SOUTHWEST FISHERIES SCIENCE CENTER

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

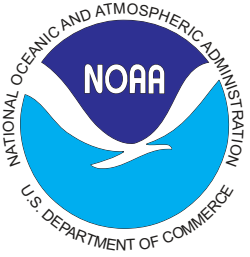
NOVEMBER 2012

PROCEEDINGS OF THE 2011 TRINATIONAL SARDINE FORUM
La Jolla, California, United States of America
December 8-9, 2011

by

Nancy C.H. Lo & Stephanie R. Schott

ADMINISTRATIVE REPORT LJ-12-06



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National Oceanic & Atmospheric Administration
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ADMINISTRATIVE REPORT LJ-12-06

2011 Trinational Sardine Forum participants at the Scripps Institution of Oceanography, 8622 Kennel Way, La Jolla, CA 92037, United States of America

http://swfsc.noaa.gov/tsf.aspx

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INTRODUCTION

On December 8th and 9th, 2011, the Southwest Fisheries Science Center (SWFSC) held the 12th annual Trinational Sardine Forum (TSF) at Sumner Auditorium in the Scripps Institution of Oceanography (SIO), UCSD, La Jolla, CA. Close to seventy participants attended from Australia, Canada, Mexico, and the United States and represented government agencies, academic institutions and industry (Appendix I). Special thanks go to both the logistics and the program committee members (Appendix II). We also thank Mr. Vince Torre, President of the California Wetfish Producers Association, for sponsoring the TSF dinner banquet.

Dr. Francisco (Cisco) Werner, the director of Southwest Fisheries Science Center (SWFSC), delivered the opening remarks. Since its origin in 2000, the Trinational Sardine Forum (TSF) has acted as a means to create better bonds and opportunities in the pursuit of greater research across national lines. Some of the same issues identified in 2000 are still applicable today, including the need for improving knowledge of age structure and reproduction, identifying movement patterns, and conducting coast-wide surveys to fill in the large gap of knowledge still present today. By 2005, John Hunter had noted that during the previous five years, significant progress had been made in the knowledge of sardines; however, still more was to be learned (Lo et al. 2005). This holds true today as our research scientists and students continue striving for a better understanding of this species.

The progress made over the last eleven years is highly indebted to the Forum. The TSF structure is based on a collection of informal meetings that provide a platform for sharing research results and conversation regarding varying degrees of problematic issues. The level of informality created by the TSF encourages all three sectors to openly discuss difficult issues and make headway in an otherwise challenging environment. The open atmosphere also engages an exchange of methodology and information, creating a larger basis of knowledge among the three countries. Beginning in April 2006, Canada, Mexico and the United States performed their first coast-wide survey. Unlike earlier years, when each country was forced to work within its own regional data, the coast-wide surveys have since provided a wealth of new data and greater comprehensive coverage. The TSF takes a large portion of this credit and creates the bonds necessary to continue this opportunity.

Two sessions followed the opening remarks: the "Regional Sardine Fisheries Reports" and "Research Plans and Reports." Representatives from Canada, Mexico, California, Oregon and Washington presented current data, aging methods and industry information. The "Research Plans and Reports" session followed. Presented papers covered a range of topics, including documenting patterns in the regional fisheries and understanding the reproductive capability, migratory patterns, stock structure, age assessment, and the impact of oceanographic and economic conditions on Pacific sardine populations (Appendix III). For posters, please see Appendix IV.

The second day included a Special Session regarding National Management Strategies of Sardine Population, presented by Dr. Kevin Hill *(SWFSC)* , Mr. Jordan Mah (*DFO)* and Mr. Martin Hernandez-Rivas Centro, Interdisciplinario de Ciencias Marinas-Insitio Politecnico National (*CICIMAR-IPN*), as Manue Nevarez, Comisión Nacional de Acuacultura y Pesca (INAPESCA) was unable to attend the meeting. The Forum then led to a highlight of this year's Focus Issue, the 2012 Coast-wide Survey, presented by Dr. David Demer (*SWFSC),* Dr. Jake Schweigert, Department of Fisheries and Oceans (*DFO),* and Dr. Tim Baumgartner, Centro de Investigación Científica y de Educación Superior de Ensenada *(CICESE).* Afterwards, Forum participants attended breakout sessions of the three Working Groups. The groups were held to facilitate conversation and ideas regarding three current issues, including Regional Biomass, Stock Structure, and Industry Trends and Issues. Afterwards, a Plenary Session was held to report the results of the Working Group discussions. A one- day Otolith workshop was held on December 10 at Torrey Pines Court, SWFSC (Appendix V) after two-day TSF.

PLENARY SESSION HIGHLIGHTS

Regional Sardine Fisheries Reports

Canada

British Columbia - Jordon Mah (DFO)

Most Pacific sardines (*Sardinops sagax*) found off the west coast of the United States and Canada occur in waters off California during peak winter and spring spawning periods. Large aggregations of sardines migrate from key spawning habitats to more northern waters prior to and during the summer and fall months to forage. This is when they can be found in British Columbia waters before returning south in the winter.

The Canadian Pacific sardine fishery is an opportunistic fishery that depends on the migration of sardines into Canadian waters. The 2011 fishery ran from June 1, 2011 to February 9, 2012, although the sardine harvest usually ends by the beginning of November each year. The first landing of the 2011 season occurred in early July, 2011.

The Department of Fisheries and Oceans Canada (DFO) established the Total Allowable Catch (TAC) for commercial harvest of Pacific sardine in British Columbia based on 2010 biomass estimates of the Northeast Pacific population from a U.S.- led stock assessment (537, 173 metric tons (tons) and an estimated migration rate of sardines into Canadian waters (27.2%), upon which a Pacific Region Pacific sardine harvest rate is established. A 15% harvest rate has been applied to the Canadian harvest control rule since 2002, the equivalent of what has been applied to the U.S. harvest control rules.

For the 2011 season, the TAC was set at 21,917 tons. The TAC was equally divided amongst 50 licenses over two license categories, commercial and communal commercial, with each license receiving an equal quota of 438.3 tons. All 50 available licenses were issued for the season.

Since 2007, harvesters have been permitted to designate multiple licenses to a single vessel which allows for increased in-season flexibility for harvesters and has helped to increase the amount of catch landed since it was implemented. For example, 8% of the TAC was harvested in 2007 compared to 96% in 2010. Table 1 shows the catch history from 2002 to 2011.

