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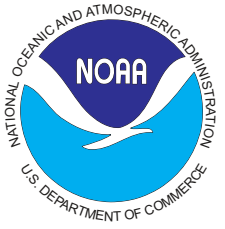
DECEMBER 2017

PROCEEDINGS OF THE 2016 TRINATIONAL SARDINE & SMALL PALEGICS FORUM
La Jolla, California, United States of America
December 8-9, 2016

by

Stephanie Flores
and
Gerard DiNardo

ADMINISTRATIVE REPORT LJ-17-03



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Southwest Fisheries Science Center
National Marine Fisheries Service
National Oceanic & Atmospheric Administration
8901 La Jolla Shores Drive
La Jolla, California 92037, United States of America

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ADMINISTRATIVE REPORT LJ-17-03

17th Annual Trinational Sardine & Small Pelagics Forum

December 8-9, 2016

LA JOLLA, CALIFORNIA, USA

Southwest Fisheries Science Center

8901 La Jolla Shores Drive
La Jolla, CA 92037-1508
Phone: (858) 546-7000

2016 Trinational Sardine and Small Pelagics Forum Participants

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

Mission Statement:

It is the mission of the Trinational Sardine and Small Pelagics Forum to collaborate in improving coast-wide stock assessment: sampling for age, size composition, reproductive state, regional biomass estimates, stock structure, development of a common data base, following industry trends and issues and understanding of the role of sardine in the ecosystem.

Background:

In recent years, Pacific sardine fisheries have once again been prosecuted along the coast of North America from Baja California, México, to British Columbia, Canada. Information and research of this trans-boundary stock is sorely needed in order to provide an accurate coast-wide assessment of this widely distributed and highly variable stock. It is the mission of the Trinational Sardine and Small Pelagics Forum to encourage collaboration between Canada, Mexico, and the United States in improving coast-wide stock assessments: sampling for age, size composition, reproductive state, regional biomass estimates, stock structure, development of a common data base, following industry trends and issues and understanding of the role of sardine in the ecosystem.

Since its beginning in 2000, the annual Trinational Sardine and Small Pelagics Forum (TSF) has rotated among Mexico, Canada, and the United States, and comprised a wide range of participants from government, academia, and industry. Government partners include the Canadian Department of Fisheries and Oceans (DFO) and the Mexican government Instituto Nacional de Pesca (INAPESCA).

Agencies:

Canadian Department of Fisheries and Oceans (DFO), Mexican government Instituto Nacional de Pesca (INAPESCA), NOAA Southwest Fisheries Science Center (SWFSC), NOAA West Coast Region (WCRO), Pacific Fishery Management Council (PFMC), Washington Department of Fish and Wildlife (WDFW), Oregon Department of Fish and Wildlife (ODFW), California Department of Fish and Wildlife (CDFW)

Academic Institutions:

Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE), Centro Interdisciplinario de Ciencias Marinas (CICIMAR), University of Washington, Scripps Institution of Oceanography, University of California San Diego (SIO)

Industry Organizations:

California Wetfish Producers Association (CWPA), Pacific Seafood, Trimarine Group, Baja Mexico International, Fortuna Sea Products, Pan Pacific.

Tribal Organizations:

Quinault Indian Nation

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INTRODUCTION

The Southwest Fisheries Science Center (SWFSC) held the 17th Annual Trinational Sardine and Small Pelagics Forum (TSF) on December 8 and 9, 2016, in the Pacific Room at the Southwest Fisheries Science Center, in La Jolla, CA. Close to fifty participants from Canada, Mexico, and the United States attended and represented government agencies, academia, and industry (Appendix I). California Wetfish Producers Association sponsored the 2016 TSF dinner banquet.

Dr. Francisco (Cisco) Werner, director of Southwest Fisheries Science Center (SWFSC), welcomed everyone and delivered the opening remarks. He thanked everyone for their attendance, especially those who traveled from other countries.

The past three to four years have been especially remarkable, with the obvious change in ocean conditions and the emergence of the “warm blob.” These changes have shown how the ocean is affected by prolonged warm conditions, and how the dynamics of species within it are changed as a result. Small pelagics are especially responsive to warm conditions, most notably within their placement (north, south, inshore, offshore). This year’s forum is especially important in terms of how to go forward with this new understanding. The results of this discussion will in turn influence the 2017 ICES and PICES meetings in Vancouver, Canada, and the discussion of ecosystem based management in policy for the years ahead.

Following the opening remarks, representatives from Canada, Mexico, and the United States presented current data, aging methods, and industry information during the Plenary Session Highlights. Kerry Griffin (PFMC) and Dale Sweetnam (SWFSC) presented the 2016 Pacific Fisheries Management Council Report, and Kevin Hill presented the Assessment of the Pacific Sardine Resource in 2016 for U.S.A Management 2016-17.

Day two of the forum included a long discussion on research plans and reports for each of the countries. Noteable new research included trace element chemistry, and recovery expertise for ageing anchovy. Other topics of discussion included the 2017 Coast-wide surveys, current fisheries closures and their effect on the industry, Mexico’s marine preserves, and the impact of environmental changes (i.e., warm blob and El Niño) on small pelagic species.

The Trinational Sardine and Small Pelagics Forum concluded with discussion on the future of the Forum. There was consensus in expanding the discussion to include other small pelagics, since we must look at the mechanism and processes that affect small pelagic species from an ecosystem perspective. Attendees determined that future conferences should be conducted in San Diego due to its central location. The 2017 Trinational Sardine and Small Pelagics Forum will be held at the SWFSC in San Diego, California, in early December.

PLENARY SESSION HIGHLIGHTS

2016 Canadian Sardine Fishery and West Coast of Vancouver Island Trawl Surveys

Wellsley Hamilton[1], Linnea Flostrand[2]

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This presentation includes summary information on British Columbia (Canada) purse seine fishery annual quotas and landings (2002-2016) 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 and 2016, 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 mid-water trawl towed at average speeds approximating 5 knots for 20 minutes. During surveys in 2006, and 2008-2014 catch sampling was conducted from night trawl tows. No sardines were captured during the 2014 and 2013 summer night surveys. No survey was conducted in 2015 due to a scheduling change to conduct the survey every second year, during even years. No survey was conducted in 2016 due to a breakdown of the trawl winch machinery on the DFO research vessel.

Discussion:

Attendees discussed the relationship between the industry and current sardine fisheries. Fishing vessels reported sardine sightings during the 2016 harvest seasons, however, the number of reports were too small to have utility. Since the Canadian fishery is fairly new, established in 2007, harvesters rely on several species in addition to sardine. While sardine are important, and the fishermen hope for a reemergence, the industry has been self-adapting to the current situation.

It was confirmed that the future of the albacore stock assessments, and their relationship with sardine stocks, would eventually include an ecosystem approach. However, this approach has not yet been formalized.

2016 Northwest Coastal Pelagic Species Fisheries Report

Cyreis Schmitt[1], Lorna Wargo[2], Alan Sarich[3]

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Sardine fisheries in OR, WA, and Quinault Indian Nation will be discussed. There will also be a discussion that includes the recent squid and anchovy fisheries in OR. The state of Oregon will also describe legacy sardine fishery data that has recently been entered into electronic format. These data include OR landings by small reporting blocks off OR and WA during 1936-1941 that have been made into GIS maps, and biodata (fish length, weight, and sex) from samples during those years. Comparisons of the historical fishery versus the current fishery will be made.

California Sardine and Small Pelagics 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 made in northern and southern fisheries, divided at Pt. Conception. Since 2000, most landings have occurred in the southern portion of the state. 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 and other coastal pelagic species.

