



Southwest Fisheries Science Center

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

JANUARY 2020

PROCEEDINGS OF THE 2019 TRINATIONAL SARDINE & SMALL PELAGICS FORUM

edited by

Stephanie Flores

ADMINISTRATIVE REPORT LJ-20-01

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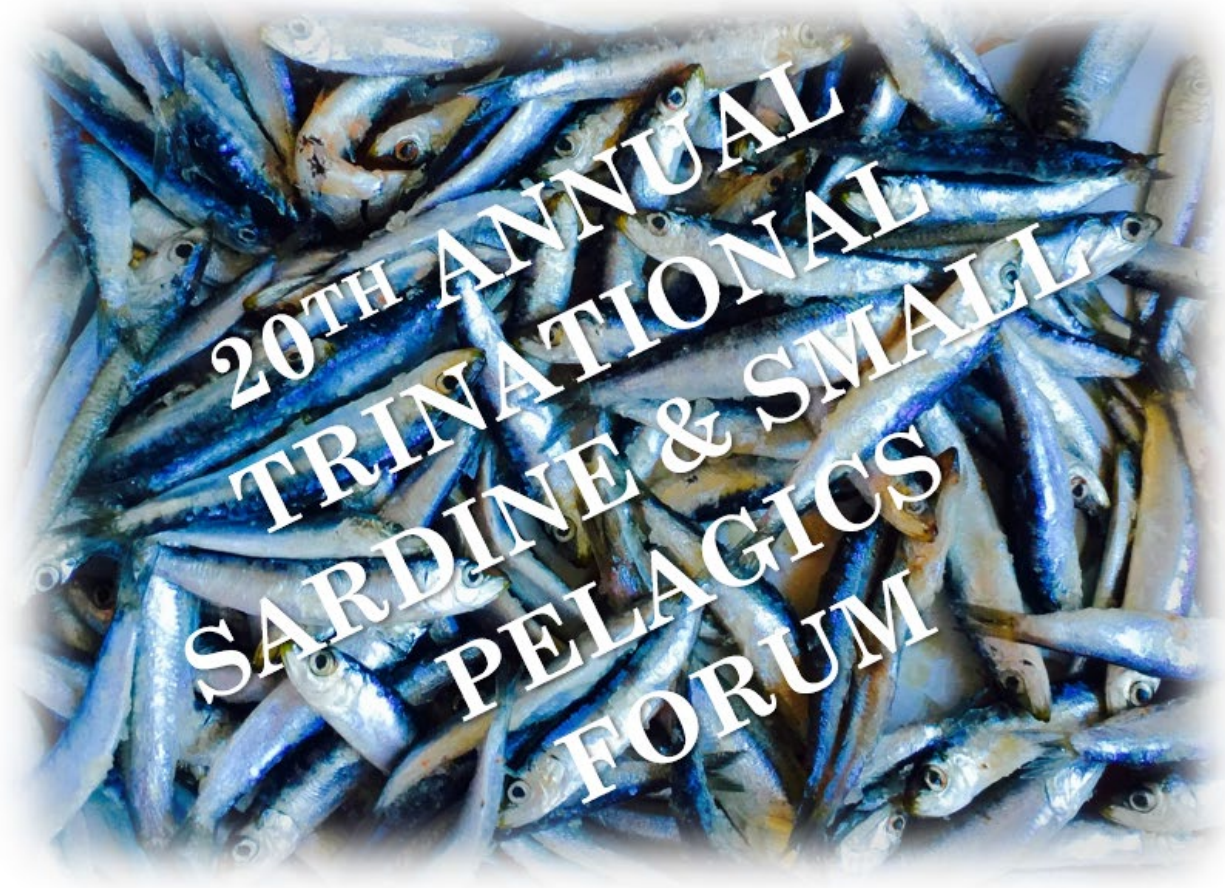
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ADMINISTRATIVE REPORT LJ-20-01

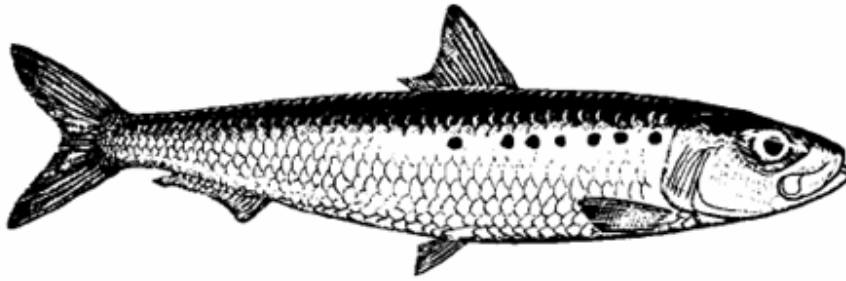
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December 5-6, 2019

La Jolla, California, USA





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2019 Trinational Sardine and Small Pelagics Forum Participants

Mission Statement

It is the mission of the Trinational Sardine and Small Pelagics Forum to collaborate on improving coast-wide science to support stock assessments: sampling for age, size composition, reproductive state, regional biomass estimates, stock structure, development of a common data base, understanding industry trends and issues, and understanding of the role of Pacific sardine (*Sardinops sagax*) in the California Current Ecosystem.

Background

The past few years have been unique with the obvious change in ocean conditions throughout the 2014 “Warm Blob” and the 2019 “Marine Heatwave.” 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). Information and research on sardine and other coastal pelagic species stocks are needed in order to provide an accurate coast-wide assessment for proper management in the upcoming years. The Trinational Sardine and Small Pelagics Forum encourages collaboration between federal and state agencies, academic institutions, industry, non-governmental organizations, and tribal organizations from Canada, Mexico, and the United States in improving coast-wide science to support stock assessments.

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).

Government entities

Canadian Department of Fisheries and Oceans (DFO), Instituto Nacional de Pesca (INAPESCA), NOAA Southwest Fisheries Science Center (SWFSC), NOAA Northwest Fisheries Science Center (NWFSC), NOAA West Coast Regional Office (WCRO), Pacific Fishery Management Council (PFMC), 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)

Industry Organizations and Non-Governmental Organizations

California Wetfish Producers Association (CWPA), Sportfishing Association of California (SAC), Pacific Seafood, Trimarine Group, Baja Mexico International, Oceano Industrial SAPI de CV, The Pew Charitable Trusts, Camara Nacional de la Industria Pesquera delegacion Sonora.

Tribal Organizations

Quinault Indian Nation

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Introduction

The Southwest Fisheries Science Center (SWFSC) hosted the 20th Annual Trinational Sardine and Small Pelagics Forum (TSF) on December 5 and 6, 2019, at the Southwest Fisheries Science Center, in La Jolla, CA, USA. Fifty-eight participants from Canada, Mexico, and the United States attended and represented government agencies, academia, and industry (Appendix I). Special thanks to Stephanie Flores (Fisheries Resources Division) and Diane Pleschner-Steele (California Wetfish Producers Association) for their aid in the logistical planning. We also thank Freddie Logan and Roszella Sanford, who helped with the local logistics.

Fisheries Resources Division Deputy Director, Dale Sweetnam, opened the meeting with greetings. He expressed admiration for several of the members who originally created the forum twenty years ago and still participate annually. SWFSC Director, Kristen Koch, delivered the opening remarks, thanking everyone for his or her attendance and making special note of those who traveled great distances. Kristen noted the Forum was created to encourage scientists, fishermen, and managers to come together to discuss the research and data from the past year. Since 1999, this conference has provided a venue for open discussion, led to partnerships among countries and between industry and science, and furthered understanding of small pelagics on the eastern Pacific Coast. Nevertheless, there is still more to understand. The development of the “Warm Blob” in 2014 and other ecosystem anomalies in recent years has shown how much more there is to discover.

Kristen also took an opportunity to thank Mr. Sweetnam for his constant support of the Forum. He attended the very first years of the conference as a member of the California Department of Fish and Wildlife, and later became the Forum’s Californian Chair when he was hired at SWFSC in 2011. Dale has been to almost every Trinational Sardine and Small Pelagics Forum in the past twenty years, with little variation, and he has devoted a large part of his career to CPS. He will be missed greatly when he retires in the near future.

Following the opening remarks, representatives from Canada, Mexico and the United States presented current quotas and landings, surveys, and industry information during the Regional Fisheries Reports. Kerry Griffin (PFMC) presented the 2019 Pacific Fisheries Management Council Report and Kevin Hill presented the Assessment of the Pacific Sardine Resource in 2019 for U.S.A Management 2019-20. The second half of the day consisted of presentations on contributed papers.

The second day of the Forum began with the remainder of the contributed papers. After a short break, Dale Sweetnam led the group discussion on three main topics: coast-wide surveys, the lingering effects of the 2014 “Warm Blob” and the 2019 “Marine Heatwave,” and southern sardine sub-stock vs. northern sardine sub-stock issues.

Dale Sweetnam closed the 20th Annual Trinational Sardine and Small Pelagics Forum with thanks to all who participated. The location of the 2020 Forum has yet to be determined.

Regional Sardine Fisheries Reports

Canadian Sardine Fishery and West Coast of Vancouver Island (Sardine) Trawl Surveys

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This presentation includes summary information on British Columbia (BC, Canada) purse seine fishery annual quotas and landings (2002-2019) and Pacific sardine (*Sardinops sagax*) observations from summer research trawl surveys conducted off the west coast of Vancouver Island.

The last season sardine have been caught and landed by the Canadian Pacific Sardine Fishery was in 2012. 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. From 2015 to 2019, fishing has been closed in following with an applied harvest control rule which incorporates annually updated Stock Synthesis assessment results of the age-1+ biomass of the northern subpopulation of sardine generated by the U.S. National Marine Fisheries Service, relative to a fishing cutoff of 150,000 tonnes.

