

## **2018 Trinational Sardine and Small Pelagics Forum**

Centro Interdisciplinario de Ciencias Marinas  
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## Agenda

### Monday, November 12<sup>th</sup>

16:00-19:00                      Registration/Check-in/Reception

### Thursday, November 13<sup>th</sup>

09:00                      Registration / Coffee

09:30                      Welcome and opening remarks: Dr. Sergio Hernández Trujillo, Director del CICIMAR.

09:45                      Meeting logistic. Martín E. Hernández Rivas.

10:00                      *Regional Sardine Fisheries Reports*. Update on Canadian sardine fishery

10:15                      *The Washington, Oregon, and Quinault Nation report: Northwest Coastal Pelagic Species Fisheries*. Cyreis Schmitt (ODFW), Lorna Wargo WDFW), Alan Sarich (Quinault Nation), presented by Dale Sweetnam\*(SWFSC)

10:35                      *California sardine and small pelagics fishery report*. Kirk Lynn and Dianna Porzio (CDFW) presented by Dale Sweetnam\*(SWFSC)

10:55                      **Break**

11:20                      *The Small Pelagic Fishery Off The West Coast Of Baja California, Mexico, Fishing Season 2017*. Concepción Enciso-Enciso, Celia Eva Coterio-Altamirano, Marianne Moreno-Willerer and Manuel O. Nevárez-Martínez.

11:40                      *Evaluación poblacional de la sardina monterrey (Sardinops sagax) en el Golfo de California, México, 1971/72 - 2016/17*. Manuel Otilio Nevárez Martínez, Ma. de los Ángeles Martínez Zavala, J. Pablo Santos Molina, Violeta E. González Maynez, Ma. Elvira González Corona, Alma E. López Lagunas, Alejandro Valdez Pelayo y Dana I. Arizmendi Rodríguez

12:00                      **Lunch**

13:00                      *Pacific Fishery Management Council Activities*. Kerry Griffin

13:20                      *Assessment of the Pacific Sardine Resource in 2015 for U.S.A. Management in 2017-2018*. Kevin T. Hill, Paul R. Crone, and Juan P. Zwolinski (SWFSC)

13:40                      *Assessment of the Temperate Stock of Pacific Sardine (Sardinops sagax) Off the West Coast of the Baja California Peninsula*. Concepción Enciso-Enciso, Manuel O. Nevárez-Martínez and Rebeca Sánchez Cárdenas.

14:00                      *Estimación de biomasa del stock de sardina monterrey y sardina crinuda de la Costa Occidental de Baja California Sur*. Marcelino Ruiz Domínguez y Casimiro Quiñonez Velázquez

### CONTRIBUTED PAPERS

- 14:20 *Reproductive Biology of Sardine Sardinops caeruleus From the Western Coast of Baja California During 2017.* Celia Eva Coter Altamirano, Concepción Enciso Enciso, Lourdes Z. Brasil B., Rubí A. Nava O., Lilia Y. García M., Héctor Valles Ríos.
- 14:40 *Northern anchovy egg production and spawning dynamics off California during the Daily Egg Production Method survey in 2017.* Emmanis Dorval, Beverly J. Macewicz, David A. Griffith, and Yuhong Gu.
- 15:00 *Egg Production series of sardines (Sardinops sagax) off Baja California.* Tim R. Baumgartner, José Augusto Valencia Gasti.
- 15:20 *Larval abundance of Sardinops sagax in Sebastián Vizcaíno area during 1997-2016, IMECOCAL and BIPO cruices.* Martín Enrique Hernández Rivas. Sylvia P. A. Jiménez Rosenberg, Reginaldo Durazo, Alejandro Hinojosa Medina, Ricardo Saldierna Martínez.
- 15:40 *Edad y crecimiento de juveniles de la Sardina crinuda (Opisthonema libertate) del Golfo de California.* Martínez-Ochoa, Edgar F., Quiñonez-Velázquez, Casimiro, Salgado-Cruz, Luis & Flores-Anaya, Ricardo.
- 16:00 **Adjourn**
- 18:00 Offsite Reception: Restaurant “Real Hacienda”, Hotel Grand Plaza.

### Wednesday, November 14<sup>th</sup>

- 9:00 *2018 SWFSC California Current Ecosystem survey conducted in summer.* Dale Sweetnam.
- 9:20 *Revisiting the Regime Problem hypothesis: 25 years later.* Vanessa Izquierdo-Peña, Salvador E. Lluch-Cota, Martín E. Hernandez-Rivas, and Raul O. Martínez-Rincón.
- 9:40 *Persistent toxicity of marine microplankton in the Southern California Bight.* Barbara Javor
- 10:00 **Break**
- Poster Sesión.** Angela D. Klemmedson, Christian S. Reiss, Emmanis Dorval, Michael E. Goebel, Ronald S. Kaufmann.
- 10:30 Plenary session. Research Plans, Experimental Fishing Permits, and Coast-wide Surveys Stock structure (genetics, microchemistry, traditional approaches, others) Fishery Closures.
- 11:00 Working group (WG) Discussion Sessions.
- 11:30 Closing Remarks (Decide on a 2019 meeting location)
- 11:45 Closing ceremony: Dr. Sergio Hernández Trujillo, Director del CICIMAR.
- 12:00 **Lunch and Adjourn**

## Working Groups/Contributors/Committees

### 19<sup>th</sup> TRINATIONAL SARDINE FORUM COMMITTEES:

#### Program Committe:

Martín E. Hernández Rivas, CICIMAR-IPN, MX  
Dale Sweetnam, SWFSC, La Jolla, CA  
Manuel O. Nevárez Martínez, INAPESCA, MX

#### Executive Commite:

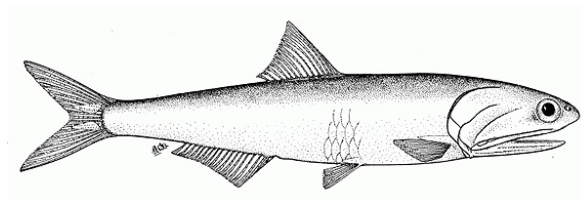
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## Acronyms

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
OAI	Ocean Associates Inc. (Contractor to SWFSC)
ODFW	Oregon Department of Fish and Wildlife
PSC	Pacific Seafood Co
SAFS	School of Aquatic and Fishery Sciences, University of Washington
SIO	Scripps Institution of Oceanography, University of California San Diego
SWFSC	Southwest Fisheries Science Center, National Marine Fisheries Service
UABC	Universidad Autónoma de Baja California
WDFW	Washington Department of Fish and Wildlife

## **Regional Sardine Fisheries Reports**

### **The Washington, Oregon, and Quinault Nation Report: Northwest Coastal Pelagic Species Fisheries.**

Cyreis Schmitt (ODFW), Lorna Wargo WDFW), Alan Sarich (Quinault Nation), presented by Dale Sweetnam\*(SWFSC)

### **California Sardine and small pelagics fishery report.**

Kirk Lynn and Dianna Porzio (CDFW) presented by Dale Sweetnam\*(SWFSC)

## **The Small Pelagic Fishery off The West Coast of Baja California, Mexico, Fishing Season 2017**

Concepción Enciso-Enciso<sup>12</sup>, Celia Eva Cotero-Altamirano<sup>3</sup>, Marianne Moreno-Willerer<sup>3</sup> and Manuel O. Nevárez-Martínez<sup>4</sup>.