In 2015, the Pacific sardine stock assessment produced a biomass estimate below the "cutoff" threshold value in the Harvest Guideline (HG) control rule of 150,000 metric tons (mt). As a result, there was no directed non-tribal commercial fishery for the 2015/16 sardine fishing year, which runs July 1 through June 30. The National Marine Fisheries Service (NMFS) implemented an annual catch limit (ACL) of 7,000 mt, with Pacific sardine being allowed only as incidental catch in other fisheries, or part of the live bait or tribal fisheries. California landings for 2015/2016 totaled approximately 164 metric tons (mt). Incidental amounts of Pacific mackerel, jack mackerel, and market squid were also landed. The 2015/16 season had higher landings within the southern fishery, making up 89 percent of the state's total landed catch. Thirty-three vessels in the California limited entry permit fishery made landings into California ports during the 2015/16 season.

The 2016 Pacific sardine biomass estimate was again below the "cutoff" value of 150,000 mt, which means there will be no directed non-tribal commercial fishery for the 2016/17 Pacific sardine fishing year. NMFS is implementing an ACL of 8,000 mt with incidental catch being subject to specific management control rules.

Discussion:

Squid catch is down this year as compared to previous seasons. Since there isn't a direct squid fishery, the Industry is able to rely more heavily on other species when squid is low. The decline in squid is likely to move northward due to El Niño conditions.

The Small Pelagic Fishery in Baja California, Fishing Season 2015

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In Baja California, the landings of small pelagic in 2015 was 16.1% lower than the historical average of 2000 to 2014 (67,398 t), with a total catch of 56,541 t, of which the sardine accounted for 58%, the anchovy 40% and the mackerel registered 2%. The highest catches were recorded between July and October with an average of 8,637 t / month and the lowest records were between November and June with an average of 2,750 t / month. The fishing effort registered was 1,148 fishing trips made with 24 vessels, with a yield of 49.3 t /trip, 25% lower than that recorded between 2005-2014 (65.7 t / trip). The fleet operated mainly in the vicinity of the south-central coast of the western coast of Baja California, the average size recorded was 154.6 mm, 50% of the catch was below the legal minimum size (150 mm).

The Small Pelagic Fishery in Bahia Magdalena, Season 2015

Hernández Rivas, Martin Enrique; Quiñonez Velázquez, Casimiro[1]; Melo Barrera, Felipe Neri[1]

Instituto Politécnico Nacional–CICIMAR
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La captura anual de peces pelágicos menores en Bahía Magdalena, desde los orígenes de esta pesquería en 1981, ha presentado amplias variaciones. Durante sus primeros veinte años la captura anual presento un incremento constante, de 4,600 t a 38,000 t por año. Desde el 2000 a 2014 la captura se estabilizo en 52,000 t, de la cual el 81% correspondió a la sardina monterrey, 10% más del porcentaje promedio que represento de 1981 a 1999. No obstante que durante el segundo periodo se incrementó en 70% el número de viajes la CPUE no descendió, por el contrario, mostro un aumento del 40%. Esta tendencia sufre un brusco cambio durante el 2015, cuando se descargaron 26,500 t de pelágicos menores (18% sardina monterrey), con un esfuerzo de 450 viajes de pesca. Durante 2015, las mayores descargas de peces pelágicos menores, en Bahía Magdalena, se presentaron de enero a octubre y de enero a agosto de sardina monterrey, debido a los bajos rendimientos la flota detuvo operaciones de pesca desde mediados de noviembre. La composición específica de la descarga total de pelágicos menores indica que la sardina monterrey representó el 18%, la crinuda el 70%, la japonesa el 5%, la macarela el 4%, la bocona el 1% y el 2% se registró como mezcla de especies. Los 450 viajes de pesca fueron realizados por 19 embarcaciones; sin embargo, siete de ellos representan 6% del total del esfuerzo de pesca. De los restantes 12 barcos, seis representaron al 69% de los viajes de pesca. La estructura de tallas de la captura de la sardina monterrey, estuvo representada por 76% de organismos con talla mayor a talla mínima legal de 150 mm LE, y de estos el 47% presentaron tallas entre 170-200 mm LE. En la estructura de edades de la captura los grupos de edad predominantes fueron: 1 (46%), 2 (30%), y 0 (20%); los grupos 3 y 4 representaron 4%. Fue posible recolectar muestras biológicas de sardina monterrey de enero-junio y octubre, durante el primer periodo se detectaron sardinas maduras (estadios 4 y 5), y en octubre inmaduros y en progreso de maduración (estadios 1 y 2). La proporción sexual no fue significativamente diferente de 1M:1H (Chi-cuadrado=0.36, p=0.55).

Translation of the Small Pelagic Fishery in Bahia Magdalena, Season 2015

Hernández Rivas, Martin Enrique; Quiñonez Velázquez, Casimiro1; Melo Barrera, Felipe Neri1

Instituto Politécnico Nacional–CICIMAR

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The annual catch of small pelagic fish in Bahia Magdalena, since the origins of this fishery in 1981, has varied widely. During its first twenty years the annual catch presented a constant increase, from 4,600 t to 38,000 t per year. From 2000 to 2014 the catch stabilized at 52,000 t, of which 81% corresponded to the Pacific sardine, 10% more than the average percentage during 1981 to 1999. Although during the second period the number of trips increased 70%, CPUE did not decline, on the contrary, showed an increase of 40%. This trend changed sharply during 2015, when 26,500 t of small pelagic fish (18% Pacific sardine) was discharged, with an effort of 450 fishing trips. During 2015, the largest discharges of minor pelagic fish occurred from January to October and from January to August of the Pacific sardine, due to low yields the fleet halted fishing operations since mid-November. The specific composition of the total discharge of small pelagic fish shows that the Pacific sardine (*Sardinops sagax)* represented 18%, sardine crinuda (*Opisthonema libertate)* 70%, Japanese sardine (*Etrumeus teres*) 5%, mackerel (*Scomber japonicus*) 4%, anchovy bocona (*Cetengraulis mysticetus*) 1%, and 2% was recorded as a mixture of species. The 450 fishing trips were carried out by 19 boats; however, seven of them represent 6% of the total fishing effort. Of the remaining 12 vessels, six accounted for 69% of fishing trips. The size structure of the catch of the Pacific sardine was represented by 76% of the fish with size greater than legal minimum size of 150 mm SL, of which 47% presented sizes between 170-200 mm SL. In the age structure of the catch, the predominant age groups were: 1 (46%), 2 (30%), and 0 (20%), and groups 3 and 4 accounted for 4%. It was possible to collect biological samples of the Pacific sardine from January-June and October, during the first part of the year mature sardines (stages 4 and 5) were detected, and in October immature and in maturation progress (stages 1 and 2). The sex ratio was not significantly different from 1M: 1F (Chi-square = 0.36, p = 0.55).

Discussion:

The 2016 survey indicated a small increase in sardine biomass, with a similar increase in biomass also present in data from Ensenada. The results of the survey are still being processed to determine the cause of this increase; however the size of the sardine seem to indicate an average recruitment.

2016 NWFSC and State Surveys Coastal Pelagic Species

Recent observations on Pacific sardine and northern anchovy from Northwest Fisheries Science Center surveys

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[2] Pacific States Marine Fisheries Commission, Hatfield Marine Science Center, Newport, Oregon, USA
[3] Cooperative Institute of Marine Resources Studies, Oregon State University, Hatfield Marine Science Center, Newport, Oregon, USA

The NWFSC has been examining larval to adult stages of coastal pelagic fish species for the past 18 years off of Oregon and Washington. We observed substantial differences in the ecology of larval coastal pelagics in 2015 and 2016 due to the anomalously warm ocean conditions. Off Newport Oregon, both northern anchovy and Pacific sardine have undergone substantial phenological and distributional shifts in their spawning times (three months earlier) and locations (further north and closer to shore), coinciding with the warmer and more stratified surface waters resulting from reduced upwelling. An additional plankton survey which has collected egg and larval data off Oregon and Washington since 1998 observed sardine eggs off northern Washington for the first time in June 2016. Diet analysis on adults of these species collected on the shelf during early summer indicated dramatically different trophic linkages during the recent warm years with a greater occurrence of offshore taxa, especially gelatinous taxa, during 2015 and 2016. Previous studies done during cooler years (i.e., strong upwelling and high productivity years) found a greater occurrence of euphausiids and copepods, suggesting there have been major alterations in trophic functioning in this normally productive ecosystem due to anomalously warm conditions associated with the 2015 ‘warm blob’ and 2016 El Nino .