Summer Department of Fisheries and Oceans (DFO) research trawl surveys have been conducted off the west coast of Vancouver Island to collect information on pelagic fish and their ecology. Some survey years were particularly focused on studying sardine distribution, relative abundance and morphometrics. Sampling design of the surveys evolved over the years but, in general, trawl locations were part of stratified random survey designs and tows were conducted in surface waters (< 50 m) using a mid-water trawl towed at average speeds approximating 5 knots for 20-30 minutes. During surveys in 2006 and 2008-2014, catch sampling was conducted from night trawl tows and average sardine catch-per-unit-effort trends declined from over 700 tonnes/ km³ in 2006 to approximately 100 tonnes/kms in 2012. No sardines were captured during the 2013 and 2014 night trawl surveys. Few or no sardines were observed in BC waters during the 2013-2019 seasons, whether from fisheries, surveys or other sources, suggesting curtailed migration and/or stock size. Since 2012, DFO surveys have caught 61 sardine in 2015, 1 in 2018, and 3 in 2019.

Discussion: The disappearance of sardine in Canadian waters has deeply affected the Canadian fisheries. Prior to this period, many fisheries relied on sardine as filler when roe and herring landings declined, making the sudden absence of sardine a significant loss.

Coastal Pelagic Species Fisheries in the U.S. Pacific Northwest

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Directed fisheries for Coastal Pelagic Species (CPS) in the U.S. Pacific Northwest were limited to small-scale fisheries for Pacific sardine (*Sardinops sagax*) for the 2018-2019 fishing year as the sardine population estimate was below the cutoff value of 1500,000 mt in the harvest guideline formula. Harvest in small scale directed fisheries for sardine occurred in Oregon. No directed CPS fisheries for Pacific mackerel (*Scomber japonicus*) occurred in the Pacific Northwest. Washington CPS fisheries were limited to northern anchovy (*Engraulis mordax*) fishing. Purse seine gear fishing for CPS off Oregon focused on market squid in 2018 and again in 2019. The Quinault Indian Nation did not participate in CPS fisheries during this period. Updated information on landings will be presented.

California Coastal Pelagic Species Report

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Coastal pelagic species (CPS), including Pacific sardine (*Sardinops sagax*), northern anchovy (*Engraulis mordax*), Pacific mackerel (*Scomber japonicus*), and jack mackerel (*Trachurus symmetricus*) are managed by the Pacific Fishery Management Council under the Coastal Pelagic Species Fishery Management Plan (CPS FMP). In 2018, the sardine stock assessment produced a biomass estimate below the “cutoff” threshold value of 150,000 metric tons (mt) in the Harvest Guideline control rule. As a result, there was no directed non-tribal commercial fishery for the 2018/2019 sardine fishing season, which runs July 1 through June 30. The National Marine Fisheries Service implemented an annual catch target of 4,000 mt, with sardine take allowed only as incidental catch in other fisheries or as part of the tribal, live bait, minor directed (less than 1 mt), exempted fishing permit, or recreational fisheries. For the 2018/2019 fishing season, total California landings for sardine were approximately 1,114 mt from 51 vessels in the federal CPS limited entry fishery, with 89 percent of the state total (988 mt) landed in Southern California. For the 2018/2019 fishing season, 2,194 mt of Pacific mackerel were landed, and for the 2018 fishing year, 17,402 mt of anchovy and 64 mt of jack mackerel were also landed.

Discussion: Incidental squid bycatch from the previous few months showed a mix of adults and juveniles but age data for non-directed had not yet been processed to provide specific information. Jack mackerel has been abundant and the fisheries may benefit from finding a market. The continuous underway fish-egg sampler (CUFES) samples in Mexico are showing a great deal of them. Stock biomass figures are still showing a deep decline of sardine despite lack of fishing for the past five years.

The Small Pelagics Fishery on the West Coast of Baja California, Mexico, Fishing Season 2018.

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Aspects of the small pelagic fishery on the western coast of the Baja California peninsula during the fishing season 2018 were analyzed. The total catch of the resource was 245,296 t, 74% above the historical average (2003-2017, 141,006 annual t). Of the total catches, 67% (164,393 t) were recorded as Pacific sardine (*Sardinops saga*); 20% (48,841 t) as northern anchovy (*Engraulis mordax*); 6% (15,361 t) as thread herring (*Opisthonema spp*); 6% (13,593 t) as Pacific mackerel (*Scomber japonicas*); and 1% (2,931 t) as bocona sardine (*Cetengraulis mysticetus*). The highest volumes of catches were recorded between the months of March to November, with an average of 23,731t/month and the rest of the months captured on average 10,573t/month. The registered fishing effort was 3,385 fishing trips made with a total of 35 vessels (25 vessels in Baja California and 10 vessels in Baja California Sur). The estimated average yield was 72.4t/trip, 10% higher than that recorded from 2003-2017. Of the total sardine catch in the region during the 2018 fishing season, 61% corresponds to the Temperate stock (92,904 t), 21% to the Warm stock (32,447 t) and 18% to the Cold stock (27,587 t). It is estimated that 37% of the sardine catch was below the legal minimum size (150 mm LP).

Key words: Baja California, small pelagic, Catch, yield, legal minimum size.

RESUMEN

Son analizados aspectos de la pesquería de pelágicos menores en la costa occidental de la península de Baja California durante la temporada de pesca de 2018. La captura total del recurso fue de 245,296 t, 74% por arriba del promedio histórico (2003-2017, 141,006 t anuales). Del total de las capturas, el 67% (164,393 t) fue sardina del Pacífico; el 20% (48,841 t) de anchoveta, el 6%, (15,361 t) de sardina crinuda, el 6%, (13,593 t) de macarela y el 1% (2,931 t) de sardina bocona. A lo largo del año las capturas se mantuvieron relativamente constantes. Sin embargo, los mayores volúmenes se registraron entre los meses de marzo a noviembre, con un promedio de 23,731 t/mes y el resto de los meses se capturaron en promedio 10,573 t/mes. El esfuerzo pesquero registrado fue de 3,385 viajes de pesca realizados con un total de 35 embarcaciones (25 embarcaciones en Baja California y 10 embarcaciones en Baja California Sur). El rendimiento promedio estimado fue de 72.4 t/viaje, 10% superior a lo registrado para el periodo 2003-2017. Del total de la captura de sardina del Pacífico en la región durante temporada 2018, el 61% corresponde al stock Templado (92,904 t), el 21% al stock cálido (32,447 t) y el 18% al stock Frio (27,587 t). Se estimó que el 37% de la captura de la sardina del Pacífico estuvo por debajo de la talla mínima legal (150 mm LP).

Palabras clave: Baja California, pelágicos menores, captura, rendimiento, talla mínima legal.

2019 Pacific Fishery Management Council Report/Update

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Pacific Fishery Management Council Activities

Overview

The Pacific Fishery Management Council (PFMC, Council) is responsible for developing and recommending management measures for federally-managed fish species on the U.S. West Coast from Canada to Mexico, from 3 to 200 miles offshore. Four fishery management plans (FMP) describe the species, harvest control rules, gear, seasons, and other items related to management. The four FMPs are salmon, groundfish, highly migratory species, and coastal pelagic species (CPS). The PFMC also has an ecosystem FMP that provides guidance and information on ecosystem matters as it applies to fisheries management.

The CPS Fishery Management Plan (FMP) includes Pacific sardine (*Sardinops sagax*), Pacific mackerel (*Scomber japonicus*), northern anchovy (*Engraulis mordax*; northern and central substocks), jack mackerel (*Trachurus symmetricus*), and market squid (*Doryteuthis [Loligo] opalescens*). Every year, the sardine biomass is assessed and harvest levels are established. Mackerel is assessed every two years, with annual management measures applied for two years at a time. The harvest levels for the other CPS stocks are set and are only updated as needed. Stock assessments for those stocks are also only done when there is a need and when there is sufficient data to support an assessment.

The Pacific sardine biomass estimate has been below the 150,000 metric ton (mt) “cutoff” level for over four years, which means that no directed commercial fishing has been allowed. The sardine fishery has been limited to incidental landings and live bait fishery. Total landings have been in the 2,000 mt range since 2015.

Recent Activities

Live bait fishing allowance

Amendment 17 to the CPS FMP was approved in 2019. The amendment allows a directed live bait fishery to continue fishing, rather than being subject to a 15% incidental take allowance, even after a CPS stock has been declared overfished. The live bait sector depends on the ability to target clean loads of CPS because that is what the recreational and albacore fleets require. The live bait fishery will be subject to allowable harvest, which are based on the biomass estimate, and have been relatively very small since 2015.

Northern anchovy

The Council continues to look at ways to manage and assess the central subpopulation of northern anchovy (CSNA), and asked the Coastal Pelagic Species Management Team (CPSMT) to continue developing procedures to periodically conduct stock assessments, and to periodically revisit harvest management reference point such as overfishing limit and acceptable biological

catch. A stock assessment for the central subpopulation of northern anchovy is scheduled for 2021.

Upcoming activities

There will be an full benchmark stock assessment for Pacific sardine in early 2020, with management measures to be set at the April 2020 PFMC meeting. For Pacific mackerel, a full stock assessment was completed in 2019, with management measures set for two years in a row, at the June 2019 PFMC meeting. There are no current plans to assess northern anchovy, jack mackerel, or squid, but we continue to look into the feasibility of accomplishing stock assessments for those stocks.

Because the Pacific sardine estimated biomass has fallen below 50,000 mt, the Council is required to develop a proposed rebuilding plan and transmit the plan to NMFS. The Council is scheduled to consider a rebuilding plan at its April, June, and September 2020 meetings, and then transmit the plan to NMFS.