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### **ABSTRACT**

We analyzed important aspects of the small pelagic fishery on the west coast of Baja California during the fishing season of 2017. The total catch of small pelagic fish was recorded in 128,510 t, which was 92% higher than the historical average of 2003-2016 (67,034 t annually). 88.5% was recorded as Pacific sardine (*Sardinops sagax*), 10.6% as anchovy (*Engraulis mordax*), 0.6% as mackerel (*Scomber japonicus*) and the rest 0.3% as bocona (*Cetengraulis mysticetus*) and Japanese sardine (*Etrumeus teres*). The highest catches were registered mainly between the months of May to December with an average of 10,709 t / month. The registered fishing effort was 1,818 fishing trips made with 37 boats. The estimated average yield was 70.7 t / trip, which was 11% higher than reported for the period 2003-2016. The average size recorded was 166.5 mm LP, where 7.4% of the total catches for Pacific sardines were below the legal minimum size (150 mm LP). The fleet operated mainly in the vicinity of Bahía Soledad, Bahía San Quintín and Bahía Vizcaíno, in the central-south off the west coast of Baja California.

Key words: Baja California, small pelagic, Catch, yield, sizes.



## **Evaluación Poblacional de la Sardina Monterrey (*Sardinops sagax*) en el Golfo de California, México, 1971/72 - 2016/17.**

Manuel Otilio Nevárez Martínez, Ma. de los Ángeles Martínez Zavala, J. Pablo Santos Molina, Violeta E. González Máñez, Ma. Elvira González Corona, Alma E. López Lagunas, Alejandro Valdez Pelayo y Dana I. Arizmendi Rodríguez  
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### **RESUMEN**

Se presenta un análisis poblacional de sardina monterrey (*Sardinops sagax*) del Golfo de California, para el periodo de 1971/72 a 2016/17. Para ello se utilizó el programa ASAP (Age Structured Assessment Program), el cual permitió estimar el tamaño de la población por grupo de edad (en número y peso), la mortalidad por pesca y también generar algunos puntos de referencia biológicos. Los resultados indicaron una gran variabilidad interanual en las series (reclutas, reproductores y totales, en números y toneladas): el reclutamiento se incrementó desde principios de los años setentas, hasta alcanzar un pico a inicios de los ochentas, cayendo a niveles muy bajos entre 1990-1991 y de nuevo una tendencia ascendente con alta variabilidad aumentando hasta un máximo histórico en la temporada 2006/07. La serie de abundancia de adultos reproductores sigue una tendencia similar, aunque los picos estuvieron corridos un año con respecto al reclutamiento. Entre 2008/09 y 2012/13 la tendencia en las series de abundancia (en número y peso) había sido descendente, sin embargo, en los últimos años se presentó una tendencia ascendente: la biomasa de reproductores aumento de alrededor de 440,000 t en 2014/15 a casi las 600,000 t en 2016/17, mientras que la biomasa explotable se comporta igual que la de reproductores, pero los valores en 2014/15 eran de casi 480,000 t mientras que este valor se incrementó a aproximadamente 820,000 t en 2016/17. La tasa de mortalidad por pesca y la tasa de explotación ( $E=1-\exp(-F)$ ) anual muestran los valores por debajo de 0.15/año durante casi todo el periodo de tiempo, con algunas temporadas en donde estos valores estuvieron entre 0.16 y 0.23, con un pico máximo en 1988/89 y el segundo pico más alto en 2008/09. Un comportamiento similar presenta  $E=C_{total}/B_{exp}$ , aunque se observan valores más altos con respecto a  $E=1-\exp(-F)$ , pero los picos se presentan en las mismas temporadas. La mortalidad por pesca y E en el RMS ( $F_{RMS}=0.290$  y  $E_{RMS}=0.252$ ), fueron mucho mayores a la  $F_{actual}=0.122$ /año y  $E_{actual}=0.115$ /año. Por otro lado, el estimado de la biomasa de reproductores en el RMS fue  $B_{RMS}=510,082$  t, biomasa que es un poco menor a la biomasa estimada para el último año. Al aplicar la regla de control (CBA =  $(B_{exp} - B_{MIN}) * FRACCION$ ) estipulada en el Plan de Manejo Pesquero, bajo la consideración de que  $B_{MIN}=120,000$  t y  $FRACCION=1-\exp(-F_{RMS})$ , se encontró que la población de sardina monterrey ha sido explotada por debajo de la CBA estimada en el periodo de tiempo analizado.

## **Pacific Fishery Management Council Activities**

Kerry Griffin

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### **ABSTRACT**

The Pacific Fishery Management Council (PFMC) is responsible for developing and recommending management measures for federally-managed fish species on the U.S. West Coast from Canada to Mexico, from three 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 FMP includes Pacific sardine, Pacific mackerel, northern anchovy (northern and central substocks), jack mackerel, and market squid. 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**

#### Small-scale fishing

In 2017 the Council adopted an FMP amendment to allow ‘small scale’ fishing to continue when the directed fishery is closed. Fishers are allowed to catch one metric ton of CPS finfish per day, with a single vessel trip per day. This will allow small-scale producers to continue operating even when the larger-scale commercial fishery is closed. The analysis of the action showed a very minimal effect on the CPS populations.

#### Northern anchovy

There has been significant interest in conducting a stock assessment for the central subpopulation of northern anchovy. However, there is scarce data and biological information to support a full assessment, and there is not yet a reliable method for estimating biomass in nearshore areas where the acoustic-trawl survey cannot access. Fishing industry partners are working with federal and state scientists to develop ways to assess the nearshore portion of CPS stocks.

#### Live bait fishing allowance

The live bait fishery supplies live CPS fish to the recreational fleet and for some albacore commercial vessels, primarily in Southern California, but also in Oregon and Washington. The CPS FMP requires that when a CPS stock becomes “overfished”, the live bait sector may only harvest incidental amounts of that stock, not to exceed 15% of any load. However, the live bait

sector depends on the ability to target clean loads of CPS because that is what the recreational and albacore fleets require.

#### Surveys and stock assessments

The NOAA acoustic-trawl survey continues to provide abundance data for CPS stocks, and is the primary source for the sardine stock assessment. Research efforts are underway to better estimate the biomass of CPS in the nearshore area, where the NOAA vessel can't access.