2016 PACIFIC FISHERY MANAGEMNET COUNCIL REPORT

Kerry Griffin[1] and Dale Sweetnam[2]

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Several topics discussed at the Pacific Fishery Management Council's 2016 meetings were presented.

Data-limited stock assessments for Coastal Pelagic Species - At the November 2015 Council meeting, the SWFSC reported that it would do a stock assessment on the Central Subpopulation of Northern Anchovy (CSNA) based on the guidance provided by the Council sponsored CPS data-limited workshop that was held, May 2-5, 2016 and reported to the Council at its September meeting (http://www.pcouncil.org/wp-content/uploads/2016/08/E2a_Workshop_Rpt_SEPT2016BB.pdf). At the workshop, the Panel reviewed both information from CPS fisheries around the world and the specifics of the data available for the CSNA. The workshop panel (Panel) agreed that the best approach for providing management advice for the CSNA was to develop an integrated stock assessment model that would use fishery-dependent monitoring data on age and length, and abundance indices based on ichthyoplankton and ATM surveys. This assessment should also consider the use of data from the SWFSC juvenile rockfish survey. However, the Panel also concluded that an integrated assessment could not be feasibly completed for "several years" due to the lack of basic biological information (see http://www.pcouncil.org/wp-content/uploads/2015/10/H4a_SWFSC_Rpt2_DataLimited_Nov2015BB.pdf).

Northern Anchovy Update – At the request of the Council, the SWFSC provided a summary of 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 SWFSC also updated the Council on the changing environmental conditions and the presence of the "Warm Blob" or the "North Pacific Marine Heat Wave" and the receding 2015-2016 El Niño, and its potential for continued effects on the biota of the California Current at its June 2014, November 2014, March 2015 and November 2015 meetings. In fact, one of the conclusions from last year's update was that "northern anchovy distribution as well as other species may have shifted both spatially and temporally out of the normal CalCOFI sampling area in recent years due to severe environmental changes (i.e., the "Warm Blob", the Pacific Decadal Oscillation, early El Niño effects) suggesting that the historical CalCOFI sampling grid in the Southern California Bight may not be adequately tracking the northward shift in anchovy abundance and distribution.

Discussion:

The prioritization of an anchovy specific survey is currently being discussed. Protocols for sardine have been finalized and those for anchovy are following suit.

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]

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Kevin Hill presented the Executive Summary from the recent Pacific sardine stock assessment. The full report can be found at the SWFSC website:
https://swfsc.noaa.gov/publications/TM/SWFSC/NOAA-TM-NMFS-SWFSC-562.pdf

Executive Summary

The following Pacific sardine assessment update was conducted to inform U.S. fishery management for the cycle that begins July 1, 2016 and ends June 30, 2017. 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). In 2015, the model was updated and served as the basis for management in 2015-16 (Hill et al. 2015). This 2016 update assessment includes one additional year of data from fishery-dependent and -independent sources and is based on similar parameterizations as included in the most recently reviewed assessments (Hill et al. 2014, 2015).

Stock
This assessment focuses on the northern subpopulation of Pacific sardine (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 the Southern California Bight (SCB, i.e., Ensenada and southern California) 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 SCB, 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 Ensenada (ENS) and southern California (SCA) ports 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
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	29,618.9	0.0
2014-1	2013-2	12,929.7	412.5	1,242.6	666.7	4,403.3	0.0	908.0	0.0
2014-2	2014-1	77,466.3	0.0	291.7	0.0	1,830.9	7,788.4	7,428.4	0.0
2015-1	2014-2	7,682.5	0.0	911.4	0.0	727.7	2,131.3	62.6	0.0
2015-2	2015-1	46,028.6	0.0	56.6	0.0	6.1	0.1	66.1	0.0

Data and Assessment

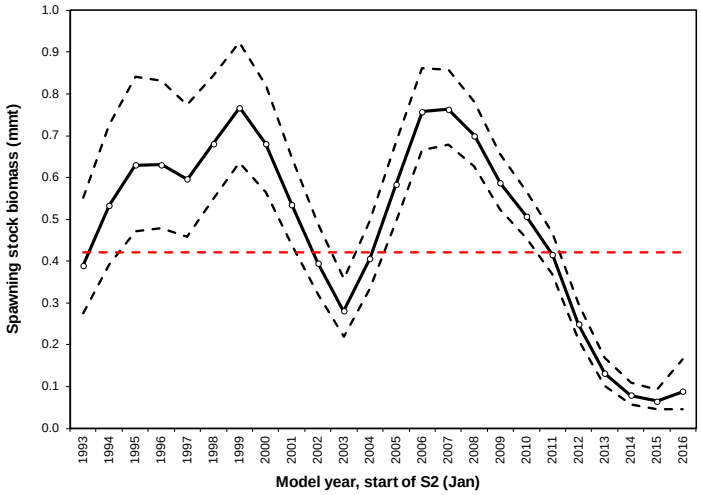
The assessment was conducted using Stock Synthesis (SS version 3.24s), and includes fishery and survey data collected from mid-1993 through 2015. The model is based on a July-June biological year (aka 'model year'), with two semester-based seasons per year (S1=Jul-Dec and S2=Jan-Jun). Catches and biological 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 by season 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 (1994-2015) and acoustic-trawl method (ATM) estimates of biomass along the west coast (2006-2015). Catchability (q) for the ATM surveys (spring and summer) was fixed at 1.0 and q's for the egg production surveys were freely estimated. Length compositions from the spring and summer ATM time series were each modeled with their own asymptotic selectivities.

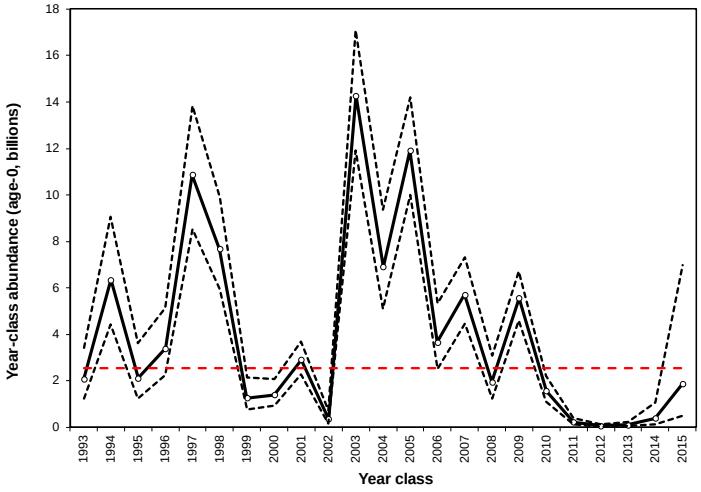
The following data were updated or appended to the update model:
Landings for 2013 through 2015 were updated for all fishing regions (ENS to WA), including projected estimates for the first half of 2016 (model year 2015-2);
Length compositions from SCA, CCA, OR, and WA fisheries were updated for model year 2014 and appended with new data for model year 2015-1 (Jul-Dec 2015);
Conditional age-at-length (CAAL) data from SCA and CCA fisheries were updated through model step 2014-2 (first half of 2015). CAAL data for OR and WA fisheries were appended through 2014-1;

A daily egg production method (DEPM) estimate of female spawning biomass (SSB) produced from the spring 2015 survey conducted between Morro Bay, CA and Newport, OR;
ATM estimates of biomass and associated length compositions from the spring and summer 2015 surveys off the U.S. west coast were added to the model. For reasons described subsequently, the summer 2015 length composition proved problematic and was excluded from the proposed update model.