Thirteen active vessels participated in the fleet in 2011, with the majority of the catch occurring on the west coast of Vancouver Island. In total, 20,719 tons of Pacific sardines were harvested up to November 21, 2011. In addition to sardines, fishers are also permitted to harvest 10 tons of chub and jack mackerel, which must also be recorded in logbooks and validated dockside. The purpose of the mackerel allowance is not to create a directed fishery, but rather to

decrease wastage of mackerel that is normally encountered when fishing for Pacific sardines. All other bycatch must be released.

All catch (target and bycatch) in the fishery is monitored through a third party service provider funded by the industry. The monitoring program has several requirements, including hailing in and out of the fishery, submission of logbooks with catch and effort information, 100% dockside validation of catch, and at-sea observers. At-sea observer coverage varies depending on the fishing location and date. Complete observer coverage is required in areas of concern for wild Chinook populations, while only 25% observer coverage is required for all other areas.

DFO has established priorities for the management of Canadian fisheries. The Department is working to ensure the monitoring program meets Canada's catch monitoring standards while being cost effective for harvesters, improving cooperation and compliance with conditions of license, and developing shared stewardship arrangements for cost sharing of science and management activities. DFO continues to work with industry to reduce levels of incidental catch through an improved monitoring program and by utilizing selective fishing practices.

Table 1. Annual summary of catch and effort in Canadian waters from 2002 to 2011 with individual vessel quota (IVQ), total allowable catch (TAC), and actual catch.

YEAR	**IVQ (mt)**	**% of TAC**	**CATCH (mt)**	**TAC (mt)**
2002	180	16%	822	5,000
2003	180	11%	1,006	9,000
2004	300	28%	4,259	15,000
2005	304	21%	3,266	15,200
2006	270	12%	1,558	13,500
2007	396	8%	1,507	19,800
2008	250	84%	10,435	12,491
2009	364	84%	15,334	18,196
2010	463	96%	22,223	23,166
*2011**	*438*	*95%*	*20,719*	*21,917*

*Data is preliminary to November 21, 2011

Canada's current price per pound is at 9 cents as compared to California's 8 cents. License quotas have doubled since the opening of the commercial fishery due to improved abundance and harvest guideline estimates; however, it appears as though the fleet's annual catch remains fairly stable over the past few years. Since the fishery has become permanent, fishermen still can use the trap nets which were used when the fishery first opened. Currently all fishermen use purse seine nets. Canada's industry supports ecosystem research by funding management and the science sectors. The industry also provides funds for other research and these funds are sometimes matched by a donor in California.

The DFO also practices shared harvests as a way to create less waste and lower incidence of mortality. If a vessel has a permit for a certain amount but only needs a percentage of that amount, the DFO allows other vessels to come side by side to the vessel and harvest the rest.

México

Bahía Magdalena – R. Félix-Uraga, F. N. Melo-Barrera, C. Quiñónez-Velázquez, E. Álvarez-Transviña, and R. García-Morales (CICIMAR – IPN, La Paz)

The commercial catches of small pelagic fishes, catches of sardines and fishing trips from 2000-2011 (January to September), indicated that catches of Pacific sardines, *Sardinops sagax* constituted the major portion of small pelagic fishes. The average yearly catch of Pacific sardine in 2000-2011 was 45,000 mt with catch in 2010 a little over 20,000 mt and in 2011 around 50,000 mt. Since 2007 the total catches of small pelagics, including Pacific sardines, have been decreasing significantly, in particular in 2010 with a large increase in 2011. The decrease of fishing trips was partially due to the availability of the resource.

2010

The monthly catch of sardines in Magdalena Bay in 2010 indicated higher catches during July-November, uncharacteristic of the typical monthly catch in this area. One reason for this abnormality was due to the hurricane Ximena in Bahía Magdalena between September 2nd and 9th 2009. Ximena nearly decimated sardine catch in November and December in 2009 and caused long-lasting damage to the surrounding area's infrastructure, plants, piers, etc. Nevertheless, the commercial catch of Pacific sardines reappeared as early as July 2010. The species composition of small pelagic fishes in Magdalena Bay in 2010 indicated that Pacific sardines constituted 56.7% , *Opisthonema* (thread herring) 22.7%, and *Etrumeus teres* (round herring) 16.7% of the total landing.

The length composition of Pacific sardines in 2010 ranged from 105 to 185 mm standard length with only 22.4% of the fish with length greater than 150 mm, Mexico's minimum legal length. Five age groups were found in the catches of Pacific sardines in Magdalena Bay in 2010, but age groups 0, 1 and 2, constituted around 90% of the landings.

Due to the shortage of Pacific sardines in the first half of 2010, it was not possible to establish the complete maturity cycle for this year, although with the information obtained in the 2nd semester, we consider that it coincides with the historical results for this fishing area.

2011

The monthly catch of sardines in Magdalena Bay during 2011 showed a more or less typical pattern in this fishing area, with higher landings from April to July. The species composition in the commercial catch in Magdalena Bay from January to August, 2011 consisted of 88.5% Pacific sardine and 7.3% thread herring. Other species like *E. teres* (round herring), *S. japonicus* (Pacific mackerel), and *C. mysticetus* (Pacific anchoveta) were minimal. The length composition of Pacific sardine in 2011 ranged from 135 to 205 mm standard length with peak between 170 to 185 mm SL (71% of the total catch). Furthermore, the vast majority of sardines measured over 150 mm, roughly 99.5%, largely contrasting 2010's meager 22.4%. Among the five age groups in Pacific sardine catch, age group 2 was the predominant age group, followed by the age group 1. The 0 age group was minimal, also different from 2010.

Pacific sardine reproduction in Magdalena Bay for 2011 occurred in January – August. This remains constant with the typical reproduction pattern for this fishing area, as estimated during the period between 1981 and 2010.

A possible explanation for this conflicting age composition between 2010 and 2011 might be linked to movement of the fish. It is very likely that the bigger and older sardines came from the North rather than the typical lots from the Gulf of California which historically contained the dominant ages 1 and 2. In 2010, the majority of the fish were smaller than 150 mm, many of which were mature individuals. The presence of these smaller mature sardines creates the likelihood that there were two stocks. To confirm this theory, the otoliths of the mature fish from both years need to be cross-checked.