#### **Upcoming activities**

For Pacific sardine there will be an update stock assessment in early 2019, with management measures to be set at the April 2019 PFMC meeting. For Pacific mackerel, a full stock assessment will be completed in early 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.

## **Assessment of the Pacific Sardine Resource in 2018 for U.S.A. Management in 2018-19.**

Kevin T. Hill<sup>1</sup>, Paul R. Crone<sup>1</sup>, and Juan P. Zwolinski<sup>1,2</sup>

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Full report:

<https://swfsc.noaa.gov/publications/TM/SWFSC/NOAA-TM-NMFS-SWFSC-600.pdf>

### **EXECUTIVE SUMMARY**

The following Pacific sardine assessment update was conducted to inform U.S. fishery management for the cycle that begins July 1, 2018 and ends June 30, 2019. Two assessment approaches were reviewed at the STAR Panel in February 2017: an AT survey-based approach (preferred by the STAT); and 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 final base model from the February 2017 STAR (Hill et al. 2017, STAR 2017) with the addition of updated/new landings (2016-17), one AT-based biomass estimate and age composition from the SWFSC's summer 2017 survey, along with one additional recruitment deviation for estimation of the 2017 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 follow:

**Table 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	37,999.5	4,396.7	16,615.0	1,581.4	7,824.9	44,316.2	6,605.0	3,231.4
2006/1	2005/2	17,600.9	11,214.6	18,290.5	17,117.0	2,032.6	101.7	0.0	0.0
2006/2	2006/1	39,636.0	0.0	18,556.0	5,015.7	15,710.5	35,546.5	4,099.0	1,575.4
2007/1	2006/2	13,981.4	13,320.0	27,546.0	20,567.0	6,013.3	0.0	0.0	0.0
2007/2	2007/1	22,865.5	11,928.2	22,047.2	5,531.2	28,768.8	42,052.3	4,662.5	1,522.3
2008/1	2007/2	23,487.8	15,618.2	25,098.6	24,776.6	2,515.3	0.0	0.0	0.0
2008/2	2008/1	43,378.3	5,930.0	8,979.6	123.6	24,195.7	22,939.9	6,435.2	10,425.0
2009/1	2008/2	25,783.2	20,244.4	10,166.8	9,874.2	11,079.9	0.0	0.0	0.0
2009/2	2009/1	30,128.0	0.0	5,214.1	109.3	13,935.1	21,481.6	8,025.2	15,334.3
2010/1	2009/2	12,989.1	7,904.2	20,333.5	20,333.5	2,908.8	437.1	510.9	421.7
2010/2	2010/1	43,831.8	9,171.2	11,261.2	699.2	1,397.1	20,414.9	11,869.6	21,801.3
2011/1	2010/2	18,513.8	11,588.5	13,192.2	12,958.9	2,720.1	0.1	0.0	0.0
2011/2	2011/1	51,822.6	17,329.6	6,498.9	182.5	7,359.3	11,023.3	8,008.4	20,718.8
2012/1	2011/2	10,534.0	9,026.1	12,648.6	10,491.1	3,672.7	2,873.9	2,931.7	0.0
2012/2	2012/1	48,534.6	0.0	8,620.7	929.9	568.7	39,744.1	32,509.6	19,172.0
2013/1	2012/2	13,609.2	12,827.9	3,101.9	972.8	84.2	149.3	1,421.4	0.0
2013/2	2013/1	37,803.5	0.0	4,997.3	110.3	811.3	27,599.0	29,618.9	0.0
2014/1	2013/2	12,929.7	412.5	1,495.2	809.3	4,403.3	0.0	908.0	0.0
2014/2	2014/1	77,466.3	0.0	1,600.9	0.0	1,830.9	7,788.4	7,428.4	0.0
2015/1	2014/2	14,452.4	0.0	1,543.2	0.0	727.7	2,131.3	62.6	0.0
2015/2	2015/1	18,379.7	0.0	1,514.8	0.0	6.1	0.1	66.1	0.0
2016/1	2015/2	22,290.2	0.0	423.4	184.8	1.1	1.4	0.0	0.0
2016/2	2016/1	36,445.5	0.0	964.5	49.4	234.1	2.7	85.2	0.0
2017/1	2016/2	28170.10	7936.40	523.10	144.70	0.10	0.10	0.00	0.00
2017/2	2017/1	74574.10	0.00	1161.70	0.00	378.20	1.20	0.00	0.00

### 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 2017. 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 (2006-2017) was included in the model. The update assessment model (ALT) included final landings from 2016, preliminary landings from 2017, one new AT-based biomass and age composition from the summer 2017 survey, along with one additional recruitment deviation for estimation of the 2017 year class.

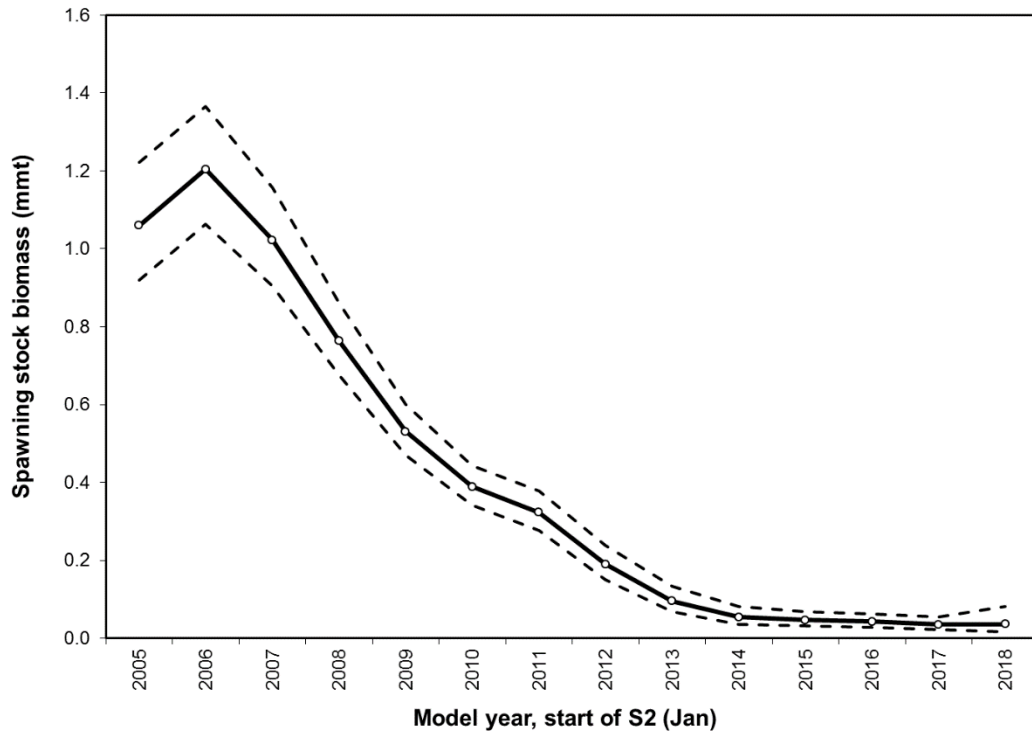
Model ALT incorporates the following specifications:

- 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 (2005-17);
- sexes were combined;
- 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;
  - age compositions with effective sample sizes calculated by dividing the number of fish sampled by 25 (externally);
- 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 ( $0.6 \text{ yr}^{-1}$ );
- recruitment deviations estimated from 2005-16;
- 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 (2006-17) 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; and
- no additional data weighting via variance adjustment factors or lambdas was implemented.