Spawning Stock Biomass and Recruitment

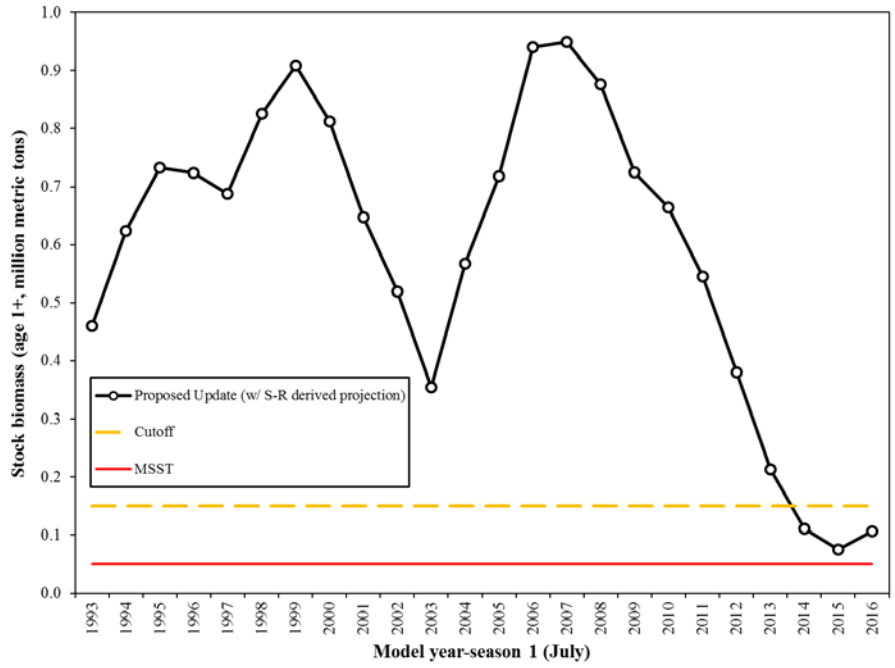
Recruitment was modeled using the Beverton-Holt (B-H) stock-recruitment relationship (σ_R=0.75). Steepness was fixed at 0.8 in model (Hill et al. 2014). Virgin recruitment (R_0) for the update model was estimated to be 2.548 billion age-0 fish. The virgin value of the spawning stock biomass (SSB) was estimated to be 0.422 million metric tons (mmt). The SSB increased throughout the 1990s, peaking at 0.767 mmt in 1999 and 0.763 mmt in 2007. Recruitment (age-0 abundance) peaked at 10.9 billion fish in 1997, 14.3 billion in 2003, and 11.9 billion in 2005. The 2010 to 2014 year classes were among the weakest in recent history. The 2015 year class (1.868 billion fish), predicted largely from the stock-recruitment curve, was poorly estimated (CV=0.76) given the paucity of data available for model year 2015.





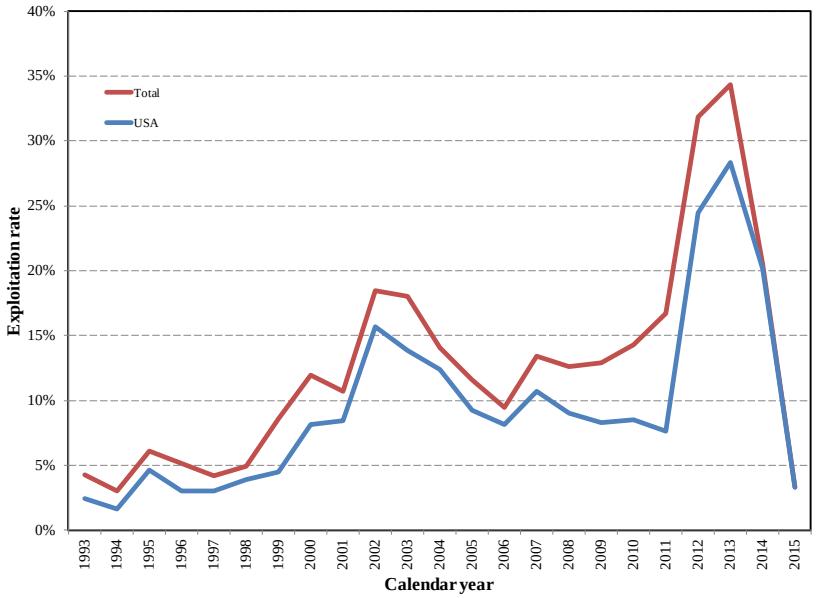
Stock Biomass

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 0.908 mmt in 1999 and 0.950 mmt in 2007. Stock biomass projected for July 2016 depends on assumptions regarding strength of recruitment in 2015. If the 2015 year class is estimated in SS (i.e., derived primarily from the S-R relationship), then stock biomass is projected to be **106,137 mt** in July 2016. If the 2015 year class is based on an average of recruitments from 2012-2014, then stock biomass is projected to be 64,422 mt in July 2016. Given ancillary survey evidence presented at the March 2016 update review, the SSC CPS Subcommittee recommended that the 2015 recruitment be estimated from the stock-recruitment relationship. The STAT concurred with this recommendation.



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, the U.S. exploitation rate has averaged about 12% since the onset of federal management, but peaked at 28% in 2013. U.S. and total exploitation rate was 3% in 2015. U.S. and total exploitation rates for the NSP, calculated from the update model, are:


40%
35%
30%
25%
20%
15%
10%
5%
0%
Exploitation rate
Total
USA
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Calendar year

Harvest Control Rules

Harvest guideline

The annual HG is calculated as follows:

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

where HG is the total U.S. directed harvest for the period July 2016 to June 2017, BIOMASS is the stock biomass (ages 1+) projected as of July 1, 2016, CUTOFF (150,000 mt) is the lowest level of biomass for which directed harvest is allowed, FRACTION (= E_{MSY} bounded 0.05-0.20) 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 proposed update model, and for either of two 2015 year-class scenarios, stock biomass is projected to be below the 150,000 mt threshold. Therefore, the HG for 2016-2017 is calculated to be 0 mt.

OFL and ABC

On March 11, 2014, the PFMC adopted the use of CalCOFI sea-surface temperature (SST) data for specifying environmentally-dependent E_{MSY} each year. E_{MSY} is calculated:
E_{MSY} = -18.46452+3.25209(T)-0.19723(T^2)+0.0041863(T^3),
where T is the three-year running average of CalCOFI SST, and E_{MSY} for OFL and ABC is bounded 0.00 to 0.25. Based on recent warm conditions in the California Current, the average temperature for 2013-2015 has increased to 16.3891 °C and the calculated E_{MSY} is 0.2865. Therefore, E_{MSY} for the 2016-17 season is bounded at 0.25.