Discussion: Kerry clarified that the sardine managed by the PFMC is the northern subpopulation (the cold stock). The Council attributes all landings as the northern stock and counts them against the northern quota.

Assessment of the Pacific Sardine Resource in 2019 for U.S. Management in 2019-20

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Full report:

<https://swfsc.noaa.gov/publications/TM/SWFSC/NOAA-TM-NMFS-SWFSC-615.pdf>

EXECUTIVE SUMMARY

The following Pacific sardine (*Sardinops sagax*) assessment update was conducted to inform U.S. fishery management for the cycle that begins July 1, 2019, and ends June 30, 2020. Two assessment approaches were reviewed at the STAR Panel in February 2017: (1) an AT survey-based approach (preferred by the STAT) and (2) a model-based assessment (model ALT). Given forecasting issues highlighted in the review (see STAR 2017 and ‘Unresolved Problems and Major Uncertainties’ below), the Panel ultimately recommended that management advice be based on model ALT for the 2017-18 fishing year. The following update of model ALT represents the update base model from the April 2018 update (Hill et al. 2018) with the addition of updated/new landings (2017-18), a revised AT biomass estimate for summer 2017, and one new AT-based biomass estimate and age composition from the SWFSC’s summer 2017 survey. Finally, one additional recruitment deviation was estimated for the 2018 year-class.

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 assessments before 2014, 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 (mt) from six major fishing regions: Ensenada (ENS), southern California (SCA), central California (CCA), Oregon (OR), Washington (WA), and British Columbia (BC). Total and NSP landings for each region over the modeled years/seasons are shown in **Table ES-1**.

Table ES-1. Pacific sardine landings (mt) for major fishing regions off northern Baja California (Ensenada, Mexico), the United States, and British Columbia (Canada). ENS and SCA landings are presented as totals and northern subpopulation (NSP) portions.

Calendar Yr-Sem	Model Yr-Seas	ENS Total	ENS NSP	SCA Total	SCA NSP	CCA	OR	WA	BC
2005-2	2005-1	37999.5	4396.7	16615.0	1581.4	7824.9	44316.2	6605.0	3231.4
2006-1	2005-2	17600.9	11214.6	18290.5	17117.0	2032.6	101.7	0.0	0.0
2006-2	2006-1	39636.0	0.0	18556.0	5015.7	15710.5	35546.5	4099.0	1575.4
2007-1	2006-2	13981.4	13320.0	27546.0	20567.0	6013.3	0.0	0.0	0.0
2007-2	2007-1	22865.5	11928.2	22047.2	5531.2	28768.8	42052.3	4662.5	1522.3
2008-1	2007-2	23487.8	15618.2	25098.6	24776.6	2515.3	0.0	0.0	0.0
2008-2	2008-1	43378.3	5930.0	8979.6	123.6	24195.7	22939.9	6435.2	10425.0
2009-1	2008-2	25783.2	20244.4	10166.8	9874.2	11079.9	0.0	0.0	0.0
2009-2	2009-1	30128.0	0.0	5214.1	109.3	13935.6	21481.6	8025.2	15334.3
2010-1	2009-2	12989.1	7904.2	20333.5	20333.5	2908.8	437.1	510.9	421.7
2010-2	2010-1	43831.8	9171.2	11261.2	699.2	1403.5	20414.9	11869.6	21801.3
2011-1	2010-2	18513.8	11588.5	13192.2	12958.9	2720.1	0.1	0.0	0.0
2011-2	2011-1	51822.6	17329.6	6498.9	182.5	7359.3	11023.3	8008.4	20718.8
2012-1	2011-2	10534.0	9026.1	12648.6	10491.1	3672.7	2873.9	2931.7	0.0
2012-2	2012-1	48534.6	0.0	8620.7	929.9	598.5	39744.1	32509.6	19172.0
2013-1	2012-2	13609.2	12827.9	3101.9	972.8	84.2	149.3	1421.4	0.0
2013-2	2013-1	37803.5	0.0	4997.3	110.3	811.3	27599.0	29618.9	0.0
2014-1	2013-2	12929.7	412.5	1495.2	809.3	4403.3	0.0	908.0	0.0
2014-2	2014-1	77466.3	0.0	1600.9	0.0	1830.9	7788.4	7428.4	0.0
2015-1	2014-2	16496.6	0.0	1543.2	0.0	727.7	2131.3	62.6	0.0
2015-2	2015-1	20971.9	0.0	1420.9	0.0	6.1	0.1	66.1	0.0
2016-1	2015-2	23536.7	0.0	423.4	184.8	1.1	1.4	0.0	0.0
2016-2	2016-1	42532.1	0.0	964.5	49.4	234.1	2.7	85.2	0.0
2017-1	2016-2	30496.0	9219.9	513.1	144.7	0.1	0.1	0.0	0.0
2017-2	2017-1	99966.6	0.0	1205.4	0.0	170.4	1.2	0.0	0.0
2018-1	2017-2	29744.2	11241.9	395.3	197.8	0.0	2.2	0.0	0.0
2018-2	2018-1	50878.2	0.0	1464.2	0.0	35.3	5.9	2.0	0.0

Data and Assessment

The integrated assessment model was developed using Stock Synthesis (SS version 3.24aa), and includes fishery and survey data collected from mid-2005 through December 2018. 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 PNW fleet (fishery). A single AT survey index of abundance from ongoing SWFSC surveys (2006-2018) was included in the model. The update assessment model (ALT) included final landings from 2017, preliminary landings from 2018, a revised biomass estimate from the summer 2017 AT survey, one new AT-based biomass and age composition from the summer 2018 survey, along with one additional recruitment deviation for estimation of the 2017 year class.

Model ALT incorporates the following specifications:

- NSP catches for the MEXCAL fleet computed using an environmental-based optimal habitat index;
- two seasons (semesters, Jul-Dec=S1 and Jan-Jun=S2) for each model year (2005-19);
- ages in population=10, with nine age bins (ages 0-8+);
- two fleets (MEXCAL and PNW), with an annual selectivity pattern for the PNW fleet and seasonal selectivity patterns (S1 and S2) for the MEXCAL fleet;
 - MEXCAL fleet: dome-shaped, age-based selectivity (one parameter per age)
 - PNW fleet: asymptotic, age-based selectivity;
- Beverton-Holt stock-recruitment relationship, with virgin recruitment (R_0), steepness (h), and initial equilibrium recruitment offset (R_1) estimated, and average recruitment variability fixed ($\sigma_R=0.75$);
- M was fixed (0.6 yr^{-1});
- recruitment deviations estimated from 2005-17;
- initial fishing mortality (F) was estimated for the MEXCAL_S1 fishery and fixed=0 for MEXCAL_S2 and PNW fisheries;
- single AT survey index of abundance (2006-18) that includes seasonal (spring and summer) observations in some years, and catchability (Q) estimated;
 - age compositions with effective sample sizes set (externally) to 1 per trawl cluster;
 - selectivity was assumed to be uniform (fully selected) for age 1+ and zero for age 0;
 - a revised biomass estimate and age composition from the summer 2017 AT survey; and
 - a new biomass estimate and age composition from the summer 2018 AT survey

Spawning Stock Biomass and Recruitment

Time series of estimated spawning stock biomass (SSB, mmt) and associated 95% confidence intervals are displayed in in **Figure ES-1** and **Table ES-2**. The virgin level of SSB was estimated to be 74,466 mt. The SSB has continually declined since 2005-06, reaching low levels in recent years (2014-present). The SSB was projected to be 19,502 mt (SD=12,069 mt; CV=0.619; Sigma=0.570) in January 2020.

Time series of estimated recruitment (age-0, billions) abundance is presented in in **Figure ES-1** and **Table ES-2**. The virgin level of recruitment (R_0) was estimated to be 1.05 billion age-0 fish. As indicated for SSB above, recruitment has largely declined since 2005-06, with the exception of a brief period of modest recruitment success from 2009-10. In particular, the 2011-17 year classes have been among the weakest in recent history. A small increase in recruitment was estimated in 2018, albeit a highly uncertain estimate (CV=0.77) based on limited data.

