SOUTHWEST FISHERIES SCIENCE CENTER

NOAA FISHERIES - NATIONAL MARINE FISHERIES SERVICE - SOUTHWEST FISHERIES SCIENCE CENTER

JUNE 2017

PROCEEDINGS OF THE 2015 TRINATIONAL SARDINE FORUM

La Jolla, California, United States of America
December 1-3, 2015

by

Stephanie Flores
and
Gerard DiNardo

ADMINISTRATIVE REPORT LJ-17-02

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La Jolla, California 92037, United States of America

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ADMINISTRATIVE REPORT LJ-17-02

2015

TRINATIONAL SARDINE FORUM

FORO TRINACIONAL DE LA SARDINA

December 1-3, 2015

2015 Trinational Sardine Forum Participants
Southwest Fisheries Science Center
8901 La Jolla Shores Drive
La Jolla, CA 92037
United States of America

https://swfsc.noaa.gov/TSF/

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INTRODUCTION

The Southwest Fisheries Science Center (SWFSC) held the 16th Annual Trinational Sardine Forum (TSF) on December 1 and 2, 2015, in the Pacific Room at the Southwest Fisheries Science Center, in La Jolla, CA. Close to sixty participants from Mexico and the United States attended and represented government agencies, academic institutions, and industry (Appendix I). California Wetfish Producers Association sponsored the 2015 TSF dinner banquet.

Dr. Francisco (Cisco) Werner, the director of Southwest Fisheries Science Center (SWFSC), welcomed everyone and delivered the opening remarks. Canada was unable to attend this year; however, several avenues of correspondence continue to unite them with the United States and Mexico. It is greatly hoped that all three countries will be able to attend in 2016.

This year is expected to be particularly unusual due to the coming El Nino. Events like this heighten the importance of this meeting, which aids in uniting the strengths of the three countries. Working together allows for the advancement of science in pace and reach otherwise unattainable on one's own. The Pacific Fisheries Management Council has asked the group to consider coast wide stock abundance and ecosystem based methods in our stock assessments. Furthermore, the group must consider expanding this meeting to include forage fish and ecosystem information as a means to broaden the scope of research and evolve the science to the next level.

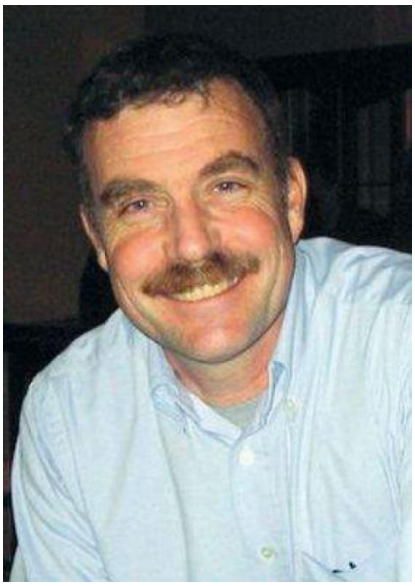
Following the opening remarks, representatives from Canada, Mexico, California, Oregon, and Washington presented current data, aging methods and industry information during the Regional Sardine Fisheries Reports section. Kerry Griffin and Dale Sweetnam then presented on the 2015 PFMC Council Report, and Kevin Hill presented the Assessment of the Pacific Sardine Resource in 2015 for USA Management.

The second day included a discussion on the 2015 fisheries closures and its impact on the squid industry. There was some discussion surrounding the 2015/2016 cruise survey season and the new acoustics of the NOAA Ship Reuben Lasker. The group also briefly discussed research plans and reports, aerial surveys, as well as current surveys and limitations.

Working Group (WG) reports were presented on the second day. Dale Sweetnam presented WG 1: Regional Biomass, John Hyde presented WG 2: Stock Structure, Age Structure, and Adult Sampling, and Mike Okoniewski presented WG 3: Industry Trends and Issues.

The Trinational Sardine Forum concluded with discussion on the future of the Forum, including expanding conversation to more pelagic species. An Otolith workshop was held the following day, a summary and agenda of the meeting can be found in Appendix 5.

REMEMBERING ROBERT "BOB" LAURENCE EMMETT



Robert (Bob) Laurence Emmett, a respected and much loved member of the sardine research community, passed away on April 27, 2015.

Bob Emmett worked with NOAA for 36 years, most of which as a Fisheries Biologist at the Northwest Fisheries Science Center. Among his many other involvements, Bob was a past chair and active member of the Pacific Fish Management Council's Coastal Pelagic Species Management Team dealing with sardine issues, and helped plan and organize many of the Trinational Sardine Forum meetings throughout the years.

In 2012, Bob organized the 13th Annual Trinational Sardine Forum in Seattle, WA. Unfortunately, he was not well enough to attend, though his efforts made the meeting a great success.

Bob was tirelessly devoted to his work and a great inspiration to all who knew him. He proved that one could truly enjoy their jobs and find passion in their work. He was warm, endlessly generous with his praise and direction, and he will be greatly missed by all those who knew him.

PLENARY SESSION HIGHLIGHTS

2015 Canadian Sardine Fishery Report

Corey Jackson[1], Linnea Flostrand[2], Sean MacConnachie[2] and Vanessa Hodes[2]

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This presentation includes summary information on British Columbia (Canada) purse seine fishery annual quotas and landings (2002-2015) and sardine observations from summer research trawl surveys conducted off the west coast of Vancouver Island (with a focus on the night survey period 2006-2014).

The Canadian Pacific Sardine Fishery was closed in 2015, due to the spring 2015 U.S. Stock Synthesis assessment of the age 1+ biomass of the northern subpopulation being forecasted and estimated at levels below the cutoff of 150, 000 tonnes. The 2013 and 2014 Canadian fishing seasons were open but no landings were made due to a lack of available sardine in the fishing grounds.

Summer DFO research trawl surveys have been conducted off the west coast of Vancouver Island to collect information on sardine ecology. Sampling design of the surveys has evolved over the years but in general, tows are conducted in surface waters (< 30 m) using a midwater trawl towed at average speeds approximating 5 knots for 20 minutes. Since 2006, sampling has been conducted at night. No sardines were captured during the 2014 and 2013 summer night surveys within the boundaries of a core survey region. No survey was conducted in 2015 due to a scheduling change to conduct the survey every second year, during even years. A survey is being planned for 2016.

Discussion
It was confirmed the sardine surveys will continue and that previously presented biomass trends are the same as those presented here.

2015 Bahía Magdalena Bay Sardine Fishery Report

Roberto Félix-Uraga[1], Martín E. Hernández Rivas, Casimiro Quiñonez-Velázquez[1], Felipe Neri Melo-Barrera.

[1] Instituto Politécnico Nacional – CICIMAR, Departamento de Pesquerías y Biología Marina Becarios COFAA y EDI.

In the past 15 years (2000-2014), landings of the small pelagic fishes in Magdalena Bay had an average of 52,052 t per year, with an average catch of 42,479 t of Pacific sardine and 748 fishing trips. During 2014, 652 fishing trips were realized and landings of small pelagic fishes were 52,440 t of which 37,623 t were Pacific sardine. Regard the specific composition of small pelagic fishes landed in Magdalena Bay in 2014, Sardinops sagax accounted for 71.7%, Opisthonema 22.1%, E. teres 3.2%, S. japonicus 0.8%, C. mysticetus 0.5% and 1.7% was a mixture of some of these species. 16 vessels landed small pelagics during 2014, but only 10 of them realized the 80% of the total fishing trips. In relation to the size composition of Pacific sardine, 99% of catches were above of the minimum legal size (150 mm SL). Most of these sardines (83.4%) had sizes between 170-215 mm SL. The age composition determined for 2014 reflects the above. Age groups 1 and 2 were the most abundant (44% and 37.4% respectively), but groups 3 and 4 were also significant amounts on landings. In all months of 2014 mature or spawning sardines were presented, but higher reproductive activity was during January to March with a minor peak in May and June. Currently Pacific sardine shows a more continuous reproductive activity. During January to October 2015, have been downloaded 24,291 t of small pelagic fishes, of which Opisthonema spp represented 16,299 t (67.1%) and only 4,870 (20%) t was Pacific sardine. The importance of the remaining small pelagic fishes was: E. teres 5.7%, S. japonicus 4.4%, C. mysticetus 0.9% and 1.9% was a mixture of species.