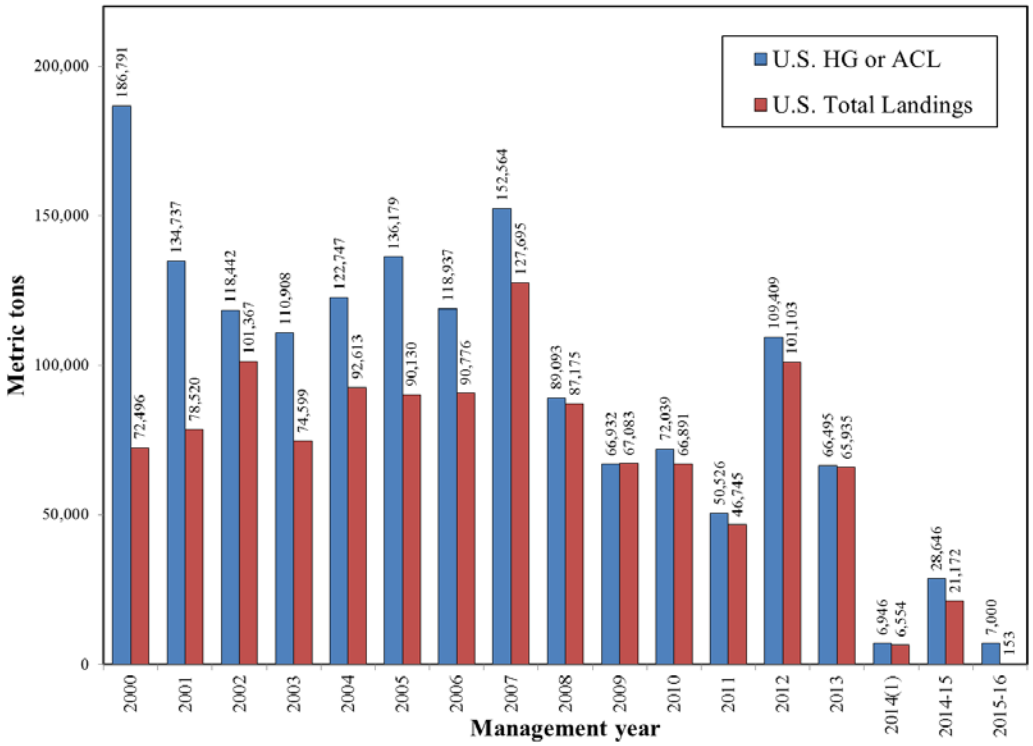
OFL and ABC values for 2016-17 depend on assumptions regarding strength of the 2015 year-class used to project stock biomass to July 1, 2016. As noted above, when the 2015 year class is freely estimated (but primarily derived from the spawner-recruit relationship), stock biomass is projected to be 106,137 mt in July 2016. When the 2015 year class is based on an average of recruitments from 2012-2014, stock biomass is projected to be 64,422 mt in July 2016. OFLs and ABCs for these two recruitment scenarios and for a range of P-star values follow:

a) HCRs when 2015 YC is derived from S-R Curve (proposed approach).

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)	106,137								
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
CalCOFI SST (2013-2015)	16.3891								
E_{MSY}	0.25								
FRACTION	0.20								
CUTOFF (mt)	150,000								
DISTRIBUTION (U.S.)	0.87								
Harvest Control Rule Values (MT)									
OFL =	**23,085**								
$ABC_{Tier\ 1}$ =	22,064	21,072	20,095	19,113	18,108	17,051	15,896	14,553	12,769
HG =	**0**								

Management performance

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



Unresolved Problems and Major Uncertainties

The biomass-weighted length composition estimated for the ATM summer 2015 survey contained an anomalously large portion of small sardine (>80% were smaller than the lowest length data bin of 9 cm). All of the small sardines sampled in summer 2015 were collected off central California. The summer ATM survey typically encounters larger fish associated with sardine movement annually to the Pacific Northwest (asymptotic selectivity inflection point is ~20 cm). Given the low probability of capturing small fish during this survey and the large portion of small fish encountered in the summer 2015 trawls, the strict update model resulted in an implausible terminal-year recruitment estimate (56.2 billion fish, reflecting a 2015 year class nearly four times greater than the largest year class in the modeled time series). Ultimately, updated selectivity for the ATM survey indicated a substantial shift to much smaller fish, and consequently, unrealistic estimated recruitment in 2015. Thus, a decision was made to exclude the summer 2015 ATM length composition from the proposed update model. The SSC's CPS Subcommittee endorsed this change during the March 2016 update review. This specific issue, along with the general problem of improving fits to length compositions from the ATM surveys, will be addressed during the next full sardine assessment in 2017.

Finally, as indicated in past CPS assessments/reviews, strength of the terminal-year recruitment is highly uncertain and poorly informed by the available data and thus, the estimate derived directly from the spawner-recruit relationship is driven by limited information and has the potential for being overly optimistic. This is important, given the terminal year recruitment (age-0) is part of the calculation of the age-1+ stock biomass projected for start of the new management year (July 1). During the 2015 sardine update assessment (Hill et al. 2015), the STAT noted a tendency of

the model to over-estimate terminal year-class abundance over the recent period of poor recruitments, i.e., 2011-2013. The STAT had also noted lack of evidence to indicate any spawning success in 2014. Thus, a recommendation was made that the 2014 recruitment be based on an average of 2011-2013 year-class abundances for projecting stock biomass to July 2015. That approach was endorsed by the SSC for purposes of setting 2015-16 harvest specifications. A similar projection approach (i.e. recent average recruitment for 2012-2014) was initially proposed by the STAT for estimating 2015 recruitment in this assessment. However, ancillary survey information presented at the March 2016 update review indicated that the 2015 year-class may be higher than the recent average. Evidence included the following: 1) a marked increase in larval sardine biomass collected along the Newport hydrographic line during the NWFSC's survey conducted during Jan-Mar 2015 (Leising et al. 2015); and 2) a spike in young (4-8 cm) sardine abundance observed in all regions (North, Core, and South) during May-Jun 2015 of the SWFSC Santa Cruz Lab's 'Rockfish Recruitment and Ecosystem Assessment' survey (Sakuma 2015). Given this ancillary evidence, the SSC's CPS Subcommittee recommended basing 2015 recruitment on the model estimate derived from the stock-recruit relationship. The STAT concurred with this recommendation, but reiterates it's request to the SSC for guidance regarding more standardized approaches to addressing terminal year-class uncertainty in ongoing CPS assessments.

RESEARCH DISCUSSION

Research Plans and Reports

United States

The Science Centers will likely face extensive budget cuts in 2017 and need to determine how to cut down the costs of surveys while maintaining the integrity of the data produced.

Juvenile salmon sampling in the Puget Sound estuary of the Northwest has been funded into 2017 and this sampling has provided opportunities for sampling various other CPS species in the region, including herring and anchovy. However, as salmon sampling effort migrates out of the estuary, sampling frequency diminishes from every two weeks to once a month. This resulted in missing anchovy this year. This survey may be a good source to review for anchovy sampling funding in the future.

New research going into 2017 includes Barbara Javor (SWFSC) and Emmanis Dorval's (SWFSC) research on trace element chemistry. Samples have been collected from southern and northern California, as well as Ensenada, but more are needed.

Diane Porzio (CDFW) and Jenny McDaniel (SWFSC) have also begun an effort to regain expertise on ageing anchovy for the first time in three decades. A collaboration between CDFW and the SWFSC has created the start of an anchovy aging program similar to that of sardine and mackerel, with strict training and testing. Samples from 2014 have been completed, with 78 left from 2013 to complete.

Mexico

Ruben Rodriguez-Sanchez (CICIMAR-IPN) is currently working on a genetic index of sardine population movement via synoptic sampling. They performed this analysis previously in 2005 using data collected in the 1900s and results were promising. They are still in need of current samples to determine if the sardine population is moving to the north or south with the current oceanographic conditions.

Coast-wide Surveys

United States:

The SWFSC will be conducting two CPS surveys, in addition to four annual CalCOFI surveys. The Center will also conducting gear selectivity research on the NOAA Ship *Shimada* prior to the spring survey to determine effectiveness of the trawling nets in catching fish in a uniform manner. The NOAA Ship *Shimada* has been scheduled for an 80 day Hake survey that will go into Canadian waters. Canada may participate in this survey if they are able to attain ship time.

Mexico:

Two cruises have been planned for 2017. The IMMECOCAL 1710 has been financed for a summer cruise and will survey productivity in oceanic fronts. IMMECOCAL 1707 is currently planned for a fall, but funding has not yet been confirmed.

