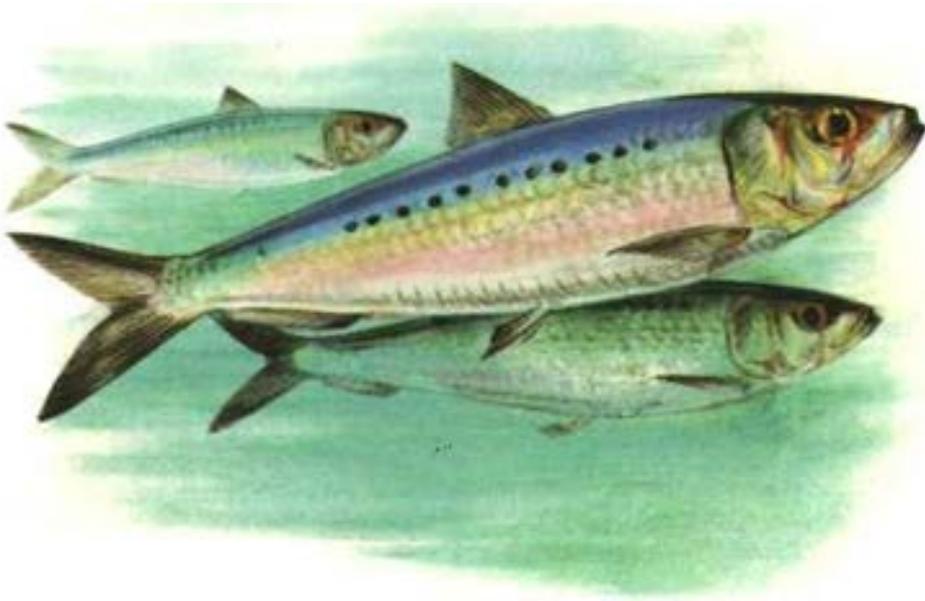


2014

TRINATIONAL SARDINE FORUM
FORO TRINACIONAL DE LA SARDINA



**15th ANNUAL MEETING
PROGRAM**



**CICIMAR-IPN CAMPUS
LA PAZ, BCS. MÉXICO
NOVEMBER 10 and 11th, 2014
<http://www.cicimar.ipn.mx>**



**TRINATIONAL SARDINE FORUM
FORO TRINACIONAL DE LA SARDINA**

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TRINATIONAL SARDINE FORUM FORO TRINACIONAL DE LA SARDINA



AGENDA

MONDAY, NOVEMBER 10th

Sala de Usos Múltiples, Instituto Politécnico Nacional-Centro Interdisciplinario de Ciencias Marinas (CICIMAR-IPN)

- 9:00 Registration
- 10:00 *Opening of the Conference*
Welcome Dra. María Margarita Casas Valdez (CICIMAR-IPN)
- 10:10 Opening Remarks; Dr. Roberto Felix Uraga (CICIMAR-IPN)
- 10:20 ***Regional Sardine Fisheries Reports (20 minutes each)***
California; Chelsea Protasio (CDFW)
- 10:40 Canadá; Jordan Mah (DFO)
- 11:00 ***Break***
- 11:20 Oregon; Jill Smith
- 11:40 Washington; Lorna Wargo (WDFW)
- 12:00 Bahía Magdalena; R. Félix-Uraga (CICIMAR -IPN, La Paz), (COFAA and EDI)
- 12:20 Observers aboard Seine Fleet in the Gulf of California; D. A. Arizmendi-Rodríguez
- 12:40 Gulf of California and Ensenada; Manuel Nevárez-Martínez (INAPESCA-CRIP Guaymas)
- 13:00 ***Lunch***

**TRINATIONAL SARDINE FORUM
FORO TRINACIONAL DE LA SARDINA**

- 14:30 **Research Plans and Reports**
STOCK ASSESSMENT OF SARDINA MONTERREY (*Sardinops caeruleus*) ON THE WEST COAST OF BAJA CALIFORNIA BY CATCH DATA 1980-2013.
Concepción Enciso-Enciso (*CRIP-Ensenada*)
- 14:50 STOCKS DISCRIMINATION OF THREAD HERRING (*Ophisthonema libertate*) IN THE NORTHWESTERN REGION OF THE MEXICAN PACIFIC COAST.
Carlos I. Pérez-Quiñonez (*CICIMAR-IPN*)
- 15:10 IS 17°C AN OPTIMAL UPPER BOUND OF TEMPERATURE TO DELINEATE THE NORTHERN STOCK OF PACIFIC SARDINE (*Sardinops sagax*)? EVIDENCE FROM LABORATORY EXPERIMENTS AND FIELD SURVEYS.
Emmanis Dorval (*SWFSC*)
- 15:30 THE SARDINE OUTBURST IN THE NORTH PART OF THE CALIFORNIA CURRENT IN MID-2010S: A RESULT OF RECENT HARVEST REGULATIONS OR NATURAL VARIATION OF THE POPULATION SIZE?
Rubén Rodríguez-Sánchez (*CICIMAR-IPN*)
- 15:50 **Break**
- 16:10 HISTORIC ANALYSIS OF CATCH AND LENGTH FOR PACIFIC SARDINE (*Sardinops caeruleus*) ON THE WEST COAST OF BAJA CALIFORNIA, PERIOD 1990-2013.
Concepción Enciso-Enciso (*CRIP-Ensenada*)
- 16:30 SURVIVING AND THRIVING: TRENDS AND PATTERNS AMONG SARDINE AND ANCHOVY LARVAE AND THEIR ENVIRONMENTS IN THE SOUTHERN CALIFORNIA BIGHT, 1951-2011.
Barbara Javor (*SWFSC*)
- 16:50 ACOUSTIC-TRAWL SURVEYS OF SARDINE DURING SPRING AND SUMMER 2014.
David A. Demer (*SWFSC*)
- 17:10 Adjourn