2015 Baja California Small Pelagic Fishery Report

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The small pelagic fishery represent an important food source, employees and economic benefits for the Countries which using these fishes as marine resource. The landings of small pelagic in 2014 was 40% higher than the historical average of 1990 – 2013 (62,863 mt), a total of 88,832 mt of small pelagic were landed in Baja California, 98.12 % was of sardine and the rest (1.88%) was mackerel and anchovy. The greater part of landings was between July to December, the monthly average catch was 2,150 mt. Fishing effort was 1003 trips and 20 vessels participating in 2014. The majority of catch occurred in waters adjacent to South Center of Baja California coast.

The average overall standard length was 169.9 mm, less than the historical standard length 175.5 mm.

2015 California Sardine Fishery Report

Chelsea Protasio and Dianna Porzio

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The Pacific Sardine fishery in California operates as both a day and night fishery with landings concentrated in two distinct fisheries, divided at Pt. Conception. The vessels in California tend to not fish on the weekend, following the same pattern as the Market Squid fishery. Aircraft spotter planes are frequently used to assist the vessels in locating schools of sardines as well as other coastal pelagic species (CPS). Since 2000, most landings have been centered in the southern portion of the state. However, the 2014/15 season had higher landings within the northern/central fishery, primarily around the Monterey Bay, making up 68 percent of the state's total landed catch. Forty-three vessels in the California limited entry permit fishery made landings into the California ports during 2014/15. As of the end of June 2015, the landings in California totaled approximately 3,754 metric tons (mt). A preliminary estimate of the mean weight of landings is 14.1 mt per trip. Incidental amounts of Pacific mackerel, jack mackerel, and market squid have also been landed.

The 2014/15 Annual Catch Target (ACT) was set at 23,293 mt for the entire US West coast, another substantial drop from the 2012 and 2013 Harvest Guidelines (HGs) of 109,409 mt and 66,495 mt respectively. Sardines were landed in California during all three allocation periods; however, on April 28, 2015, the fishery closed during the third allocation period. In the previous seven years, allocation periods closed early because catch limits were reached.

The 2015 sardine biomass estimate was below the cutoff threshold value in the HG control rule of 150,000 metric tons (mt). As a result, there is no directed non-tribal commercial fishery for the 2015/2016 sardine fishing year. Pacific sardine may be harvested only as part of either the live bait fishery, the tribal fishery, or as incidental catch in other fisheries.

Discussion

Attendees discussed the utility of the aerial survey and whether sardine observed in shallow water areas during the aerial survey, and outside the normal trawling areas, was due to abundance and fish concentrating further in shore or merely the ability to see fish in the trawling area during the day. While it is difficult to determine, the mismatch between trawling time in the ATM and the aerial survey may also contribute. Attempts were made to photograph at night, but

there is only a short window in which to do so. While the aerial survey is limited to the Southern California Bight, it would be preferable to expand the footprint to encompass the ecological range of CPS.

2015 Oregon Sardine Fishery Report

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In 2014, the sardine fishery year changed from a calendar year to a July 1 through June 30 schedule in federal regulations, although allowable harvest was allocated among the same three fishing periods as in previous years. To accommodate the transition to a new fishery year, an interim harvest guideline was adopted for January 1-June 30, 2014. The Oregon sardine fishery is greatly influenced by the timing of peak availability of sardines in northwest waters and environmental factors, as well as the federal fishing period allocations. Oregon vessels operate as a day fishery and often fish northwest waters in common with vessels from Washington. There are 25 limited-entry sardine permits and they are transferable twice a year.

For the interim 2014 sardine fishery, no purse seine landings were made in Oregon.

For the 2014-2015 sardine fishery, 18 vessels landed a total of 9,758 mt in Oregon, half the allowed U.S. harvest of 19,576mt for the directed fishery. These sardine landings averaged $437/mt and brought $4.3 million in ex-vessel revenue to the fleet. Landings were made during all three fishing periods: 7218 mt during July 1- 22, 2014; 7274 mt during September 15-19, 2014; and 5,084 mt during January 1-April 25, 2015. Oregon closed the third period three days earlier than the federal fishery closure on April 28, 2015. In addition, landed bycatch of Pacific mackerel and jack mackerel during the 2014-2015 sardine fishery totaled 1,008 mt and 245 mt, respectively. Landings of these species averaged $264/mt and accounted for an additional $0.3 million in ex-vessel revenue.

For the 2014-2015 fishery, 42 landings were sampled for sardine biological information: 15 in July during the first fishing period, 12 in September during the second, and 15 in March and April during the third. Twenty-five sardines were collected per sample. For the first fishing period, females averaged 221mm and 179.5gm and males averaged 217mm and 169.6gm. For the second fishing period, females averaged 220mm and 194.0gm and males averaged 216mm and 184.2gm. For the third fishing period, females averaged 222mm and 176.1gm and males averaged 219mm and 170.3gm. Most females during the third period had visible eggs present (maturity stage 3).

2015 Washington Sardine Fishery Report

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Pacific sardines are the primary coastal pelagic species harvested in Washington waters. The Washington sardine fishery opens annually by rule on April 1. In 2014, the US Pacific sardine fishing year changed from a January – December season to a July 1 – June 30 season. This change was made to better accommodate the delivery of scientific survey data to the sardine stock assessment process. To accomplish the shift, a separate allocation was adopted for the interim 6-month period, January 1 – June 30, 2014. In the interim period three vessels participated in the Washington sardine fishery. Landings from January 1 through June 30, 2014 totaled 910 metric tons, or 13 percent of the 6,946 mt harvest guideline. The fishery also landed 14 mt Pacific mackerel and 13.5 mt jack mackerel. During the subsequent full fishing season, July 1, 2014 – June 30, 2015, all of the directed fishery CPS harvest was landed in July and September 2014. Eight vessels, or half of the Washington state licensed fleet, participated in the fishery. Sardine landings totaled 6,276 mt, or 22 percent of the US harvest guideline. Total direct value of landings was $2.8 million. Incidentally landed species included 489 mt Pacific mackerel and 158 mt jackmackerel. These landings represent the second highest total for Pacific mackerel and the highest total for jack mackerel since the directed sardine fishery began in Washington in 2000.

Discussion

It was pointed out that peak catches of sardine occurs from July through September. It was also noted that catch in Oregon and Washington is regulated through landing licenses. This allows fishermen to catch fish off the coast of Oregon to land their product in Washington.

2015 PACIFIC FISHERY MANAGEMENT COUNCIL REPORT

Kerry Griffin[1] and Dale Sweetnam[2]

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Several Topics will be presented that were discussed at the Pacific Fishery Management Council's November 2015 meeting:

Pacific Sardine Distribution Workshop

The Council considered the report on the August 2015 Pacific Sardine Distribution Workshop, which reviewed several potential alternatives to the current distribution term in the Pacific sardine harvest control rule. While there are potential alternative approaches to determining the average long-term distribution of the northern subpopulation of Pacific sardine that could be explored further, the Council accepted the conclusion that no currently-available alternative is superior to the existing distribution term and did not schedule further consideration of changing the distribution term at this time.

Northern Anchovy Update

At the request of the Council, the Southwest Fisheries Science Center (SWFSC) summarized the most up to date survey information regarding the status of northern anchovy populations and other Coastal Pelagic Species (CPS) along the west coast. The most recent survey data was discussed in relation to the unusual environmental conditions observed in the California Current the last three years. Preliminary evidence of multiple spawning locations and high numbers of potential recruits of both northern anchovy subpopulations and Pacific sardine along the west coast suggests that 2015 may be a better year for CPS than has been observed in the past few years. However, while the increased recruitment signals are positive, it is premature to assess their overall contribution to the stock without conducting a formal stock assessment.

