concerning other pertinent meeting arrangements. The NMFS Project Contact is also responsible for providing the Chair a copy of the SoW in advance of the panel review meeting. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

Foreign National Security Clearance: When CIE reviewers participate during a panel review meeting at a government facility, the NMFS Project Contact is responsible for obtaining the Foreign National Security Clearance approval for CIE reviewers who are non-US citizens. For this reason, the CIE reviewers shall provide requested information (e.g., first and last name, contact information, gender, birth date, passport number, country of passport, travel dates, country of citizenship, country of current residence, and home country) to the NMFS Project Contact for the purpose of their security clearance, and this information shall be submitted at least 30 days before the peer review in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations available at the Deemed Exports NAO website:
http://deemedexports.noaa.gov/compliance_access_control_procedures/noaa-foreign-national-registration-system.html

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send by electronic mail or make available at an FTP site to the CIE reviewers all necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE on where to send documents. The CIE reviewers shall read all documents in preparation for the peer review, for example:

- Recent stock assessment documents since 2013;
- STAR Panel- and SSC-related documents pertaining to reviews of past assessments;
- CIE-related summary reports pertaining to past assessments; and

- Miscellaneous documents, such as ToR, logistical considerations.

Pre-review documents will be provided up to two weeks before the peer review. Any delays in submission of pre-review documents for the CIE peer review will result in delays with the CIE peer review process, including a SoW modification to the schedule of milestones and deliverables. Furthermore, the CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein.

Panel Review Meeting: The CIE reviewers shall conduct the independent peer review in accordance with the SoW and ToRs. **Modifications to the SoW and ToR cannot be made during the peer review, and any SoW or ToR modification prior to the peer review shall be approved by the COTR and CIE Lead Coordinator.** The CIE reviewers shall actively participate in a professional and respectful manner as a member of the meeting review panel, and their peer review tasks shall be focused on the ToRs as specified in the contract SoW.

Respective roles of the CIE reviewers and STAR Panel chair are described in Appendix 2 (see p. 6-8). The CIE reviewers will serve a role that is equivalent to the other panelists, differing only in the fact that he/she are considered an 'external' member (i.e., outside the Pacific Fishery Management Council family and not involved in management or assessment of West Coast CPS). The CIE reviewers will serve at the behest of the STAR Panel Chair, adhering to all aspects of the PFMC's ToR as described in Appendix 2. The STAR Panel chair is responsible for: 1) developing an agenda, 2) ensuring that STAR Panel members (including the CIE reviewers), and STAT Teams follow the Terms of Reference, 3) participating in the review of the assessment (along with the CIE reviewers), 4) guiding the STAR Panel (including the CIE Reviewers) and STAT Team to mutually agreeable solutions.

The NMFS Project Contact is responsible for any facility arrangements (e.g., conference room for panel review meetings or teleconference arrangements). The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements, including the meeting facility arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: The CIE reviewers shall complete an independent peer review report in accordance with the SoW. The CIE reviewers shall complete the independent peer review according to required format and content as described in Appendix 1. The CIE reviewers shall complete the independent peer review addressing each ToR as described in Appendix 2.

Other Tasks – Contribution to Summary Report: The CIE reviewers will assist the Chair of the panel review meeting with contributions to the Summary Report. The CIE reviewers are not required to reach a consensus, and should instead provide a brief summary of their views on the summary of findings and conclusions reached by the review panel in accordance with the ToRs.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by the CIE reviewers in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review;
2) Participate during the panel review meeting in La Jolla, California during March 3-5, 2014 as called for in the SoW, and conduct an independent peer review in accordance with the ToRs (Appendix 2);
3) No later than March 24, 2014, the CIE reviewers shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and Dr. David Die., CIE Regional Coordinator, via email to ddie@rsmas.miami.edu. The CIE report shall be written using the format and content requirements specified in Appendix 1, and address each ToR in Appendix 2.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

January 20, 2014	CIE sends reviewers contact information to the COTR, who then sends this to the NMFS Project Contact
February 14, 2014	NMFS Project Contact sends the CIE Reviewers the pre-review documents
March 3-5, 2014	The reviewers participate and conduct an independent peer review during the panel review meeting
March 24, 2014	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
April 14, 2014	CIE submits CIE independent peer review reports to the COTR
April 22, 2014	The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: Requests to modify this SoW must be made through the Contracting Officer's Technical Representative (COTR) who submits the modification for approval to the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the CIE within 10 working days after receipt of all required information of the decision on substitutions. The COTR can approve changes to the milestone dates, list of pre-review documents, and Terms of Reference (ToR) of the SoW as long as the role and ability of the CIE Reviewers to complete the SoW deliverable in accordance with the ToRs and deliverable schedule are not adversely impacted. The SoW and ToRs cannot be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (the CIE independent peer review reports) to the COTR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COTR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards: (1) the CIE report shall have the format and content in accordance with Appendix 1, (2) the CIE report shall address each ToR as specified in Appendix 2, (3) the CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon notification of acceptance by the COTR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COTR. The COTR will distribute the approved CIE reports to the NMFS Project Contact and regional Center Director.

Support Personnel:

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Appendix 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations.

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR, and Conclusions and Recommendations in accordance with the ToRs.

   a. Reviewer should describe in their own words the review activities completed during the panel review meeting, including providing a detailed summary of findings, conclusions, and recommendations.

   b. Reviewer should discuss their independent views on each ToR even if these were consistent with those of other panelists, and especially where there were divergent views.

   c. Reviewer should elaborate on any points raised in the Summary Report that they feel might require further clarification.

   d. Reviewer shall provide a critique of the NMFS review process, including suggestions for improvements of both process and products.

   e. The CIE independent report shall be a stand-alone document for others to understand the proceedings and findings of the meeting, regardless of whether or not they read the summary report. The CIE independent report shall be an independent peer review of each ToRs, and shall not simply repeat the contents of the summary report.

3. The reviewer report shall include as separate appendices as follows:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Statement of Work
   Appendix 3: Panel Membership or other pertinent information from the panel review meeting.

Appendix 2: Terms of Reference for the Peer Review of the Pacific sardine stock assessment

The CIE reviewers are one of the four equal members of the STAR panel. The principal responsibilities of the STAR Panel are to review stock assessment data inputs, analytical models, and to provide complete STAR Panel reports.

Along with the entire STAR Panel, the CIE Reviewer's duties include:
1. Reviewing draft stock assessment and other pertinent information (e.g.; previous assessments and STAR Panel reports);
2. Working with STAT Teams to ensure assessments are reviewed as needed;
3. Documenting meeting discussions;
4. Reviewing summaries of stock status (prepared by STAT Teams) for inclusion in the Stock Assessment and Fishery Evaluation (SAFE) document;
5. Recommending alternative methods and/or modifications of proposed methods, as appropriate during the STAR Panel meeting, and;
6. The STAR Panel's terms of reference concern technical aspects of stock assessment work. The STAR Panel should strive for a risk neutral approach in its reports and deliberations.

The STAR Panel, including the CIE Reviewers, are responsible for determining if a stock assessment or technical analysis is sufficiently complete. It is their responsibility to identify assessments that cannot be reviewed or completed for any reason. The decision that an assessment is complete should be made by Panel consensus. If agreement cannot be reached, then the nature of the disagreement must be described in the Panels' and CIE Reviewer's reports.

The review solely concerns technical aspects of stock assessment. It is therefore important that the Panel strive for a risk neutral perspective in its reports and deliberations. Assessment results based on model scenarios that have a flawed technical basis, or are questionable on other grounds, should be identified by the Panel and excluded from the set upon which management advice is to be developed. The STAR Panel should comment on the degree to which the accepted model scenarios describe and quantify the major sources of uncertainty Confidence intervals of indices and model outputs, as well as other measures of uncertainty that could affect management decisions, should be provided in completed stock assessments and the reports prepared by STAR Panels.