TRINATIONAL SARDINE FORUM FORO TRINACIONAL DE LA SARDINA

TUESDAY, NOVEMBER 11th

Sala de Usos Múltiples, Instituto Politécnico Nacional-Centro Interdisciplinario de Ciencias Marinas (CICIMAR-IPN)

- 9:00 **Research Plans and Reports (continued)**
EFFECT OF MESOSCALE EDDIES AND STREAMERS ON SARDINE SPAWNING HABITAT AND RECRUITMENT SUCCESS OFF SOUTHERN AND CENTRAL CALIFORNIA.
Sam McClatchie (*SWFSC*)
- 9:20 REGIME VS CLIMATE REGIME SARDINE/ANCHOVY IN THE CALIFORNIA CURRENT. HOW REAL IS THE SYNCHRONICITY OF THESE EVENTS?
Vanessa Izquierdo-Peña (*CICIMAR-IPN*)
- 9:40 REPRODUCTIVE BIOLOGY OF PACIFIC THREAD HERRING *Opisthonema libertate* FROM SOUTH OF GULF OF CALIFORNIA DURING 2012-2013.
Eva Cotero-Altamirano (*CRIP-Ensenada*)
- 10:00 MULTI-MODEL APPROACH TO GROWTH DESCRIPTION OF THE THREAD HERRING (*Opisthonema libertate*) IN THE SOUTH PART OF THE GULF OF CALIFORNIA.
Marcelino Ruiz-Domínguez (*CICIMAR-IPN*)
- 10:20 SPECIES DISCRIMINATION OF GENUS *Opisthonema* GILL, 1861 IN THE SOUTHEAST COAST OF THE GULF CALIFORNIA USING MORPHOMETRIC AND GENETIC ANALYSIS.
Carlos I. Pérez-Quiñonez (*CICIMAR-IPN*)
- 10:40 **Break**
- 11:00 Special Session: National Management Strategies of Sardine Population.
Kevin Hill (*SWFSC*) and Manuel Nevárez-Martínez (*INAPESCA-CRIP*)
- 11:30 Focus Issue: 2015 Coast-wide Survey
David Demer (*SWFSC*), Jordan Mah (*DFO*) and Manuel Nevárez-Martínez (*INAPESCA-CRIP*)



**TRINATIONAL SARDINE FORUM
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- 12:30 **Lunch**
- 14:00 **Working Group (WG) Breakout Sessions**
WG1. Regional Biomass
David Demer (*SWFSC*)
- WG2. Stock Structure, Age Structure, and Adult Sampling
Russ Vetter (*SWFSC*)
- WG3. Industry Trends and Issues
Jordan Mah (*DFO*)
- 15:00 **Break**
- 15:30 Plenary Sessions for reporting results of WG discussions
- 17:00 Closing Remarks
- 17:30 End of conference
- 18:00 Dinner at Grand Plaza Hotel
(a pass is required for dinner)

WORKING GROUPS/CONTRIBUTERS/COMMITTEES

EXECUTIVE COMMITTEE

U.S.	Dale Sweetnam/Kevin Hill	SWFSC	La Jolla, California
Can.	Jordan Mah	DFO	Vancouver, BC
Mex.	Roberto Félix	CICIMAR	La Paz, BCS

PROGRAM COMMITTEE

U.S.	Dale Sweetnam/ David Demer	SWFSC	La Jolla, California
Can.	Jordan Mah	DFO	Vancouver, BC
Mex.	Martín Hernández/Roberto Félix	CICIMAR	Ensenada, BC

LOGISTICS COMMITTEE

Mex.	Martín E. Hernández-Rivas	CRIP-La Paz	La Paz, Mexico
Mex.	Roberto Félix-Uraga	CICIMAR-IPN	La Paz, Mexico
U.S.	Cisco Werner/Dale Sweetnam	SWFSC,	La Jolla CA
Mex.	Claudia A. Silva-Segundo	CRIP-La Paz	La Paz, Mexico
Mex.	Marcela S. Zuñiga-Flores	CRIP-La Paz	La Paz, Mexico

Working Groups:

- WG1: Regional Biomass; David Demer
- WG2: Stock Structure; Age Structure and Adult Sampling; Russ Vetter
- WG3: Industry Trends and Issues; Jordan Mah



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ACRONYMS

CICESE	Centro de Investigación Científica y de Educación Superior de Ensenada
CICIMAR	Centro Interdisciplinario de Ciencias Marinas
CRIP	Centro Regional de Investigación Pesquera
DFO	Department of Fisheries and Oceans Canada
INAPESCA	Instituto Nacional de la Pesca
IPN	Instituto Politécnico Nacional
NWFSC	Northwest Fisheries Science Center
PSC	Pacific Seafood Co
CWPA	California Wetfish Producers Association
CDFW	California Department of Fish and Wildlife



TRINATIONAL SARDINE FORUM FORO TRINACIONAL DE LA SARDINA



CONTRIBUTED ABSTRACTS AND SUMMARIES-ORAL PRESENTATIONS

CALIFORNIA SARDINE FISHERY REPORT

Chelsea Protasio

California Department of Fish and Wildlife; 831-649-2994

The Pacific Sardine fishery in California operates as both a day and night fishery with landings concentrated in two distinct fisheries, divided at Pt. Conception. The vessels in California tend to not fish on the weekend, following the same pattern as the Market Squid fishery. Since 2000, most landings have been centered in the southern portion of the state. This season had higher landings within the northern/central fishery, primarily around the Monterey Bay, making up 48 percent of the state's total landed catch. Aircraft spotter planes are frequently used to assist the vessels in locating schools of sardines as well as other coastal pelagic species. Forty-four vessels in the California limited entry permit fishery made landings into the California ports during 2014. On September 20, 2014, the fishery closed after a short five day allocation period. As of mid-October, the landings in California totaled approximately 7,566 metric tons (mt). A preliminary estimate of the mean weight of landings is 23.5 mt per trip. Incidental amounts of Pacific mackerel, jack mackerel, and market squid have also been landed.