Data-limited stock assessments for Coastal Pelagic Species

The SWFSC presented information on data-limited stock assessment methods for CPS stocks, including the two anchovy subpopulations, and discuss a prioritized assessment schedule to fulfill national mandates of updating assessments of U.S. fish stocks. The Council requested the SWFSC finalize their initial planning to conduct a stock assessment of the central population of northern anchovy in time to be presented at the November 2016 Council meeting, including plans to convene a scientific workshop to be held in Spring 2016 designed to develop the optimum approaches for data-limited CPS stocks.

ASSESSMENT OF THE PACIFIC SARDINE RESOURCE IN 2015 FOR U.S.A. MANAGEMENT IN 2015-16

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Executive Summary

The following Pacific sardine assessment update was conducted to inform U.S. fishery management for the fishing year that begins July 1, 2015 and ends June 30, 2016. Model 'T' represented the final base model from the most recent stock assessment review (STAR) conducted in March 2014 (Hill et al. 2014, STAR 2014). This update assessment appends Model T with one additional year of data from fishery-dependent and -independent sources and is based on similar parameterizations as included in the most recently reviewed Model T.

Stock

This 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 Ensenada (ENS) to British Columbia (BC) were from the northern subpopulation. There is now general scientific consensus that catches landed in ENS and SCA likely represent a mixture of the southern subpopulation (warm months) and northern subpopulation (cool 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 each year 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 southern California (SCA) ports in order to exclude both 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
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	10,534.0	9,026.1	11,906.2	10,018.8	3,672.7	2,873.9	2,931.7	0.0
2012-2	2012-1	48,534.6	0.0	6,896.1	883.6	568.7	39,744.1	32,509.6	19,172.0
2013-1	2012-2	13,609.2	12,827.9	2,592.2	769.7	84.2	149.3	1,421.4	0.0
2013-2	2013-1	37,803.5	0.0	3,658.1	62.9	811.3	27,599.0	29,203.7	0.0
2014-1	2013-2	17,667.5	2,106.2	1,237.7	666.7	4,404.0	0.0	908.0	0.0
2014-2	2014-1	49,076.6	0.0	320.0	0.0	1,830.8	7,788.4	7,208.5	0.0

Data and Assessment

The assessment was conducted using Stock Synthesis (SS version 3.24s), and includes fishery and survey data collected from mid-1993 through 2014. The model is based on a July-June fishing year (aka 'model 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 modeled as a single PacNW fleet (fishery). 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 (2006-2014). 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 freely estimated. The spring and summer ATM time series were modeled with independent, asymptotic selectivities.

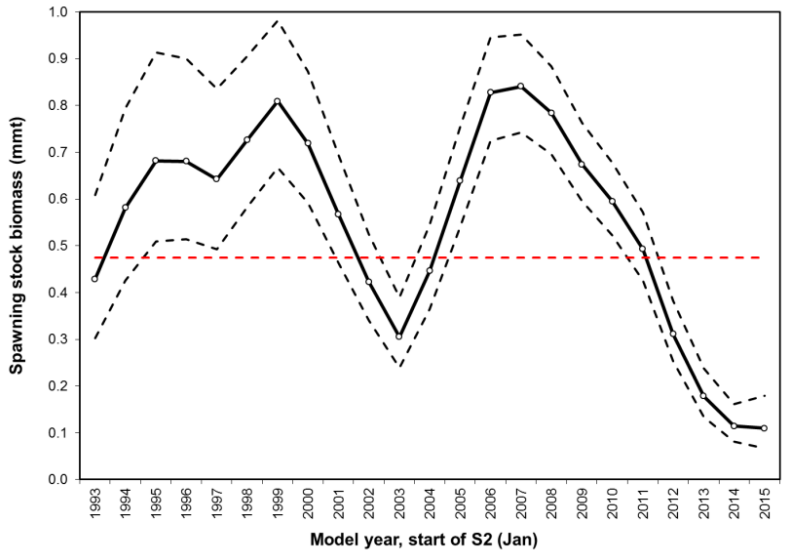
The following data were updated or appended to the update model:

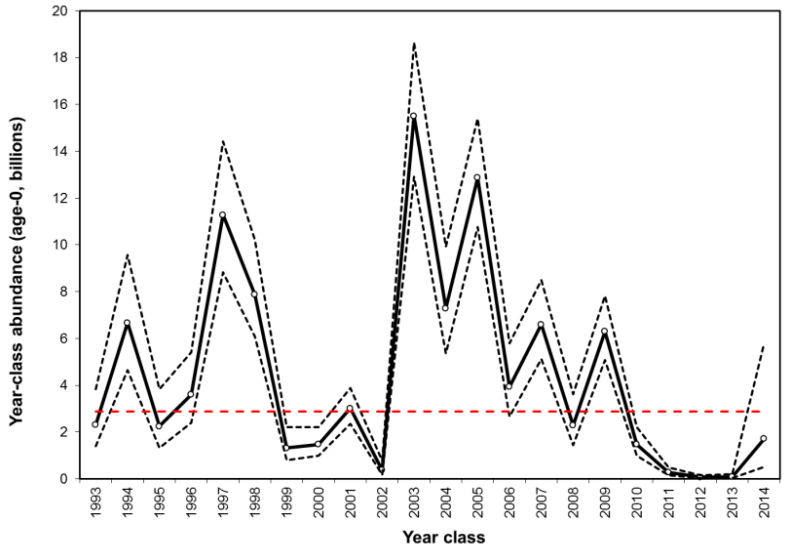
- Landings for 2012 through 2014 were updated for all fishing regions (ENS to WA), including projected estimates for the first half of 2015 (model year 2014-2);
- Length compositions from SCA, CCA, OR, and WA fisheries were updated for model year 2013 and appended with the first semester of model year 2014 (Jul-Dec 2014 samples);
- Conditional age-at-length data from SCA, CCA, OR, and WA were updated through Dec 2013. Age data were not yet available for 2014;
- ATM estimates of biomass from the spring 2014 survey off California and the summer 2014 SaKe survey off the U.S. west coast (San Diego to Vancouver Island) were added to the model; and

Due to very sparse data collected in the most recent CalCOFI survey conducted in the spring 2014 off California, it was not possible to produce an updated DEPM estimate of SSB for this index of abundance.

Spawning Stock Biomass and Recruitment

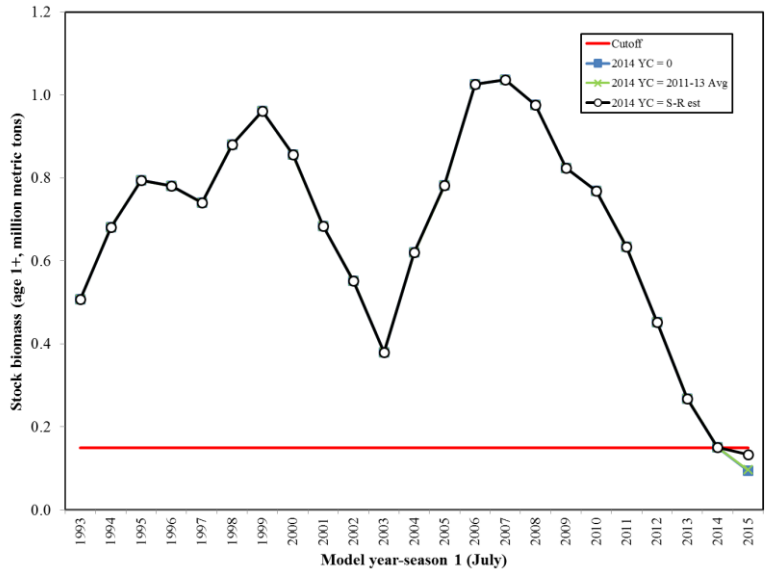
Recruitment was modeled using the Beverton-Holt (B-H) stock-recruitment relationship (σR=0.75). Steepness estimates typically bounded at 1.0 for most model scenarios evaluated in sensitivity analysis, with steepness being fixed at 0.8 in the final base model, based on a reasonable range for clupeid stocks indicated from stock-recruitment meta-analysis research. Virgin recruitment (R0) for the final base model was estimated to be 2.884 billion age-0 fish. The virgin value of the spawning stock biomass (SSB) was estimated to be 0.475 million metric tons (mmt). The SSB increased throughout the 1990s, peaking at 0.809 mmt in 1999 and 0.841 mmt in 2007. Recruitment (age-0 abundance) peaked at 11.3 billion fish in 1997, 15.5 billion in 2003, and 12.9 billion in 2005. The 2010 to 2013 year classes were among the weakest in recent history. The 2014 year class, derived largely from the predicted stock-recruitment curve, was poorly estimated (CV=0.69) and unrealistically high, given the paucity of spawning activity during spring 2014.