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

Appendix 3: Draft agenda: CPS STAR Panel

Monday 3 March

08h30	Call to Order and Administrative Matters	
	Introductions	Punt/Key
	Facilites, e-mail, network, etc.	Sweetnam
	Work plan and Terms of Reference	Griffin
	Report Outline and Appointment of Rapporteurs	Punt/Key
09h00	Pacific Sardine assessment presentation	Hill/Crone
10h00	Break	
10h30	Pacific Sardine assessment presentation	Hill/Crone
11h30	Acoustic and trawl survey	Zwolinski
12h00	Bayesian estimates of spawning fraction	Dorval
12h30	Lunch	
13h30	Pacific Sardine assessment presentation (continue)	Hill/Crone
14h30	Panel discussion and analysis requests	Panel
15h00	Break	
15h30	Public comments and general issues	
17h00	Adjourn	

Tuesday 4 March

08h00.	Assessment Team Responses	Hill/Crone
10h30	Break	
11h00.	Discussion and STAR Panel requests	Panel
12h30	Lunch	
13h30	Report drafting	Panel
15h00	Break	
15h30	Assessment Team Responses	Hill/Crone
16h30	Discussion and STAR Panel requests	
17h00	Adjourn	

Wednesday 5 March

08h00.	Assessment Team Responses	Hill/Crone
10h30	Break	
11h00.	Discussion and STAR Panel requests	Panel
12h30	Lunch	
13h30	Finalize STAR Panel Report	Panel
15h00	Break	
15h30	Finalize STAR Panel Report	Panel
17h00	Adjourn	

Thursday 6 March (Optional, CIE Reviewers not required to attend)

08h00 Data Preparation for future CPS Stock Assessments
17h00 Adjourn

Appendix 4: STAR Panel Summary Report (Template)

- Names and affiliations of STAR Panel members

- List of analyses requested by the STAR Panel, the rationale for each request, and a brief summary the STAT responses to each request

- Comments on the technical merits and/or deficiencies in the assessment and recommendations for remedies

- Explanation of areas of disagreement regarding STAR Panel recommendations
  - Among STAR Panel members (including concerns raised by the CPSMT and CPSAS representatives)
  - Between the STAR Panel and STAT Team

- Unresolved problems and major uncertainties, e.g., any special issues that complicate scientific assessment, questions about the best model scenario, etc.

- Management, data or fishery issues raised by the public and CPSMT and CPSAS representatives during the STAR Panel

- Prioritized recommendations for future research and data collection

Annex 3

STAR Panel membership and other pertinent information

STAR Panel Members:
André Punt (Chair), Scientific and Statistical Committee (SSC), Univ. of Washington
Meisha Key, SSC, California Department of Fish and Wildlife
José De Oliveira, Center for Independent Experts (CIE); Cefas
John Simmonds, Center for Independent Experts (CIE); ICES

Pacific Fishery Management Council (Council) Representatives:
Kerry Griffin, Council Staff
Diane Pleschner-Steele, CPSAS Advisor to STAR Panel
Chelsea Protasio, CPSMT Advisor to STAR Panel

Pacific Sardine Stock Assessment Team:
Kevin Hill, NOAA / SWFSC
Paul Crone, NOAA / SWFSC
Dave Demer, NOAA / SWFSC
Juan Zwolinski, NOAA / SWFSC
Emmanis Dorval, NOAA / SWFSC
Beverly Macewicz, NOAA / SWFSC

Other Attendees
Jenny McDaniel, SWFSC
Kirk Lynn, CDFG
Dale Sweetnam, SWFSC
Erin Reed, SWFSC
Ed Weber, SWFSC
Josh Lindsay, NMFS WCR
Russ Vetter, SWFSC
Al Carter, Ocean Companies
Richard Carroll, Jessie's Ilwaco Fish Company
Elizabeth Helmers, CDFW
Nancy Lo, SWFSC
Sam McClatchie, SWFSC
Richard Parrish, NMFS Emeritus
Yukong Gu, SWFSC
Jeff Laake, AFSC
Kevin Piner, SWFSC
William Watson, SWFSC
Elaine Acuňa, SWFSC
Anna Holder, CDFW
Joel Van Nord, CWPA
Noelle Bowlin, SWFSC
Mike Okoniewski, Pacific Seafood
Cisco Werner, SWFSC
Sarah Shoffler, SWFSC
Kristen Koch, SWFSC
Chris Francis, NIWA
Emily Gardner, SWFSC

Alex Da Silva, IATTC
Steven Teo, SWFSC
George Cutter, SWFSC
Mark Maunder, IATTC

AFSC – Alaska Fisheries Science Center
CDFW – California Department of Fish and Wildlife
CEFAS - Centre for Environment, Fisheries & Aquaculture Science
CPSAS - Coastal Pelagic Species Advisory Subpanel
CIE – Council on Independent Experts
CPSMT - Coastal Pelagic Species Management Team
CWPA – California Wetfish Producers Association
IATTC – Inter-American Tropical Tuna Commission
ICES – International Council for the Exploration of the Sea
NIWA - National Institute of Water and Atmospheric Research
NMFS - National Marine Fisheries Service
SSC - Scientific and Statistical Committee (of the Pacific Fishery Management Council)
SWFSC - Southwest Fisheries Science Center (National Oceanic and Atmospheric Administration)
WCR – West Coast Region

Annex 4

Relevant information from STAR Panel Report

Table A4.1. Requests, Rationale and Responses from STAR Panel Report. [Note: all Figures and tables referred to in the following table refer back to the STAR Panel Report, unless otherwise indicated.]

Nr	Request	Rationale	Response	Model(s)
A	Compare the yearly length-composition data for the Ensenada fishery that are included in the MexCal data set for the NSP scenario with the corresponding southern California length compositions. Also, compare the yearly length-composition data for the Oregon-Washington catches with those for the British Columbia fishery.	There are no age-length data for the Ensenada fishery or for the British Columbia fishery available for use in the assessment at this time, but model H implicitly assumes that the length frequencies for the Ensenada fishery are the same as those for the southern California fishery and that the length-frequencies for the British Columbia fishery are the same as those for the Oregon-Washington fishery.	This request was not required because the Panel focused on model G (length-based) that was presented as the potential base case model and not model H (age-based). Model H was not a focus for the Panel review because it was not as fully tested as model G and because the construction of the catch age-composition data ignored the length data for Mexico and British Columbia. However, this request has been put forward as a research recommendation.	-
B	Compute age-compositions for the ATM survey by multiplying the survey length-frequencies by the associated age-length keys. Compare the mean age-at-length time-series north and south of 40°10' from the ATM survey.	The age data for the ATM survey presented in the draft report were unweighted.	This request was not required because the Panel focused on model G (length-based) that was presented as potential base case model and not model H (age-based). However, this request has been put forward as a research recommendation.	-
C	Construct catch time series using a one month shorter and longer monthly duration for when the San Pedro and Ensenada fisheries are catching southern subpopulation fish.	To evaluate the sensitivity of the catches to the cutoff (50%) that is used to assign catches to the NSP.	Figure 1 shows that the results are likely to be somewhat sensitive to the cut-off chosen to define catches from the northern subpopulation. A research recommendation was raised to examine this issue further.	-
D	Overlay the habitat map with the spring survey results for the 2013 ATM survey.	The survey did not go north of San Francisco. The Panel was interested to know whether the areas north of San Francisco would have been expected to have been suitable habitat for Pacific sardine.	The plots showed no evidence of substantial suitable habitat north of San Francisco in the two weeks around the time the survey was conducted, which suggests that the survey should have provided an adequate sample of the population.	-
E	Provide additional information regarding the apparent discrepancy between the biomass estimates from the ATM survey in the Washington / Oregon area and the landings in	The Panel wished to have more information on this apparent discrepancy.	Juan Zwolinski noted that the ATM survey sampled the region between 44° 47.2'N and 48°18'N and from the 50m to the 1500m depth isobaths from 07/31/2012 to 08/10/2012. The resulting point estimate of sardine	-