In 2013, the Pacific Fishery Management Council adopted changing the fishery start date to July 1 starting in 2014, which now coincides with the Pacific mackerel fishery start date. Allocation schemes will remain consistent: 1 July – 14 September (40%), 15 September – 31 December (25%), and 1 January – 30 June (35% of total allocation).

The 2014/15 Annual Catch Target (ACT) was set at 23,293 mt for the entire US West coast, a substantial drop from the 2012 Harvest Guideline (HG) of 109,409 mt. Sardines were landed in California during all three allocation periods. In the previous six years, allocation periods closed early because catch limits were reached. For the sixth straight year, squid accounted for more landed tonnage than sardine during September for the California fleet, a change from prior years.

TRINATIONAL SARDINE FORUM FORO TRINACIONAL DE LA SARDINA

2014 CANADIAN PACIFIC SARDINE FISHERY AND WEST COAST OF VANCOUVER ISLAND TRAWL SURVEY

¹Jordan Mah, ²Linnea Flostrand and ²Vanessa Hodes

¹Fisheries and Oceans Canada, Pacific Region Headquarters, 200 - 401 Burrard Street, Vancouver, BC V6C 3S4; ²Fisheries and Oceans Canada, Pacific Biological Station, 3190 Hammond Bay Rd. Nanaimo, BC V9T 6N7

As of September 25, 2014, there have been no fishery landings of Pacific sardine in B.C. waters in 2014 nor were there any in 2013. Based on the Canadian Pacific sardine fishery's harvest guidelines, for the 2014 B.C. fishing season (June 1 2014- February 9 2015) a Total Allowable Catch (TAC) of 17,174 metric tonnes was allocated for the commercial fishery for 2014. A total of 50 sardine licences are available, each having an equal share of the TAC (343.5 metric tonnes per licence).

Summer surveys directed at collecting information on sardines off the WCVI started in 1997. Fishing is conducted in surface waters (< 30 m) using a mid water trawl towed at average speeds approximating 5 knots. Since 2006, sampling has been conducted at night. No sardines were captured during the 2014 and 2013 summer WCVI night surveys within the boundaries of a core survey region, therefore the mean sardine biomass density is 0 tonnes per km³ of surface water. In 2014, 59 trawl stations were sampled (August 5-15th) and in 2013, 60 trawl stations were sampled 10 night shifts (from August 6 to 16th). All tow periods were 20 minutes. The locations of the stations were identified prior to the survey by randomly selecting sites along a ~10x10km grid representing approximately equal sampling intensity within 8 strata of a defined core survey region.



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2014 OREGON SARDINE FISHERY REPORT

Jill Smith

The Pacific sardine fishery in Oregon operates as a day fishery with vessels based primarily in Astoria where processing plants for sardine operate. In addition to federal fishing period allocations, the timing of peak availability of sardines in northwest waters and environmental factors greatly affect when vessels fish. Aircraft are often used to assist in locating schools for sardines and weather and tides are major factors affecting when vessels are able to transit in and out of the Columbia River from Astoria, the major sardine fishery port. Nineteen of the 25 vessels in the Oregon limited entry permit fishery made landings into Oregon during 2014. All landings were made into the Astoria area. Five Oregon plants processed sardines during 2014, fewer than in recent years due to a reduced harvest guideline.

During 2014, sardines were landed into Oregon during two fishing periods: July 1-22 and September 15-19. The fishery closed for the remainder of the year on September 20, 2014 because the allocation had been attained. Preliminary estimates of sardine landings into Oregon totaled about 7,627 metric tons (mt), with an ex-vessel value of \$3.5 million for 2014. A preliminary estimate of the mean weight of these landings is 50mt. About half the landings were taken during each fishing period: 3,879mt in July and 3,748mt in September. Pacific mackerel and jack mackerel were also landed during the 2014 sardine fishery, totaling about 966mt and 245mt, respectively.

Twenty-eight landings were sampled for sardine biological information: 16 during the first fishing period and 12 during the second. Twenty-five sardines were collected per sample. For the first fishing period, females averaged 221mm and 179.9gm and males averaged 217mm and 170.9gm. For the second fishing period, females averaged 219mm and 193.5gm and males averaged 216mm and 184.3gm.



TRINATIONAL SARDINE FORUM FORO TRINACIONAL DE LA SARDINA



2013 WASHINGTON AND QUINAULT SARDINE FISHERY REPORT

¹Lorna Wargo, Carol Henry and Alan Sarich

¹Fish Program, Marine Resources, Washington Department of Fish and Wildlife

Lorna.Wargo@dfw.wa.gov

Pacific sardines are the primary coastal pelagic species harvested in Washington waters. The Washington State sardine fishery opens annually by rule on April 1. In 2013, the first landing was made on June 23. Twelve of the 16 Washington limited entry licenses were actively fished; in addition was one temporary annual permit was issued and fished in 2013.