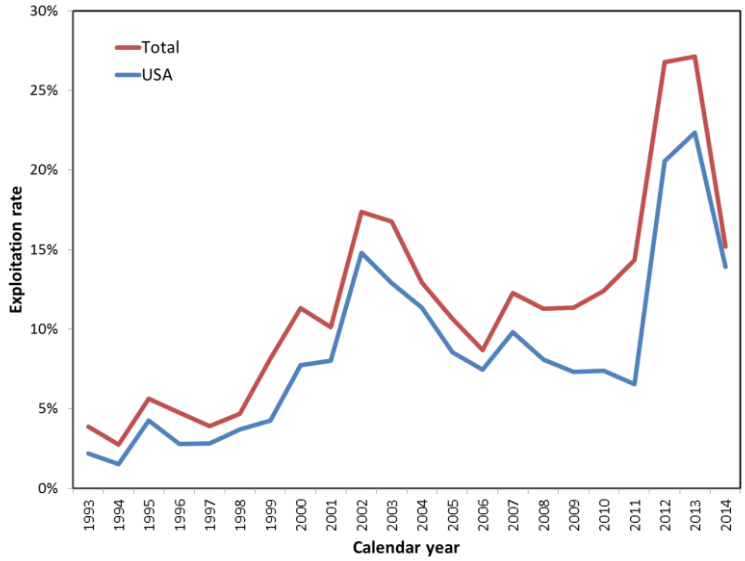
Stock Biomass

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 0.961 mmt in 1999 and 1.037 mmt in 2007. Stock biomass is projected to be less than 150,000 mt as of July 2015. When the 2014 year class is freely estimated, then stock biomass is projected to be 132,884 mt in July 2015. When the 2014 year class is based on an average of recruitments from 2011-2013, then stock biomass is projected to be 96,688 mt in July 2015. Given the lack of evidence for spawning in 2014, and the fact that recent recruitments have been over-estimated in the past several assessments, the latter is considered to represent the most likely scenario and is recommended for calculating harvest control rules (HCR) in 2015-2016.



Exploitation Status

Exploitation rate is defined as the calendar year NSP catch divided by the total mid-year biomass (July-1, ages 0+). Based on update model estimates, exploitation rate for the U.S. fishery peaked at 22.4% in 2013. U.S. exploitation rate was 13.9% in 2014. U.S. exploitation rate has averaged about 11% since the onset of Council management in 2000. U.S. and total exploitation rates for the NSP, calculated from the update model, are:



Harvest Control Rules

Harvest guideline

The annual HG is calculated as follows:

HG = (BIOMASS – CUTOFF) • FRACTION • DISTRIBUTION;

where HG is the total U.S. quota for the period July 2015 to June 2016, BIOMASS is the stock biomass (ages 1+) projected as of July 1, 2015, CUTOFF (150,000 mt) is the lowest level of biomass for which directed harvest is allowed, FRACTION (5-20%) 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. Based on results from the update model, and regardless of assumptions regarding strength of the 2014 year-class, stock biomass is projected to be below the 150,000 mt threshold. Therefore, HG for 2015-2016 is calculated to be 0 mt.

OFL and ABC

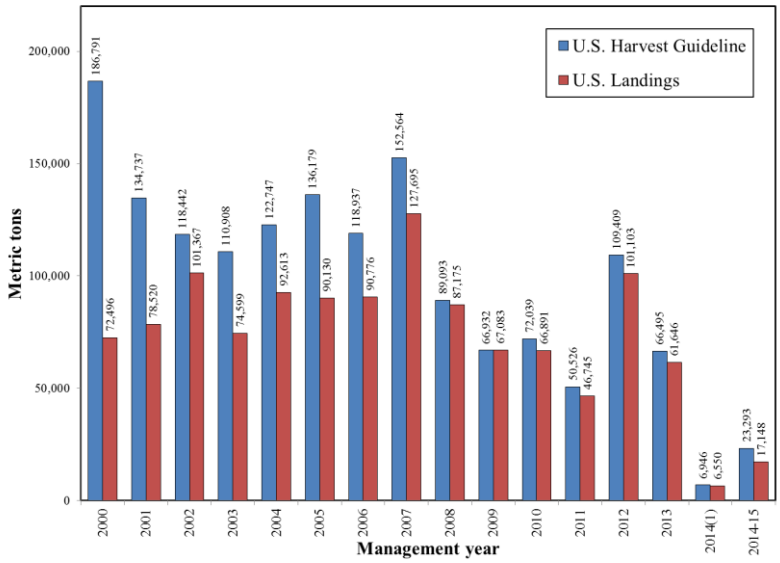
On March 11, 2014, the PFMC adopted the use of CalCOFI SST data for specifying environmentally-dependent EMSY each year, beginning July 2014. Based on this recent decision, the following tables of OFL and ABCs are based on an EMSY = 0.157239, which corresponds to the three-year running average of CalCOFI SST for 2012-2014 (15.562 °C). OFL and ABC values for 2015-2016 will depend on assumptions regarding strength of the 2014 year-class used to project stock biomass to July 1, 2015. As noted above, when the 2014 year class is freely estimated (albeit primarily derived from the spawner-recruit relationship) then stock biomass is projected to be 132,884 mt in July 2015. When the 2014 year class is based on an average of recruitments from 2011-2013, then stock biomass is projected to be 96,688 mt in July 2015. Given the lack of spawning activity observed during spring 2014, the latter scenario is considered more realistic. The OFLs and ABCs for the average recruitment scenario and for a range of P-star values follow:

b) HCRs when 2014 YC is based on the average of 2011-2013 YC sizes.

Harvest Control Rule Formulas										
OFL = BIOMASS * E_{MSY} * DISTRIBUTION; where E_{MSY} is bounded 0.00 to 0.25										
$ABC_{P\text{-}star}$ = BIOMASS * $BUFFER_{P\text{-}star}$ * E_{MSY} * DISTRIBUTION; where E_{MSY} is bounded 0.00 to 0.25										
HG = (BIOMASS - CUTOFF) * FRACTION * DISTRIBUTION; where FRACTION is E_{MSY} bounded 0.05 to 0.20										
Harvest Formula Parameters										
BIOMASS (ages 1+, mt)	96,688									
P-star	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05
ABC $Buffer_{Tier\ 1}$	0.95577	0.91283	0.87048	0.82797	0.78442	0.73861	0.68859	0.63043	0.55314
CalCOFI SST (2012-2014)	15.562								
E_{MSY}	0.157239								
FRACTION	0.157239								
CUTOFF (mt)	150,000								
DISTRIBUTION (U.S.)	0.87								
Harvest Control Rule Values (MT)									
OFL =	**13,227**								
$ABC_{Tier\ 1}$ =	12,642	12,074	11,514	10,951	10,375	9,769	9,108	8,338	7,316
HG =	**0**								

Management performance

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



Unresolved Problems and Major Uncertainties

Population estimates from this update model scaled an average 26% lower than stock biomass estimated in the 2014 assessment (Model T). This change was attributed to a shift in the spring ATM length selectivity to small sizes as well as the updated fit to the ATM surveys that included the very low estimated biomass observed in 2014. This selectivity sensitivity was observed previously in the 2014 full assessment (see sections Retrospective analyses and Likelihood profile for virgin recruitment) and was part of the STAR 2014 panel deliberations (see STAR 2014), but was unable to be effectively resolved in 2014. During the SSC CPS Subcommittee's review of this update, it became apparent that the final 2014 assessment did not correspond to the best overall fit to the data. This was due to an uneven likelihood surface and the 2014 model converging to a local minimum. This problem was discovered by re-running the 2014 model from a lower initial R0 value and estimating this parameter in a later phase. The 2015 update model was subsequently run through a series of convergence tests to ensure the current model represents the optimal solution.