Nr	Request	Rationale	Response	Model(s)
	this area, based on the information from 2012.		biomass was 13,333 mt. The sampling variance was high, resulting in a 95% confidence interval of [3,918, 27,559] mt. During the same time period, the commercial fishery off Oregon and Washington caught 9,747 mt. The ATM surveyed the area to the north, including northern Washington and western Vancouver Island, B.C. There, the sardine biomass was estimated at 18,675 mt, with a 95% confidence interval of [2,661, 54,017] mt. It was likely that by 08/10/2012, 32,008 mt of sardine, with 95% confidence interval [12,439, 68,945] mt, would have been available for the Oregon and Washington fisheries, assuming that all the sardine observed off western Vancouver Island migrated from the south.	
F	With model G (from initial draft), reweight the fishery and survey length-composition and conditional age-at-length data by applying the Francis (2011) weighting method (Equation TA1.8). The weighting factors should be implemented as changes to the lambdas in the SS model.	The compositional data may not be appropriately weighted.	The upper panel of Table 2 lists the factors to weight the input sample sizes (which are lower than the actual number of fish sized and aged), for each length-composition and conditional age-at-length data component that needs to be weighted. The response to this request (and requests L, M, and N) was based on model 'K' in which the conditional age-at-length data are not downweighted by 0.5 (see Table 1 for the specifications for the models investigated during the Panel requests). The Francis method suggested that the length-compositions needed to be downweighted substantially. In contrast, this method also suggested that the conditional age-at-length data for the MexCal fleets and the ATM survey need to be upweighted. Implementing these weighting factors (model F) led to a markedly lower biomass trajectory and substantially changed selectivity patterns for the two MexCal fisheries. The results from this request led to requests L, M, N and O.	F
G	With model G (from initial draft), include the NWSS aerial survey data. Summarize the results in terms of residual patterns and the information given in Table 8 of the draft document.	The Panel wished to understand whether the aerial survey data would be influential if they were included in the assessment.	The biomass trajectory was lower than for model G when the NWSS aerial survey was included in the assessment, but otherwise the results were not substantially different. The Panel did not see evidence to disagree with the STAT's recommendation to leave	G, but including aerial survey

Nr	Request	Rationale	Response	Model(s)
			this survey out of the assessment.	
H	With model G (from initial draft), examine scenarios in which catchability is the same for the spring and summer ATM surveys. Consider values for ATM survey catchability from 0.7 to 1.1 in steps of 0.2. Summarize the results in terms of residual patterns and the information given in Table 8 {draft assessment document}.	The Panel noted that the ATM survey scientists expressed the view that the spring and summer surveys were directly comparable and wished to understand whether this view is supported by the data included in the assessment.	There is no evidence to support having separate *q*'s for the spring and summer ATM surveys in terms of the change to the value of the objective function. The single *q* is closer to that from the spring surveys, which is expected given the relative number of ATM survey data points for spring (6) and summer (3). The spring survey selectivity pattern switches to being less knife-edged for the higher *q*s, but the change for this and the biomass trajectory did not occur in a systematic way as the ATM survey catchability was changed from 0.7 to 1.1. This request led to an additional request (P).	G-H
I	With model G (from initial draft), replace the Beverton-Holt stock-recruitment relationship with the Ricker form of this relationship. Estimate steepness rather than assuming it equals 0.8	Several past assessments were based on the Ricker form of the stock-recruitment relationship, with steepness estimated. The Panel wished to explore the sensitivity to this change from prior assessments.	The scale of biomass is slightly lower with the Ricker stock-recruitment relationship, with no difference in likelihoods between the two model runs. Steepness was estimated at 2.05.	G-I
J	With model G (from initial draft), set $M = 0.5yr^{-1}$.	The analysis of Zwolinski and Demer (2013) suggests that *M* is higher ($0.52yr^{-1}$) than the model G assumption of $0.4yr^{-1}$.	As expected, the scale of the biomass was higher, and the ATM survey *q*'s were lower (spring=0.58, summer=0.63). The change in likelihood was 3 units with the higher *M*, but given the concerns with the weights assigned to the length and conditional age-at-length data, this is not considered to be a substantial change.	G-J
K	Conduct an assessment where all the weighting factors (lambdas) are set to 1 and compare the results for this model to those for model G (from the initial draft assessment).	The selection of the factors to weight the length-composition and conditional age-at-length data was based on this model.	The STAT provided model K which showed increasing the weights on the conditional age-at-length data from 0.5 to 1 substantially lowered the biomass trajectory.	K
L	Based on model K, apply the Francis method to estimate weighting factors for the length-composition and conditional age-at-length data, pooling the two MexCal fleets, pooling the spring and summer ATM survey data and analyzing the PacNW separately.	Some of the weighting factors are based on very few compositions and consequently the weighting factors are uncertain (Table 2, upper).	This was model L. The weighting factors for the pooled fleets are as expected, but the confidence intervals, particularly for the ATM survey, are narrower (Table 2, lower). The Panel considered it appropriate to pool across fleets when computing the weights for the length-composition and conditional age-at-length data.	L
M	Based on model K, change only the weights assigned to the length-composition data using	The Panel wished to understand whether the length-frequency or conditional age-at-	This was model M. The biomass estimates for the early years were sensitive to changing the weights assigned	M

Nr	Request	Rationale	Response	Model(s)
	the weighting factors from Request F.	length data were most influential.	to the length-frequency data. However, the trend in abundance over recent years was unchanged and the biomass scale was largely unchanged. The Panel concluded that how the conditional age-at-length data are weighted was the major cause of the change in results observed for request F.	
N	Based on model K, change only the weighting factors assigned to the conditional age-at-length data using the weighting factors from Request F.	The Panel wished to understand whether the length-frequency or conditional age-at-length data were most influential.	The biomass trajectory for model N was markedly lower (and survey *q* markedly higher) when the conditional age-at-length data were changed.	N
O	Same as for request N, except that the weighting factor for the conditional age-at-length data sets for the PacNW fishery is assumed to equal 1.	The weighting factor for the conditional age-at-length data for the PacNW fleet was less than one, in contrast to the weighting factors for the MexCal fleets and the ATM survey.	The results for model O were essentially identical to those for request N.	O
P	Same as for model G, except that catchability and selectivity for spring and summer ATM surveys are assumed to be the same.	The Panel wished to understand whether there is support for separating the two surveys.	The fits to the survey length-frequency data for model P were not as good as for model G, even after accounting for there being three fewer parameters. The biomass trajectory was lower than for model G, and the ATM survey catchability was 2.38, a value considered implausible. The single ATM survey selectivity was less knife-edged and to the right of those for the spring and summer ATM survey selectivities from model G, which was unexpected. The model appeared to increase the selection at smaller lengths to account for the summer survey which had appreciable catches at these lengths. The consequence was to then reduce selection at the greater lengths that were previously fully selected when the surveys were fitted with separate selection patterns.	P
Q	Same as for model P, except that the weight assigned to ATM survey length-frequency data was increased from 1 to 20.	The Panel wished to understand whether it is possible to fit the length-frequency data for the ATM survey, at least in principle.	The fits to the ATM length-frequency data for model Q were better, but the model was still unable to adequately mimic all of the length-frequencies.	Q
R	Conduct models R, S, T, W and U.	The Panel wished to understand the trade-offs in results among various treatments of ATM survey catchability and selectivity. Some of these models ignore the ATM	Figure 2 summarizes the biomass trajectories from these models. Models R and S, in which selectivity for the spring and summer ATM surveys was assumed to be the same, led to higher estimates of biomass	R, S, T, U, W