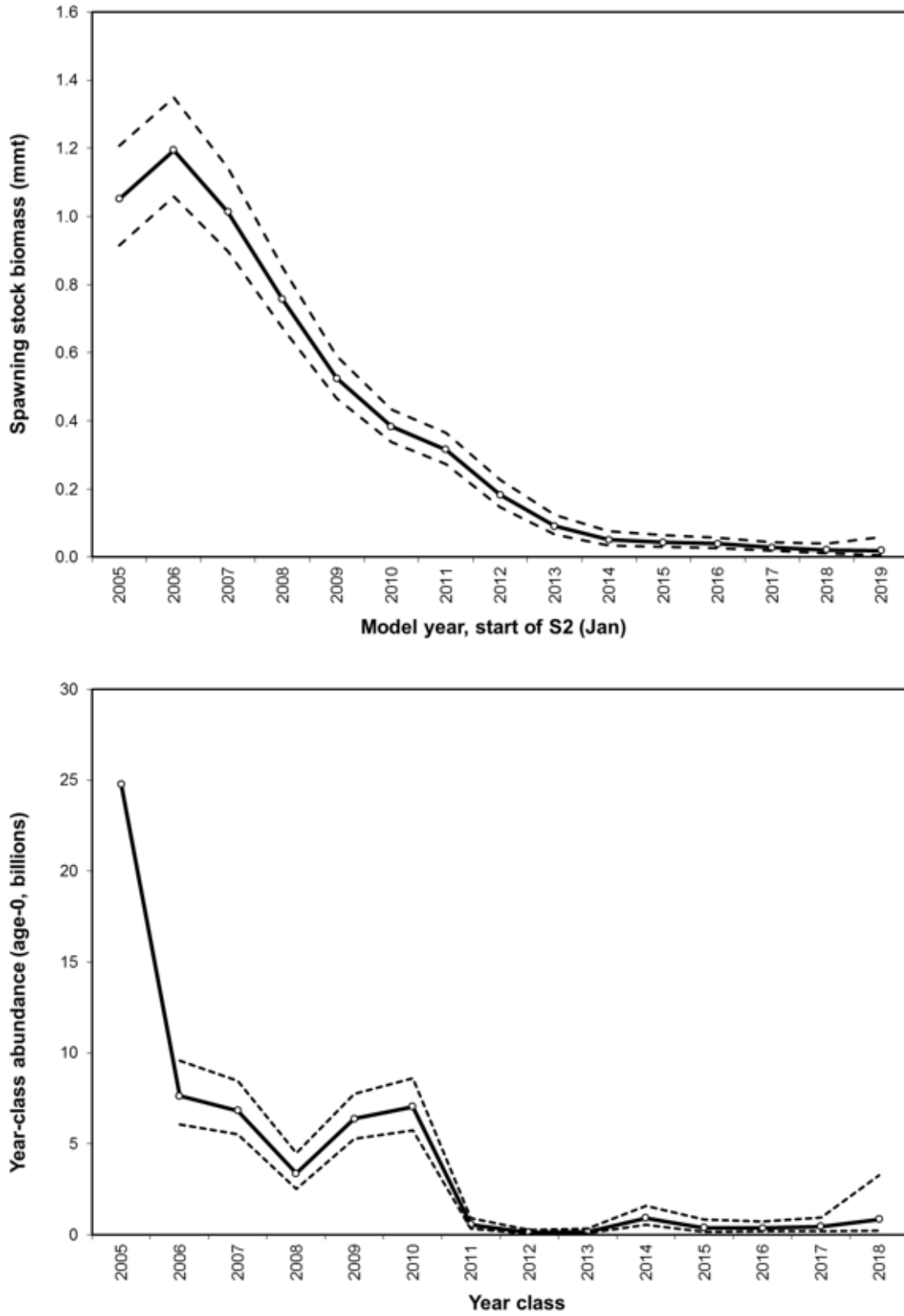


Figure ES-1. Spawning stock biomass (upper) and recruitment time series (lower) ($\pm 95\%$ CI) for model ALT-2019.

Table ES-2. Spawning stock biomass (SSB) and recruitment (year-class abundance) estimates and asymptotic standard errors for model ALT-2019.

Calendar Yr-Sem	Model Yr-Seas	SSB (mt)	SSB Std Dev	Year class abundance (1,000s)	YC Std Dev
-	VIRG-1	-	-	1,050,620	297,748
-	VIRG-2	74,466	21,104	-	-
-	INIT-1	-	-	7,883,970	3,603,220
-	INIT-2	301,147	82,359	-	-
2005-2	2005-1	-	-	24,770,700	-
2006-1	2005-2	1,051,190	74,638	-	-
2006-2	2006-1	-	-	7,622,380	888,087
2007-1	2006-2	1,194,360	74,296	-	-
2007-2	2007-1	-	-	6,831,930	750,309
2008-1	2007-2	1,013,150	62,090	-	-
2008-2	2008-1	-	-	3,362,190	503,580
2009-1	2008-2	756,584	45,137	-	-
2009-2	2009-1	-	-	6,383,870	626,151
2010-1	2009-2	524,418	31,480	-	-
2010-2	2010-1	-	-	7,035,220	728,952
2011-1	2010-2	382,967	24,480	-	-
2011-2	2011-1	-	-	556,796	136,539
2012-1	2011-2	315,887	23,576	-	-
2012-2	2012-1	-	-	129,561	46,429
2013-1	2012-2	183,221	20,432	-	-
2013-2	2013-1	-	-	170,464	59,722
2014-1	2013-2	90,715	14,844	-	-
2014-2	2014-1	-	-	926,669	260,882
2015-1	2014-2	50,999	10,378	-	-
2015-2	2015-1	-	-	374,181	165,051
2016-1	2015-2	43,802	8,684	-	-
2016-2	2016-1	-	-	360,443	133,797
2017-1	2016-2	39,848	7,660	-	-
2017-2	2017-1	-	-	445,779	178,128
2018-1	2017-2	28,481	6,610	-	-
2018-2	2018-1	-	-	851,448	659,686
2019-1	2018-2	21,038	6,894	-	-
2019-2	2019-1	-	-	-	-
2020-1	2019-2	19,502	12,069	-	-

Stock Biomass for PFMC Management in 2019-20

Stock biomass, used for calculating annual harvest specifications, is defined as the sum of the biomass for sardine ages one and older (age 1+) at the start of the management year. Time series of estimated stock biomass (mmt) from model ALT and the AT survey are presented in the figure below. As discussed above for both SSB and recruitment, a similar trend of declining stock biomass has been observed since 2005-06, peaking at 1.76 mmt in 2006, and plateauing at recent low levels since 2014. Model ALT stock biomass is projected to be **27,547 mt in July**

2019. Pacific sardine NSP stock biomass is now below the 50,000 mt minimum stock size threshold (MSST) defined in the CPS-FMP.

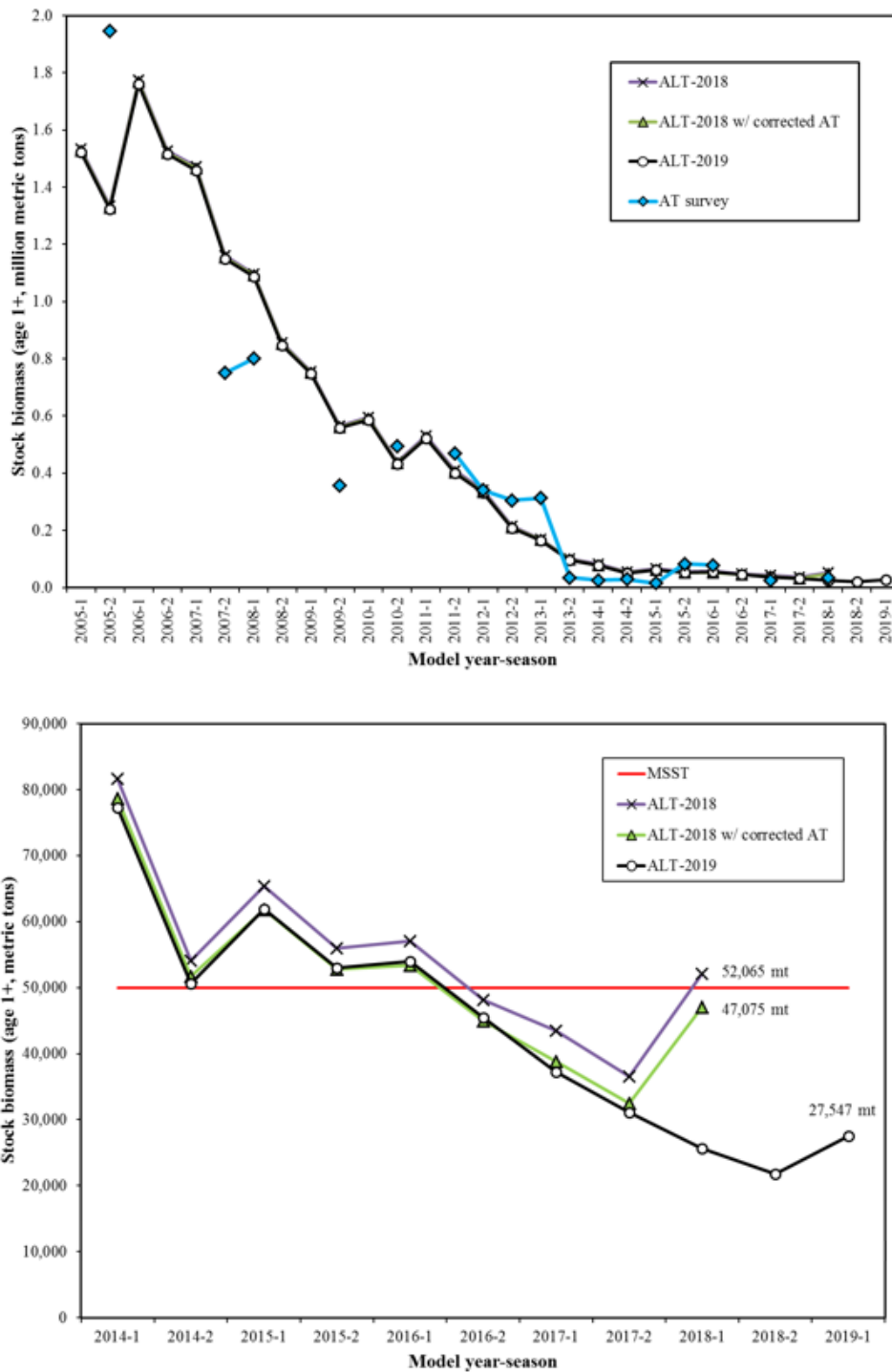


Figure ES-2. Estimated stock biomass (age 1+ fish, mt) time series for the AT survey and model ALT-2019 (upper) and 2014-19 (lower).

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 model ALT estimates, the U.S. exploitation rate has averaged about 11% since 2005, peaking at 36.7% in 2013. The U.S. rate was <1% in 2018. The U.S. and total exploitation rates for the NSP, calculated from model ALT, are presented in Figure ES-3.