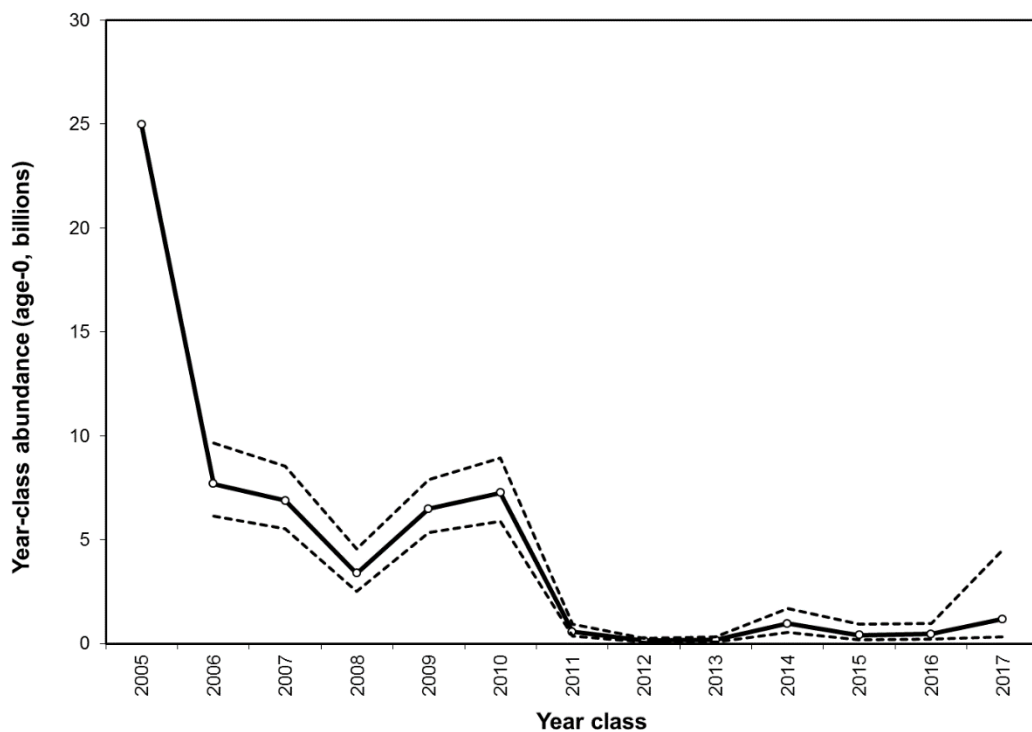
### Spawning Stock Biomass and Recruitment

Time series of estimated spawning stock biomass (SSB, mmt) and associated 95% confidence intervals are displayed in the figure and table below. The virgin level of SSB was estimated to be 86,431 mt. The SSB has continually declined since 2005-06, reaching low levels in recent years (2014-present). The SSB was projected to be 36,651 mt (SD=15,867 mt) in January 2019.

Time series of estimated recruitment (age-0, billions) abundance is presented in the figure and table below. The virgin level of recruitment ( $R_0$ ) was estimated to be 1.22 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 2011-16 year classes have been among the weakest in recent history. A small increase in recruitment was observed in 2017, albeit a highly uncertain estimate (CV=77%) based on limited data.



**Figure 1.** Spawning stock biomass time series ( $\pm 95\%$  CI) for model ALT



**Figure 2.** Recruit (age-0 fish, billions) abundance time series ( $\pm 95\%$  CI) for model ALT.



**Table 2.** Spawning stock biomass (SSB) and recruitment (Recruits) estimates and asymptotic standard errors for model ALT. SSB estimates were calculated at the beginning of Season 2 of each model year (January). Recruits were age-0 fish calculated at the beginning of each model year (July).