Nr	Request	Rationale	Response	Model(s)
		survey conditional age-at-length data because these data were not computed accounting for the sampling scheme for the survey.	compared to model G, whereas model T which estimated separate selectivity patterns for the spring and summer ATM surveys, led to lower estimates of biomass; in contrast model W, which is the same as model T but estimates separate catchabilities for the ATM surveys, led to higher estimates of biomass than even model S. Model U in which the conditional age-at-length data for the MexCal and PacNW fisheries were markedly downweighted led to much lower biomass estimates and unrealistically high estimates of survey catchability.	
S	Repeat request Q, but omit the ATM survey length-frequency data for spring 2012.	This length-frequency was considered unreliable by the ATM survey team.	This model (V) was not able to adequately fit the remaining ATM survey length-frequencies.	V
T	Conduct analyses for a range of values to the extent which the conditional age-at-length data are downweighted. The analyses should be conducted for model specifications G-2, W-2, W-3, and T-2 (See Table 1).	The Panel wished to understand the impact of different weighting factors on the results of the model.	The outputs for models based on configuration W-3 all led to values for the ATM survey catchability coefficients which were considered unrealistically low (~0.25). The biomass trajectories for recent years were more robust for the models based on configuration T-2, but there was considerable sensitivity of biomass estimates for the early years (Figure 3). The biomass trajectories for recent years fell into two groups (one group based on weighting factors on the conditional age-at-length data of 0.1, 0.2 and 0.4; another group based on weighting factors of 0.3, and 0.5 and larger). The biomass trajectories were more stable for model runs based on configuration W-2 than configuration W-3. The weighting factor is 0.035 for configuration W-2 if it is chosen so that the average ATM (spring and summer) survey catchability is 1. Alternatively, this weighting factor is ~0.7 if the analysis is based on configuration G-2. Downweighting is more severe for model configuration W-2 because this model configuration ignores the ATM conditional age-at-length data which tends to support lower biomass estimates. However, the STAT noted that choosing a weighting factor to achieve a given average ATM survey catchability coefficient may not be a robust way to provide management advice. The Panel concurred	G-2, W-2, W-3, T-2, T-2_0.2, T-2_0.7

Nr	Request	Rationale	Response	Model(s)
			with this view.	
At this point in the meeting, the STAT and Panel agreed to proceed with models which are variants of configuration T-2, i.e. the weighting factors for the length-frequency data are set to 1, catchability is set to 1 for both the spring and summer ATM surveys, separate selectivity patterns are estimated for the spring and summer ATM surveys, and the ATM survey conditional age-at-length data are ignored. The STAT and Panel agreed to focus on two models: T-2_0.2 and T-2_0.7. The difference between these two models is the weight assigned to the fishery conditional age-at-length data. These choices for weighting factors were selected because they are representative of the two groups in Figure 3.				
U	Apply models T-2_0.2 and T-2_0.7 when the length-frequencies for the 2011 and 2012 spring ATM surveys are ignored.	It was speculated that some of the model sensitivity was due to attempts to fit these two length-frequencies (the fits to these length-frequencies are always poor).	The results when the weighting factor for the conditional age-at-length data was set to 0.7 were similar to those when the weighting factor was set to 0.2 (Figure 4), suggesting that at least one reason for the two groups of results in Figure 3 are conflicts when fitting to the length-frequencies for the 2011 and 2012 spring ATM surveys.	T-2_0.2a, T-2_0.7a
V	Apply models T-2_0.2 and T-2_0.7 when the data for the last four years are ignored.	The Panel wished to understand whether a retrospective analysis might help to distinguish between these two models.	The results from both models changed markedly when the data for last four years were ignored (Figure 5).	Retros on T-2_0.2 and T-2_0.7
The STAT and Panel agreed that model T-2_0.2 would be the base model given the relative lack of sensitivity to omitting data (see request U).				

Table A4.2. Summary of the models requested of the STAT during the review. "F" indicates that the weights assigned to the composition type were based on Francis (2011), method TA1.8; "F-pool" indicates that the factor to weight the composition concerned pooled information across fleets / seasons; "split" under the "ATM Q" and "ATM sel" (selectivity) columns indicates that separate parameters were estimated for the spring / summer surveys; "equal" under the "ATM Q" and "ATM sel" columns indicates that the parameters concerned were assumed to be the same for the spring / summer surveys, "1" under "ATM Q" indicates that survey catchability was assumed to be 1; "profile" in the last three lines implies that the STAT were requested to profile over the weighting factor concerned. The final model is in bold and shaded grey.

	Lambda: Length composition			Lambda: Conditional age-at-length			Q	Sel	Additional
Model	MexCal (1+2)	PacNW	ATM	MexCal (1+2)	PacNW	ATM	ATM	ATM	
G	1	1	1	0.5	0.5	0.5	split	Split	
K	1	1	1	1	1	1	split	Split	
F	F	F	F	F	F	F	split	Split	
L	F-pool	F	F-pool	F-pool	F	F-pool	split	Split	
M	F	F	F	1	1	1	split	Split	
N	1	1	1	F	F	F	split	Split	
O	1	1	1	F	1	F	split	Split	
P	1	1	1	0.5	0.5	0.5	equal	Equal	
Q	1	1	20	0.5	0.5	0.5	equal	Equal	
R	1	1	1	0.5	0.5	0	equal	Equal	
S	1	1	1	0.5	0.5	0	1	Equal	
T	1	1	1	0.5	0.5	0	1	Split	
U	1	1	1	0.01	0.01	0.5	split	Split	
V	1	1	20	0.5	0.5	0.5	equal	Equal	Excl. ATM spr 2012
W	1	1	1	0.5	0.5	0	split	Split	
G-2	1	1	1	profile	profile	profile	split	Split	
W-2	1	1	1	profile	profile	0	split	Split	
W-3	F-pool	F	F-pool	profile	profile	0	split	Split	
T-2	1	1	1	profile	profile	0	1	Split	
T-2-0.2	**1**	**1**	**1**	**0.2**	**0.2**	**0**	**1**	**Split**	
T-2-0.7	1	1	1	0.7	0.7	0	1	Split	
T-2_0.2a	1	1	1	0.2	0.2	0	1	Split	Excl. ATM spr 2011-12
T-2_0.7a	1	1	1	0.7	0.7	0	1	Split	Excl. ATM spr 2011-12
X	1	1	1	1	1	0	1	Split	Time blocking PNW
X-1	1	1	1	1	1	0	split	Split	Time blocking PNW

Models X and X-1, although supplied by STAT, were not requested or considered by the STAR panel due to time constraints.

Annex 5

Final model (T-2_0.2)

The final base model incorporates the following specifications (from STAR Panel report):

- catches for the MexCal fleet computed using the environmentally-based method;
- two seasons (semesters, Jul-Dec=S1 and Jan-Jun=S2) for each assessment year from 1993 to 2013;
- sexes were combined;
- two fisheries (MexCal and PacNW fleets), with an annual selectivity pattern for the PacNW fleet and seasonal selectivity patterns (S1 and S2) for the MexCal fleet;
  - MexCal fleet:
    - dome-shaped length-based selectivity with two periods of time blocking (1993-1998, 1999-2013);
  - PacNW fleet:
    - asymptotic length-based selectivity for a single time period;
  - length compositions with effective sample sizes calculated by dividing the number of fish sampled by 25 (externally) and lambda weighting=1 (internally);
  - conditional age-at-length compositions with effective sample sizes calculated by dividing the number of fish sampled by 25 (externally) and lambda weighting=0.2 (internally);
- Beverton-Holt stock-recruitment relationship "steepness" was fixed (0.8);
- *M* was fixed (0.4 yr^{-1});
- recruitment deviations estimated from 1987-2012;
- virgin (R_0), and initial recruitment offset (R_1) were estimated, and σ_R was fixed (0.75);
- initial *F*s set to 0 for all fleets (non-equilibrium model following the initial age composition method in SS);
- DEPM and TEP indices of spawning biomass with *q* estimated for both surveys;
- ATM survey biomass 2006-2013, partitioned into two (spring and summer) surveys, with *q*=1 for each survey;
  - length compositions with effective sample sizes set to 1 per haul (externally) and lambda weighting=1 (internally);
  - asymptotic length-based selectivity for spring and summer surveys;
  - conditional age-at-length data from the ATM surveys excluded;
- NWSS aerial survey index of abundance (biomass) and associated length compositions excluded.