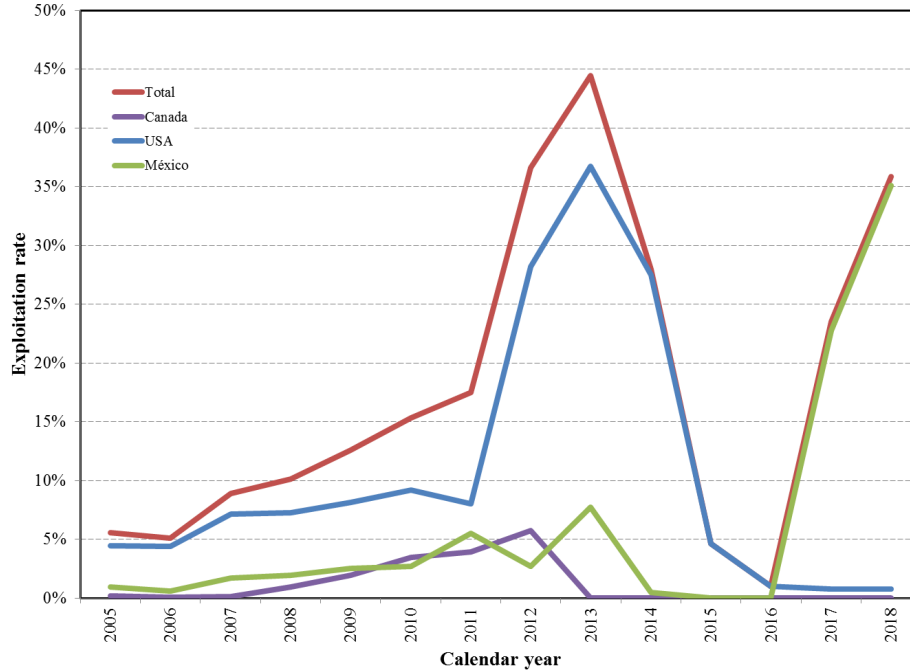


Figure ES-3. Annual exploitation rates (CY landings / July total biomass) for model ALT-2019.

Harvest Control Rules

Harvest guideline

The annual harvest guideline (HG) is calculated as follows:

$$HG = (BIOMASS - CUTOFF) \cdot FRACTION \cdot DISTRIBUTION;$$

where HG is the total U.S. directed harvest for the period July 1, 2019 to June 30, 2020, BIOMASS is the stock biomass (ages 1+, mt) projected as of July 1, 2019, 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 model ALT, estimated stock biomass is projected to be below the 150,000 mt threshold and thus, the HG for 2019-20 would 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. The E_{MSY} is calculated as,

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

where T is the three-year running average of CalCOFI SST, and E_{MSY} for OFL and ABC is bounded between 0 to 0.25. Based on the recent warmer conditions in the CCE, the average temperature for 2016-18 decreased to 16.1123 °C, resulting in $E_{MSY}=0.243$.

Harvest estimates for model ALT are presented in the **Table ES-3**. Estimated stock biomass in July 2019 was **27,547 mt**. The overfishing limit (OFL, 2019-20) associated with that biomass was **5,816 mt**. The SSB was projected to be 19,502 mt (SD=12,069 mt; CV=0.619) in January 2019, so the corresponding Sigma for calculating P-star buffers is 0.57 rather than the new default value (0.5) for Tier 1 assessments. Acceptable biological catches (ABC, 2019-20) for a range of *P-star* values based on the newly adopted sigma method for model ALT-2019 presented in **Table ES-3**.

Table ES-3. Harvest control rules for the 2019-20 management cycle.

Harvest Control Rule Formulas

OFL = BIOMASS * EMSY * DISTRIBUTION; where EMSY is bounded 0.00 to 0.25

ABCP-star = BIOMASS * BUFFERP-star * EMSY * DISTRIBUTION; where EMSY is bounded 0.00 to 0.25

HG = (BIOMASS - CUTOFF) * FRACTION * DISTRIBUTION; where FRACTION is EMSY bounded 0.05 to 0.20

Table ES-3a. Harvest Formula Parameters

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10
BIOMASS (ages 1+, mt)	27,547	-	-	-	-	-	-	-	-
P-star	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05
ABC Buffer _(Sigma 0.570)	0.93093	0.86564	0.80296	0.74181	0.68103	0.61920	0.55417	0.48196	0.39188
ABC Buffer _{Tier 2}	0.88191	0.77620	0.68023	0.59191	0.50942	0.43101	0.35472	0.27761	0.19304
CalCOFI SST (2016-2018)	16.1123	-	-	-	-	-	-	-	-
EMSY	0.242675	-	-	-	-	-	-	-	-
FRACTION	0.200000	-	-	-	-	-	-	-	-
CUTOFF (mt)	150,000	-	-	-	-	-	-	-	-
DISTRIBUTION (U.S.)	0.87	-	-	-	-	-	-	-	-

Table ES-3b. Harvest Control Rule Values (MT)

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10
OFL =	5,816	-	-	-	-	-	-	-	-
ABC _{Tier 1} =	5,414	5,034	4,670	4,314	3,961	3,601	3,223	2,803	2,279
ABC _{Tier 2} =	5,129	4,514	3,956	3,443	2,963	2,507	2,063	1,615	1,123
HG =	0	-	-	-	-	-	-	-	-

Management Performance

The U.S. HG/ACL values and catches since the onset of federal management are presented in Figure ES-4.

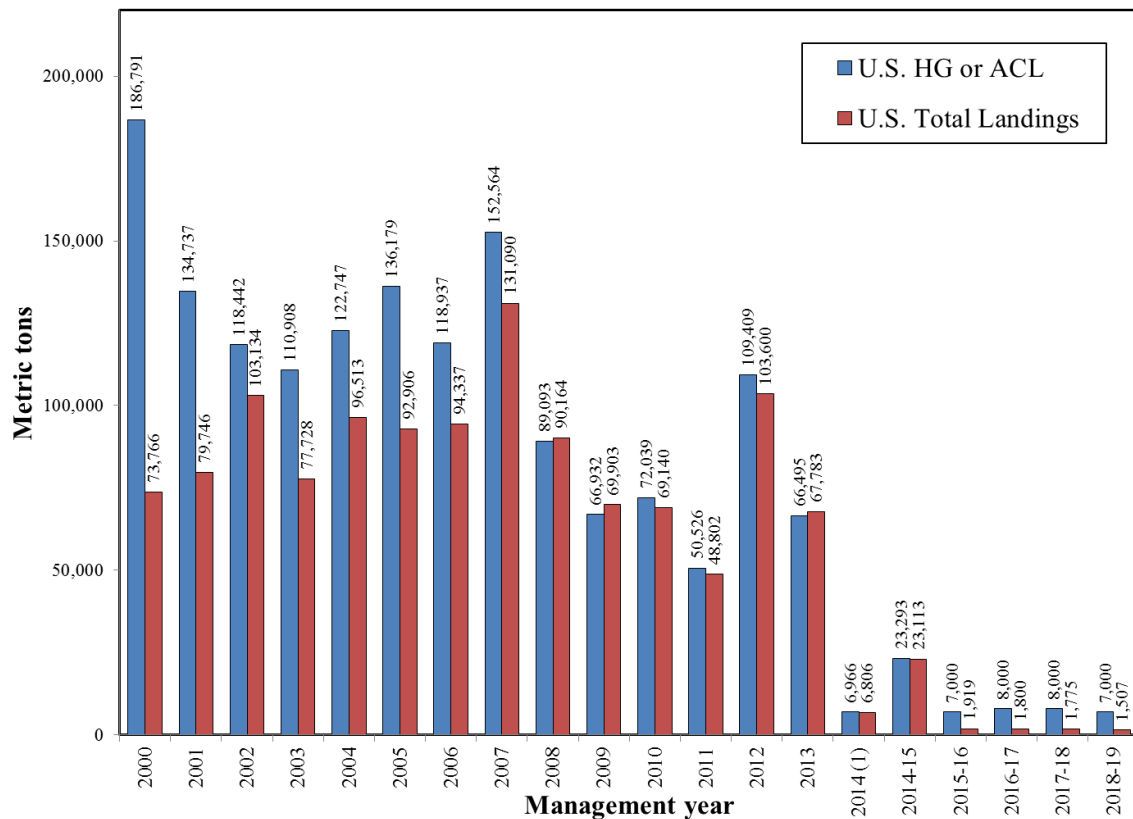


Figure ES-4. U.S. Pacific sardine HGs or ACLs and landings since 2000.

Discussion: Several questions addressed survey techniques and the distinction between the northern and southern sardine stocks. The 2019 California Current Ecosystem Survey sampled closer to shore and farther offshore than previous years' surveys. Fisheries Resources Division (FRD) staff coordinated sampling with industry vessels nearshore off Washington, Oregon, and Southern California, and with unmanned surface vehicles nearshore off Washington, Oregon, and northern California, and offshore between central Oregon and Pt. Conception, southern California. The additional coverage sampled the target species in areas too shallow for Lasker to safely navigate, and in offshore areas that have not been surveyed routinely in the past. Data from this survey had not yet been published at the time of the Forum but is now available at [Assessment of the Pacific Sardine Resource in 2019 for U.S. Management in 2019-20](#).

There was a question of how survey timing was chosen and how that might affect what portion(s) of stocks are sampled. Sampling is performed in the summer as this is the most likely time to sample the entire stock in the area. The fish sampled south of Point Conception are likely the same ones present south months later due to their migration to warmer waters.

There was discussion about why this method is being used instead of the DEPM (daily egg production method). DEPM was used prior to the development of acoustic methods and the DEPM

is noisy and prone to sampling error. However, DEPM surveys are still sometimes conducted targeting anchovy, the species for which the technique was developed.

Finally, distinction between the northern and southern subpopulation of sardine was also heavily discussed. Years ago, everything north of Ensenada was included in the stock assessment; however, this changed as research led to the current hypothesis of two stocks, one northern and one southern. At this time, the dividing line between the two stocks is at 16.7 °C. The PFMC, however, was only developed to manage the northern stock, and any sardine caught off the coast of California is managed as such. At this time, there is not an assessment to determine the condition of the southern stock which is a transboundary stock between U.S. and Mexico.