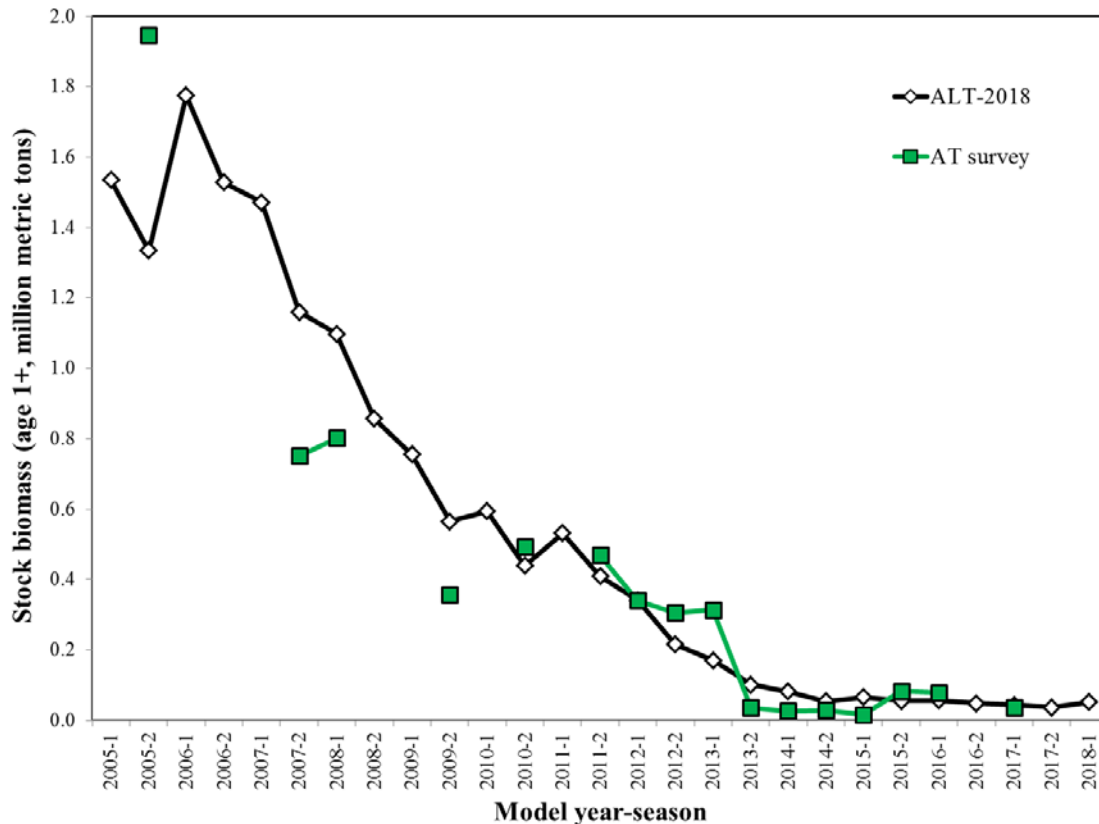
Calendar Yr-Sem	Model Yr-Seas	SSB (mt)	SSB Std Dev	Year class abundance (1000s)	Recruits Std Dev
-	VIRG-1	-	-	1,219,430	352,606
-	VIRG-2	86,431	24,992	-	-
-	INIT-1	-	-	8,485,550	3,887,180
-	INIT-2	310,016	85,120	-	-
<b>2005/2</b>	2005/1	-	-	24,961,200	-
<b>2006/1</b>	2005/2	1,059,660	77,048	-	-
<b>2006/2</b>	2006/1	-	-	7,690,170	899,841
<b>2007/1</b>	2006/2	1,204,400	77,125	-	-
<b>2007/2</b>	2007/1	-	-	6,872,620	759,179
<b>2008/1</b>	2007/2	1,022,610	64,721	-	-
<b>2008/2</b>	2008/1	-	-	3,390,450	510,566
<b>2009/1</b>	2008/2	764,224	47,354	-	-
<b>2009/2</b>	2009/1	-	-	6,490,380	649,386
<b>2010/1</b>	2009/2	530,481	33,318	-	-
<b>2010/2</b>	2010/1	-	-	7,248,050	773,373
<b>2011/1</b>	2010/2	389,116	26,270	-	-
<b>2011/2</b>	2011/1	-	-	571,079	141,498
<b>2012/1</b>	2011/2	323,330	25,503	-	-
<b>2012/2</b>	2012/1	-	-	133,399	47,950
<b>2013/1</b>	2012/2	190,005	22,097	-	-
<b>2013/2</b>	2013/1	-	-	176,326	61,904
<b>2014/1</b>	2013/2	95,658	16,040	-	-
<b>2014/2</b>	2014/1	-	-	958,161	279,848
<b>2015/1</b>	2014/2	54,402	11,186	-	-
<b>2015/2</b>	2015/1	-	-	403,227	183,415
<b>2016/1</b>	2015/2	46,439	9,326	-	-
<b>2016/2</b>	2016/1	-	-	469,733	178,163
<b>2017/1</b>	2016/2	42,441	8,317	-	-
<b>2017/2</b>	2017/1	-	-	1,180,820	911,442
<b>2018/1</b>	2018/2	35,075	8,394	-	-

#### Stock Biomass for PFMC Management in 2018-19

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



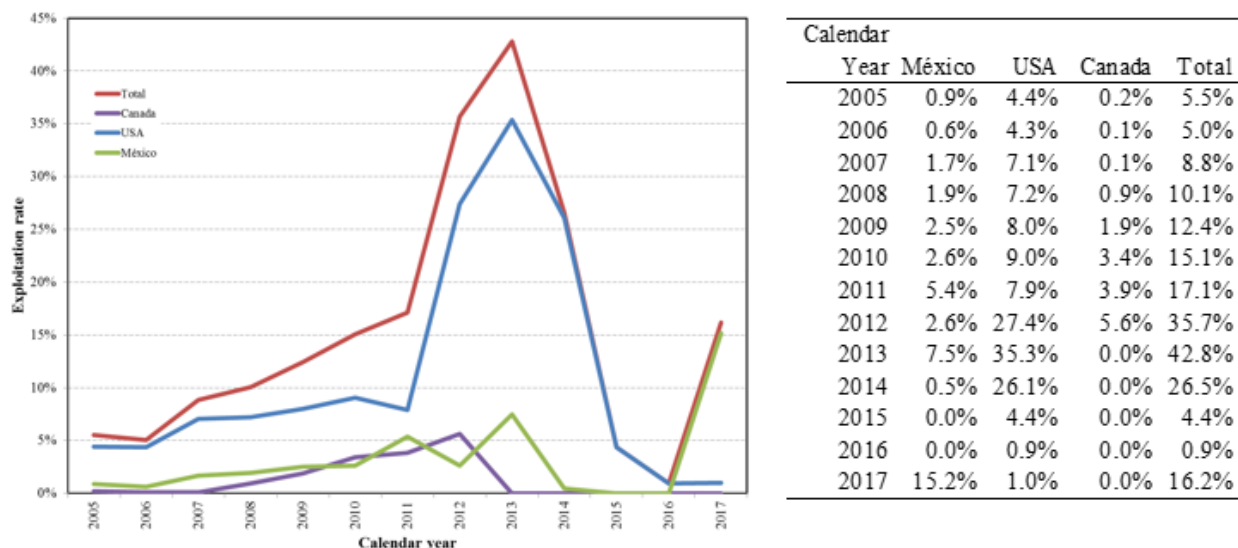
of estimated stock biomass (mmt) from model ALT and the AT survey are presented in the figure below. As discussed above for both SSB and recruitment, a similar trend of declining stock biomass has been observed since 2005-06, peaking at 1.8 mmt in 2006, and plateauing at recent low levels since 2014. Model ALT stock biomass is projected to be **52,065 mt in July 2018**.



**Figure 3.** Estimated stock biomass (age 1+ fish, mt) time series for the AT survey and model ALT.

### 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 35% in 2013. The U.S. rate was 1% in 2017. The U.S. and total exploitation rates for the NSP, calculated from model ALT, are presented in the figure and table below.



**Figure 4.** Annual exploitation rate (CY landings / July total biomass) for model ALT.

## 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, 2018 to June 30, 2019, BIOMASS is the stock biomass (ages 1+, mt) projected as of July 1, 2018, 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 2018-19 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 2015-17 increased to 16.6425 °C, resulting in  $E_{MSY}=0.25$ .

Harvest estimates for model ALT are presented in the following table. Estimated stock biomass in July 2018 was **52,065 mt**. The overfishing limit (OFL, 2018-19) associated with that biomass was **11,324 mt**. The SSB was projected to be 36,651 mt (SD=15,867 mt; CV=43.3%) in January 2019, so the corresponding Sigma for calculating P-star buffers is 0.415 rather than the default value (0.36) for Tier 1 assessments. Acceptable biological catches (ABC, 2018-19) for a range of  $P$ -star values ( $\sigma=0.415$ ; Tier 2  $\sigma=0.72$ ) associated with model ALT are presented in the following table.