Ensenada –report not received

Gulf of California – Manuel O. Nevárez Martínez, Ma. Ángeles Martínez Zavala, J. Pablo Santos Molinar and Angel R. Godinez Cota (CRIP)

The small pelagic fish of the Gulf of California sustain the most important massive fishery in Mexico. The catch is sustained for several species of sardines, anchovies and mackerel, although the Pacific sardine (*Sardinops sagax*) historically has been the targeted species. Here the catches are presented for the fishing season 2009-2010. There was a total catch of 360,952 t, of which 71.0% was Pacific sardines, 23.6% was "Crinuda" sardine (*Opisthonema* spp.), 2.3% was "Bocona" (an anchovy, *Cetengraulis mysticetus*), 0.1% was northern anchovies (*Engraulis mordax*), 1.0% was mackerel (*Scomber japonicus*), 1.5% was round herring (*Etrumeus teres*), and a 0.1% was "Piña" sardines (*Oligoplites* spp.). The catch per month ranged

from 9.476 to 62.340 t, although more than 20,000 t were recorded for most months, and the highest value was recorded in May. There were 2,769 fishing trips, with a nominal CPUE of 149.1 t per trip. Because of an "El Niño" event, the sea surface temperature were high, with positive anomalies in the months of October to March. On the other hand, the pattern of winds was not normal; the winds blew with a southern component, which does not promote upwelling along the Sonora coast. Those environmental features could explain (at least partly) the behavior of Pacific sardine catches during 2009-2010 and the significant increment of the landings of "crinuda" sardines.

United States

California – Kirk Lynn, Mandy Lewis, and Dianna Porzio (CDFG)

Since a recent peak in 2007 (80,980 metric tons), sardine landings in California have shown a downward trend, with 2011 landings at 27,688 metric tons from 895 landings, the lowest levels since 1994. This trend coincides with a reduction in the coast-wide harvest guideline from 152,654 metric tons in 2007 to 50,526 metric tons in 2011. The average price per pound (8 cents/lb.), however, reached its highest level since 1989. This was mainly due to the price for Monterey fish doubling to 12 cents/lb. during the 3rd allocation period, reflecting an increase in quality. Total state ex-vessel revenues reached $5.4 million in 2011, an increase from $4.3 million last year, but down from $5.5 million in 2009. For the year, sardines ranked 2nd in tonnage landed (27,704 mt), and 6th in value ($5.4 million) of all California fisheries for the year. Compared to 2010, the volume of the fishery (33,658 mt) decreased and the value ($4.3 million) increased, when sardine also ranked 2nd and 6th, respectively, in those categories. Drum seiners have become more prevalent in recent years, used for 28% of the 2011 catch; this gear was responsible for only 13% of the sardine catch in 2000.

The most recently available age data from 2010 sampled fish shows a pattern of younger fish in both the Southern (San Pedro) and Central California (Monterey) areas compared to the three previous years. The age data from years 2007-2009 had shown a preponderance of 1-yr-olds from San Pedro, and 2-yr-olds in Monterey. This has changed to about equal numbers of 0 and 1-yr-old fish in both areas for 2010. There has been a steady decline in total number of samples per year as a result of more harvest constraints and fewer fishing days each year since 2007.

Sardine lengths from 2011 show a much larger average difference by area, with San Pedro sardines averaging 155 mm and those from Monterey 186 mm. These lengths increased from 2010 mean lengths of 147 mm and 151 mm for San Pedro and Monterey, respectively. In addition, the Monterey samples had a bimodal distribution of lengths, indicating two age classes. The majority of the larger sardines from Monterey were sampled in January. Occasionally groups of larger sardines are sampled in Monterey as they migrate north.

The California sardine fishery in 2011 resembled that in 2009, with a relatively short first allocation period, followed by even briefer second and third periods. The 2011 HG had been reduced from 72,039 metric tons in 2010 to 50,526 metric tons, causing an increase in effort and an early closure to the first period. The second and third allocation periods were closed 12 and 7 days after opening, respectively. During these months sardines are fished by all three states, although the availability of market squid decreased the California sardine effort. For the third straight year squid accounted for more landed tonnage than sardine during September for the California fleet, a change from prior years.

The first allocation period ended March 4, the second July 12, and the third September 21. The fishery was open for a total of 83 days, or 23% of the year. The average number of landings per day increased in all three periods compared to 2010.

Oregon– Gregory Krutzikowsky and Jill Smith (ODFW), presented by Dale Sweetnam (SWFSC)

The Pacific sardine fishery in Oregon operates as a day fishery with vessels based primarily in Astoria where processing plants for sardines operate. Many vessels utilize aircraft to assist in locating schools of sardines and setting their nets when weather permits. Weather and tides are major factors in fishing operations and timing of vessels transiting in and out of the Columbia River. Sixteen of the twenty-five state-limited entry permit vessels participated in the 2011 sardine fishery. Oregon landings totaled 8,291 mt or 21% of the federal 42,488 mt actual directed harvest allocation. The mean weight of the 144 landings was 57.6 mt. Only the first year when the renewed Oregon sardine fishery was ramping up in 1999 after its more than 50 year hiatus had lower total landings. The ex-vessel value of sardines totaled approximately $2.4 million. Sardines were only landed in the second and third allocation periods. As in the previous three years, all three allocation periods were closed early because the allocation was reached. Early closures have occurred since 2008 resulting in a change in the peak month of harvest from August to July, and harvest later than September has been eliminated. Incidental catch landed in the sardine fishery consisted of 4.7 mt of Pacific mackerel with other species caught in past years absent. Based on logbook records, bycatch of salmonids remained low in 2011 at a rate of 0.0087 salmon/mt, the same as in 2010. Of the 72 salmon caught, 49% were released live. Sardines sampled in 2011ranged from 145 to 237 mm standard length and from 45.4 to 231.5 g in weight. Mean length was 208.1 mm and mean weight was 151.3 g in 2011. The average age of fish sampled from the fishery has increased from 2.3 years in 2005 to 5.2 years in 2010, with the 2011 catch samples yet to be aged. The 851 sardines sampled in 2011 had a male to female sex ratio of 0.77:1.

Washington[1] – presented by Dale Sweetnam (SWFSC)

From 2000 to 2009, Washington's Emerging Commercial Fishery Act (ECFA) controlled the licensing procedures for the harvest of Washington's Pacific sardines. During this period, the sale or transfer of an emerging commercial fishery license was prohibited. In 2009, this legislation was changed to allow for 16 permanent licenses and the issuance of temporary annual permits under the surveillance of the WDFW Director. Combined, the permanent and temporary annual licenses must not exceed 25 total; however, permanent sardine licenses can now be sold or transferred.