A preliminary total of 29,562 metric tons of sardines were landed into Washington through October 17, 2013. The season remains open through December 31, 2013, but weather and colder waters moving in prevented fishermen from successful fishing after mid-October. Approximately 45, 29 and 12 percent of the 450 landings made to-date fell in July, August and September, respectively. All landings were made into either Westport or Ilwaco, and according to logbook records nearly 81% of the catch was from waters adjacent to Washington. The average landing was about 74 metric tons. Approximately 495 sets were made with 444 (90%) of them successful. The average catch per successful set was about 59 metric tons.

Pacific sardines are the targeted catch in the Washington fishery, but anchovy, mackerel, and squid can also be retained and landed. In 2013, fish landing receipts documented landings of 131 metric tons of mackerel.

The Quinault Indian Nation has participated in the Pacific Sardine fishery since 2012. This Treaty fishery operates independent of the non-treaty allocation periods. Quinault fishers harvested 585.5 metric tons of sardines and 0.11 mt of mackerel within QIN's Usual and Accustomed fishing areas beginning on July 7 and the final catch was recorded on August 23. Foggy conditions and inability to find sardines within open areas contributed to an early end of successful sets.

TRINATIONAL SARDINE FORUM FORO TRINACIONAL DE LA SARDINA

SARDINE FISHERY IN MAGDALENA BAY, 2013-14

Roberto Félix-Uraga¹, Casimiro Quiñonez-Velázquez¹, Felipe Neri Melo-Barrera¹ y Martín E. Hernández Rivas.

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

In the past 14 years, landings of the small pelagic fishes in Magdalena Bay had an average of 52,024 t per year, with an average catch of 42,826 t for the Pacific sardine and 755 fishing trips. During 2013, 796 fishing trips were realized and landings of small pelagic fishes were 54,666 t of which 29,274 t were Pacific sardine. Regarding the specific composition of small pelagics landed in Magdalena Bay in 2013, *Sardinops sagax* accounted for 53.6%, *Opisthonema* 18.9%, *E. teres* 5.0%, *S. japonicus* 4.4%, *C. mysticetus* 7.9% and 10.3% was a mixture of some of these species. 15 vessels landed small pelagics during 2013, but only 9 of them realized the 90% of the total fishing trips. In relation to the size composition of Pacific sardine, 97.3% of catches were above of the minimum legal size (150 mm SL). Most of these sardines (87.7%) had sizes between 170-215 mm SL. The age composition determined for 2013 reflects the above. Age group 1 was the most abundant, but groups 2, 3 and 4 were also significant amounts on landings. In all months of 2013 mature or spawning sardines were presented, but higher reproductive activity was during February and April. Currently Pacific sardine shows a more continuous reproductive activity. During January to July 2014, were downloaded 44,414 t of small pelagic fishes, of which 37,389 t was Pacific sardine. The importance of the remaining small pelagics was: *Opisthonema* spp 9.1%, *E. teres* 4.8%, *S. japonicus* 1.4%, *C. mysticetus* 0.3% and 3.0% was a mixture of species.

OBSERVERS ABOARD SEINE FLEET IN THE GULF OF CALIFORNIA

¹*Dana I. Arizmendi-Rodríguez, ¹Jesus G. Padilla-Serrato, ²Manuel O. Nevárez-Martínez,
³Concepción Enciso-Enciso and ¹Eduardo Álvarez-Trasviña

¹Centro Regional de Investigación Pesquera Guaymas – INAPESCA; ²Dirección General de Investigación Pesquera en el Pacífico – INAPESCA; ³Centro Regional de Investigación Pesquera Ensenada – INAPESCA

[*dana.arizmendi@inapesca.gob.mx](mailto:dana.arizmendi@inapesca.gob.mx)

Activities and results from the observers aboard the fleet program are described as part of the project “Monitoring of the constraints imposed by MSC (Marine Stewardship Council) for certification process of small pelagic fishery in the Gulf of California”. Information was collected from January 2013 to February 2014 by nine observers aboard the fleet. Areas of fleet operation were determined with the information generated. Non-parametric models were used to evaluate if size of sample was sufficient to determine the number of associated species from species accumulation curves. Biological Value Index (BVI) was used to identify the important species in abundance, time, and space in addition to the ecological of specific richness, diversity, and equity. The seine fleet showed activity on both coasts of the Gulf of California (Baja California Peninsula, Sonora, and Sinaloa). Observations were made on 1,402 catches, of which 553 “water” sets (meaning sets with zero catch), 425 thread herring, 95 Monterey sardine and, 329 were different small pelagic species (californian anchovy, chub mackerel, pacific anchoveta, red-eye round herring and leatherjacket). From the 88 by-catch species 79 were fish, five were crustacean, three mollusks, and one cnidarian. The biological value index (BVI) showed bronze-striped grunt, finescale triggerfish and pacific sierra as the most dominant fish species. Seventeen species of birds were identified, where the most abundant were the brown pelican and heermann’s gull. The BVI showed brown pelican, heermann’s gull, laughing gull, brown boobie, blue-footed boobie and ring-billed gull as the most dominant. We recommend continuing with the observers program, which will allow generating important information about fishing activity and their associations.

Keywords: MSC, dominance, equality, specific richness, seine fleet.