The 2014 year-class strength is highly uncertain and poorly informed by the available data. The model estimate of recruitment in 2014 is unrealistically high given the lack of spawning observed from the surveys during spring 2014. This is important, given the 2014 year-class is part of the calculation of the age 1+ stock biomass for July 2015. The STAT's proposed alternative approach would be to base the 2014 year-class estimate on average recruitment levels from 2011-13, account for natural and fishing mortality throughout 2014, and add the resulting age-1 biomass to the age 2+ biomass from the update model to determine the stock biomass for July 2015.

RESEARCH DISCUSSION

Research Plans and Reports

There was considerable discussion on staffing requirements, particularly since the PFMC is asking for input to support management of Northern anchovy. Current surveys conducted by SWFSC focus on sardine. Providing data on Northern anchovy will require modifications to the sardine survey, which will increase uncertainty in future sardine assessments. Each year the SWFSC conducts two CPS surveys, in addition to the four annual CalCOFI surveys. The utility of these surveys should be assessed relative to sardine stock assessment needs to determine if all surveys are needed.

New Acoustics of Lasker

D. Demer discussed aspects of the cruise for the summer of 2016. At the time of the conference, the approach of the summer survey hadn't yet been discussed, but the length (79 days) would be the same as it had been in previous years. This will be an off year for the Pacific hake survey, and D. Demer believed this is one of the most important years to do a full fledge survey (sardine and hake). In addition, he believed that working in some additional experimental work could be instrumental, though it would require some structural changes to allow time for everything needed.

The Lasker was recently outfitted with new instrumentation, including the Simrad EK60, ME70, MS70, and SX90 echosounders/sonars. Also new is a low frequency long range sonar, with the ability to look closer to the shore and surface. One of the issues regarding CPS schools are their reactions to vessels,whether the schools move outside of the detection range which could potentially bias survey findings. The low frequency long-range sonar will help us investigate these reactions. The ship also has 70 wideband sonar- 3d observations outfitted to the side of vessel to record fish schools' reactions to vessels. Again, this allows a closer look at schools near the surface and in a three dimensional shape to provide further information as to how they react as vessels pass.

Simrad will be transitioning from the EK60 (5 frequencies) to the wideband EK80 (6 frequencies). The new wideband gear enhances our ability to discriminate between taxa and to aid in the direction of scatters (behavior).

There are some challenges with the new instrumentation, largely including synchronization and coordination of the instruments. Testing will commence in 2016 during the CPS survey.

Aerial Surveys

SWFSC, in conjunction with an Industry group in the Pacific North West, coordinated aerial flybys of the Shimada during SaKe 2015 in an attempt to photograph schools being sampled by

the survey In addition to the camera, those on board took notes on what they saw. In general there was an agreement as to the types of schools present.

Survey Limitations-Addressing Techniques

As with any survey, improvements can always be made. The SWFSC CPS survey is constantly being improved as additional information becomes available. There was agreement that some uncertainties in the survey protocols will require direct experiments (e.g., net selectivity/catchability) while other questions can be addressed with existing data. For example can necessary data be provided to support stock assessments if only a single CPS survey was conducted? A question was also raised as to whether the acoustic signals collected during the daytime were the same schools as those found in the trawl at night. Efforts are underway to address some of these questions and the new sonar gear on the Lasker will help, but it's clear that direct testing will be required.

In regard to survey timing and frequency, the assessment scientists suggested keeping the CalCOFI spring survey from San Diego to San Francisco to observe eggs only (as adult sampling takes too much time) and the summer CPS survey, with a broadening of the offshore extent for mackerel and anchovy. Hill also argued that we should focus on improving trawl sampling. The DEPM survey has been useful but it's not the most consistent survey time series in terms of noise, making it difficult to use in modelling. While it provides a good indication of whether fish are spawning, using this information to calculate spawning stock biomass (SSB) has its limitations. Originally developed for anchovy and only applied to sardine thereafter, DEPM tends to underestimate stock biomass. Given changing ocean conditions it would make more sense to survey during the summer when CPS populations are known to be present in the waters.

WORKING GROUP REPORTS

Working Group 1: Regional Biomass

2015 Pacific Sardine Stock Assessment shows cyclic decline in population.

Survey update from 2015 from ASSESSMENT OF THE PACIFIC SARDINE RESOURCE IN 2016 FOR U.S.A. MANAGEMENT IN 2016-17

Kevin T. Hill[1], Paul R. Crone[1], Emmanis Dorval[2], and Beverly J. Macewicz[1]
[1]Southwest Fisheries Science Center
[2] Contractor, Ocean Associates Inc.

Pacific sardines are known for wide swings in their population: the small, highly productive species multiplies quickly in good conditions and can decline sharply at other times, even in the absence of fishing. Scientists have worked for decades to understand those swings, including the decline since 2008 that led to the Pacific Fishery Management Council's recommendation this April to suspend commercial sardine fishing off the West Coast for the first time in decades.

The basis of the Council's action was an updated stock assessment by NOAA Fisheries' Southwest Fisheries Science Center. Stock assessments are management tools that estimate the status and size of the sardine population so the Council can allow fisheries managers to set fishing quotas.

The sardine assessment models combine NOAA data on the past/current abundance of sardine eggs, larvae and mature fish with other data on sardine biology and catch. The data on sardine abundance comes from two SWFSC surveys conducted off the West Coast each year. These surveys employ two methods to estimate the current size of the sardine population. They use underwater acoustic equipment (like sonar) to estimate the size of fish schools, followed by the use of trawl nets to verify the species comprising the schools. Additionally, the surveys employ devices that measure the density of sardine eggs in the water as a gauge of sardine spawning. Scientists can then calculate how large the spawning population must be to produce the measured density of sardine eggs.

These data feed a computer model to estimate sardine population trends and provide the foundation for projections of the total population of sardines off the West Coast in the next fishing year.

The assessment produced this year suggests that the environmental conditions associated with a series of years with cool water temperatures beginning about 2007 may have reduced the survival of juvenile sardines to the point that the population declined. The number of surviving

young fish appears to have dropped to the lowest levels in recent history and has likely remained low in 2014. This has led to a steady decline in the fishable sardine stock biomass, which is defined as the total volume of sardines at least a year old. This is the measure the Council and NOAA Fisheries relies on when setting fishing quotas.

The current decline illustrates the boom-and-bust nature of sardine populations. The sardine biomass rose from about 300,000 metric tons in 2004 to a high point of more than 1 million in 2008 and will decrease to about 97,000 metric tons by this coming July.

The model used for the assessment resulted in the 2015 biomass estimate of 97,000 metric tons, which resulted in the Council's action to close the 2015-2016 sardine fishing season, as well as the remainder of the 2014-2015 sardine fishing season. Even though the sardine population is presently not overfished and overfishing is not occurring, the continued lack of recruitment observed in the past few years could decrease the population even without fishing pressure.

Survey Activities

2015 Winter CalCOFI Survey

The Winter CalCOFI Survey spanned from January 15 through February 8, 2016, on the SIO RV *New Horizon*. The survey worked the 113 station CalCOFI pattern from San Diego to San Francisco. The scientific team was able to complete 100 of the 104 proposed stations before weather deteriorated off of Point Reyes, requiring the ship to return to port.

The survey witnessed oligotrophic conditions on coastal stations as well as offshore stations that have normally seen higher chlorophyll and nutrient levels. Average mixed layer was relatively deep at 70 meters and chlorophyll levels were low even in the inshore stations. Offshore SSTs continue to show anomalously high temperatures (19°C) for this time of year.

Ichthyoplankton samples were unusually low in all collection types (PRPOOS, pairovet, manta, bongo, and CUFES samples). Only a very few sardine and anchovy eggs were collected by CUFES as very patchy distributions in the innermost coastal stations. Pelagic tuna crabs (*Pleuroncodes planipes*) turned up consistently in the plankton samples although in low numbers. Despite low productivity and sparse plankton samples, marine mammal and sea bird populations seemed to be abundant.