Washington's annual coast-wide harvest guideline is managed in periodic increments. This generally yields to January 1: 35%; July 1: 40% and September 15: 25%. However as a result of smaller harvest guidelines in the past few years, the January increment has been pushed back until April 1. Therefore, the Washington sardine fishery now opens annually on April 1.

126 total landings for Washington in 2011 brought in 7,918 metric tons, an average of 63 metric tons per landing. There has been a steady increase in the landing size and a simultaneous decrease in the number of landings. Since 2008, the fishery has experienced closures between the periodic harvests due to the currently reduced harvest guidelines. The most favorable weather and ocean conditions occur from May through October. Landings could be influenced by a number of factors, including season length, weather and ocean conditions, processing capacity, sardine abundance, and skipper experience. While processing capability limits the number and size of harvests, these facility capabilities have significantly increased since the earlier years of the fishery.

[1] Washington Dept. of Fish and Wildlife. (2011). Summary of the Washington Purse Seine Fishery for Pacific Sardine *(Sardinops sagax)*. 11 pp.

FOCUS ISSUE: 2012 Coast-wide survey

Moderator: Russ Vetter (SWFSC)

Dr. Vetter began the 2012 Coast-wide Survey discussion by acknowledging the industry's recent sardine research attempts, including two survey workshops initiated by the industry in June 1-3, 2010 and May 23-24, 2011. Based on data dating back to the 1930s, the most efficient way of conducting sea surveys for Pacific sardines is during the peak spawning season in the spawning area, which is off California in April. Currently, in addition to the DEPM spawning biomass estimates in April, SWFSC also includes biomass estimates from acoustic trawl surveys and the biomass estimates from aerial surveys off the Northwest in the summer. SWFSC conducted coast-wide surveys in April of 2006 and in April and July of 2008. SWFSC plans to conduct April and July coast-wide surveys in 2012 as mentioned in the 2011 survey workshop. For the 2012 Sardine Survey, SWFSC hopes to have Canadian, U.S. (R/V *Shimada*) and Mexican ships overlap with U.S. research vessels to collect data side by side to compare the gear efficiency for future calibration. In Mexico, a few CalCOFI lines close to the U.S. and Mexican border will be occupied by both U.S. and Mexican vessels.

Note: In April, 2012, SWFSC and NWSFC had jointly decided to conduct a sardine-hake acoustic-trawl survey in late June through late August, 2012 to replace the summer survey in Canadian waters aboard R/V *Shimada*. This survey will cover the area from the north end of Vancouver to Morro Bay, while the area south of Morro Bay to the U.S.-Mexico border will be surveyed aboard *Ocean Starr* to conduct the July CalCOFI survey followed by the August ichthyoplankton-acoustic-trawl survey. This will be in conjunction with the routine IMECOCAL survey from the U.S.-Mexico border down to Punta Eugenia.

Canada - Jake Schweigert (DFO)

Jake Schweigert began by discussing the two windows of opportunity for this survey: spring in San Diego and summer in feeding grounds off Canada, Washington and Oregon. The Canadian survey is normally conducted aboard the R/V *Ricker* in late July and early August, when the abundance of Pacific sardine has reached its peak in mid-summer. Sardine, most in the upper 30-m water depth, are randomly distributed throughout the region. Canadian researchers assume that their trawl net has 100% catchability, which needs to be tested and verified. Since 2006, the survey has been conducted at night using a mid-water rope trawl (<30 m depth). Historical data from research surveys indicated that 86% of positive catches were within core region boundaries and a small portion were from farther offshore or in the inlets.

The design for the Canadian survey consists of a random design with a square area representing the sampling unit of 161 potential stations. The average of vessel days is 10-12 days, and the survey aims at occupying 70-75 stations, roughly 44% of the total stations.

Canadian researchers also tried to extend their survey design down to Washington and Oregon areas to cover up to 40 km offshore. The total number of potential stations would be 130 off Washington and 230 off Oregon, a total of 360 stations. With 40% sampling rate, Canada would occupy 52 stations and 92 stations off Washington and Oregon, respectively. The data from 2003-2005 NW surveys off Washington and Oregon indicated that most sardine were distributed within 50 km (30 nm) offshore. A question was raised regarding whether the random survey design will be applied to Oregon water. Most likely, the design can be revised based on future data.

U.S.A. - David Demer (SWFSC)

Dave Demer emphasized the importance of the survey to encompass the entire stock and to allocate the effort to the high(est) density, in particular for method comparison. Using similar survey equipment (e.g. acoustic and trawls) and overlapping sampling effort of any two countries (e.g. U.S. and Canada; U.S. and Mexico) as much as possible may achieve the two main objectives: covering main stock and interweaving effort in areas with highest sardine densities.

Some evidence shows that the stock may be further north; therefore, it might best benefit the survey for the U.S. R/V *Shimada* to begin as far north as possible and head southward. Hopefully while the R/V *Shimada* surveys the northern portion, another vessel, such as the *Ocean Starr*, could either sail initially side by side with *Ricker* in Canada and then continue south or start where the R/V *Ricker* stops.

By having such an extended area and overlap, this survey will provide data needed to obtain a precise estimate even if no side by side ship arrangement is possible to allow the comparison of sampling methods. It was also suggested that the coast-wide survey should not emphasize a single species but that data of other species should also be collected.

Mexico - Tim Baumgartner (CICESE)

During the survey workshop held in May 23-24, 2011, La Jolla, CA, it was recommended that three CalCOFI lines (97,100 and 103) be occupied by U.S. and Mexican research vessels, such as the U.S. *Shimada*. If so, a permit would be required for R/V *Shimada* to go into Mexico water. Russ Vetter indicated it is unlikely that there will be an overlap of vessels between U.S. and Mexico and between U.S. and Canada for this reason.

Regarding IMECOCAL survey, Tim Baumgartner indicated that the Mexican government had approved the permit for offshore trawling for sardines by a 40-meter North sea trawler in 2008. However, the financial arrangements fell through because of an international credit crisis. Tim reapplied for the permit in February, 2011, and it is likely that the permit will be approved.