**STOCK ASSESSMENT OF SARDINA MONTERREY (*Sardinops caeruleus*) ON THE WEST
COAST OF BAJA CALIFORNIA BY CATCH DATA 1980-2013**

Concepción Enciso-Enciso¹, Casimiro Quiñonez-Velázquez² y Roberto Felix-Uraga²

¹Instituto Nacional de Pesca (CRIP-Ensenada), ²Instituto Politécnico Nacional (IPN-
CICIMAR)

Km 97.5 Carretera Tijuana-Ensenada, Parque Industrial Fondepport, El Sauzal de Rodríguez,
C.P. 22760, Ensenada, Baja California, México.

concepcion.enciso@inapesca.gob.mx

The objective of fisheries management is to maintain the biomass of fish stocks to levels that can produce the maximum sustainable yield (MSY). However, periodic assessments of the biomass of the populations are not currently common. In the present study we used the method of Martell & Froese (2013) to estimate the MSY of the sardina monterrey stock on the west coast of Baja California. Catch-data recorded for the period 1980-2013, and the value of resilience (r) were used for the species. With the results of the model performance, the catch at maximum sustainable yield (C_{MSY}) was 138,147 t and the 95% confidence interval between 102,338-186,486 t; the carrying capacity $K=1,043,483$ t ($515,515$ t < K < $2,112,172$ t); intrinsic population growth rate $r=0.530$ years⁻¹ (0.222 years⁻¹ < r < 1.260 years⁻¹) and biomass at MSY (B_{MSY})=521,742 t ($257,758$ t < B_{RMS} < $1,056,086$ t). Moreover, the response of the population to different scenarios of fishing pressure as management measures, through an exercise with three potential scenarios of biomass was evaluated: Keep biomass above MSY, lower MSY and at risk of collapse. In order to assess changes in population biomass at different levels of fishing.

Keywords: *Sardina monterrey*, west coast of Baja California, biomass, assessment.

**STOCKS DISCRIMINATION OF THREAD HERRING (*Opisthonema libertate*) IN THE
NORTHWESTERN REGION OF THE MEXICAN PACIFIC COAST**

Carlos I. Pérez-Quiñonez¹, Casimiro Quiñonez-Velázquez¹, Francisco J. Vergara-Solana¹,
Griselma Guadalupe Rubio-Castro¹, Marcelino Ruiz-Domínguez¹ & Jorge Saúl Ramírez-
Pérez²

¹IPN-CICIMAR, ²UAS-FACIMAR
nash14ivan@hotmail.com

The stocks identification of exploited fish populations is of great importance in the management of fisheries. This allows the recognition of groups in the population, its geographic boundaries and consequently the determination of the particular biological characteristics. The potential presence of a structured population by stocks should be considered a prerequisite in the fisheries analysis. In the present study, using geometric morphometric the differences in body shape of thread herring sardine *Opisthonema libertate* from three fishing areas in the northwestern coast of the Mexican Pacific were evaluated. The fish morphometric from three fishing areas is evaluated through 19 points (semi-land and landmarks) that define the contours of the body. One sample (n=100 sardines) was random selected from each fishing area (Mazatlán, Bahía Magdalena, and Guaymas). Each specimen was photographed (digital camera) on the left side as well as a size reference. The effect of size, position and orientation of the spatial configurations of digital images, were standardized across the Procrustes superimposition procedure. Significant differences between areas (AMOVA, $p < 0.05$) were detected, and canonical variates analysis (CVA) detected two significant VC (VC1 $\Lambda = 0.055$, $p < 0.001$; Λ CV2 = 0.82, $p < 0.01$), and spatial distribution of the scores indicates a clear separation of the three groups of fish. Furthermore, using the Mahalanobis distances each specimen was assigned to one of the fishing areas, the percentage of correct assignment to fish from Bahía Magdalena was 77%; Guaymas 54%; and Mazatlán 54%. Finally, the paired differences (between zones) using Procrustes distances were evaluated, in all cases the differences were significant (F-Goodall test, $p < 0.001$). The results suggest a population structured stocks based on the phenotypic expression of the body shape.

Keywords: Geometric morphometry, body shape, *Opisthonema libertate*.

TRINATIONAL SARDINE FORUM FORO TRINACIONAL DE LA SARDINA

IS 17°C AN OPTIMAL UPPER BOUND OF TEMPERATURE TO DELINEATE THE NORTHERN STOCK OF PACIFIC SARDINE (*Sardinops sagax*)? EVIDENCE FROM LABORATORY EXPERIMENTS AND FIELD SURVEYS

Emmanis Dorval

Ocean Associates Inc. under contract to Southwest Fisheries Center (SWFSC), 8901 La Jolla Shores Drive, La Jolla CA 92037; Phone: 858-546-7079

Emmanis.dorval@noaa.gov

The management of Pacific sardine assumes two distinct populations, the northern and southern stocks, off the North America Pacific coast. The northern stock may range from Punta Eugenia (Mexico) to southern Alaska, whereas the southern stock can migrate from Baja California up to point Conception (California). While these stocks overlap in space, they are hypothesized to be dynamically separated in time via their north-south seasonal migration and through their adaptation to different range of temperatures. Further, the northern stock is assessed (and landings are allocated among stocks) by assuming this population is restricted to oceanographic water of less than 17°C. Laboratory experiments conducted in the 1960s-1990s and the Daily Egg Production Method surveys have consistently shown that the temperature for spawning, egg and larval development in the northern stock were consistently below 15°C. However, there is less evidence that the maximum temperature at which juvenile and adult from the northern stock can optimally grow is below 17°C. Recent experiments conducted at the SWFSC aquarium suggested that both survival and growth rates were optimal at 17°C compared to 13°C and 21°C for juvenile sardine reared to adult stage. Mortality rates were highest in the 21°C treatment, whereas absolute growth rates were lower at 13°C and 21°C than at 17°C. Furthermore, a time series of temperature developed from otolith oxygen stable isotope ($\delta^{18}O$) demonstrated that young-of-the-year sardine collected in the southern California Bight during the 1994-2002 period resided in water between 13°C and 18°C. These results showed that 17°C may not be an optimal upper bound of temperature for delineating the northern stock, and thus may bias allocation of landings when using the temperature-at-catch proportion method in stock assessment.