SCIENTIFIC AND STATISTICAL COMMITTEE REPORT ON SARDINE ASSESSMENT, SPECIFICATIONS, AND MANAGEMENT MEASURES

The Scientific and Statistical Committee (SSC) reviewed the 2014 stock assessment of the northern subpopulation of Pacific sardine. Dr. Kevin Hill presented the results of the stock assessment and Dr. André Punt provided an overview of the Stock Assessment Review (STAR) Panel report.

A number of changes were made to the 2014 assessment in comparison to the 2011 full assessment. These include: 1) A new sea surface temperature-based method used for assigning catch by port and month to the northern or southern subpopulations. The SSC agrees that this is an improvement over previous methods, but more research could be done to better differentiate catch of the two stocks, as outlined in the STAR Panel report. A result of this approach is a reduction in estimated historical catch for the northern subpopulation. 2) The acoustic-trawl method (ATM) survey was split into spring and summer survey time series with independently estimated selectivity curves.

The 2014 assessment uses four indices of abundance: Daily-Egg-Production Method (DEPM) indices; Total Egg Production indices (for those years without a DEPM index); the spring ATM index; and the summer ATM index, with length composition data from the ATM surveys. Catchability for both ATM surveys are fixed at 1, as was the case for the single ATM time series in the last assessment. The northwest aerial survey indices and composition data were not included in the current assessment.

Fishery data are grouped into two fleets (PacNW and MexCal). Length data and conditional age-at-length data from both fleets are used in the model. After considerable exploration of alternative weighting schemes, fishery conditional age-at-length data were downweighted relative to the other data in the assessment, while ATM survey conditional age-at-length data were removed altogether.

Four areas of uncertainty are highlighted in the stock assessment: 1) uncertainty in recent recruitments, and relationship of recruitment to environmental conditions; 2) uncertainty in the stock structure of Pacific Sardine off of North America; 3) uncertainty in catchability for the ATM surveys; 4) appropriate data weighting in the stock assessment model.

While the recent trend in biomass is well defined, there is considerable uncertainty in the absolute scale of the population. Related to this, the difference in absolute scale between the aerial and summer ATM survey indices in the area of overlap remains a point of concern. The SSC recommends research into the catchability for the ATM surveys and the representativeness of the nighttime tow samples in terms of both the coastal pelagic species composition and sardine size- and age-composition. Similar research into the accuracy of the aerial survey could be conducted. The SSC reiterates the need for a methodology review of the ATM surveys.

Additional uncertainty in the age 1+ biomass is due to the considerable uncertainty in the 2013 recruitment. Modeling a temperature-recruitment relationship in the assessment could help address this issue. The declining trend in sea surface temperature, along with poor recruitments in 2010, 2011 and 2012 leads to some concern that the 2013 recruitment estimate in the assessment may be biased high.

The SSC notes that the assessment and overfishing limit (OFL) are for the northern subpopulation of Pacific sardine, but some portion of the U.S. catch in each year is likely from the southern subpopulation. In addition, age-0 sardine are being harvested, but these fish are not included in the summary biomass.

The change in timing of the assessment review from September to March provided five extra months for the Stock Assessment Team (STAT) to receive and analyze the data and develop the model. Dr. Hill commented that this extra time was helpful in developing the assessment. The SSC notes that, despite this, some materials for review were not complete before the STAR Panel, and recommends that in future the Pacific sardine STAT should endeavour to follow the Terms of Reference.

The SSC endorses the 2014 Pacific sardine stock assessment as the best available science, and recommends an OFL of 39,210 mt for the northern subpopulation of Pacific sardine. The SSC further recommends that the assessment be considered a category 1 assessment.

PFMC
04/07/14

COASTAL PELAGIC SPECIES MANAGEMENT TEAM REPORT ON SARDINE ASSESSMENT, SPECIFICATIONS, AND MANAGEMENT MEASURES

The Coastal Pelagic Species Management Team (CPSMT) and the Coastal Pelagic Species Advisory Subpanel (CPSAS) jointly received a presentation from Dr. Kevin Hill concerning the Pacific sardine stock assessment conducted in 2014. The CPSMT recommends that the Pacific Fishery Management Council (Council) adopt the full assessment (model T) for management of the 2014-2015 sardine fishery (Agenda Item H.1.b, Stock Assessment Report). Based upon the 369,506 metric tons (mt) age 1+ biomass estimated from this assessment, the harvest control rule produces a harvest guideline (HG) of 28,646 mt (Table 1 below).

The upcoming season marks the implementation of a new fishery year schedule, from July 1- June 30. The CPSMT notes the biomass of age 1+ fish (369,506 mt as of July 1) estimated from the assessment, and used to set harvest guidelines, now coincides with the start date for the fishing year, unlike past years when the fishery year began on January 1. The CPSMT notes the stock assessment produced an estimate that is very similar to the catch-only projection of 378,120 mt for the interim (January –June) 2014 fishery.

The CPSMT commends the Stock Assessment Team (STAT) for incorporating numerous changes based on previous research recommendations. These improvements result in better model parameterization and stock structure. These changes include: defining the assessed stock using an environmental variable instead of port of landing, basing the spawner-recruit relationship on Beverton-Holt instead of using the Ricker curve, and the Acoustic-Trawl Method survey splitting from a single to a spring and summer time series.

As indicated above, the current stock assessment uses an environmentally-based method from satellite-based sea surface temperature (SST) data to differentiate sardine catch into northern and southern stocks, for the purpose of excluding the southern stock catch from the assessment model. The catch differentiation method is used to refine the estimate of fishery exploitation rate and biomass for the northern stock. Based on the overall distribution of both stocks and the low amount of southern stock harvested in U.S. waters, the CPSMT does not consider catch of southern stock as negatively impacting either stock. The CPSMT notes that there is some de facto management of the southern stock in U.S. waters, given that all U.S. catch of Pacific sardine is counted towards allocation limits and that all Pacific sardine harvest must comply with federal and/or tribal regulations. The CPSMT recognizes that this is a complex issue and may need additional evaluation in the future as the science develops.

Regarding the uncertainty surrounding the recruitment of the 2013 year class into the 2014-2015 fishery, the CPSMT notes this results from moving the start of the sardine fishery year from January to July. In past assessments, this year class would not have been incorporated in the estimate of stock biomass for management purposes. But with the timing change, recruitment of this year class was taken from the stock recruitment relationship and had no observed data from which to derive the estimate. There was insufficient time to address this uncertainty during this year's Stock Assessment Review (STAR) Panel review. For future assessments, the STAT has identified methods to reduce the level of uncertainty.

We encourage efforts to provide complementary and/or corroborative information to improve our understanding and assessment of the sardine stock. The CPSMT believes that a methodology review

of the aerial survey is necessary before new survey data are incorporated in the stock assessment. Likewise, the CPSMT encourages a methodology review of the acoustic trawl method (ATM) survey.