If this proposal is approved, a research team needs to be formed to include CICIMAR, CICESE and others. Several factors need to be discussed, especially how to coordinate the acoustics and trawling operations. Currently, INAPESCA is responsible for acoustics with EK60, led by Manuel Nevárez. The survey will also call for a Nordic high speed trawl net. Russ Vetter suggested meeting with Cisco Werner, the SWFSC director, regarding an update to INAPESCA and indicated that the long term goal would be for Mexico to have more regular scientific surveys. There will soon be a regular program of biomass survey in the Gulf and Mexico plans to begin an effort for some regular acoustic trawl and biomass investigation.

This collaboration only has until April to prepare. However, if Mexico denies the permit and the U.S. only has ship, researchers may need to turn to the fishing industry for financing. Roberto Félix-Uraga indicated that Mexico's academia sector does not have ships, but is willing to collaborate with a fishing company. The industry has already invited CICIMAR to participate.

Roger Hewitt remarked that it seems as though CICES and CICIMAR have the tools and INAPESCA has the management authority. Unfortunately there were no representatives of INAPESCA present at the TSF, an issue Roger pointed out. While this survey has the funding available for INAPESCA to build a 55-meter research vessel and an inactive fishing vessel in Ensenada, actions have been stunted in the wait for the permit to be authorized. Upon its approval, the vessel should be running by April. At the time of the meeting, it was not certain if INAPESCA had given approval, even though Manuel Nevarez indicated that it was approved.

As for the acoustic system EK60,Tim Baumgartner has a project through INAPESCA. Many had hoped that the TSF would provide the time necessary for CICES and CICMAR to come to some agreement.

The aerial survey will be conducted by the Northwest LLC (Limited Liability Company). This survey will be similar to 2011's, with closer transects and fewer replicates, and with the possibility to overlap with the ship. Fishing season dates may hinder taking the point sets. The Northwest does not plan on using LIDAR (Light Detection And Ranging). The Southern California fishing industry is working to get a grant for LIDAR and camera systems.

WORKING GROUP REPORTS

Working Group 1: Regional Biomass, Nancy Lo (SWFSC)

Report for working group 1- regional estimates of biomass of 2011 and recommendations

Partial list of members: Tim Baumgartner, Martin E. Hernandez-Rivas, Sandy McFarlane, Jake Schwartz, Linnea Flostrand, Vanessa Hodes, Robert Emmett, Andrew Claiborne, Yanira Green-Ruiz, Darrell Kapp, Nancy C. H. Lo, Beverly Macewicz, Rick Brodeur , Manuel Nevárez, Enrique Morales, Kevin Hill, and Marisa Litz.

Activities:

1. Coast-wide survey, CalCOFI, and IMECOCAL April cruises, 2011

Objectives: To estimate spawning biomass of Pacific sardines from Baja California, Mexico to Vancouver Island, British Columbia, Canada.

1.1. California DEPM and CalCOFI, March-April cruises, 2011

The spring 2011 California Current Ecosystem (CCE) survey was conducted aboard one NOAA research vessel and a chartered fishing vessel. The NOAA ship *Bell M. Shimada* (March 23-April 27) covered the area off the west coast of the U.S. from Cape Flattery, Washington to San Diego, California, with most of the stations off California located within the area from San Francisco to San Diego (CalCOFI lines 63.3 to 93.3 from March 27 to April 25). The F/V *Frosti* (March 26-April 28) covered the area from San Francisco to San Diego, California (CalCOFI lines 61.7 to 95, data collected April 1-26). Within the CCE survey the *Shimada* occupied the primary CalCOFI lines, 76.7 to 93.3, from April 10 to 25 for the spring CalCOFI cruise. During the CCE and the CalCOFI surveys, CalVET tows, Bongo tows, CUFES and trawls were conducted aboard both vessels. Data from both CCE and CalCOFI surveys were included in the estimation of spawning biomass of Pacific sardines (Lo et al. 2011).

In addition to sardine eggs and yolk-sac larvae collected with the CalVET net, yolk-sac larvae collected with the Bongo net have been included to model the sardine embryonic mortality curve since 2000. Beginning in 2001 (Lo et al. 2001), CUFES data from the ichthyoplankton surveys have been used only to map the spatial distribution of the sardine spawning population with the survey area post-stratified into high-density (Region 1) and low-density (Region 2) areas according to the sardine egg density from CUFES collections. Staged eggs from CalVET tows and yolk-sac larvae from CalVET and Bongo tows in the high-density area have been used

to model embryonic mortality in the high-density area and the daily egg production, P_0, for the whole survey area.

For adult samples, the survey plan was to use the *Shimada* and the *Frosti* to conduct 3 – 5 trawls a night either near regular CalCOFI stations or at random sites on the survey line regardless of the presence of sardine eggs in CUFES collections. At night a Nordic 264 rope trawl with 3.0 m^2 foam core doors was towed for 30 minutes at the surface (0 – 11 meters). The trawl was modified for surface trawling with Polyform floats attached to the head rope and trawl wings. The trawl was modified with a marine mammal extruder device placed midsection just forward of the cod-end. In addition, on the *Frosti*, the first trawl of the night (about a half hour after sunset) was towed without the Polyform floats to depths of 15 to 20 meters to potentially catch fish that might still be moving up toward the surface from daytime depths, since dark had not fully descended. For the whole CCE survey, trawling occurred from March 23 to April 25, 2011, and 37 of the 105 trawls conducted at night were positive for Pacific sardines. A single trawl off Astoria, Oregon collected 2 immature sardines. The other 36 trawls with sardines were located in the south below latitude 37.4°N (Figure 1).

Since 2009, in addition to the estimates of spawning biomass based on the past procedure where P_0 was weighted by the size (km^2) of each region and the adult parameters were estimated from all trawl samples in the entire survey area, an alternative estimator based on stratified sampling for each parameter was included (Hill et al. 2009) for years when adequate adult samples were available (1986, 1987, 1994, 2004, 2005, 2007 – present). As such, the original time series of spawning biomass may not be comparable due to slightly different estimation procedures and the refined survey designs over time. This alternative method was also used to estimate the female spawning biomass that is now used as a data time series for stock assessment computations. Here, we report the time series of spawning biomass, female spawning biomass, and total egg production based on both the traditional method and the stratified estimation procedure.