Contributed Papers

Effects of Circulation of the California Current on the Production of Phytoplankton, Zooplankton and Small Pelagic Fish off Baja California.

Timothy Baumgartner¹ and Eliana Gómez-Ocampo²

¹Centro de Investigación Científica y Educación Superior

²Universidad Autónoma de Baja California

The structure and circulation of the California Current determines the quality of the pelagic habitat off Baja California. The formation of the Ensenada Front creates a hydrographic barrier that reduces the flow of nutrients from the waters north of the Ensenada front and in turn, reduces the levels of primary, secondary and tertiary production south of the front. We present the structure and consequences of this barrier for the production of phytoplankton, zooplankton and for the spawning of Pacific sardine (*Sardinops sagax*) in the waters off Baja California. We compare and contrast the profiles of primary production in the California Cooperative Oceanic Fisheries Investigations (CalCOFI) survey area with that in the Investigaciones Mexicanas de la Corriente de California (IMECOCAL) area to demonstrate the significant difference in productivity between the two areas.

Information and Examples of Fisheries and Oceans Canada Pacific Pelagic Fish and Ecosystem Studies.

Linnea Flostrand and Jennifer Boldt,

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Pacific Biological Station,
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This presentation gave a brief overview of Department of Fisheries and Oceans (DFO) Pacific science review processes and provided examples of pelagic fish and ecosystem studies. Featured topics were the *Canadian Science Advisory Secretariat*; annual State of the Pacific Ocean meetings and reports; British Columbia Pacific Herring (*Clupea pallasii*) stock assessments and ecological studies; and recent initiatives and observations associated with integrated west coast of Vancouver Island trawl surveys.

Stock Assessment and Management of the Tempered Stock of Pacific Sardine (*Sardinops Sagax*) on the West Coast off the Baja California Peninsula, Mexico (1989-2018).

Concepción Enciso-Enciso^{1,2}, Manuel O. Nevárez-Martínez¹, Rebeca Sánchez-Cárdenas³, Guillermo Rodríguez-Domínguez³, Luis A. Salcido-Guevara³, Carolina Minte-Vera⁴ y Martin E. Hernández-Rivas⁵.

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The stock assessment of the temperate stock of Pacific sardine (*Sardinops sagax*) of the western coast of Baja California peninsula for the period from 1989 to 2018 was presented. From data of catches by age, fishing effort and independent indicators of the fishery (Egg index and biomass estimated by hydroacoustics), a statistical analysis of age capture (ACE) was applied, allowing to estimate the size of the population biomass by age groups and generate some biological reference points for its management. For the period analyzed, the total estimated biomass presented a great inter-annual variability ranging between 723,571 and 1,470,813 t, and an average of 983,254 t; for the year 2018, total biomass was estimated at 872,745 t and a 95% confidence interval between 758,269 t and 1,063,846 t. The spawning biomass presented a similar inter-annual trend, with a minimum of 396,870 t and a maximum of 866,987 t; for 2018 it was estimated at 623,360 t and a 95% confidence interval between 508,884 t and 814,462 t. The annual exploitation rate (E) ranged from 0.089 to 0.226 year⁻¹, with an average of 0.163 year⁻¹. The fishing mortality and the exploitation rate in the maximum sustainable yield ($F_{MSY} = 0.276$ and $E_{MSY} = 0.241$), which were above the values of each one of the years throughout the analyzed period. When applying the Control Rule established in the Fisheries Management Plan, under the consideration that $B_{MIN} = 52,935$ t, it was found that the Temperate Stock of Pacific sardine has been exploited below the Control Rule (Biologically Acceptable Catch). Therefore, it is inferred that the Temperate Stock of sardine has been exploited sustainably throughout the time period analyzed (1989-2018).

Key words: Pacific Sardine, abundance, active management, Control Rule.

RESUMEN

Se presenta la evaluación del stock Templado de sardina monterrey (*Sardinops sagax*) de la costa occidental de la península de Baja California para el periodo de 1989 a 2018. A partir de datos de capturas por edades, el esfuerzo pesquero e indicadores independientes de la pesquería (Índice de huevos y estimación de biomasa por hidroacústica), se aplicó un análisis estadístico de captura por edades (ACE), permitiendo estimar el tamaño de la biomasa poblacional por grupos de edad y generar algunos puntos de referencia biológicos para su manejo. Para el periodo analizado la biomasa total estimada presentó una gran variabilidad interanual oscilado entre 723,571 y 1,470,813 t, y un promedio de 983,254 t; para el año de 2018 la biomasa total se estimó en 872,745 t y un intervalo de confianza al 95% entre 758,269 t y 1,063,846 t. La biomasa reproductora

presentó una tendencia interanual similar, con un mínimo de 396,870 t y un máximo de 866,987 t, para el 2018 se estimó en 623,360 t y un intervalo de confianza al 95% entre 508,884 t y 814,462 t. La tasa de explotación anual (E) osciló entre 0.089 y 0.226 año⁻¹, con un promedio de 0.163 año⁻¹. La mortalidad por pesca y la tasa de explotación en el máximo rendimiento sostenible ($F_{RMS}=0.276$ y $E_{RMS}=0.241$), las cuales estuvieron por arriba de los valores de cada uno de los años a lo largo del periodo analizado. Al aplicar la regla de control establecida en el Plan de Manejo Pesquero, bajo la consideración de que $B_{MIN}=52,935$ t, se encontró que el stock templado de sardina del Pacifico ha sido explotada por debajo de la Regla de Control (Captura Biológicamente Aceptable). Por lo anterior, se infiere que el stock templado de sardina ha sido aprovechado de manera sustentable a lo largo del periodo de explotación analizado (1989-2018).

Palabras clave: Sardina del Pacifico, abundancia, manejo activo, Regla de Control.

Length Conversions and Mass–Length Relationships of Five Forage-Fish Species in the California Current Ecosystem.

Juan P. Zwolinski, Danial G. Palance, Beverly J. Macewicz, Kevin L. Stierhoff, David A. Demer

Length-measurement conversions and seasonal mass–length relationships (MLR) for Pacific herring (*Clupea pallasii*), northern anchovy (*Engraulis mordax*), Pacific sardine (*Sardinops sagax*), Pacific mackerel (*Scomber japonicas*) and jack mackerel (*Trachurus symmetricus*) in the California Current are presented. The conversions between total (LT), fork (LF,) and standard lengths (LS) should facilitate comparisons of data across disciplines and institutions. These equations resulted from an analysis of measurements spanning 14 years and the western seaboard of North America, from the north end of Vancouver Island to the U.S.–Mexico border. Major-axis regressions were used to calculate reciprocal length-measurement conversions (e.g., LT to LS and LS to LT) and generalized linear models and ordinary least-squares models were used to create MLRs that account for seasonal variations. The MLR models indicated seasonal differences for all species except Pacific herring, for which there was no multi-season data. Discrepancies between these and published models were examined, along with the suitability and benefit of the various types of models used for length-measurement conversion and MLRs.

Distribution, Biomass, and Demography of Coastal Pelagic Fishes in the California Current Ecosystem During Summer 2019 Based on Acoustic-Trawl Sampling.

Kevin L. Stierhoff¹, Juan P. Zwolinski², and David A. Demer¹

¹Southwest Fisheries Science Center, NMFS/NOAA, La Jolla

²Institute of Marine Sciences, University of California Santa Cruz

Since 2006, the Southwest Fisheries Science Center has used acoustic-trawl method (ATM) surveys to provide direct estimates of the distributions, biomasses, and lengths of small pelagic fishes in the California Current Ecosystem (CCE). In summer 2019, an ATM survey was conducted over the continental shelf between Vancouver Island, Canada, and San Diego, CA, aboard NOAA Ship *Reuben Lasker*. The survey spanned much or all of the anticipated distribution of Pacific sardine (*Sardinops sagax*), northern anchovy (*Engraulis mordax*), Pacific mackerel (*Scomber japonicus*), jack mackerel (*Trachurus symmetricus*), and Pacific herring (*Clupea pallasii*). Sampling in the nearshore was supplemented by two fishing vessels and an unmanned surface vehicle (USV), while sampling in the offshore was conducted by *Lasker* and a third USV. Biomasses of the northern stock of Pacific sardine and the central stock of northern anchovy were not different from estimates from summer 2018. The biomasses of the northern stock of northern anchovy, southern stock of Pacific sardine, and Pacific mackerel were lower than 2018, while the biomasses of jack mackerel and Pacific herring increased. Jack mackerel biomass was dominant offshore, whereas northern anchovy were most abundant in nearshore samples.

Discussion: Kevin confirmed that sardine appear to be schooling with other species this year. When asked whether data suggests that a new cohort has entered the system, he responded that it is possible. If so, they are most likely young of year (YOY), though this cannot be confirmed until the samples are aged.

Acoustic-Trawl Method Surveys Inform Precautionary, Ecosystem Approaches to Management of Forage Fishes in the California Current.

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¹Southwest Fisheries Science Center, NMFS/NOAA, La Jolla

²Institute of Marine Sciences, University of California Santa Cruz

In 2006, during a cooling trend indicated by the Pacific Decadal Oscillation Index (PDO), the Southwest Fisheries Science Center revived acoustic-trawl method (ATM) surveys to directly assess the distributions, abundances and lengths of Pacific sardine (*Sardinops sagax*), northern anchovy (*Engraulis mordax*), Pacific mackerel (*Scomber japonicus*), jack mackerel (*Trachurus symmetricus*), Pacific herring (*Clupea pallasii*) in the California Current. Since then, data have been collected during spring, summer, or both, using multi-frequency echosounders, surface trawls, a continuous underway fish-egg sampler (CUFES), and conductivity-temperature-depth

probes (CTDs). The resulting time series have served to characterize: dynamics in potential sardine habitat; a halt to seasonal sardine migration; a persisting environmental correlation with sardine recruitment; a reduction in cohorts comprising the stock, variations in rates of growth and natural mortality; a decline in sardine biomass; and transitions in the dominant forage-fish species from sardine to mackerels and now anchovy. These and more results of the ATM surveys are critical to the prediction of climate-driven fish stock productivity that might be used to manage fisheries with ecosystem approaches.