Harvest Specifications for 2014-2015

Table 1 (below) contains the overfishing limit (OFL) and a range of acceptable biological catch (ABC) values based on various P* (probability of overfishing) values. Considering the results of the full stock assessment conducted in 2011 for 2012, the Council chose a P* of 0.40 for the 2013 and interim 2014 fisheries. At its March 2014 meeting, and based on SSC guidance, the Council approved changing the temperature index from Scripps Pier (SIO) to CalCOFI (California Cooperative Oceanic Fisheries Investigations) for the purposes of estimating F_{MSY} (or E_{MSY}) in the OFL and ABC control rules for the 2014-2015 fishery and beyond. The estimated value of E_{MSY} derived from the CalCOFI index is 0.1219697. Also at the March 2014 meeting, the Council initiated action to change the temperature index for purposes of calculating HG FRACTION, with final action scheduled for November 2014. For the 2014-2015 fishery, the value for FRACTION (15 percent) used to calculate the HG is based on the Scripps Institution of Oceanography (SIO) temperature index.

Based on the values in Table 1, the CPSMT computed the HG according to the current fishery management plan formula (with SIO index) and also an alternative harvest level (expressed as annual catch limit [ACL]/ACT) using the CalCOFI index. Seasonal allocation schemes for HG and ACL are presented in Tables 2 and 3, respectively.

The Quinault Indian Nation requests 4,000 mt of Pacific sardine for their participation in the 2014-2015 fishery (Agenda Item H.1.a, Attachment 1). Acknowledging that a set-aside for the Quinault Indian Nation has yet to be determined, the CPSMT presents allocation schemes (Tables 2 and 3 below) incorporating the requested set-aside of 4,000 mt.

The Northwest Sardine Survey LLC notified the Council it is withdrawing its request for an exempted fishing permit for 2014-2015 (Agenda Item H.1.a, Attachment 2), so no set aside is necessary for an exempted fishing permit this year

The CPSMT incorporates the CPSAS recommendation that the incidental catch for CPS fisheries in each of the three allocation periods should be set to 500 mt (Tables 2 and 3) and that the incidental landing allowance for CPS fisheries be no more than 45 percent Pacific sardine by weight after the directed fishery closes.

Although the fishery year changed, the rollover provisions from the first fishing period to the second and from the second to the third remain the same as in previous years. The first fishing period is now July 1- September 14; the second period is September 15 – December 31 and the third fishing period is January 1- June 30. Any allocation remaining on June 30 is not rolled over to the next fishery year.

According to the CPS FMP framework, the ACL must be equal to or below the ABC, and typically the Council has set the ACL equal to the ABC. An ACT is equal to the HG or ACL, whichever value is less. Although the HG based on SIO is below the ABC, the Team recommends adopting the ACT based on the calculation in Table 1. Table 1 presents a calculation for an ACL, substituting the CalCOFI index for the SIO index in the HG formula. This resulting ACL is below the calculated HG and therefore, it would be the basis for the ACT for the 2014-2015 fishery.

The use of the ACL for setting the harvest level is atypical, but the team recognizes that the HG is likely to be based on the CalCOFI index for future fishery years and therefore, the CPSMT recommends the Council use the CalCOFI index, as the SSC has determined that it is best available science for the other sardine harvest control rules (OFL and ABC).

Table 1. Pacific sardine harvest formula parameters for 2014-2015.

Harvest Control Rule Formulas									
OFL = BIOMASS * E_{MSY} * DISTRIBUTION							(CalCOFI temperature index)		
ABC = BIOMASS * $BUFFER_{P\text{-}star}$ * E_{MSY} * DISTRIBUTION							(CalCOFI temperature index)		
HG = (BIOMASS – CUTOFF) * FRACTION * DISTRIBUTION							(SIO temperature index)		
ACL/ACT = (BIOMASS – CUTOFF) * E_{MSY} * DISTRIBUTION							(CalCOFI temperature index)		
Harvest Formula Parameters									
BIOMASS (ages 1+, mt)	369,506								
P-star	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05
ABC $Buffer_{Tier\ 1}$	0.9558	0.9128	0.8705	0.8280	0.7844	0.7386	0.6886	0.6304	0.5531
E_{MSY}	0.12197								
FRACTION	0.15								
CUTOFF (mt)	150,000								
DISTRIBUTION (U.S.)	0.87								
Harvest Control Rule Values (MT)									
OFL =	**39,210**								
$ABC_{Tier\ 1}$ =	37,475	35,792	34,131	32,464	30,757	28,961	26,999	24,719	21,688
HG =	28,646								
ACL/ACT =	**23,293**								

Table 2. Preliminary allocation scheme based on HG (with SIO index) for the 2014-2015 Pacific sardine fishery. Values in metric tons (mt)

HG = 28,646 mt; Tribal set-aside = 4,000 mt; Adjusted HG = 24,646 mt				
	Jul. 1 - Sep. 14	Sep. 15 - Dec. 31	Jan. 1 – Jun. 30	Total
Seasonal Allocation	9,858 (40%)	6,162 (25%)	8,626 (35%)	24,646
Incidental Set-Aside	500	500	500	1,500
Adjusted (Directed) Allocation	9,358	5,662	8,126	23,146

Table 3. Proposed preliminary allocation scheme based on ACL/ACT (with CalCOFI index) for the 2014-2015 Pacific sardine fishery. Values in metric tons (mt)

ACL/ACT = 23,293 mt; Tribal set-aside = 4,000 mt; Adjusted ACL/ACT = 19,293 mt				
	Jul. 1 – Sep. 14	Sep. 15 – Dec. 31	Jan. 1 – Jun. 30	Total
Seasonal Allocation	7,718 (40%)	4,823 (25%)	6,752 (35%)	19,293
Incidental Set-Aside	500	500	500	1,500
Adjusted (Directed) Allocation	7,218	4,323	6,252	17,793

PFMC 04/08/14

COASTAL PELAGIC SPECIES ADVISORY SUBPANEL REPORT ON SARDINE ASSESSMENT, SPECIFICATIONS, AND MANAGMENT MEASURES

The Coastal Pelagic Species Advisory Subpanel (CPSAS) and Coastal Pelagic Species Management Team (CPSMT) received a joint briefing from Dr. Kevin Hill. The CPSAS also reviewed the Pacific Sardine Stock Assessment Review (STAR) Panel Report and Northwest Aerial Survey Report (Agenda Items H.1.a), and the Sardine Stock Assessment Report for USA management in 2014-15 (Agenda Item H.1.b).

The CPSAS thanks the STAR Panel and Stock Assessment Team for their efforts to improve management of the U.S. sardine fishery. The CPSAS appreciates the Council's consideration of the following points in deliberating management measures for the 2014-2015 sardine fishery:

1. Although the current stock assessment reflects a declining trend, the absolute scale of the population is still in question, as it was in 2011.
2. Industry remains concerned about the ability of the current acoustic trawl method (ATM) surveys to measure the full extent of the biomass. The ATM surveys are now driving the assessment model. We are also disappointed that industry-sponsored aerial surveys have been removed. We sincerely hope that going forward we can develop a truly collaborative research program for the CPS complex.
3. Sardine recruitment is influenced by environmental conditions. La Niña conditions in 2000-2002 caused a dip in the sardine population similar to the last three years, but El Niño restored the biomass to 1.37 million mt in 2006. Another El Niño is likely on the way this fall.
4. Recent analysis shows that the Amendment 8 Harvest Control Rule (HCR) was ultra-conservative, and the Amendment 13 HCR is even more conservative, with the overfishing limit (OFL) and acceptable biological catch (ABC) control rules added as additional layers of precaution.
5. Based on the CPS Fishery Management Plan, the current HCR prescribes a 15 percent FRACTION, and results in a HG of 28,646 mt. This HG is considerably lower than the OFL of 39,210 mt and Category 1 ABC of 35,792 mt at P* .40, and is even lower than an ABC at a P* of 0.20.
6. Until the HG harvest FRACTION changes are implemented, it would be premature to apply a different HCR FRACTION for setting harvest.
7. The CPSAS appreciates efforts to better address catches of northern and southern substocks in the stock assessment. We concur with recommendations of the STAR Panel and Scientific and Statistical Committee that more research is needed. Absent additional research, we expect that all sardines landed in U.S. waters will be managed status quo under the CPS FMP.
8. Please consider that achieving Optimum Yield requires balancing fishery opportunity, economic stability, and ecosystem needs. Each 1,000 mt reduction in harvest equates to a loss of $800,000 in direct economic activity. The sardine HCR is a highly precautionary management policy. The industry wants to maintain a sustainable resource.