The spawning biomass of Pacific sardines (*Sardinops sagax*) in April 2011 was estimated using the daily egg production method (DEPM) calculated by two methods: 1) the traditional method where the egg production (P_0) was a weighted mean while each adult parameter was an unstratified estimate, and 2) a stratified procedure where the estimate of total spawning biomass is the sum of the estimated spawning biomass in each of two regions representing high and low spawning activity. The two estimates of the spawning biomass were 383,286 mt (CV = 0.32) and 373,348 mt (CV = 0.28), respectively, for the standard DEPM survey area of 314,480.69 km^2 off the west coast of North America from San Diego, California to north of San Francisco, California (CalCOFI line 60.0-95.0). The daily egg production estimate (P_0, a weighted average with area as the weight) was 1.16/.05m^2 (CV = 0.26). In the standard DEPM area, the estimates of female spawning biomass calculated by the two methods were 225,155 mt (CV = 0.32) and 219,386 mt (CV = 0.28), respectively. A small region close to Astoria, Oregon (47.1° - 45.9°N) was sampled for sardines. No eggs and only 2 immature sardines were collected in this area.

Hence, coast-wide estimates of sardine spawning biomass and female spawning biomass were not calculated.

The estimated daily specific fecundity was 19.04 (number of eggs/population weight (g)/day) using the following estimates of reproductive parameters from 244 mature female Pacific sardines collected from 30 positive trawls: *F*, mean batch fecundity, 38,369 eggs/batch (CV = 0.07); *S*, fraction spawning per day, 0.1078 females spawning per day (CV = 0.18); W_f, mean female fish weight, 127.6 g (CV = 0.05); and *R*, sex ratio of females by weight, 0.587 (CV = 0.06). Since 2005, trawling has been conducted randomly or at CalCOFI stations, which resulted in sampling adult sardines in both high (Region 1) and low (Region 2) sardine egg-density areas. During the 2011 survey, the number of tows positive for mature female sardines was similar in Regions 1 and 2 (14 and 16 respectively), while four tows in Region 2 contained solely immature sardines.

The estimates of spawning biomass of Pacific sardines off California in 1994 – 2011 based on the traditional method are: 127,000 mt, 80,000 mt, 83,000 mt, 410,000 mt, 314,000 mt, 282,000 mt, 1.06 million mt, 791,000 mt, 206,000 mt, 485,000 mt, 300,000 mt, 600,000 mt, 837,000 mt, 392,000 mt, 117,000 mt, 185,000, 108,000mt and 383,000 mt (for the standard DEPM area), respectively. These estimates of spawning biomass indicate that there has been considerable fluctuation during this time (the peaks occurred in 2000 and 2006) and that biomass declined in 2008-2010 and increased in 2011. The time series of spawning biomass was one of the fishery-independent inputs to the annual stock assessment of Pacific sardines from 1985 – 2008. Since 2009, the time series of spawning biomass was replaced by female spawning biomass for years when sufficient trawl samples were available and the total egg production for other years as inputs to the stock assessment of Pacific sardines.

Acoustic data for Pacific sardines have been conducted since early 1990s. The time series of biomass of Pacific sardines from 2006, 2008, 2010 and 2011 from acoustic data have been reported (Zwolinski et al. 2012, Hill et al. 2011) (Figure 2 and 3)

1.2 IMECOCAL in 2011: no reports

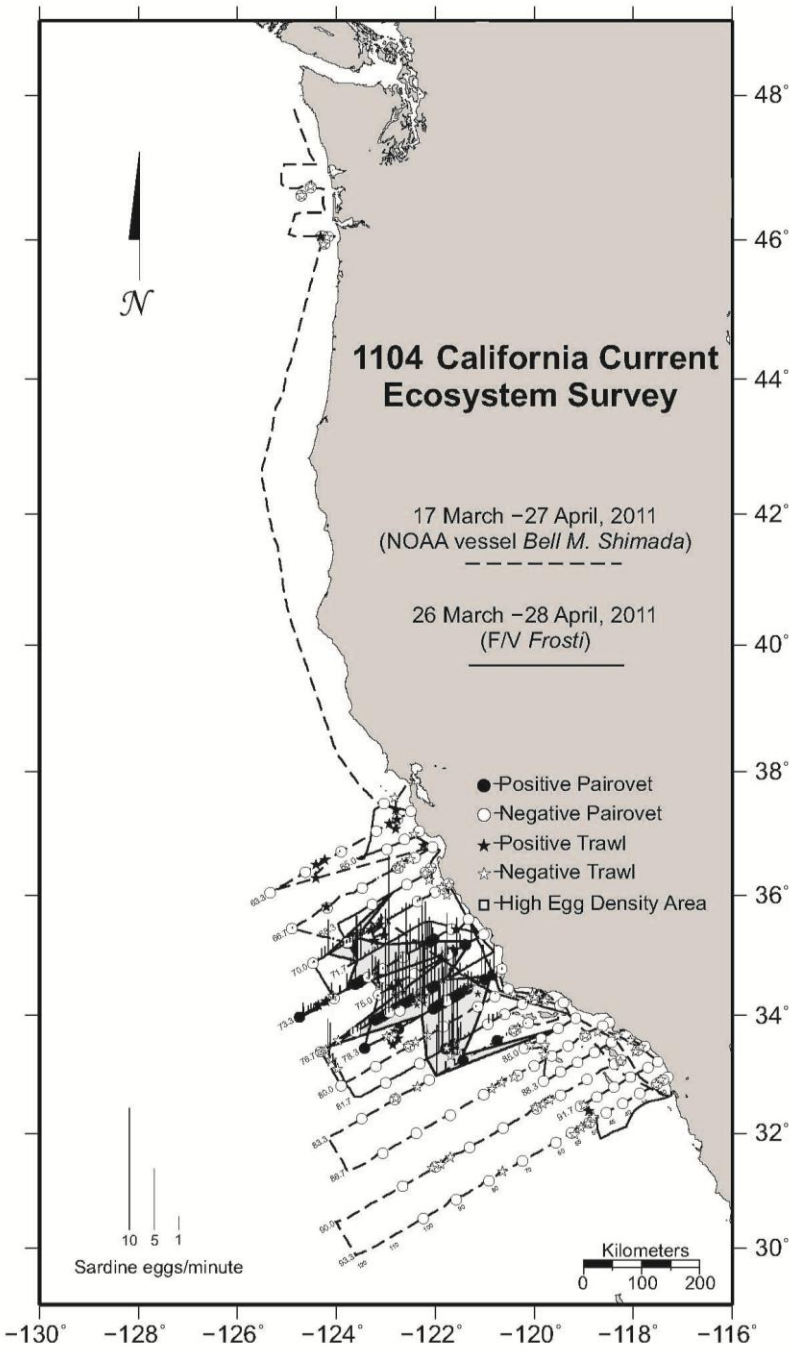


Figure 1. Location of sardine eggs collected from CalVET, a.k.a. Pairovet; (solid circle is a positive catch and open circle is zero catch) and from CUFES (stick denotes positive collection), and trawl locations (solid star is catch with sardine adults and open star is catch without sardines) during the 2011 survey aboard two vessels: F/V *Frosti* (solid line) and R/V *Shimada* (dash line). Shaded area is Region 1, the high egg-density area, and the rest of survey area is Region 2.