The CUFES system has not yet been installed in the FV Alpha Helix, but this will hopefully be completed in 2017. The production company that created the system has since gone out of business and there is no pattern on how to mount the system, so they are attempting to find guidance on proper installation.

Canada:

Canada has been working on a biannual schedule for surveys, and 2017 would have been an off year, however, a night survey hasn't been conducted since 2014. It is still uncertain whether any will be conducted, since nothing has been funded at the time of the meeting. Collaboration during the hake survey is still undetermined due to funding and vessel time.

CCGES W. E. Ricker experienced a breakdown in late 2016. This may further affect the ability to conduct surveys in 2017. Update: The DFO vessel Ricker has since been decommissioned in 2017.

Environmental Effects of the Warm Blob and El Niño

The effects of the "Warm Blob" and other oceanographic conditions in the Pacific Ocean were discussed at the recent CalCOFI meeting held on December 5-6, 2016. Discussion also centered on increasing ocean acidification, toxic algae blooms, etc. These and many other issues are coming at a rapid rate and are affecting a variety of species, and in turn, their fisheries. The extent of this impact on the primary productivity is still unknown, but is likely to be significant.

Pacific Islands Biosphere Reserve

The Mexican government is complying with their commitment to protect habitats within the Pacific and is in the planning stages of creating several reserves. The original plan was for the entirety of the Gulf of California to be under the reserve, however, the government is taking the fisheries into consideration and this will likely affect the final decision. Still, these reserves will likely impact the industry, especially the tuna fishery, though the extent of which cannot yet be determined.

WORKING GROUP REPORTS

Working Group 1: Survey Activities

Winter CalCOFI Survey:

The Winter CalCOFI Survey spanned from January 6-29, 2016, on the NOAA ship *Reuben Lasker*. This constitutes the second full scale survey achieved by the ship since NOAA took ownership of the new vessel. The survey worked the 113 station CalCOFI pattern from San Diego to north to San Francisco and back. The scientific team was able to complete all of the 104 winter CalCOFI stations, an achievement reached for the first time in several years.

Sea surface temperatures were seasonally warm in the offshore waters (18 C) as well as inshore (~16.5 C), though there was a slight drop in surface temperatures while occupying the inshore stations. Samples were characterized by the occurrence of subtropical organisms such as the tuna crab (*Pleuroncodes planipes*) and a surprise showing of a large paper nautilus (*Argonauta* sp.) in the Manta (neuston) sample. Spawning of northern anchovy (*Engraulis mordax*) and Pacific sardine (*Sardinops sagax*) was detected on the inshore stations around the Huntington flats. An item of note is the consistent occurrence of Pacific mackerel (*Scomber japonicas*) eggs and larvae in the CUFES samples. While generally found more offshore in warm waters, the occurrence of these eggs and larvae has been seen throughout the entire CalCOFI distribution and continues to be found in the current northern transects.

One of the main takeaways from this survey is the incredible bloom of the colonial tunicate pyrosome (*Pyrosoma atlanticum*) throughout all areas of the CalCOFI region, though it eased slightly north of Point Conception, when it was replaced in the CUFES samples by significant copepod numbers. A concern is that due to their pyrosome high growth and consumption rate that the spring CPS sardine survey may not only see an absence of pelagic fish eggs but also will be plagued by record numbers of fully developed pyrosomes caught in the surface trawls. This resembles a similar problem that occurred in 2012.

Spring CalCOFI Survey

The Spring CalCOFI Survey took place on the NOAA Ship *Bell M. Shimada*, from April 1-23, 2016. The ship occupied 102 stations of the original 104 stations scheduled within the Southern California Bight.

El Nino waters dominated most of the area from San Diego to San Francisco, anomaly averaging 2-3 degree high. CUFES (Continuous Underway Fish Egg Sampler) captured very few sardine (*Sardinops sagax*) eggs. Because of the warm 17 degree water pushing up from the south, sardine eggs were captured in small amounts offshore on CalCOFI lines 70.0 to 93.3 while jack mackerel (*Trachurus symmetricus*) and pacific mackerel (*Scomber japonicas*) were the most abundant captured by CUFES.Very few eggs were captured in the CalCOFI Bongo net.

CPS-DEPM Survey

The annual spring DEPM (Daily Egg Production Method) survey for CPS (Coastal Pelagic Species) took place on the NOAA ship *Reuben Lasker* from March 22- April 23. The survey began at 44 degrees north latitude near the northern extent of the "optimal" sardine potential habitat (http://swfscdata.nmfs.noaa.gov/AST/sardineHabitat/habitat.asp). The survey followed an adaptive sampling plan to sample the entire "northern" sub-population of Pacific sardine, as well as other CPS, and krill.

In preparation for the Spring Coastal Pelagic fish Species (CPS) Survey aboard Reuben Lasker, the Advanced Survey Technologies Group (AST) installed a pan-tilt-zoom video camera and temperature, pressure, and sound speed sensors on the ship's centerboard. The data was used to observe epi-pelagic fishes within and above the acoustic near-field of the transducers, and to monitor changes in environmental parameters that may modulate the echosounder calibration uncertainty. AST also installed a multiplexer that periodically measures transducer impedances and ambient noise measured with the echosounders, as well as a multiplexer system that alternates transmissions between the ship's narrow-bandwidth EK60 echosounders and AST's wide-bandwidth EK80 echosounders. Using acoustic measures of the range to the seabed, AST's EK Adaptive Logging (EAL) software minimizes the transmit interval and logging and display ranges while avoiding aliased seabed echoes, and directs the Simrad K-Sync system to synchronize the transmissions from the EK60s, EK80s, and ME70 multibeam sonar. An Underway CTD (UCTD) winch and probe was also installed to monitor the three-dimensional oceanographic habitats of CPS and krill. Instrumentation to monitor passive acoustic signals from the ship's hydrophones and new TD50 software to three-dimensionally image the seabed and fish schools in ME70 data were installed as well. AST calibrated the EK60 and EK80 echosounders while the ship was docked at 10th Ave. Pier prior to the beginning of the survey.

The survey was characterized by two distinctly different legs in regards to species composition and environmental conditions. Leg 1 enjoyed relatively mild and calm weather in the northern region (up to Newport, Oregon) and produced abundant catches of juvenile CPS (Pacific sardine, jack mackerel and Pacific mackerel). Leg 2 picked up where leg 1 left off in regards to location but was hampered by high winds and large seas. Very little acoustical CPS signal was observed and pelagic fish eggs collected by CUFES were dominated by Dover sole (*Microstomus pacificus*), Medusa fish (*Icichthys lockingtoni*), King-of-the-salmon (*Trachipterus altivelis*) and ragfish (*Icosteus aenigmaticus*). Unlike leg 1, trawl samples collected during leg 2 were completely dominated by large catches of the colonial tunicate (*Pyrosoma atlanticum)* with almost no or little CPS.

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

While there was significant discussion on the impact of oceanographic conditions on sardine distribution and migratory patterns, particularly given the recent events starting in 2014, the working group could not agree on future sardine/anchovy research.

Working Group 3: Industry Trends and Issues

The Pacific Fishery Management Council voted to keep the sardine fishery closed for the second year in a row in early April. Industry representatives discussed the effects of this closure and given the additional restriction on anchovy, the Industry's main source of revenue for 2016/2017 will stem from mackerel and squid. Mackerel catch has been low, and the California market is in competition with northern states, which have greater catch numbers. Squid catch has been decent, but not enough to offset the financial loss from the restricted catch. Industry representatives estimated this would be a hard year for the fisheries.

There was further discussion debating the presence of sardine and anchovy off the coast and the current health of the populations, but did not end with a specific resolution.