2015 Spring CalCOFI Survey

The Spring CalCOFI Survey took place on the SIO RV *New Horizon*, from April 4-20, 2015.
The ship occupied 70 stations (61 standard and 9 SSCCOOS) of the original 75 stations planned within the Southern California Bight. This was the *New Horizon*'s final project before the ship was decommissioned.

Zooplankton samples consisted of large catches of small pyrosomes on night stations. Roughly 20 Small Loggerhead turtles were seen both inshore and offshore, and many Mola mola were seen as well. There were virtual carpets of Velella on line 80, clogging the manta net. The extent of these concentrations haven't been present in over a decade. Warm sea surface temperatures also brought pelagic tuna crabs and *Halobates*.

Pacific mackerel eggs were abundant in CUFES. The survey captured eggs on all lines and further offshore than typical of pacific mackerel. On station 90.0 80.0 there were thousands of pacific mackerel under the lights as the CTD was lowered into the water.

2015 CPS-DEPM Survey

The CPS-DEPM Survey took place on the FSU *Shimada* from March 28- May 1, 2015. The cruise was an acoustic-trawl and DEPM survey to determine the distributions and abundances of pelagic fish stocks, their prey, and their biotic and abiotic environments in the area of the

California Current between Cape Mendocino, California, and San Diego, California. Based on warm sea surface temperature anomalies, the most recent sardine habitat map, and reports of sardine catches off Oregon, the departure point was shifted from San Francisco to the south of Newport.

Despite the shift in the departure point, very few sardine eggs were found on the survey. Those that were collected were mainly between Cape Blanco and Cape Mendocino, much further north than their normal location off the central coast, south of San Francisco. Almost no sardine eggs were collected off southern California, apart from a few very close to shore in the Southern California Bight. CPS egg counts were dominated by jack mackerel eggs off southern California. The survey also collected very few adult sardine in the trawls. These were located mainly off Oregon, and were in spawning condition.

Working Group 2: Stock Structure, Age Structure, and Adult Sampling

In previous years, sardine stock structure research has been an attempt to attain as much information possible from a wide array of sources. Much of the current focus is analyzing otoliths and archiving adult samples/working on previous year's samples and data. The question now is whether the best course of action should be to attain even more information, less but greater focus on certain areas, or whether focus should be redirected in another direction. The option of shifting focus to anchovy was introduced as a possible new direction, as this stock will likely rise in importance over the upcoming years.

There didn't seem to be any agreed upon direction for the future of sardine/anchovy studies, though the group did appear to agree that temporal and spatial changes in spawning need to be further examined.

Working Group 3: Industry Trends and Issues

The industry view of the current trends was discussed. As of December, there was no fishing for sardine, and the fleet itself has been greatly reduced in recent years. Demand for longline tuna bait has diminished greatly. In Alaska, sardine once replaced herring as bait, but this trend may reverse if the current catch levels persist. There has even been discussion of importing sardine to Alaska for bait. The industry is concerned that the public will find a substitute supplier if the industry remains restricted from supplying the demand for sardine. The longer the fleets have to hold out the more the markets will turn to other suppliers. U.S. fleets have already lost many holdings in Canada. With limitations in catch, the sardine industry has come to rely more heavily on squid in past years. However, as we brace for El Niño, the squid catch will decline further.

M. Okienowski reinforced that they are just as invested as any other sector in the conservation of the stock, fishermen's lives are dependent on this resource. They understand there will be fluctuations throughout the years, but they also have a vested interest in the practices and it is how they make their living. The Industry is interested in finding the closest number between what is necessary to repopulate the stock without taking out the industry's source of revenue.

An industry perspective from Mexico was provided. It appears as though the sardine have gone further south, towards the peninsula, as they are no longer present in Ensenada. They don't know whether the northern stock is not coming down as far, or the south is not going up as high. In 2014 there was a record catch of 80k tons, so the sardine are there but seemed to be moving differently. He believed this behavior had to do with the varying water temperatures. The industry and boats are having bad years, despite records catches, as the costs of operation are much higher.

Fleets in the Gulf of California have taken steps to protect plants and employees. As a measure, they have decided not to fish any sardine. Instead, the main catch is anchovy, herring, etc. Their production 6 years ago were 500t, but in the last two seasons were 209t/240t, composed of negligible amounts of sardine.

CONCLUSION

The two full-day Forum was well attended and provided many opportunities to share information across national lines.

The conclusion of the Forum focused on the future of the meetings. Attendees were asked to decide whether the Trinational Sardine Forum should expand to include more pelagic species (e.g. anchovy, herring, etc.) as these species are becoming more prevalent. While the Forum has long encompassed all CPS, the decision to officially change the name and mission of the forum was opened for discussion. While there was some minor discussion regarding how this decision would impact the output of the meeting, it was agreed that the Forum should expand its scope to include other small pelagics. By doing so, this would provide more opportunities for Canada to rejoin the discussion.

The Forum concluded with closing remarks from Dale Sweetnam (SWFSC) thanking everyone for making the time to attend.

The 2016 Trinational Sardine Forum will be held in San Diego, California in early December. Please visit https://swfsc.noaa.gov/tsf/ for more information.

ACRONYMS

CDFW	California Department of Fish and Wildlife
CIAD	Centro de Investigación en Alimentación y Desarrollo
CICESE	Centro de Investigación Científica y de Educación Superior de Ensenada
CICIMAR	Centro Interdisciplinario de Ciencias Marinas
CONAPESCA	Comisión Nacional de Acuacultura y Pesca
CRIP	Centro Regional de Investigación Pesquera
DFO	Department of Fisheries and Oceans, Canada
FACIMAR	Facultad de Ciencias del Mar
IMECOCAL	Investigaciones Mexicanas de la Corriente de California
INAPESCA	Instituto Nacional de la Pesca
IPN	Instituto Politécnico Nacional
NOAA	National Oceanic and Atmospheric Administration
NMFS	National Marine Fisheries Service
NWFSC	Northwest Fisheries Science Center
ODFW	Oregon Department of Fish and Wildlife
PSC	Pacific Seafood Co
SAFS	School of Aquatic and Fishery Sciences, University of Washington
SARDI	South Australia Research and Development Institute
SIO	Scripps Institution of Oceanography, University of California San Diego
SWFSC	Southwest Fisheries Science Center, National Marine Fisheries Service
UBC	University of British Columbia
WDFW	Washington Department of Fish and Wildlife

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APPENDIX II: AGENDA

Monday, November 30th

Arrival in La Jolla, CA

Tuesday, December 1st

8:00 Registration

9:00 Welcome and opening remarks – Dr. Cisco Werner, Southwest Fisheries Science Center

9:20 Meeting Logistics – Dale Sweetnam, Southwest Fisheries Science Center

9:25 Regional Sardine Fisheries Reports (15 minutes each)

Canadian 2015 Report; Linnea Flostrand

Washington Sardine Fisheries Report; Lorna Wargo (WDFW)

Oregon Sardine Fisheries Report; Jill Smith (ODFW)

10:10 Break

10:30 California Sardine Fisheries Report; Chelsea Protasio and Dianna Porzio (CDFW)

10:45 Small Pelagic Fishery on the West Coast of Baja California, 2014 Fishing Season; Concepción Enciso-Enciso* and Celia Eva Cotero-Altamirano (INAPESCA CRIP-Ensenada)

11:00 Pacific Sardine Fishery in Magdalena Bay, 2014-2015; Martín E. Hernández Rivas (CICIMAR)

11:15 2015 Pacific Fishery Management Council Report/Update; Kerry Griffin (PFMC) and Dale Sweetnam (SWFSC)

11:30 Assessment of the Pacific Sardine Resource in 2015 for U.S.A. Management in 2015-16; Kevin Hill (SWFSC)

12:00 *Lunch*

13:30 Impact of Climate Variability and Change on the Pelagic Ecosystem and Fisheries of the California Current; Tim Baumgartner (CICESE)

13:50 Contrasting and complementing time-series of sardine abundance along the California Current system; Ruben Rodriguez-Sanchez (CICIMAR-INP)