TRINATIONAL SARDINE FORUM FORO TRINACIONAL DE LA SARDINA

THE SARDINE OUTBURST IN THE NORTH PART OF THE CALIFORNIA CURRENT IN MID-2010S: A RESULT OF RECENT HARVEST REGULATIONS OR NATURAL VARIATION OF THE POPULATION SIZE?

Rubén Rodríguez-Sánchez* and Héctor Villalobos-Ortiz

Instituto Politécnico Nacional-CICIMAR; La Paz, B.C.S., México

[*rrodrig@ipn.mx](mailto:rrodrig@ipn.mx)

A steep decline of sardine *Sardinops sagax* since 2006 in northern part of the California Current prompted regulators to approve sharp limits on commercial fishing. Based on scientific knowledge, it is widely accepted that changing ocean conditions, including cooler ocean water, are the main cause of decline, although commercial fishing also can affect the species' numbers. A similar situation occurred in the mid-1900s. Based on indices of current oceanographic conditions and distribution of sardine abundances, apparently, changes of biomass and distribution of sardine population is recurring now, perhaps with similar socioeconomic and ecological consequences. The near-term recovery of sardine in the northern part of the California Current system could be due the return of warmer oceanographic conditions, perhaps due the adoption of a precautionary strategy for managing the sardine population, or both. General scientific acceptance of causes of this recovery is unlikely in the short term, and will probably require considerable data collection and complex analysis. The latter considering that large-scale, long-term patterns are increasingly being used to better understand the role of ecological and climate processes for worldwide changes of biomass and distribution of fish populations. To approach the issue of scale and the interpretation of sardine patterns in time and space, we use here a mirror representation of year to year changes of biomass and distribution of sardine population, when sardine population was increasing and shifting its center of distribution northward, in the period 1980-1997, possibly due to changes in food supply and transport. These two environmental aspects in our study period along the California Current are represented by interannual changes in oceanographic fronts. In theory, the convergence between adjacent water masses improved biological production (i.e. food) in oceanographic fronts what affect sardine recruitment. Our results show that oceanographic fronts modify their frequency and geographical position as result of advection changes between the external, cold California Current moving southward and the internal, warm countercurrent California moving northward.

**HISTORIC ANALYSIS OF CATCH AND LENGTH FOR PACIFIC SARDINE (*Sardinops caeruleus*)
ON THE WEST COAST OF BAJA CALIFORNIA, PERIOD 1990-2013**

Concepción Enciso-Enciso* y Celia Eva Cotero-Altamirano

Instituto Nacional de Pesca (CRIP-Ensenada)

Km 97.5 Carretera Tijuana-Ensenada, Parque Industrial Fondepport, El Sauzal de Rodríguez,
C.P. 22760, Ensenada, Baja California, México

*concepcion.enciso@inapesca.gob.mx

The small pelagic fishery resources are of major importance in the Mexican Pacific Ocean in term of catch. For the period 1990-2013, this fishery in Baja California represented 52% of the total catch, with an average of 58.968 t per year, of which 81% were sardine, 15% mackerel and 4% anchovy. We compared the sardine catches between years, months and seasons, and in all cases we detected significant differences ($p < 0.05$). For the 2013 season a total of 43.992 t were reported, of which 95% were sardine, 4% anchovy and 1% mackerel. For such capture was applied a total effort of 690 fishing trips and operated 18 vessels, the estimated CPUE averaged 64 t / trip, it was presented a marked seasonality in catches, was found the highest from August to January with an average of 76 t / trip and the lowest from February to July, with an average of 39 t / trip. Also the sizes were compared between years, seasons and months analyzed. Significant differences were found in all cases ($p < 0.05$). For the 2013 fishing season in sardine standard length varied between 119 and 271 mm, with an average of 182.6 mm. Regarding the pattern length vs. total weight ratio, a positive allometric growth was found with $b = 3.1061$ ($3.1057 < b < 3.1065$) where 87.7% of the variation was explained by the potential model.

Keywords: Sardine pacific, west coast of Baja California, catch, length.



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SURVIVING AND THRIVING: TRENDS AND PATTERNS AMONG SARDINE AND ANCHOVY LARVAE AND THEIR ENVIRONMENTS IN THE SOUTHERN CALIFORNIA BIGHT, 1951-2011

Barbara Javor

Southwest Fisheries Science Center
La Jolla, CA USA

Pacific sardine and Northern anchovy share a range of pelagic habitats in the Southern California Bight (SCB). Quarterly CalCOFI data from bongo tows and water samples collected during 1951-2011, a period spanning the mid-century decline and subsequent population boom of sardine until recent years, revealed long-term trends and patterns of larval distributions of both species in the SCB. The CalCOFI data were analyzed to illustrate multi-decade profiles according to seasonal, geographical, and environmental criteria. The results were generally similar to recently published accounts on spawning habitats of sardine in the SCB that employed annual CUFES samples and satellite-derived temperatures and chlorophyll concentrations. The data indicated a change in sardine behavior starting in 1992-3 that possibly resulted from the adult spawning population in the SCB beginning annual summer migrations to the Pacific Northwest. In spring sample subsets consisting of “thriving” larvae (defined as >1000 larvae/10 m²), the optimal larval sardine habitat in the SCB was 12.40°-15.25°C and 0.15-1.00 µg/L chlorophyll, and the optimal larval anchovy habitat was 13.49°-17.12°C and 0.10-1.26 µg/L chlorophyll. This retrospective survey provides some insights that might explain preferred habitats and the recent decline in the Pacific sardine population in US waters.