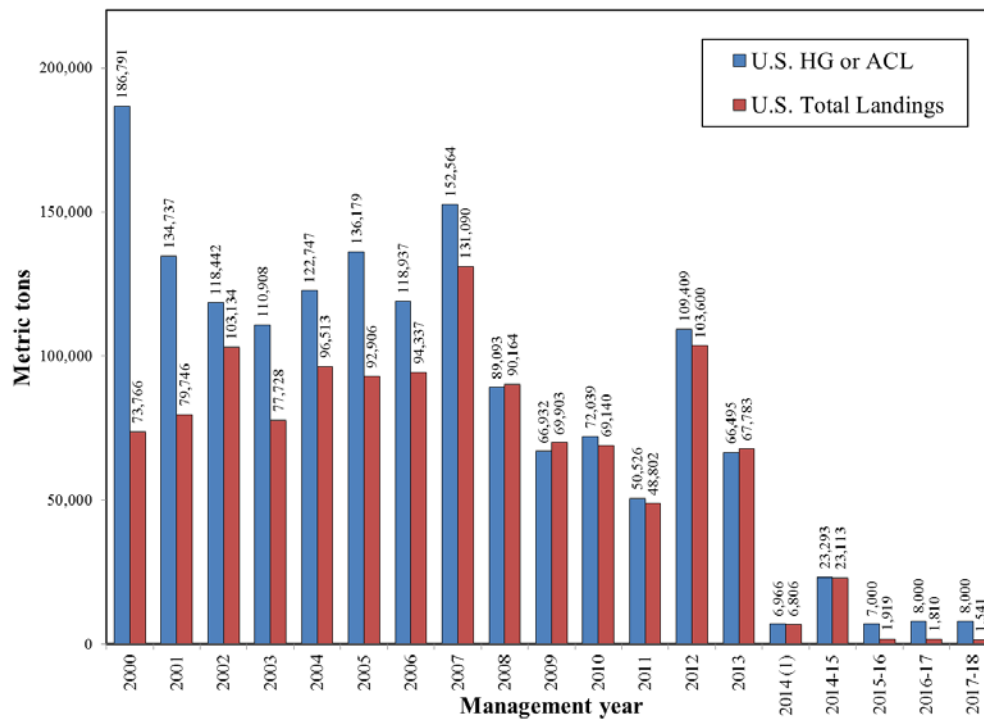
Harvest control rules for updated model ALT:

Harvest Control Rule Formulas										
OFL = BIOMASS * $E_{MSY}$ * DISTRIBUTION; where $E_{MSY}$ is bounded 0.00 to 0.25										
ABC <sub>P-star</sub> = BIOMASS * BUFFER <sub>P-star</sub> * $E_{MSY}$ * 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)	52,065									
P-star	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05	
ABC Buffer <sub>(Sigma 0.415)</sub>	0.94924	0.90030	0.85237	0.80462	0.75609	0.70548	0.65074	0.58787	0.50568	
ABC Buffer <sub>Tier 2</sub>	0.91350	0.83326	0.75773	0.68553	0.61531	0.54555	0.47415	0.39744	0.30596	
CalCOFI SST (2015-2017)	16.6435									
$E_{MSY}$	0.25									
FRACTION	0.20									
CUTOFF (mt)	150,000									
DISTRIBUTION (U.S.)	0.87									
Harvest Control Rule Values (MT)										
OFL =	11,324									
ABC <sub>(Sigma 0.415)</sub> =	10,749	10,195	9,652	9,112	8,562	7,989	7,369	6,657	5,726	
ABC <sub>Tier 2</sub> =	10,345	9,436	8,581	7,763	6,968	6,178	5,369	4,501	3,465	
HG =	0									

**Figure 5.** Harvest control rules for the model-based assessment (model ALT).

### Management Performance

The U.S. HG/ACL values and catches since the onset of federal management are presented in the figure below.



**Figure 6.** U.S. Pacific sardine harvest guidelines or acceptable catch limits and landings since the onset of federal management.

## **Assessment of the Temperate Stock of Pacific Sardine (*Sardinops Sagax*) Off the West Coast of the Baja California Peninsula.**

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### **SUMMARY**

An approximation of the assessment of the Pacific sardine temperate stock (*Sardinops sagax*) off the west coast of the Baja California peninsula for the period from 1989 to 2017 is presented. Based on catch data by age, fishing effort and indicators independent of the fishery (hydroacoustics), a statistical analysis of catch by age (CAGEAN) was applied, which allowed estimating the size of the population biomass by age groups and some biological reference points for its management. The results indicated a great interannual variability in the dataset of the spawning stock and recruits. For the period analyzed, the recruitment showed an upward trend, ranging from 1.017 to 3.839 million individuals. The total biomass presented a similar trend oscillating between 244,048 and 657,720 t, and an average of 460,044 t; for the 2017, the total biomass was estimated at 594,067 t with a 95% confidence interval between 510,882 and 677,254 t. The exploitable biomass also presented a great interannual variability, with a minimum of 200,656 t in the year of 1989 and a maximum of 567,542 t in 2013, for the 2017 it was estimated in 501,839 t and a 95% confidence interval between 419,161 and 584,516 t. The annual exploitation rate (E) ranged between 0.047 and 0.205 year<sup>-1</sup>, with an average of 0.102 year<sup>-1</sup>. The fishing mortality and the exploitation rate in the maximum sustainable yield ( $F_{MSY} = 0.208$  and  $E_{MSY} = 0.188$ ), were higher than the estimated values throughout the period analyzed except for the season 1998 and 2000. Likewise, the Biologically Acceptable Catch,  $BAC_{2018} = (BT_{2017} - BMIN) * FRACTION$ , was estimated as a Harvest Control Rule for the active management of the resource and the level of exploitation is projected throughout this season (2018).

Key words: Monterrey sardine, temperate stock, abundance, management measures.