14:10 Intrinsic variability of forage populations and fish declines in the Southern California Current System; Sam McClatchie (SWFSC)

14:30 Break

15:00 Reproductive biology of Sardinops caeruleus from the Pacific coast of Baja California during 2014; Celia Eva Cotero-Altamirano (INAPESCA CRIP-Ensenada)

15:20 Pacific sardine (Sardinops sagax) size and age specific spawning during 1986-2015; Bev macewicz (SWFSC)

15:40 Pacific mackerel biomass, recruitment, growth, and mortality during 2006-2015; David Demer (SWFSC)

16:00 Stronger than average recruitment to the central stock of Northern anchovy in 2015; Juan Zwolinski (SWFSC)

16:20 The Rewilding of the California Current: Marine mammal forage requirements and implications for forage fish management; Russ Vetter (SWFSC)

17:00 *Adjourn*

18:00 Dinner at The Fish Market (downtown San Diego) with no-host bar (Courtesy of California Wetfish Producers Association)

<u>Wednesday, December 2nd</u>

8:00 Research Plans and Reports

- Coast-wide Surveys
- Stock structure (genetics, microchemistry, traditional approaches, others)
- Fishery Closures
- Environmental effects of the Warm Blob and El Nino

10:00 *Break*

10:30 Working group (WG) breakout sessions

WG1) Regional biomass-Dale Sweetnam

WG2) Stock structure, age structure and adult sampling- John Hyde

WG3) Industry trends and issues- Mike Okoniewski

12:00 *Lunch*

13:30 Plenary Sessions results of WG discussions

14:30 Closing remarks

15:00 *Adjourn*

<u>Thursday, December 3rd</u>

Acoustic Data Analysis meeting (Krill Room)

Otolith Aging Workshop (Pacific Room)

9:00 Welcome and Introductions

9:15 SPARC otolith exchange data summary

9:30 Ageing session
Examination of SPARC exchange otoliths and discussion.

12:00 *Lunch break*

13:00 Ageing session wrap up
Establishment of reference collection and discussion.

15:45 Closing remarks
Summary and future plans for SPARC.

APPENDIX III: CONTRIBUTED ABSTRACTS AND SUMMARIES, ORAL PRESENTATIONS

Impact of climate variability and change on the pelagic ecosystem and fisheries of the California Current

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Abstract: The California Current (CC) forms the eastern limb of the large-scale circulation of the North Pacific Ocean gyre. The CC flows equatorward along the west coast of the United States and Mexico carrying relatively cool, low salinity subarctic water down to the tip of the peninsula of Baja California. The organization and structure of the pelagic ecosystem of the California current is strongly linked to the ocean dynamics of the upper 200 m and subject to interannual to decadal fluctuations and longer term change in the ocean-atmosphere climate over the north pacific. This presentation examines the links between interannual and decadal climate variability and the changes in the state of the pelagic ecosystem in the California current off Baja California using data for the years 2000-2013 from the ocean monitoring by the IMECOCAL (Mexican program for research on the California Current). The relationship of the climate and ecosystem changes to fisheries is exemplified by the change in distribution and productivity of the sardine population associated with climate. Our motivation is to summarize our current understanding of the relation between climate and ecosystem response and to indicate the transboundary nature of the fishery between Mexican and U.S waters.

Key Words: California Current, Baja California, IMECOCAL, climate

Contrasting and complementing time-series of sardine abundance along the California Current system

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Different analytical approaches and several sources of data are used to investigate sardine abundance and changes in population size. For the northern stock, all available information is incorporated into the stock assessment using a peer-reviewed method (Stock Synthesis). Population models from Murphy (1966), MacCall (1979), and Hill et al. (2010, 2015) provided yearly time-series of recruit abundance (age 0) (R) and stock biomass (age 2+) (B2+) from 1930 to the present. Another source of data that has been used to explain the long-term dynamics of sardine population size and its spatial variability along the southern California Current system (SCCS) is based on an index of relative abundance of sardine (CPUE) estimated from records of catches of young sardine as live-bait for tuna boats. The available data from this source are CPUE time-series from 1931 to1997 for five areas (A-E), including from the California coast (CPUEA) to the southern end of the Baja California peninsula (CPUEE). These independent, complementary time-series are analyzed here to examine potential relationships between them, geographical overlap representing similar dynamics, and preliminary developments for combining and integrating both sources of information. Population biomass time-series R, B2+ and R/B2+ (recruits per spawning biomass or stock productivity) were correlated individually with CPUE from each area and with CPUE from pooled areas of different extensions (i.e., CPUEA+B, CPUEA+B+C+D+E). Of all the combinations between the assessment time-series and the full range of CPUE indices along the SCCS, R was found to best correlate with CPUEA (r2= 0.78), and correlation values with CPUE of any other single or pooled areas diminished southward and they were not statistically significant, which suggests that: 1) both time-series, relative abundance index of young sardine off California (CPUEA) and recruits abundance of age 0 (R), can be used to explain similar temporal dynamics of sardine off California. Thus, CPUEA may be incorporated into a long-term stock assessment model to link the historic and recent eras of abundance; 2) along the Baja California peninsula, sardine population dynamics are different to that represented by R or CPUEA, and the temporal variability among adjacent areas is different. To combine and integrate both sources of information, our preliminary results are based on the Fox model and the R α CPUE relationship is used to estimate recruit abundance (age 0) when the stock was not exploited or the Virgin Stock (Bv). For the California area, these independent, complementary time-series can be related as R = 658.13 CPUEA (r2= 0.893) and CPUEAA = e3.62-0-0056(effort in area A). Similar approaches to estimate Bv for other areas along the Baja peninsula are also calculated using the live-bait records as baseline data.

Intrinsic variability of forage populations and fish declines in the Southern California Current System

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Declining numbers of forage fish off southern California in the last decade have wide implications for fisheries, mammal and seabird predators, and for stock assessment. Recent work reported 72% declines in the abundance of cool water associated fish species since the 1980s, based on a principal component analysis of 27 species from consistently sampled CalCOFI stations (Koslow et al., 2015). Using the same sampling scheme, we noted a decline in the abundances of fish larvae, but found that the larval declines were driven primarily by six abundant species (anchovy, hake, sardine, Sebastes spp. and two numerically dominant cool water mesopelagic species, California smoothtongue and northern lampfish). When three commercial species (sardine, anchovy and hake) were removed, the declining trend disappeared.

Diversity analyses show that the fish assemblages are resilient over the last thirty years (1985-2014) despite the occasional extreme ENSO event that causes significant perturbation in the structure and diversity of assemblages. While the assemblage structure and diversity has been stable over thirty years, we see changes in the proportional dominance of species from 1985-2011, particularly at the offshore California Current station in winter and spring seasons. Stable diversity of the ichthyoplankton assemblage initially seems to be inconsistent with fish declines off southern California.

However, decline of a few abundant species is not incompatible with stable diversity because diversity is determined by the skewed distribution of the broader assemblage of over 400 species. We conclude that the southern California offshore ichthyoplankton assemblage is resilient, despite some changes in species composition manifest in the offshore regions, and that declines in three numerically abundant species does not necessarily indicate a community under stress. We would argue that the major stressor of the offshore ichthyoplankton assemblage at this time is extreme ENSO events operating at the inter-annual scale, rather than decadal-scale climate trends in acidification, oxygen, and temperature.

The next step in our research is to place the CalCOFI time series data in the context of intrinsic variability of forage populations based on a new 500-year paleontological reconstructed record of fish scales and environmental variables from the years 1000-1500 AD.

Reproductive biology of *Sardinops caeruleus* from the Pacific coast of Baja California during 2014

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Abstract. The most important of massive resources in the Mexico are the small pelagic fishes with emphasis in the Pacific Sardine Sardinops caeruleus. Mexico according to the Law general of fisheries and aquaculture sustainable the National Fishery Institute as scientific advisor to Fishery Authority maintain a monitoring the principal fisheries like small pelagic fishes with the objective of manage fisheries to do they sustainable use of resources. Biological samples were collected from sardine commercial fleet. The landings sardine began on May and continued through December, 2014. Standard lengths of the sardines, individual weights, sex and maturity was registered. In the lab samples both female and males gonads were processed with histological techniques. Analyzing the cellular structures in the gametogenesis process in the gonads for reproductive activity; the size structure was bimodal, the standard length was between 110 to 230 mm. The spawning peak was on August, the majority of individual had asexual maturity of 2 on September and October. A relationship between the reproduction and the temperature and upwelling was observed. A change of reproduction time was observed of winter-spring to summer time. The length at maturity was estimate at 189 mm.