Discussion: Sardine migration patterns changed dramatically in 2014. The last time NOAA surveys found sardine in abundance off Vancouver Island was in 2013, since then they appear to be consolidating in southern California. They also appear to be breaking up into smaller, mixed groups with species such as jack mackerel rather than the previous large groups of sardine. The reason for this shift is unclear, but could be due to the recent increase in temperature.

The 2019 California Current Ecosystem Survey showed similarly changed migration patterns for anchovy. Anchovy compressed closer to the coast than previous years; fishing in the north was largely in estuaries or tight along the coastline. At this time, it is unclear whether this was due to environmental differences, such as the heatwave, or sampling bias due to the effort to sample closer to the coast.

The recent warming trends of the 2014 Warm Blob and the 2019 Heatwave garnered questions regarding the sudden decrease of sardine and increase of anchovy, despite historically warm conditions indicating a rise of sardine. While warmer water has been present for roughly six years, the cycling of these species is generally on a decadal time scale.

An Overview of the California Live Bait Marine Fishery.

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The California live bait fishery is a unique and extremely valuable component of the state's recreational fishing community and economy. Originally introduced in 1910, fishing for live bait quickly became specialized with the introduction of lampara and purse seine nets in 1912 to provide the rapidly expanding sport fishing industry with live northern anchovy (*Engraulis mordax*) and Pacific sardine (*Sardinops sagax*). Live bait is used by recreational anglers targeting a variety of gamefish such as tunas and bass on commercial passenger fishing vessels (CPFVs), private boats, and kayaks predominantly in Southern California. Demand for live bait shifts throughout the year depending on location and the target species. The live bait fishery seeks pure schools of anchovy and sardine, which have the highest demand by sportfishing boats and anglers. The ability to capture anchovy or sardine depends on the species' availability and behavior. The live bait fleet currently consists of approximately 15 vessels along the California coast. Since 2000, the fishery has averaged an annual total catch of approximately 3,000 metric tons, of which 75 percent was sardine. The first system for determining the amount of live bait taken was instituted by the California Department of Fish and Wildlife (CDFW; then Division of

Fish and Game, Bureau of Marine Fisheries) in 1938 and a voluntary logbook program began in 1939. Since 2000, live bait has been federally managed within the Coastal Pelagic Species (CPS) complex by the Pacific Fishery Management Council (PFMC) and the National Marine Fisheries Service under the CPS Fishery Management Plan (CPS FMP). Catch data from a CDFW monitoring program are used in stock assessments and for determining annual catch limits. Due to recent estimates of low sardine biomass levels, the directed large-scale sardine fishery has been closed since 2015 and the stock was declared overfished in 2019. In June 2019, Amendment 17 to the CPS FMP was adopted allowing directed live bait fishing when a stock is overfished. Concurrently, the live bait industry is now submitting electronic landing receipts to the Department to ensure take is accounted for and within sustainable levels.

Discussion: Diana clarified that there is a point of contention in how the sardine/anchovy are counted. Fish are not weighed when entering the bait barge such as they are when landed commercially at the docks. Instead, the captain estimates the amount for the landing receipt. The bait barge then sells the fish to the consumer via scoops but these are not weighed nor a standard size. These methods provide no definitive way to determine the actual count.

Aerial Survey of Small Pelagic Species in Nearshore California Waters.

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Pacific sardine (*Sardinops sagax*) and northern anchovy (*Engraulis mordax*) are important West Coast fisheries managed within the Coastal Pelagic Species (CPS) complex by the Pacific Fishery Management Council (PFMC) and the National Marine Fisheries Service. Current survey indices used in annual stock assessments to manage the Pacific sardine fishery have only just recently included nearshore biomass, and thus did not provide a complete picture of overall stock until recently. The California Department of Fish and Wildlife and the California Wetfish Producers Association have collaborated in conducting an aerial survey of nearshore Pacific sardine biomass within the Southern California Bight since the summer of 2012, and northern anchovy since 2013. In 2017, the survey was extended to include nearshore abundance in Northern California. The PFMC conditionally approved the aerial survey methodology for use in future CPS stock assessments in June 2017. A nearshore cooperative survey project began in late 2018 to develop a variance estimator and further refine an observer bias correction factor. Analysis of within- and among-transect variance has shown that parallel surveys across transects can provide reasonable variance estimates. Survey data indicate observer estimates are negatively biased, underestimating Pacific sardine biomass by approximately 14%. Pacific sardine and northern anchovy biomass estimates for Northern California surveys in 2017 have been large relative to those from ship surveys restricted to waters outside of a few miles from the coast, comprising more than 146% and 35%, respectively, of offshore estimates.

Discussion: Kirk clarified that the sampling unit is the total biomass encountered over one transect line. Each of the strata include three lines flown three times for a total of nine lines flown.

Reproductive Biology of Sardine *Sardinops Caeruleus* from the Western Coast of Baja California During 2018.

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The reproductive behavior of a species and its relation with the environment has a relevant importance in the dynamics of populations, in particular those that are commercially exploited. This research provides fundamental elements that support the normativity and management instruments.

The most important resource of the small pelagic fishes in Mexico are the Pacific sardine (*Sardinops caeruleus*). A monitoring program is maintained by the National Fishery Institute as scientific advisor to Fishery Authority, according to the General Law of fisheries and aquaculture is the management of sustainable fisheries.

Biological samples were collected from the sardine commercial fleet to determine reproductive biology during the 2018 season. Sardine standard lengths, individual weights, sex, and maturity were registered. In the lab, samples of both female and male gonads were processed with histological techniques.

The results indicated that the size structure was between 80 - 210 mm, with an average of 156 mm and a mode 170 mm of standard length. Reproductive activity was observed throughout the year, the spawning peak was detected in March, and another important one in November. Strong relationships both of temperature and upwelling with maturity was observed during the study. The length at maturity was at 161 mm

Could phytoplankton toxicity limit sardine productivity?

Barbara Javor
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Pacific sardine particle-feed on zooplankton prey as well as filter-feed on phytoplankton. We hypothesize that episodes of toxicity in phytoplankton populations might influence Pacific sardine (*Sardinops sagax*) productivity and hence modulate booms and busts in sardine populations. To test that theory, we are conducting bioassays of phytoplankton toxicity in seawater collected weekly at the Scripps Institution of Oceanography pier. The bioassay uses 2-

d-old brine shrimp larvae that are incubated 24 h with phytoplankton suspensions. The results are recorded as percent mortality. A significant episode of high mortality was detected in the summer of 2018, and two episodes of high mortality were observed in the summer of 2019. Bioassays conducted with surface seawater during the June 2018 CalCOFI cruise confirmed the toxicity was detectable throughout the Southern California Bight. Although chemical analyses of the toxins are not available, we expect the active agents are probably oxylipins that are not routinely tracked in harmful algal blooms in the California Current Ecosystem by the Southern California Coastal Ocean Observing System (SCCOOS) monitoring program. If the brine shrimp bioassay reflects patterns of toxicity in marine filter feeders, then it is reasonable to propose that episodes of phytoplankton toxicity might influence sardine productivity.

Discussion: Barbara clarified her hypothesis that phytoplankton toxicity only affects adult sardine. Sardine are not filter feeders during their larval or early juvenile phases but feed on phytoplankton later in life. This may also explain the boom and bust found in krill, which are also filter feeders. Barbara further explained that her research has been limited to samples taken off Scripps Pier, which provides a controlled environment and time series. However, sampling has been limited to available resources and she hopes to expand her research in the future.

Research Discussion

Coast-wide Surveys

Mexico

Instituto Nacional De Pesca (INAPESCA) Coastal Pelagic Survey 2019

A coastal pelagic survey aboard R/V *Dr. Jorge Carranza Fraser* took place over 50 days from July-August 2019 and surveyed from Ensenada south to the end of the Baja peninsula. The survey involved the Inter-American-Tropical-Tuna-Commission for a concurrent dolphin estimation survey, in which a 14-day trial tested drone estimations. The review data from this survey hasn't been completed, but if all goes well, there may be a similar, 100+ day survey next year.

Investigaciones Mexicanas de la Corriente de California (IMECOCAL) Survey

In the past few years, IMECOCAL survey time has decreased substantially. The current project funded by the National Council of Science and Technology in Mexico (CONACYT) was proposed by a colleague who sadly passed away in 2016 before the project actually began and Tim Baumgartner was asked to take over the project. Funding had been requested for only one summer cruise per year for three years to study the effects of ocean fronts on primary productivity. However, the proposal was funded in 2015 when the cost of ship time was roughly one half of the cost in 2019. This of course severely limited the amount of time at sea. This year's cruise schedule was also upset since the ship was in dry-dock from mid-June through mid-October, a total of three months. The original request for an August cruise finally became a December cruise. After a good deal of administrative restrictions that the Centro de Investigación

Científica y de Educación Superior de Ensenada (CICESE) faced with the port authorities, they were able to set out to sea on November 30 for 8 days. The 8-day cruise followed the standard California Cooperative Oceanic Fisheries Investigations (CalCOFI) lines from lines 100 off Ensenada through 113 south of Punta Baja. The stations occupied are from the nearshore station 30 to the offshore station 60.