CONCLUSION

The two full-day Forum was well attended and provided many opportunities to share information across national lines. The Trinational Sardine and Small Pelagics Forum concluded with discussion on the future location of the Forum. Attendees determined that future conferences should be conducted in San Diego due to its central location.

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

The 2017 Trinational Sardine and Small Pelagics Forum will be held at the SWFSC 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

Wednesday, December 7th

Afternoon	Arrival in La Jolla, CA

Thursday, December 8th

8:00	Registration, Check-in
9:00	Welcome and opening remarks - Dr. Cisco Werner, Southwest Fisheries Science Center
9:15	Meeting Logistics – Dale Sweetnam, Southwest Fisheries Science Center
9:25	**Regional Sardine Fisheries Reports** Updates on: Canadian sardine fishery and West Coast of Vancouver Island trawl surveys 2016; Wellsley Hamiliton* (DFO Canada)
9:40	Northwest Coastal Pelagic Species Fisheries; Cyreis Schmitt (ODFW) or Dale Sweetnam*(SWFSC)
9:55	California sardine and small pelagics fishery report; Chelsea Protasio* and Dianna Porzio (CDFW)
10:15	**Break**
10:45	The small pelagic fishery in Baja California, fishing season 2015; Concepción Enciso-Enciso*, Lourdes Z. Brasil-Buitimea y Celia Eva Cotero-Altamirano (INAPESCA CRIP-Ensenada)
11:00	The Small Pelagic Fishery in Bahia Magdalena, Season 2015; **Hernández Rivas, Martin Enrique*** (CICIMAR)**, Quiñonez Velázquez, Casimiro** (CICIMAR)**, Melo Barrera, Felipe Neri** (Becarios COFAA-EDI-IPN)
11:15	2016 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 **Contributed papers**
Recent observations on Pacific sardine and northern anchovy from Northwest Fisheries Science Center surveys; Kym Jacobson* (NWFSC), Ric Brodeur (NWFSC), Mary Hunsicker (NWFSC), Toby Auth (PSMFC), and Cheryl Morgan (CIMEC)

13:50 Overview and status of the sardine population off Baja California; Tim Baumgartner* and Augusto Valencia (CICESE)

14:10 Architecture of the recovery of the sardine population in the California Current. A spatial blueprint to elucidate local and broad scale environmental drivers, and their interactions; Ruben Rodriguez-Sanchez*(CICIMAR) and Héctor Villalobos (CICIMAR)

14:30 **Break**

15:00 Collapse and recovery of forage fish populations; Sam McClatchie* (SWFSC), Andrew R. Thompson (SWFSC), Ingrid L. Hendy (DEES-UM) and William Watson (SWFSC)

15:20 Reproductive biology of Sardinops caeruleus from the Pacific coast of Baja California during 2015; Celia Eva Cotero-Altamirano, Concepción Enciso-Enciso*, Héctor Valles Ríos, Lourdes Brasil Buitumea, Laila Hernández Escalante (CRIP-Ensenada)

15:40 Pacific sardine spawning dynamics and egg production in the California Current Ecosystem during the Daily Egg Production Method survey in 2016; Emmanis Dorval* (OAI-SWFSC), Beverly J. Macewicz (SWFSC), David A. Griffith (SWFSC), and Yuhong Gu (OAI-SWFSC)

16:00 Southern California Coastal Pelagic Species Aerial Survey; Kirk Lynn* (CDFW), Dianna Porzio (CDFW), Laura Ryley (CDFW), and Trung Nguyen (CDFW)

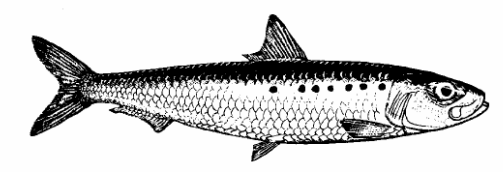
16:20 Acoustic trawl surveys in the California Current during 2016: preliminary results and research needs; Juan P. Zwolinski* (CIMEC-SWFSC), David A. Demer (SWFSC), Beverly J. Macewicz (SWFSC), George R. Cutter Jr.(SWFSC), Scott A. Mau (SWFSC), David W. Murfin (SWFSC), Josiah S. Renfree (SWFSC), Thomas S. Sessions (SWFSC), and Kevin L. Stierhoff (SWFSC)

17:00 *Adjourn*

18:00-21:00 Dinner at The Fish Market (downtown San Diego) with no-host bar (Courtesy of California Wetfish Producers Association)

Friday, December 9th

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) Discussion 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	Closing remarks
14:00	*Adjourn*



APPENDIX III: CONTRIBUTED ABSTRACTS AND SUMMARIES, ORAL PRESENTATIONS

Overview and status of the sardine population off Baja California

Tim Baumgartner and Augusto Valencia

Centro de Investigación Científica y Educación Superior de Ensenada

The Pacific sardine (*Sardinops sagax*) of the California Current showed a reduction in landings off Baja California and near disappearance off California in 2015. A moratorium on fishing was instituted in California for the 2015-16 fishing season as the projected biomass has fallen below 150,000 MT (roughly 133,000 mt) to be continued into 2016-17 with the projection of decreasing biomass. The landings by the Ensenada fleet that consist of both the northern and southern stocks were generally increasing from 2004 through 2014 with an overall average of just under 59,000 MT while the landings in 2015 abruptly dropped 36%. One of the causes of this abrupt reduction was apparently a shift in availability, with the southward movement of sardines away from the traditional fishing grounds near Ensenada. We show how the change from winter-spring to summer-fall ocean conditions affects the availability of sardines and thus the change in seasonal landings at Ensenada. The fishery-independent egg surveys used to estimate the area of sardine spawning habitat off Baja California during spring periods from 2000 through 2013 showed an increased distribution of eggs and the size of the spawning area southwards from central Baja California (Punta Eugenia ~28° N) extending southwards to Bahía Magdalena (~24° N). This southern distribution off Baja California led to an increase of the total spawning fraction in waters of Mexico and may be related to the reduced spawning observed in U.S. waters. This distribution in spawning was associated with large-scale fluctuations in ocean conditions resulting in southward shift in favorable habitat for sardines. The shift in spawning is of course associated with a southward shift in adults that has in turn produced concern in the local industry that must contend with increased fishing effort by the Ensenada fleet resulting in higher costs and the closing of a number of processing plants.

Architecture of the recovery of the sardine population in the California Current. A spatial blueprint to elucidate local and broad scale environmental drivers, and their interactions

Ruben Rodriguez-Sanchez and Héctor Villalobos

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It is widely accepted that biological variability occurs on a range of space and time scales. Nevertheless, until recently, scientific inference about sardine population dynamics was supported mostly on the analysis and description of biological and ecological processes on time-scales, solely. However, even now, scientific debate regarding environmental drivers, future trends and subsequent ecological and societal impacts of sardine populations in changing ocean systems is hampered by a lack of geographic baselines, and an understanding of the causes of spatial patterns within large marine ecosystems (LME). An oversimplified assumption of uniform biomass expansion-contraction shifts is the prevailing paradigm. This as consequence of assuming that environmental drivers affect sardine biomass levels in the same way across LME within the same time-scale. We provide evidence against this paradigm by reviewing and integrating the spatial patterns of sardine in the California Current (CC), particularly those related to specific temporal scales of SST. We focus on seasonal migrations, inter-annual distribution changes during ENSO events, and latitudinal shifts in the center of distribution and bulk of abundance on multi-decadal scale. The ultimate goal is to understand how spatial processes at different scales may be inter-related to produce the observed macro-scale changes in abundance. To address this issue, we reconstruct the seasonal and inter-annual spatial dynamic of sardine population during the last warming period, when sardine biomass recovered in the CC, based on spatially explicit monthly CPUE records of tuna bait-boats along the southern part of the CC during an 18-years period (1980-1997). Our results suggest that the reappearance of sardine in the north part of the CC ecosystem was a result of population movement that originated from its core distribution in Baja California Sur, Mexico. Moreover, rather than a uniform pole-ward shift, we provide a nuanced description of spatial variability in order to properly elucidate and test drivers and interactions between all scales of climate-ocean variability.