Pacific sardine (*Sardinops sagax*) size and age specific spawning during 1986-2015

Beverly Macewicz

Southwest Fishery Sciences Center-NOAA, La Jolla, CA, USA

No abstract available

Pacific mackerel biomass, recruitment, growth, and mortality during 2006-2015

David A. Demer, Juan P. Zwolinski, Beverly J. Macewicz, George R. Cutter Jr., Brian E. Elliot, Scott A. Mau, David W. Murfin, Josiah S. Renfree, Thomas S. Sessions, and Kevin L. Stierhoff

Southwest Fishery Sciences Center-NOAA, La Jolla, CA, USA

Acoustic-trawl surveys conducted during spring, summer, or both, from 2006-2015, have provided maps of densities and estimates of biomasses and density-weighted length distributions for multiple species of small pelagic fish (CPS). The maps of Pacific mackerel catches indicate that the spring surveys sampled a variable portion of the stock, but the summer surveys may have sampled the entire stock. Trends in the demographics data indicate that the stock had relatively strong recruitments prior to the 2006, 2011, and 2015 surveys. The time series of data from the middle cohort may provide estimates of growth and natural mortality. The estimates of Pacific mackerel biomass from the summer surveys provide an indication of the recent stock trajectory. These results are discussed in the context of the environment and other species comprising the CPS assemblage.

Stronger than average recruitment to the central stock of northern anchovy in 2015

Juan P. Zwolinski[1], David A. Demer[2], Beverly J. Macewicz[2], George R. Cutter Jr.[2], Brian E. Elliot[2], Scott A. Mau[2], David W. Murfin[2], Josiah S. Renfree[2], Thomas S. Sessions[2], and Kevin L. Stierhoff[2]

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Northern anchovy (*Engraulis mordax*) are short-lived, highly fecund clupeoids that exhibit large swings in abundance. Similar to other small coastal pelagic fish species (CPS), anchovy are periodically abundant forage for other fishes, mammals, and birds within the California Current Ecosystem (CCE). Anchovy are also the target of fisheries off Washington, Oregon, and California which market them as live bait, fishmeal, and human food. Since the early 1990s, U.S. landings from the two sub-populations of northern anchovy in the CCE have comprised a small fraction of the total CPS catches, presumably due to low availability, market influences, or both. A recently published assessment claims that the "central" anchovy stock collapsed prior to 2012, but recent landings at California have been above average. The results of acoustic-trawl surveys conducted during 2006-2014 confirm that the anchovy biomass in the CCE was low, but the anchovy catches during the summer 2015 survey were comparatively more broadly distributed. Furthermore, relative to the previous decade, the central population of anchovy included a larger proportion of juveniles in 2015, indicating a good 2014 or 2015 recruitment. The strength of this recruitment will be evaluated using data from the 2016 spring and summer acoustic-trawl surveys.

The rewilding of the California Current: Marine mammal forage requirements and implications for forage fish management

Russ Vetter and Sam McClatchie

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Landmark legislation passed in the mid-1970s led to the implementation of the Magnuson-Stevens Fishery Conservation and Management Act, the Marine Mammal Protection Act and the Endangered Species Act. Now, 40 years later we examine the relative magnitude of forage fish harvests and the increased demands of marine mammals for forage within the US west coast EEZ. In general exploited populations of pinnipeds and great whales have increased at near theoretical maximum demographic rates since the 1970's. Small cetacean populations were rarely targeted for direct harvest, and demographic impacts of bycatch and harassment mortality are poorly known. However, in some cases, small cetacean populations have also shown remarkable increases within the EEZ during this 40 year period. These increases may be due to migration into the EEZ due to direct and indirect effects of climate and forage distribution, as well as changes in local survivorship. Broad-scale surveys of marine mammals and fishery-independent forage surveys, coupled with high resolution physiological ecology studies of the bio-energetic demands of marine mammals, shed new light on the changing natural mortality (M) versus fishing mortality (F) of forage fish populations. Increasing numbers of pinnipeds and cetaceans has increased natural mortality of forage fishes in the last 40 years, but is not explicitly accounted for in current or anticipated forage fish assessments. We attempt a first order quantification of pinniped and cetacean forage fish predation, and compare its magnitude to estimates of forage fish catches.

APPENDIX IV: CONTRIBUTED ABSTRACTS AND SUMMARIES, POSTER PRESENTATIONS

Can otolith length and weight be used to improve age estimation of Pacific mackerel (*Scomber japonicus*)? Evidence from a laboratory experiment.

Julianne Taylor[1, 2], Emmanis Dorval[1, 2], Jenny McDaniel[1], and Helena Aryafar[1, 2]

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[2] Ocean Associates Inc. (OAI) Contracted to SWFSC. La Jolla, CA 92037, U.S.A.

Pacific mackerel are one of four species within the Coastal Pelagic Species complex that supports an important commercial fishery within the California Current Ecosystem. This population is exploited commercially from southeastern Alaska to Banderas Bay, Mexico and within the Gulf of Mexico. For this stock, parameters such as recruitment and biomass that are used in the age-structured assessment model are critically dependent on the accuracy and precision of age estimates. Many studies have used otolith length and weight as proxies for age determination for improving ageing precision in assessment models. However, it is important to first demonstrate a strong relationship between somatic growth and otolith growth before otolith length and weight can be used for age determination. For this study, juvenile Pacific mackerel were collected at the Everingham Bait Barge in Mission Bay throughout October and November of 2013. Fish were acclimated for two months, then tagged and reared for 12 months (January 2013 – January 2014) in three tanks at temperatures of 13˚C, 17˚C and 21˚C. Results showed that fish otolith weight significantly increased with somatic weight regardless of temperature. Additionally, the relationship between otolith length and weight with body length and weight for fish of similar ages varied with temperature. Data suggested that otolith weight and length were determined more by water temperature than by fish age. These parameters may help with better age estimates for stock assessment models.

APPENDIX V: OTOLITH WORKSHOP

Attendees

SWFSC	*Jenny McDaniel, Helena Aryafar, Julianne Taylor, Paul Crone, Bev Macewicz,, and Emmanis Dorval*
CDFW	*Dianna Porzio, Mandy Lewis, Leeanne Laughlin, Kirk Lynn, Jeannette Miller, Alex Kesaris, and Michelle Horeczko*
WDFW	*Lorna Wargo*
CICIMAR	*Ruben Rodriguez Sanchez*
Pacific Seafood Group	*Mike Okoniewski*

Summary

On December 03, 2015, the SWFSC hosted the Tri-National Sardine Forum Sardine Otolith Workshop. Representatives from the SWFSC, state and international agencies, and industry were in attendance. During the workshop, Jenny McDaniel presented preliminary results of the sardine otolith exchange initiated by the Small Pelagics Ageing Consortium (SPARC) followed by an interactive ageing session. The group reviewed otoliths and ageing methods, identified common issues encountered during sardine ageing, and discussed the need for continued collaboration to improve and standardize protocols. The workshop was available via WebEx for attendees unable to participate onsite. WebEx participants were able to view otoliths and participate in discussions.

OTOLITH WORKSHOP AGENDA

Thursday, December 03, 2015

Southwest Fisheries Science Center
Pacific Room
8901 La Jolla Shores Drive
La Jolla, CA 92037
USA

9:00am – 9:15am	Welcome and introductions
9:15am – 9:30am	SPARC otolith exchange data summary
9:30am – 12:00pm	Ageing session Examination of SPARC exchange otoliths and discussion
12:00pm – 1:00 pm	Lunch break
1:00pm- 3:45pm	Ageing session wrap up Establishment of reference collection and discussion
3:45pm – 4:00pm	Closing remarks Summary and future plans for SPARC.