The conductivity-temperature-depth probes (CTDs) casts are always made to 1000 m at the offshore stations with sufficient depth. An oblique bongo net tow for zooplankton is made down to 200 meters at each station. Chlorophyll is collected at standard depths down to 200 m, calibrated with fluorimeter mounted on the rosette with the CTD. One station on each of the five lines was dedicated to measuring primary productivity using carbon 13; 210 samples were taken and incubated mainly on deck, but with some in the water. A new researcher at CICESE also sampled for marine bacteria for the first time on an IMECOCAL cruise, a new method for us to gain a more comprehensive look at the ocean.

Although the ship has new and expensive multibeam echo-sounder, it is not used for fisheries but for exploration of geothermal sources. The older and smaller CICESE vessel (The R/V *Francisco Ulloa*) used a continuous underway fish-egg sampler (CUFES) for fourteen years from 2000 through 2013 to sample small pelagic fish eggs. However, at present the R/V Alpha Helix lacks CUFES due to the requirement of an outboard installation. This will require a proposal or proposals of roughly 80 K to first purchase and install a CUFES system with a container to house the system and other accessories, and another 250 K or so for hydroacoustics. The plan now is to request another institution which has an EK-60 to install it on the AH for one survey per year for small pelagics until we can generate funds to purchase a system.

United States

The intention of the Trilateral Forum has always been to coordinate a survey along the entire Pacific Coast, from Canada through Mexico. The summer coastal pelagic species (CPS) survey has been able to expand into Canada; however, Baja's permit process continues to limit the group's ability to perform the survey south of the U.S. border.

The Fisheries Resources Division was granted several CPS surveys aboard the R/V *Reuben Lasker* in 2020. Currently the plan is for the division to perform a 25-day Winter California Cooperative Oceanic Fisheries Investigations (CalCOFI) cruise aboard the R/V *Reuben Lasker* in January, and a 25-day spring CPS survey to conduct a daily egg production method (DEPM) focused on anchovy followed by a 17-day spring CalCOFI survey aboard R/V *Shimada*. Both the summer and fall CalCOFI surveys will take place aboard Scripps Institution of Oceanography vessels. An 80-day summer CPS survey is planned on the R/V *Reuben Lasker* using the acoustic trawl (AT) method.

Lingering effects of the 2014 “Warm Blob” and the 2019 “Marine Heatwave”

In 2014, scientists detected a warm stretch of water off the West Coast. Nicknamed "The Warm Blob," the 2014-2016 marine heatwave was the largest on record. In May 2019, yet another marine heatwave has formed. Since its peak in August, the mass has decreased in size and moved

further offshore, with likely minimal coastal impacts (Leising et al., *in review*). Nevertheless, the size and intensity of these two events are remarkably similar. The area extent in November 2019 was still twice the size of Alaska and on average nearly two standard deviations above normal. It is possible this heatwave may influence yet another warm period.

Warmer than average waters may have influenced northern anchovy (*Engraulis mordax*) production this year. The spring CalCOFI survey recorded the highest levels of anchovy larvae in the program's 70-year history and nearly double the previous record. Time will tell whether this boom in larvae will translate to an increase in the adult population.

It appears that the Pacific sardine (*Sardinops sagax*) southern sub-stock have been present in the Southern California Bight the past two years, the opposite of what is identified in the two-stock theory that suggests the northern stock is in Ensenada part of the year. Scientists are unsure whether this will continue as the Marine Heatwave may be influencing this northward distribution. Rockfish have similarly shown a northward pull. Species previously distributed in Californian waters are now present in Oregon and Washington in such large quantities that they have begun changing the hake fishery.

Sardine Sub-Stock Discussion

There was discussion about the classification between the southern and northern Pacific sardine (*Sardinops sagax*) stock. At this time, the two stocks are divided based on a temperature cutoff of 16.7 °C, while previously they were thought to be one stock. Current science generally supports the two-stock theory. An in-depth discussion among the group discussed what the science does and does not show, emphasizing that the two stocks have shown separate dynamics over the periods of years.

California industry members described the socioeconomic impacts of the sardine fishery being closed to all but the live bait fishery as devastating. They and other industry members expressed appreciation at being involved in such discussions since they are imperative/critical to the livelihood of the industry. Some industry members also expressed continued dedication and support of existing surveys to collect as much data as possible.

Conclusion

The two full-day Forum was well attended and provided many opportunities to share information across international lines. The Forum concluded with closing remarks from Dale Sweetnam (SWFSC) thanking everyone for making the time to attend.

The Trinational Sardine and Small Pelagics Forum concluded with no final decision on the location of the 2020 forum. There were potential recommendations for the 2020 forum to be held either in La Paz, Mexico, December 12-16, 2020, or in Portland, Oregon, at an undetermined date.

Appendix I: List Of Participants

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Appendix I: Agenda

Thursday, December 5th

- 8:00 Registration/Check-in
- 9:00 Welcome and opening remarks. Kristen Koch, Director, Southwest Fisheries Science Center
- 9:15 Meeting logistics. Dale Sweetnam, Southwest Fisheries Science Center
- 9:20 Regional Sardine Fisheries Reports
Canadian Sardine Fishery and West Coast of Vancouver Island (Sardine) Trawl Surveys. Linnea Flostrand*, Jennifer Boldt, Bradley Langman (DFO)
- 9:45 Coastal Pelagic Species Fisheries in the U.S. Pacific Northwest. Greg Krutzikowsky* (ODFW), Lorna Wargo (WDFW), Alan Sarich (Quinault Nation).
- 10:00 California Coastal Pelagic Species Report. Trung Nguyen* (CDFW)
- 10:15 **Break**
- 10:45 The Small Pelagics Fishery on the West Coast of Baja California, Mexico, Fishing Season 2018. Concepción Enciso-Enciso* (CRIAP- Mazatlán), Celia Eva Cotero-Altamirano (CRIAP- Mazatlán), Marianne Moreno-Willerer (CRIAP- Mazatlán), and Casimiro Quiñonez Valenzuela (CICIMAR-IPN)
- 11:00 2019 Pacific Fishery Management Council Report/Update. Kerry Griffin* (PFMC)
- 11:15 Assessment of the Pacific Sardine Resource in 2019 for U.S.A. Management in 2019-20. Kevin T. Hill*, Paul R. Crone, and Juan P. Zwolinski (SWFSC)
- 12:00 **Lunch**
- 13:00 Contributed papers
Effects of Circulation of the California Current on the Production of Phytoplankton, Zooplankton and Small Pelagic Fish off Baja California. Timothy Baumgartner* (CICES) & Eliana Gómez-Ocampo (UABC)
- 13:30 Information and Examples of Fisheries and Oceans Canada Pacific Pelagic Fish and Ecosystem Studies. Linnea Flostrand* & Jennifer Boldt (DFO)
- 14:00 Stock Assessment and Management of the Tempered Stock of Pacific Sardine *Sardinops Sagax* on the West Coast off the Baja California Peninsula, Mexico (1989-2018). Concepción Enciso-Enciso* (INAPESCA, FACIMAR-UAS), Manuel O. Nevárez-Martínez (INAPESCA), Rebeca Sánchez-Cárdenas (FACIMAR-UAS), Guillermo Rodríguez-Domínguez (FACIMAR-UAS), Luis A. Salcido-Guevara (FACIMAR-UAS), Carolina Minte-Vera (CIAT) & Martin E. Hernández-Rivas (CICIMAR-IPN).
- 14:30 Length Conversions and Mass–Length Relationships of Five Forage-Fish Species in the California Current Ecosystem. Juan P. Zwolinski* (IMS-UCSC, SWFSC), Danial G.

Palance (NOAA CORPS), Beverly J. Macewicz (SWFSC), Kevin L. Stierhoff (SWFSC), David A. Demer (SWFSC)

15:00 Distribution, Biomass, and Demography of Coastal Pelagic Fishes in the California Current Ecosystem During Summer 2019 Based on Acoustic-Trawl Sampling. Kevin L. Stierhoff* (SWFSC), David A. Demer (SWFSC), Juan P. Zwolinski (IMS-UCSC, SWFSC)

15:30 Acoustic-Trawl Method Surveys Inform Precautionary, Ecosystem Approaches to Management of Forage Fishes in the California Current. David A. Demer* (SWFSC), Kevin L. Stierhoff (SWFSC), Juan P. Zwolinski (IMS-UCSC, SWFSC)

16:00 *Adjourn*

Onsite Reception: International Meet and Greet in the SWFSC courtyard. Dinner provided.

Friday, December 6th

8:30 An Overview of the California Live Bait Marine Fishery. Dianna Porzio*, Kirk Lynn, Trung Nguyen (CDFW)

9:00 Aerial Survey of Small Pelagic Species in Nearshore California Waters. Kirk Lynn* (CDFW), Emmanis Dorval (NOAA Affiliate OAI/SWFSC), Dianna Porzio (CDFW), Trung Nguyen (CDFW)

9:30 Reproductive Biology of Sardine *Sardinops Caeruleus* from the Western Coast of Baja California During 2018. Celia Eva Cotero Altamirano*, Concepción Enciso Enciso, Marianne Moreno Willerer., Rubí A. Nava O., Lilia Y. García M, Julio Peralta, Héctor Valles Ríos (INSAPESCA)

10:00 Could phytoplankton toxicity limit sardine productivity? Barbara Javor (SWFSC Volunteer)

10:30 ***Break***

11:00 Group Discussion

- Coast-wide surveys
- Lingering effects of the 2014 "Warm Blob" and the 2019 " Marine Heatwave"
- Southern Sardine Sub-Stock vs Northern Sardine Sub-Stock Issues

12:00 Closing Remarks & Location of the 2020 Forum

12:30 ***Adjourn*** and ***Lunch***