Management Measures

(1) The CPSAS recommends the following management measures for the July 1, 2014 – June 30, 2015 sardine fishery, based on the harvest guideline of 28,646 metric tons (mt) as outlined in the Stock Assessment Report (Agenda Item H.1.b).

HG = 28,646 mt Tribal Allocation = 4,000 mt Adjusted HG = 24,646 mt				
	Jul 1- Sep 14	Sep 15 – Dec 31	Jan 1- Jun 30	Total
Seasonal Allocation (mt)	9,858 (40%)	6,162 (25%)	8,626 (35%)	24,646
Incidental Set-Aside (mt)	500	500	500	1,500
Adjusted (Directed) Allocation (mt)	9,358	5,662	8,126	23,146

(2) After the closure of the directed sardine fishery in any period, the incidental landing allowance in other CPS fisheries should be 45 percent Pacific sardine by weight, to account for the possibility of mixed-fish catches. We recommend only 500 mt incidental set-aside per period, which is half of prior incidental set-asides. Any unused allocation in each of the first two periods will be rolled into the next period's directed fishery. Any incidental set aside not used in the third period will be foregone.

The CPSAS is considering options for 2015-2016 and beyond to shift a portion of the incidental set-aside from future periods.

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DECISION SUMMARY DOCUMENT
PACIFIC FISHERY MANAGEMENT COUNCIL
April 5-10, 2014

HABITAT

Current Habitat Issues

The Council directed staff to send a letter, to the National Marine Fisheries Service (Agenda Item B.1.a, Supplemental Attachment 3) on the Bay-Delta Conservation Plan, with the edits recommended by the Habitat Committee (HC). The Council also directed staff to send the letter in Agenda Item B.1.a, Supplemental Attachment 4, to the Bureau of Ocean Energy Management but to include striking the section on the Oregon Ocean Uses Atlas and substituting the language recommended by the Groundfish Advisory Subpanel. In addition, the Council directed the HC to draft a general letter on the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries' boundary expansion process for the advance June briefing book, towards a goal of enabling input and additions by other Council advisory bodies. The Council also tasked the HC with several other matters for Council consideration at the June Council meeting (see Council blog at http://www.pcouncil.org/blog/).

PACIFIC HALIBUT MANAGEMENT

Final Incidental Landing Restrictions for 2014-2015 Salmon Troll Fishery

The Council recommended maintaining the current Pacific halibut landing limits in regulation of no more than one Pacific halibut per each four Chinook, except one Pacific halibut may be landed without meeting the ratio requirement, and no more than 12 halibut landed per trip. These limits would remain in regulation, unless modified by inseason action, from May 1, 2014 through December 31, 2014 and April 1-30, 2015. Additionally, to improve the accounting of landings, the Council recommends that both pounds and numbers of Pacific halibut be reported on state fish tickets.

GROUNDFISH MANAGEMENT

Fisheries in 2015-2016 and Beyond: Adopt Biennial Specifications Final Preferred Alternatives

The Council adopted all the 2015 and 2016 overfishing limits (OFLs) endorsed by the Scientific and Statistical Committee (SSC). The Council also confirmed all the preliminary preferred 2015 and 2016 acceptable biological catches (ABCs) previously adopted, with the exception of specifying an overfishing probability (P*) of 0.4 for spiny dogfish and a P* of 0.45 for the Washington substock of cabezon to determine the ABCs for those stocks. The Council adopted a reconfigured Other Fish complex comprised of kelp greenling coast wide, the Washington substock of cabezon, and leopard shark with OFL and ABC contributions from kelp greenling in California, Washington cabezon, and leopard shark to determine the complex specifications. The Council confirmed the preliminary preferred 2015 and 2016 annual catch limits, except higher values were adopted for Dover sole (50,000 mt), widow rockfish (2,000 mt), and spiny dogfish (2,101 mt in 2015 and 2,085 mt in 2016). The Council confirmed the preliminary preferred annual catch target (ACT) of 4 mt and an ACL of 10 mt for cowcod south of 40º10' N

latitude. Adopted values for these catch limits are shown in Table 5 of Agenda Item C.4.a, Supplemental REVISED Attachment 2.

The Council elected to defer a decision on a new target year to rebuild cowcod until their June 2014 meeting. The Council confirmed its Ecosystem Component species designations displayed in Table 4, page 12 of Agenda Item C.4.a, Supplemental REVISED Attachment 2; and noted that would include all other skates, other than longnose skate.

The Council also adopted preliminary preferred management measures, including allocations for all fisheries. Final action on harvest specifications and management measures is scheduled for the 2015-2016 groundfish fisheries and Amendment 24 to the fishery management plan is scheduled for the June 2014 Council meeting.

Implement 2014 Pacific Whiting Fishery under the U.S.-Canada Pacific Whiting Agreement

The Council adopted a yield set-aside of 1,500 mt of Pacific whiting to accommodate 2014 research activities and incidental bycatch in the pink shrimp fishery.

Sablefish Catch Share Program Review Phase 1 (This Includes Electronic Fish Tickets for Open Access Sablefish Deliveries)

The Council requested the program review document be expanded to provide additional explanation and data on the origins of the endorsement system and changes to the regulatory environment which have occurred since the program was implemented, as well as to respond to recommendations in the SSC report. A topic the Council may take up in June 2014 is whether to consider allowing vessels in the fixed gear sablefish catch share program to switch between longline and fishpot gear. With respect to the rules for determining which permits an entity controls for the purpose of evaluating compliance with the three-permit control limit, the Council selected Action Alternative 2a: for up to two vessels, if a vessel owner has a 20 percent or less ownership share in a vessel the limited entry fixed gear permits associated with that vessel would be exempt from counting against that owner's three-permit control. With respect to consideration of Federal requirement for electronic fish tickets for fixed gear sablefish landings, the Council modified the alternatives by adopting the NMFS recommendations that are contained in Agenda Item C.6.a, Supplemental Attachment 3 (eliminating unnecessarily specific language and removing suboptions for maintaining paper tickets). It should be noted that Alternative 4 would require electronic fish tickets for vessels delivering sablefish taken on open access trips.

Electronic Monitoring Program Development Including Preliminary Approval of Exempted Fishing Permits

The Council recommended that four of the five Exempted Fishing Permit (EFP) applications for use of electronic monitoring be forwarded for further consideration and potential final approval at the June 2014 meeting in Garden Grove, California, Agenda Item C.7.a, Attachment 7 (Leipzig), Attachment 8 (CA Risk Pool), and Attachment 9 (Mann/Paine); and in Agenda Item C.7.a, Supplemental Attachment 12 (Eder et al.). The Council provided guidance to the applicants for

refinement and asked that applicants consider resubmitting applications for the June 2014 Council meeting. The following additions to the applications were requested by the Council: regarding the Leipzig EFP application – limit the number of vessels and require up to 100 percent observer coverage; regarding the CA Risk Pool application – limit the number of vessels and require up to 100 percent observer coverage on the bottom trawl vessels; regarding the Eder et al. application – limit the number of vessels. The Council also requested that the EFPs, address how the halibut viability assessments could be conducted without the presence of a human observer, with the intention that halibut retention not be permitted. In addition, the Council recommended that EFP applicants include a feature requiring providing National Marine Fisheries Service (NMFS) and the States a list of vessels and processors that will be participating in the EFP a minimum of 30 days before they commence their EFP. The West Coast Region Sand Point office also volunteered to work with applicants on an ad hoc basis to improve EFP applications and would consider convening a meeting in the near future.