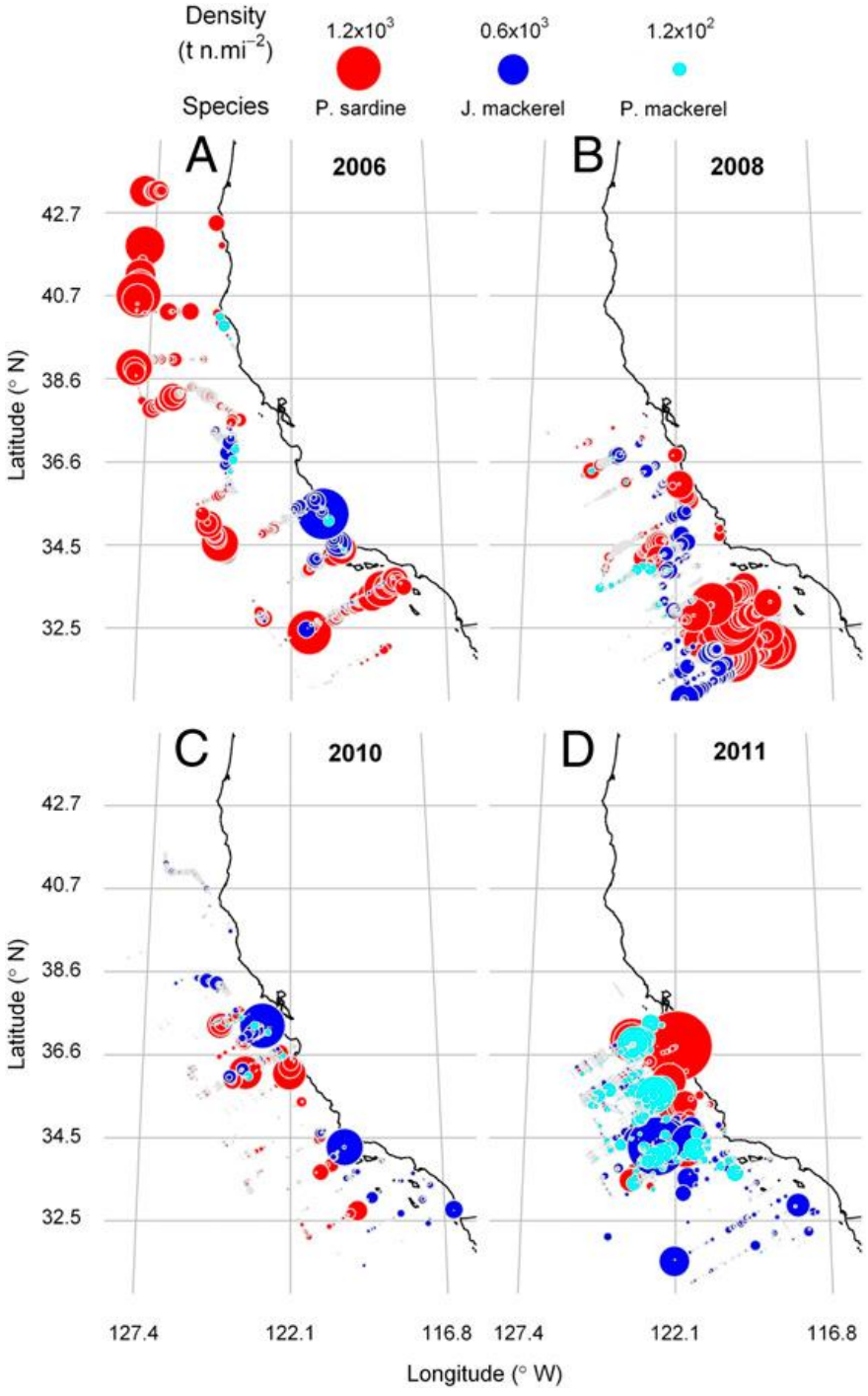


Figure 2: Distribution and abundance of sardines and mackerel off the west coast of the United States during springs of 2006, 2008, 2010, and 2011, estimated from our acoustic-trawl surveys (11). Our survey results show that in 2011 sardines were surpassed by jack and Pacific mackerel as the dominant epipelagic fish species (Zwolinski et al. 2012)