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ACOUSTIC-TRAWL SURVEYS OF SARDINE DURING SPRING AND SUMMER 2014

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

¹Southwest Fisheries Science Center, ²University of California at Santa Cruz

The abundances, distributions, and demographics of Pacific sardine (*Sardinops sagax*) in the California Current Ecosystem have been surveyed using the acoustic-trawl method (ATM) during spring 2006, 2008, 2010, 2011, 2012, 2013, and 2014, and summers 2008, 2012, 2013 and 2014.

These surveys spanned the northern sub-population of sardine located off southern and central California during spring; and north of Point Conception, off the west coasts of the USA and Canada during summer. We present maps of sardine and other coastal pelagic fish distributions during the spring and summer 2014 surveys. We show time series of sardine biomass and density-weighted length distributions. The ATM estimates of sardine biomass decreased, approximately 84%, from between 0.9 to 3.1 million metric tons (MT) in spring 2006 to between 0.2 to 0.5 MT in summer 2013 (Zwolinski et al., in press, *Oceanography*). In spring and summer 2014, the ATM-survey observations show (1) no appreciable recruitment since 2009/10, and (2) the effects of mortality on the residual stock.

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EFFECT OF MESOSCALE EDDIES AND STREAMERS ON SARDINE SPAWNING HABITAT AND RECRUITMENT SUCCESS OFF SOUTHERN AND CENTRAL CALIFORNIA

Karen Nieto^{1,2}, Sam McClatchie¹, Edward D. Weber¹, and Cleridy E. Lennert-Cody³

¹National Oceanic and Atmospheric Administration, Southwest Fisheries Science Center, La Jolla, California, USA; ²European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra, Italy; ³Inter-American Tropical Tuna Commission, La Jolla, California, USA

We quantified the effect of mesoscale eddies and streamers on the spatial distribution of Pacific sardine spawning habitat using a merged altimetry data set and a statistical spawning habitat model. The distribution of eggs could be predicted using sea-surface temperature, chlorophyll concentration, and eddy kinetic energy (EKE) similarly to previous studies. Eddies alone did not have a significant additional or emergent effect on the probability of capturing eggs beyond these predictors. Rather, mesoscale features (eddies and streamers) entrained water with the appropriate conditions in terms of temperature, chlorophyll, and EKE. These dynamic features moved appropriate spawning habitat for sardine offshore to areas where appropriate habitat otherwise would not exist. Using centroids of predicted sardine habitat, we showed that sardine recruitment success was inversely correlated with distance from shore of predicted sardine habitat centroids. This indicates that offshore transport has a negative effect on sardine recruitment, despite expanding favorable spawning habitat further offshore.

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REGIME VS CLIMATE REGIME SARDINE/ANCHOVY IN THE CALIFORNIA CURRENT. HOW REAL IS THE SYNCHRONICITY OF THESE EVENTS?

Izquierdo-Peña V., Chavez F, Monique M, Hernandez-Rivas M & Aceves-Medina G.
vaneizqpe@gmail.com

Changes in the environment affect the abundance and distribution of fish at different time scales, as they modulate their rate of survival, growth, reproduction and migration. The effect of environment on low frequency time scales has been previously documented while at regime level there is a lack of knowledge. It has been hypothesized that the cold and warm phases of the regime are associated with fluctuations in the abundance of sardines and anchovies, and that these fluctuations are synchronous with eastern-edge continental currents (e.g., Humboldt and Japan Currents). This study analyzed data from larval abundance of sardine (*Sardinops sagax*) and anchovy (*Engraulis mordax*) in the California Current to test if: 1) regime changes can be detected in the fish early life-stages, and 2) if the regime signal and the effects on the abundance of fish larvae is similar in the north and south of the California Current. Commercial catch data for two areas of the California Current (USA and Mexico) from 1926 to 2013 were analyzed and compared with both catches of sardine in the Humboldt Current and anchovy in the Japan Current. Larvae data were obtained from the CalCOFI and IMECOCAL databases for the time periods from 1951-1984 and 1997-2002, respectively. Catch and abundance data of larvae were compared with the PDO and NPI indices applying the hypothesis of double integration. The results showed that fluctuations in abundance of fish larvae are indicative of a regime signal in the California Current. Regime changes had a differential effect in the north and south portions of the California Current. There was an apparent delay in the regime signal which was evident in the populations of sardine and anchovy when compared with Mexico. One of the most outstanding results is that sardine catches from the California Current do not vary synchronously with the catches from Japan as it had been established on the regime hypothesis.

Keywords: Climate change, climate indices, commercial catches, larval

REPRODUCTIVE BIOLOGY OF PACIFIC THREAD HERRING *Opisthonema libertate* FROM
SOUTH OF GULF OF CALIFORNIA DURING 2012-2013

¹*Cotero Altamirano C. E., H. Valles R., ²M.L. Jacob-Cervantes, ² V. Henández, ² R. Vallarta-Zárate, ²J. Payán Alejo, ²D. Becerra Arroyo y ²Jazmín A. Aguirre Sánchez

¹ CRIP Ensenada, B. C., Km 97.5 Carretera Tijuana-Ensenada, Parque Fondeport El Sauzal de Rodríguez, C.P. 22760, Ensenada, B. C. C.P.22760; ² CRIP Mazatlán, Sin.