Collapse and recovery of forage fish populations

Sam McClatchie[1], Andrew R. Thompson[1], Ingrid L. Hendy[2] and William Watson[1]

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We use a 500-year paleorecord off southern California to determine collapse frequency, cross-correlation, persistence, and return times of exploited forage fish populations. The paleorecord shows that “collapse” (defined as < 10% of the mean peak biomass) is a normal state repeatedly experienced by anchovy, hake and sardine which were collapsed 29 − 40% of the time, prior to commercial fishing exploitation. Mean (±SD) persistence of 1/3 mean peak biomass from the paleorecord was 19±18, 15 ± 17, and 12 ± 7 years for anchovy, hake, and sardine. Mean return times to the same biomass was 8 years for anchovy, but 22 years for sardine and hake. Further, we find that the current paradigm of sardine-anchovy alternations is an artifact of short time series, and that sardine and anchovy are positively correlated on the 500-year time scale, consistent with coherent declines of both species off California. Persistence and return times, combined with positive sardine-anchovy correlation indicates that on average 1−2 decades of fishable biomass will be followed by 1−2 decades of low forage. Forage populations are resilient on the 500-year time scale, but their collapse and recovery cycle is fitted to pulsed exploitation strategies.

Reproductive biology of Sardinops caeruleus from the Pacific coast of Baja California during 2015

Celia Eva Cotero-Altamirano*, Concepción Enciso-Enciso, Héctor Valles Ríos, Lourdes Brasil Buitumea, Laila Hernández Escalante

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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 January and continued through December, 2015. 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. The size structure was between 116 - 291 mm and average of 156 mm of the standard length. We analyze the cellular structures in the gametogenesis process in the gonads for reproductive activity the spawning peak was on May, incidence of immature individuals was observed in February. A relationship between the reproduction and the temperature and upwelling was observed. A slowly return of winter-spring reproduction time was detected. The length at maturity was estimate at 168 mm.

Pacific sardine spawning dynamics and egg production in the California Current Ecosystem during the Daily Egg Production Method survey in 2016

Emmanis Dorval[1], Beverly J. Macewicz[2], David A. Griffith[2], and Yuhong Gu[1]

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[2] NOAA-National Marine Fisheries Service, Southwest Fisheries Science Center, la Jolla Ca 92037

The 2016 daily egg production method (DEPM) survey for Pacific sardine (*Sardinops sagax*) was conducted in March/April off the west coast of the USA from about Lincoln Beach, Oregon (44.85°N) to Muir Beach, California (37.84°N). The survey covered a total area of 133,488.5 km^2 from March 22 to April 22. Pacific sardine eggs, larvae and adults were most abundant between 43.14 °N and 44.40°N (Brandon, OR to Waldport, OR) indicating that similarly to 2015 the stock was located outside of the spawning core traditional area, which has been mostly centered between north of San Francisco to San Diego (CalCOFI lines 60.0 - 93.0) from 1994 to 2013. Preliminary data showed that the daily egg production estimate (P0, an average weighted by area) was 0.07/0.05m^2 (CV = 0.58). Thus, in 2016 egg production continued to decline and was much lower than in 2015 (0.17/.05m^2, CV = 0.72) and 2013 (1.34/0.05 m^2, CV=0.30). We will discuss the implication of these results on estimating the 2016 spawning stock biomass (SSB) of Pacific sardine and the trajectory of SSB in the California Current Ecosystem over the last decade.

Southern California Coastal Pelagic Species Aerial Survey

Kirk Lynn, Dianna Porzio, Laura Ryley, and Trung Nguyen

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Current survey indices used in annual stock assessments to manage the federal Pacific sardine (*Sardinops sagax*) fishery do not include nearshore sardine biomass in southern California waters. The California Department of Fish and Wildlife (CDFW), in collaboration with the California Wetfish Producers Association (CWPA), has conducted aerial surveys using direct observer estimates of sardine biomass within the Southern California Bight (SCB) since the summer of 2012. Island and mainland coastal areas were surveyed during spring and summer seasons. Beginning in summer 2013, additional small pelagic species, such as northern anchovy (*Engraulis mordax*), have been included in the survey. Boat sampling has been used to validate aerial identifications of fish school species, and to obtain biological information. We observed fish primarily along coastal areas; most notably, large aggregations were seen in nearshore waters off Santa Barbara-Ventura and Orange County. The survey observed declines in abundance of sardine and anchovy in 2014, with apparent increases for both species beginning in early 2016. A September 2016 study paired the CDFW-CWPA nearshore aerial survey with an acoustic trawl survey that was limited to operating outside of nearshore waters to provide a better estimate of sardine in the entire SCB. Further work will provide information on sardine and anchovy abundance and distribution to account for areas not covered in present surveys. Continued data collection on sampled fish and habitat associations can add to understanding of population and stock structure.

Acoustic trawl surveys in the California Current during 2016: preliminary results and research needs

Juan P. Zwolinski[1], David A. Demer[2], Beverly J. Macewicz[2], George R. Cutter Jr.[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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Two acoustic-trawl (AT) surveys of coastal pelagic fish species (CPS) were conducted in the California Current during 2016. The spring survey, optimized to sample the entire northern subpopulation of Pacific sardine, spanned Northern and Central California. The summer survey, targeting the entire epipelagic community, extended from the U.S.-Mexico border to Vancouver Island, Canada. Both surveys confirmed increases in the biomasses of Pacific sardine and northern anchovy, due to recruitments first observed in 2015. Most of the increase in northern anchovy biomass was associated with the central subpopulation, located south of Monterey Bay and north of Point Conception. However, the northern subpopulation of northern anchovy, located off Oregon and Washington, was also larger than in 2015. Pacific and jack mackerels were widespread throughout the spring and summer survey areas.

The spring and summer 2016 survey results provide further indication of large intra- and inter-annual variabilities in CPS distributions and abundances. The bi-annual surveys have been invaluable for understanding and tracking CPS life histories. For example, the spring and summer CPS surveys results have provided quantitative knowledge of potential habitat, stock distribution and abundance, recruitment, growth, and natural mortality for the northern stock of Pacific sardine. The annual spring and summer surveys should provide equally valuable information about resurging Northern anchovy populations. The acoustic-trawl surveys also provide a basis for efficiently and concomitantly conducting complementary sampling using daily egg production (DEP) and aerial-optical (AO) methods. Results from the DEP and AO surveys will provide independent confirmation of trends observed in AT results.

APPENDIX IV: CONTRIBUTED ABSTRACTS AND SUMMARIES, POSTER PRESENTATIONS

Megan H. Human[1], Noelle M. Bowlin[2], Andrew R. Thompson[2], William Watson[2], Ed D. Weber[2]

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The Daily Egg Production Method (DEPM) is a useful tool in assessing the spawning biomass of Pacific Sardine. This method uses an exponential mortality model derived from the temperature-dependent rates of egg development established 20 years ago using eggs collected from net tow samples with an estimated time of fertilization. To determine if this relationship is still current we collected ripe male and female sardines during trawl surveys and fertilized the eggs at sea. The eggs were reared in constant temperature baths between 12°C and 21°C, collected at regular time intervals, preserved, and later staged in the laboratory. Preliminary results from the temperature-dependent egg-development model suggest eggs in our experiment developed more quickly at comparable temperatures than in previous experiments. These results may be due to differences in experimental design; we were able begin recording developmental stages upon fertilization instead of using estimates of peak spawning times. However, further experimentation is needed. This research can be used to update the temperature-dependent egg development curve used in the parameter estimation for the DEPM.