## **Estimación de Biomasa Del Stock de Sardina Monterrey y Sardina Crinuda de la Costa Occidental de Baja California Sur**

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La Sardina monterrey (*Sardinops sagax*) y sardina crinuda (*Opisthonema spp*) son los dos recursos del grupo de pelágicos menores que reportan mayores capturas en México, lo cual conlleva una importante presión de pesca. Además, la presión ambiental que influye sobre la dinámica de la población. Para entender algunas de las respuestas del recurso a estas presiones; tales como cambios en biomasa, dato importante en el control de la mortalidad por pesca en un plan de manejo para lograr un óptimo aprovechamiento, se requiere evaluar el estado del recurso periódicamente. Para evaluar el estado de las poblaciones de sardina monterrey y de la sardina crinuda (*Opisthonema libertate*) de la costa occidental de BCS, se utilizó el modelo CATCH-MSY propuesto por Martell & Froese (2012). El análisis se basó en las series históricas de captura (1981-2017) desembarcada en Bahía Magdalena y un intervalo (0.22-1.0) de valores de resiliencia. Los estimados de biomasa y puntos de referencia objetivo indicaron una biomasa total para sardina crinuda en 2018 igual a 50,268 t, el máximo rendimiento sostenible (MRS) fue 11,124 t, con una biomasa mínima requerida de BMRS=45,929 t. La biomasa promedio del stock durante los últimos 5 años fue mayor al nivel óptimo (Est=1.29), lo que sugiere que el stock no muestra signos de sobre explotación; sin embargo, la biomasa presenta una marcada tendencia negativa, y de superarse el RMS, se pondría al stock en riesgo. Para la para sardina monterrey, el estimado de biomasa total para 2018 fue 217,923 t, el MRS=37,511 t y la BMRS=199,762 t. La biomasa promedio durante los últimos 5 años se encuentra en nivel óptimo (Est=1.04). Desde el año 2000 la biomasa de este stock disminuyo paulatinamente hasta 2015. De 2016 a la fecha, la biomasa se mantiene por arriba de la BMRS con una tendencia ascendente.

## Contributed Papers

### **Reproductive Biology of Sardine (*Sardinops caeruleus*) From the Western Coast of Baja California during 2017**

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#### **ABSTRACT**

The reproductive behavior of the species and its relation with the environment, has a relevant importance in the dynamics of populations, in particular those that are commercially exploited, in this way it contributes with fundamental elements that support the normativity and management instruments. The small pelagic fishes are the most important of massive resource in the Mexico were the Pacific Sardine *Sardinops caeruleus* is the objective specie. 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 as goal is the management fisheries to do they sustainable. Biological samples were collected from sardine commercial fleet to determine reproductive biology during 2017 In the lab samples both female and males gonads were processed with histological techniques. The results indicated standard length distribution was between 120 y 205 mm and average was 161 mm and a mode 160 mm, was observed a significate difference in the standard length between sex was 161 mm for male and 163 mm for female. The reproductive pick was May and June and other smaller in February and March. The length and maturity was in 168 mm for female and 166 for the males.

## **Northern anchovy egg production and spawning dynamics off California during the Daily Egg Production Method survey in 2017**

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### **ABSTRACT**

In 2017 a daily egg production method (DEPM) survey was conducted in March/April off California to evaluate the spawning biomass of the Central Stock of northern anchovy (CSNA, *Engraulis mordax*). From March 21 to April 22, the survey covered a total area of 130,816.2 km<sup>2</sup> beginning in San Diego, CA (32.55°N) and ending north of San Francisco, CA (38.06°N, north of CalCOFI line 60). The survey area was stratified into a low and high egg density regions, using data from the Continuous Underway Fish Egg Sampler (CUFES). Northern anchovy spawned in waters ranging from 11° to 17°C, averaging 14.14°C over the survey period. Eggs, larvae and adults were most abundant in the southern California Bight (SCB) where the high density region (> 1 egg/min in CUFES samples) was located. The daily egg production estimate ( $P_0$ , an average weighted by area) was 3.43 eggs/0.05 m<sup>2</sup> (CV = 0.58) for the whole survey area. Based on an un-stratified method, female spawning biomass was estimated to be 171,689 mt (CV = 0.35) in the whole survey area; whereas in the SCB female biomass was estimated to be 152,181 mt (CV=0.43), using a stratified method. These results showed that the CSNA was recovering from the low period of productivity from 2009 to 2015 and exhibited similar spawning dynamics as in the 1980s.

## **Egg Production series of sardines (*Sardinops sagax*) off Baja California**

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### **ABSTRACT**

The Daily Egg Production Method (DEPM) was used to calculate a time series of egg production of the Pacific sardine (*Sardinops sagax*) off the peninsula of Baja California. The data were collected during IMECOCAL springtime cruises over the period 2000 through 2013. The series is limited to the spawning stock that is a southern extension of the “northern” stock off California. Ichthyoplankton data used in this study were obtained from egg densities collected by the CUFES (Continuous Underway Fish Egg Sampler) system and CalVET (CalCOFI Vertical Egg Tow) net tows from the R/V *Francisco de Ulloa*. We include only samples that are found in water between 14.5 and 17.5°C. Positive samples of sardine eggs range from 81 (taken from 426 samples in 2001) to 1 (from 584 samples in 2005). In order to have any confidence in the values for egg production we have limited consideration only to >12 positive egg samples. The maximum egg production is 0.888 (2001) and the minimum is 0.161 (2013). Distributions and abundances for each year are provided for the eggs. Spawning occurred between 14.7° and 16.6° C and the variability in egg production appears to be related to interannual change in regional ocean conditions represented by the index of the Pacific Decadal Oscillation (PDO).



## **Larval Abundance of *Sardinops sagax* In Sebastian Vizcaíno Area During 1997-2016 Imecocal and Bipo Cruises**

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### **ABSTRACT**

Sebastian Vizcaíno Bay has traditionally been considered a center of spawning for the Pacific sardine (*Sardinops sagax*). Several papers mentioned this area, as the major spawning ground during the periods of low abundance of Pacific sardine, and how, this spawning ground shift to central California during high abundance periods.

In order to establish if the three stocks (c.f. Félix-Uraga) spawning in Punta Eugenia vicinity, we analyzed the larval abundance of sardine in an area of 35,678 km<sup>2</sup>; Vizcaino priority region for conservation according with the Mexican National Biodiversity Commission.

We found the presence of two stocks, cold and temperate. The cold stock spawning in April primarily, and in some years in January, the temperate stock spawning in summer, fall and mainly in winter.

The tendency of the cold stock was to increase from April 1999 to April 2004, after that, the larval abundance is low until March 2013 when reach a second peak and diminished in the subsequent years; while the temperate stock seems to be increasing from January 1998 to August 2000. These stock decrease from 2000 until October 2011, and show a great abundance in January 2012. After this date, no more oceanographic cruises were conducted in the area.

Apparently, the larval abundance follow the tendency of the changes in the California Current System.

Additionally, the larval index of sardine larvae by cruise were calculated.