Regarding the full fleet regulatory development process, a Groundfish Electronic Monitoring Policy Advisory Committee and Technical Advisory Committee meeting is scheduled for May 7-8 in Seattle, Washington to refine regulatory options for each fleet sector. The Council will consider sector specific progress at the June 2014 Council meeting.

Fisheries in 2015-2016 and Beyond: Stock complex Restructuring

The Council adopted the status quo slope rockfish complexes with a sorting requirement for rougheye and blackspotted rockfish as the preliminary preferred alternative for 2015 and beyond. In addition, only the action alternative proposed for analysis under Agenda Item C.8.a, Attachment 2, Option A was forwarded for additional detailed analysis. More detailed analysis of these two alternatives will be provided for the June 2014 Council meeting when the final preferred alternative will be decided.

SALMON MANAGEMENT

Methodology Review for 2014

The Council adopted the following preliminary topics for the 2014 methodology review (lead agencies are in parentheses):

- Willapa Bay natural coho conservation objective, annual catch limit and status determination criteria (Salmon Technical Team, Washington Department of Fish and Wildlife (WDFW).
- Southern Oregon coastal Chinook conservation objective (Oregon Department of Fish and Wildlife).
- Standardized method for calculation of age-2 Fishery Regulation Assessment Model (FRAM) stock scalars Model Evaluation Workgroup (MEW).
- Progress report on new Chinook FRAM base period (MEW).
- New conservation objective for Grays Harbor Chinook (WDFW, Quinault Indian Nation).

The Council is scheduled to review progress and select final topics at the September 2014 Council meeting in Spokane, Washington.

Lower Columbia Natural Coho Harvest Rate Matrix Review

The Council received a status update from the Lower Columbia River Natural Coho Workgroup (LRC Workgroup) and approved a process, schedule, and initial assignments. The LRC Workgroup is tentatively scheduled to meet in Portland on May 15, 2014 to review the status of Lower Columbia River coho stocks, alternative harvest policies, risk assessment methods and criteria, and to draft a report on coho populations in the upper Willamette River. The Council is scheduled to receive an update on progress at the June 2014 Council meeting in Garden Grove, California.

Final Action on 2014 Salmon Management Measures

The Council adopted management measures for commercial and recreational ocean salmon fisheries for 2014. Details are posted on the Council website at http://www.pcouncil.org.

COASTAL PELAGIC SPECIES MANAGEMENT

Sardine Assessment, Specifications, and Management Measures

The Council approved an OFL of 39,210 mt and an ABC of 35,792 mt, based on a P* value of 0.40. The Council set the ACL and ACT equal to 23,293 mt, and adopted a 500 mt incidental set aside for each of the three fishing periods. Accounting for a Quinault Indian Nation allotment of 4,000 mt and a total of 1,500 mt incidental set-aside, the period allocations will be as follows: Period 1 (July 1-September 14, 2014) = 7,218 mt; Period 2 (September 15-December 31, 2014) = 4,323 mt; and Period 3 (January 1-June 30, 2015) = 6,252 mt. Any uncaught allocation from Periods 1 and 2 will be rolled into the subsequent period. Any uncaught allocation from Period 3 will not be rolled into the subsequent period. The Council also adopted a mixed load allowance of up to 45 percent sardines caught in other coastal pelagic species fisheries, after directed fishing is closed.

ECOSYSTEM BASED MANAGEMENT

Protecting Unfished and Unmanaged Forage Fish Species Initiative

The Council approved a range of alternatives for protecting unfished and unmanaged forage fish species and identified the Ecosystem Trophic Role pathway as a preliminary preferred alternative. Under this pathway, protective measures for forage species would be added to each of the Council's four fishery management plans (FMP), perhaps under an omnibus process aggregating the four actions into one process. The Council is scheduled to review the alternatives and proposed amendatory FMP language at the September Council meeting in Spokane, Washington.

ADMINISTRATIVE MATTERS

Advisory Body Position Appointments and Council Operating Procedures

The Council Chair appointed Dr. Galen Johnson to the Scientific and Statistical Committee seat on the Model Evaluation Workgroup.

The Council appointed LCDR Joe Giammanco to the USCG 11th District seat on the Enforcement Consultants and LT Shannon Anthony as his alternate.

The Council added a seat on the Groundfish Management Team for the West Coast Groundfish Observer Program, with seating an individual scheduled for the June 2014 Council meeting.

The Council approved an updated management schedule for Pacific halibut in Council Operating Procedure 9.

Future Council Meeting Agenda and Workload Planning

The next meeting of the Pacific Fishery Management Council is scheduled for June 2014 in Garden Grove, California. The Council made a number of changes to the draft proposed June Council meeting graphic shown in Agenda Item J.3.a, Supplemental Attachment 4; a revised graphic will be posted on the Council website in the near future. In particular, the Pacific Halibut Catch Share Plan Change Scoping agenda item was dropped, the Highly Migratory EFP and swordfish fishery changes were postponed to further discussion at the June 2014 Council meeting, and the Habitat Committee meeting was postponed until later in the week.

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RECENT TECHNICAL MEMORANDUMS

SWFSC Technical Memorandums are accessible online at the SWFSC web site (http://swfsc.noaa.gov). Copies are also available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161 (http://www.ntis.gov). Recent issues of NOAA Technical Memorandums from the NMFS Southwest Fisheries Science Center are listed below:

NOAA-TM-NMFS-SWFSC-521 Abundance and biomass estimates of demersal fishes at the footprint and piggy bank from optical surveys using a remotely operated vehicle (ROV).
STIERHOFF, K. L., J. L. BUTLER, S. A. MAU, and D. W. MURFIN
(September 2013)

522 Klamath-Trinity basin fall run chinook salmon scale age analysis evaluation.
SATTERTHWAITE, W. H., M. R. O'FARRELL, and M. S. MOHR
(September 2013)

523 Status review of the Northeastern Pacific population of white sharks *(CARCHARODON CARCHARIAS)* under the endangered species act.
DEWAR, H., T. EGUCHI, J. HYDE, D. KINZEY, S. KOHIN, J. MOORE, B. L. TAYLOR, and R. VETTER
(December 2013)

524 AMLR 2010-2011 field season report.
WALSH, J. G., ed.
(February 2014)

525 The Sacramento harvest model (SHM).
MOHR, M. S., and M. R. O'FARRELL
(February 2014)

526 Marine mammal, sea turtle and seabird bycatch in California gillnet fisheries in 2012.
CARRETTA, J. V., L. ENRIQUEZ, and C. VILLAFANA
(February 2014)

527 White abalone at San Clemente Island: population estimates and management recommendations.
STIERHOFF, K. L., M. NEUMANN, S. A. MAU and D. W. MURFIN
(May 2014)

528 Recommendations for pooling annual bycatch estimates when events are rare.
CARRETTA, J. V. and J. E. MOORE
(May 2014)

529 Documentation of a relational database for the California recreational fisheries survey onboard observer sampling program,1999-2011.
MONK, M., E. J. DICK and D. PEARSON
(July, 2014)

530 Life cycle modeling framework for Sacramento River winter-run chinook salmon.
HENDRIX, N., A. CRISS, E. DANNER, C.M. GREENE, H. IMAKI, A. PIKE, and S. LINDLEY
(July, 2014)