*eva.cotero@inapesca.gob.mx

The small pelagic fishery represent an important food source, employees and economic benefits for the Countries which using these fishes as marine resource. In Mexico they are very important fishery resource in terms of size of fish catches in the South California Gulf. The fishery is constitute for three species of tread herring *Opisthonema libertate* (Günther, 1867), *O. bulleri* (Regan, 1904) y *O. medirastre* Berry y Barret, 1864. Sinaloa harvest 133,302 metric tons of Pacific thread herring *Opisthonema spp.* and had the second place of the small pelagic fishes in national catches in 2012. 81 samples were obtained (5619 organism) on board both the commercial fleet and cruise realized in the South of California Gulf during 2012-2013. The biological data was recorded for each fishes; species was discriminate through gill arc; the gonads were removed and preserved in 10% neutral buffered formalin; a piece of preserved gonad was removed and prepared in the lab with conventional histological techniques in to obtain histological slides; all slides were analyzes and classified emphasizing in the different oocytes class and the presence of postovulatory follicles and the characteristic in atretic stages using a compound microscope; with these peculiarities the individual were designates their maturity stage and observed the reproductive behavior of the tread herring. The 40% of organism analyzed were *Opisthonema libertate*. At this time we using only the result of this species. The average of the standard length was at 167 mm; the reproductive activity was observed a long the year and the pick spawning was in September. Fifty percent of the females reached sexual maturity by 162 mm standard length.

Key words: Thread herring *Opisthonema libertate*, reproduction, length at 50%, discrimination of *Opistonema*

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MULTI-MODEL APPROACH TO GROWTH DESCRIPTION OF THE THREAD HERRING (*Opisthonema libertate*) IN THE SOUTH PART OF THE GULF OF CALIFORNIA

Marcelino Ruiz Domínguez¹, Casimiro Quiñonez Velázquez¹, Saúl Ramírez Pérez², Carlos I. Pérez Quiñonez¹ y Griselda G. Rubio Castro¹

¹CICIMAR-IPN; ²FACIMAR-UAS
marcelinoruizdom@hotmail.com

Lack of information on the population parameters can generate under- or over-estimates in biomass changes. In the present study, the accuracy in age determination of three hard structures scales, *cleithra*, and otoliths was evaluated. With a multi-model approach the growth parameters for thread herring *Opisthonema libertate* were estimated. Biological samples were sampled from the landings of the sardine fleet in the port of Mazatlán, during 2011-2014. Because fishing is multi-specific, first the taxonomic identification was made, resulting 863 thread herring sardines *O. libertate*; and after recorded biometrics and extraction of hard structures. Changes in the size structure, length-weight relationship and Fulton's condition factor were analyzed. Otoliths proved to be the most appropriate structure for aging, and in order to make more evident the growth marks the otolith were burned for 10 minutes. Five growth models were fitted to age-length data: von Bertalanffy, Gompertz, logistic, Richards and Schnute. The best model was selected using the Akaike information criterion. No significant differences in size between the sexes were detected, growth was isometric and minimum values of the Fulton's condition factor were observed during June to October. According to the Akaike value the von Bertalanffy model best described the individual growth ($L_{\infty} = 20.3$, $k = 0.48$, $t_0 = -1.9$). However, in all cases Akaike differences were < 2 , and suggest that all five models are statistically robust to describe the growth of the species.

SPECIES DISCRIMINATION OF GENUS *Opisthonema* GILL, 1861 IN THE SOUTHEAST COAST OF THE GULF CALIFORNIA USING MORPHOMETRIC AND GENETIC ANALYSIS

Carlos I. Pérez-Quiñonez¹, Francisco Javier García Rodríguez¹, Casimiro Quiñonez-Velázquez¹, Francisco J. Vergara-Solana¹, Griselda Guadalupe Rubio-Castro¹, Jorge S. Ramírez-Pérez² & Marcelino Ruiz-Domínguez¹

¹Instituto Politécnico Nacional-CICIMAR, ²Universidad Autónoma de Sinaloa (FACIMAR)
nash14ivan@hotmail.com

In the southern Gulf of California, the fishing fleet catches thread herring (*Opisthonema libertate* (Günther, 1867); *O. bulleri* (Regan, 1904); *O. medirastre* (Berry & Barrett, 1963) and Pacific anchovy (*Cetengraulis mysticetus* (Günther, 1867)). Sardines are sympatric and morphologically similar so the captures are reported without discriminating species. The thread herring fishery resource has played an important economic role in the coasts of the southern Gulf of California, not only by the volume of capture but also for the significant amount of direct and indirect jobs. The aim of this thesis is to analyze the morphometric and genetic characteristics of the genus *Opisthonema* distributed in the southern part of the Gulf of California. A total of 1,598 organisms were sampled from sardine landings in Mazatlán, Sinaloa, during September 2011 to January 2014. Of which 1,254 were classified to taxonomically to species, based on: number and characteristics of ceratobranchial bone rakers of the first gill arch. The specified classification was: 13.3% of individuals as *O. bulleri*; 33.8% of *O. medirastre*; and 52.9% of *O. libertate*. For the geometric morphometric analysis 71 samples *per* species were randomly selected. A Canonical Analysis generated two significant variables, which suggest the presence of three groups. A Multiple Analysis of variance identified significant differences between groups ($p < 0.01$) and paired comparison using Procrustes distances showed significant differences in all cases ($p < 0.01$). The percentage of correct assignment using the squared Mahalanobis distances was: 79% for *O. libertate*, 83% for *O. bulleri* and 73% for *O. medirastre*. Molecular analyzes based on COI sequences from the mtDNA, supporting the existence of the three recognized species, since the levels of intra-specific divergence ranged between 0% and 0.5%, and inter-specific between 2.9% to 5.1%. The morphological and genetic results support the existence of three taxa for the southern Gulf of California.

Keywords: *Opisthonema*, mtDNA, COI, geometric morphometry, taxonomy, species discrimination, barcode, intra and inter-specific divergence.



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