## **Edad y Crecimiento de Juveniles de la Sardina Crinuda (*Opisthonema libertate*) Del Golfo de California**

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### **RESUMEN**

El recurso pesquero denominado sardina crinuda presenta importantes volúmenes de captura. A la fecha, es una de las principales pesquerías en México. El tamaño de la clase anual queda definido durante las fases tempranas del desarrollo de los peces previo al reclutamiento. Para evaluar estas etapas de la ontogenia se requiere la edad de los juveniles en días. Esta información nos permite estimar las tasas de crecimiento y las fechas de nacimientos; y en consecuencia conocer las condiciones ambientales que promueven altas tasa de crecimiento y supervivencia. Durante 2014 y 2015 se recolectaron en el Golfo de California peces juveniles de pelágicos menores, con la finalidad de obtener indicadores tempranos del reclutamiento. En el presente trabajo, se analizaron las muestras biológicas de la sardina crinuda *Opisthonema libertate*. Se estimó la relación peso-longitud, se determinó la edad utilizando la microestructura de los otolitos, el crecimiento individual fue descrito utilizando un enfoque multimodelo (Gompertz, von Bertalanffy y Richards), y los estimadores de los parámetros se obtuvieron por máxima verosimilitud. Para elegir el mejor modelo se aplicó el criterio de información de Akaike. Se estimaron las fechas de nacimiento y se relacionaron con variables ambientales (TSM y Clorofila-a). Se identificó un crecimiento alométrico ( $b=3.4$ ,  $p<0.05$ ) para los juveniles menores a 100 mm de LE. Se estimó un APE=4.6% entre dos lecturas independientes del número de marcas de crecimiento en los otolitos. Cada marca de crecimiento corresponde a un día de edad, y varió entre 41 y 226 días. Las diferencias de Akaike ( $>2$ ) identificaron a los modelos de von Bertalanffy y Richards como estadísticamente robustos para describir el crecimiento de los juveniles de *O. libertate*, mientras que el modelo de Gompertz no mostro soporte estadístico. De acuerdo con el criterio de Akaike, el modelo para describir la tendencia de los datos edad-talla fue von Bertalanffy ( $L_{\infty} = 114.6$ ,  $k = 0.0086$  y  $t_0 = -0.198$ ). Las distribuciones de fechas de nacimiento mostraron que los picos de supervivencia ocurrieron en marzo y mayo de 2014 entre una TSM de 19 a 22° C y un máximo de clorofila-a (19.74 mg-m<sup>3</sup>). Durante 2015, la supervivencia fue comparativamente menor y los sobrevivientes nacieron principalmente en mayo, junio y julio con TSM de 22 a 29° C y valores bajos de Clorofila-a (7.27 – 0.70 mg-m<sup>3</sup>). La identificación de condiciones ambientales que promueven adecuadas tasas de crecimiento y supervivencia durante las etapas tempranas del desarrollo de los peces, permitirá identificar las potenciales ventanas ambientales que se asocien con adecuados índices de reclutamiento.

## Revisiting the Regime Problem hypothesis: 25 Years Later

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### ABSTRACT

Small pelagics have been a central research topic for more than 60 years because of their ecological role, their economic importance, and the apparent multidecadal large fluctuations in catches, synchronic fluctuations from remote regions, and the alternation between the abundance of sardine and anchovies within each system. Strong evidence supports the observation that low-frequency small pelagics fluctuations occur naturally. However, the synchrony and the alternation have been questioned. In this study, the Regime Problem hypothesis is revisited by updating the fish catch time series to 2015, and by incorporating into the analyses stocks not originally considered due to the time series lengths. The specific questions addressed here are: 1) whether the synchronic fluctuations of small pelagics catches from remote regions and the species alternation between species within each system, observed for the last century in the Regime Problem literature, remains after updating the time series, and 2) If a multidecadal signal can also be detected in regions that were not considered in the original Regime hypothesis framework. Results indicate that the multidecadal synchrony between systems and alternation between species remains clear for the Kuroshio and Humboldt systems. The California small pelagics cannot be considered to be in phase with the other systems, that in Benguela alternation is not evident during at least the last two decades, and that there is not a single worldwide mode of variability teleconnecting all small pelagics.

Keywords: Alternation, Synchrony, Small pelagics, Climate

## **Persistent Toxicity of Marine Microplankton in the Southern California Bight**

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### **ABSTRACT**

Booms and busts of Pacific Sardine populations may be directly related to the food they eat. Unlike other small, coastal pelagic fish that thrive on zooplankton, Pacific Sardine are both predators and filter-feeders on phytoplankton. I hypothesize that oxidized lipids (oxylipins) produced by certain diatoms include toxic metabolites that play a role in limiting sardine survival and reproduction in the Southern California Bight (SCB). The theory is being tested in bioassays with brine shrimp larvae to assess the toxicity of concentrated microplankton in the 10-100  $\mu\text{m}$  size range. In onboard assays during the June, 2018 CalCOFI cruise, nearly all the concentrated plankton samples in the SCB down to 30 m depth were significantly toxic (10-92% mortality of brine shrimp larvae in the 24-h bioassay). Weekly samples of Scripps Pier seawater from July through October showed peak toxicities in concentrated plankton in early September (>60% mortality) before diminishing to <30% mortality at later dates. Dose-response assays during the peak mortality period showed maximal toxicity in 40x plankton concentration. Bioassays with unconcentrated microplankton showed low mortalities (<5%). The results with concentrated plankton represent *potential* toxicity that serve as a measure of comparison. Chemical analyses of the bioactive plankton samples are underway. Toxins in the microplankton appear to be a persistent feature in the SCB. I hypothesize that spikes of toxic oxylipins in the plankton could result in periodic failures in survival and reproduction among Pacific Sardine, and repeated spikes over several years might result in a population bust.

## **2018 SWFSC California Current Ecosystem Survey Conducted in Summer**

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No abstract

## Poster Sesión

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### ABSTRACT

Myctophids are ecologically important in the Southern Ocean, where they constitute a key energy resource for top predators. Understanding their population dynamics is limited by a paucity of data due to sampling challenges. Antarctic fur seal (*Arctocephalus gazella*) scats provide large collections of otoliths that can be used to form time series of demographic parameters for important mesopelagic taxa. Combined with standardized measures of foraging duration, otolith abundance in scats reflects prey availability. We examined interannual variability in otoliths per foraging hour for fur seals on Livingston Island from 2000 through 2015. Additionally, we examined temporal trends in age and reconstructed length of the myctophid *Gymnoscopelus nicholsi* using scat-recovered otoliths. Foraging duration varied interannually, with myctophids declining from approximately 30 otoliths per foraging hour to fewer than 10. Ages of *G. nicholsi* from scat samples ranged from 2 to 6 years and were dominated by ages 3 and 4. Reconstructed fish lengths ranged from 97 to 156 mm. While mean reconstructed length did not change significantly over the time series, mean age declined. Older age classes were scarcer in scat samples, and age-6 animals were not found after 2008. The decline in the number of otoliths in Antarctic fur seal scat samples coupled with the negative trend in mean age suggests trends of diminishing *G. nicholsi* abundance and altered population structure on the South Shetland Island shelf during this 16 year period. This study demonstrates the utility of central-place foragers in assessing populations of unfished but ecologically important mesopelagic fishes.