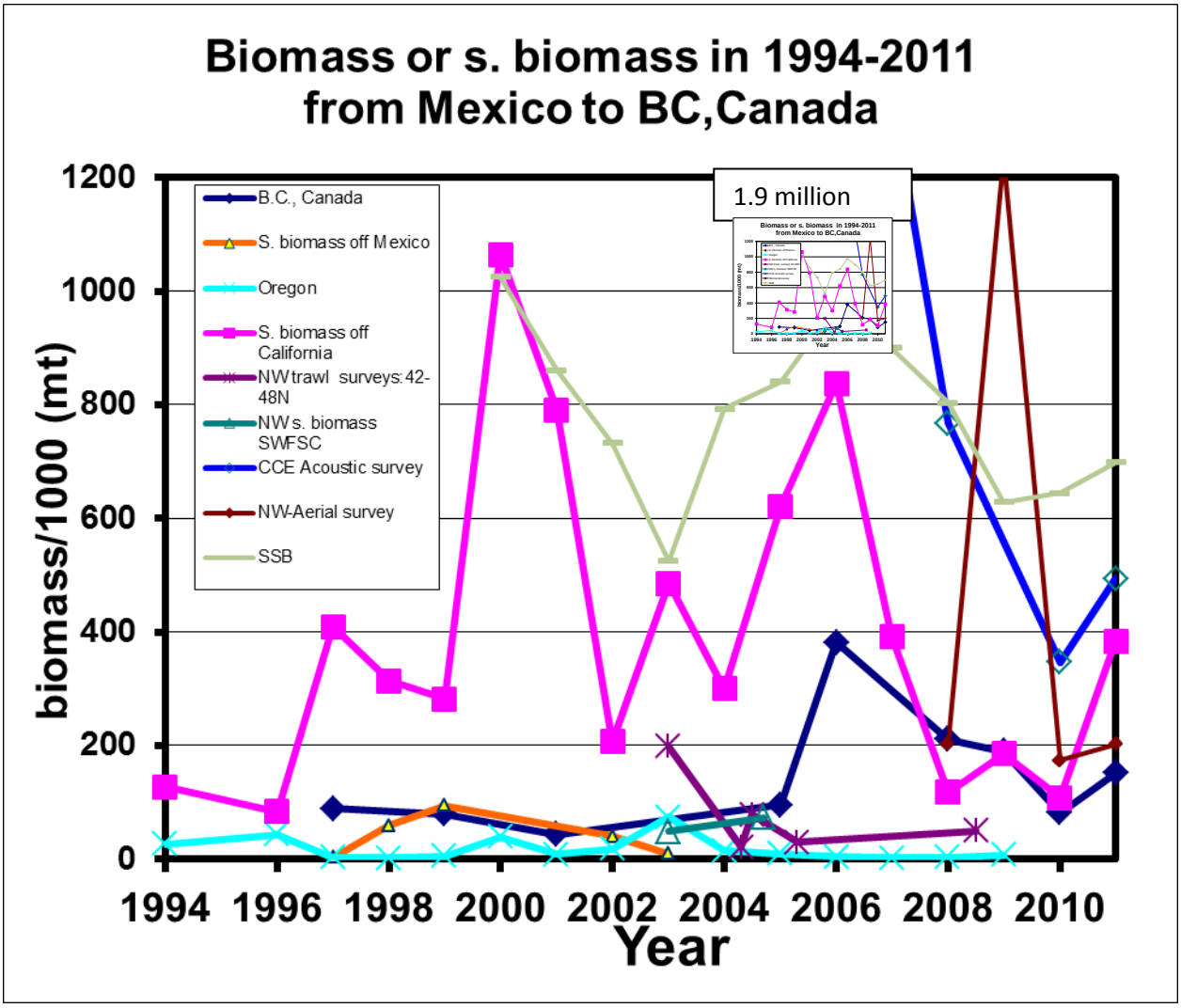


Figure 3: Time series of estimates of biomass and spawning biomass (s. biomass) from 1994-2011 from Mexico to British Columbia and spawning stock biomass (SSB) from 2011 stock assessment. Note the biomass estimate from the acoustic survey in 2006 was 1.9 million mt with large variance (Hunter and Baumgartner 2002; Lo and Allen 2008; Emmett and Lo 2009; Schweigert et al. 2010; Rodriguez-Sanchez et al. 2010; Hill et al. 2011).

2. Pacific Sardine Biomass Estimates and Associated Information off Northern Oregon and Southern Washington in 2011.

Objective: To estimate spawning biomass of Pacific sardine off Oregon since 1994.

Surveys

Two surface trawl surveys and one purse seine survey collected Pacific sardines (*Sardinops sagax*) off Oregon/Washington in 2011:

a) The Predator/Forage Fish Survey collected sardines monthly (May-September) at night using surface trawls off the Willapa Bay (Figure 4)

b) The Bonneville Power Administration (BPA) Columbia River Plume Study collected fish during daytime using surface trawls from northern Washington to Newport, Oregon in May, June and September (Figure 5)

c) The lower Columbia River Estuary Purse Seine Study collected fish during daytime by purse seine by monthly sampling at two locations in the lower Columbia River estuary (Figure 6) from May-July and September.

Abundance estimates and size/age of Pacific sardine

We did not estimate sardine population sizes off the Columbia River in 2011. We were unable to conduct our typical annual survey (surface trawling twice a month at 12 stations, Figure 4) in 2011 because of funding constraints.

We did conduct six surface trawls off Willapa Bay (one of our annual survey lines) from May-August 2011. During the July survey we captured 5 sardines. This is the fewest sardines we have ever captured during the 12 years of this survey. They ranged in length from 130 to 140 mm FL (Figure 7). We suspect that we caught few sardines because of record high Columbia River flows in 2011 (Figure 8).

During the Plume Study we captured primarily one larger size class of sardines (Figure 9) indicating relatively poor spawning recruitment in 2010 (i.e., few age-1 sardines). A few small <175 mm FL sardines were caught in May and June 2011. Sardine length-frequency information from the Estuary Purse Seine Study shows that small sardines (i.e., <175 mm FL) were utilizing the Columbia River estuary (Figure 10) in the daytime in September 2011.

Oceanographic Conditions in 2011

La Niña ocean conditions were evident off the Pacific Northwest in 2011. As a result, ocean sea surface temperatures were cool in May, June, and September 2011 (Figure 11). In

May, we captured very few sardines (1-2 individuals at 3 stations). In June and September 2011, sardines were found mostly off La Push, WA in 13-14°C waters (Figure 11).

Past surveys have found that during years with anomalous cold ocean conditions sardines do not successfully spawn and recruit off the Pacific Northwest. Relatively good sardine spawning and recruitment has been observed when June sea surface temperatures are warm, such as in 2003-2005 and 2009 (Figure 12). However, the ocean in June 2011 was anomalously cool and under La Niña and negative Pacific Decadal Oscillation (PDO) conditions. There is a direct positive relationship between the abundance of 0-age sardines found off Oregon/Washington during the September Plume cruises and average July-September PDO (Figure 13). We hypothesize that the cool ocean conditions limited the spawning/recruitment opportunities for sardines off the Pacific Northwest in 2011.

Conclusion

No 0-age sardines were captured in 2011, indicating that sardines did not successfully spawn and recruit off the Pacific Northwest in 2011, probably because of the relatively cool ocean conditions and negative PDO. Columbia River flows were extremely high in 2011 which caused reduced surface salinities in a broad area off the mouth of the Columbia River. These lower salinities appeared to encourage sardines to distribute themselves north of the Columbia River and out of low salinity waters. Unfortunately this also indicates that the area off the Columbia River is not a very good “index site” of sardine population abundance off Oregon/Washington.

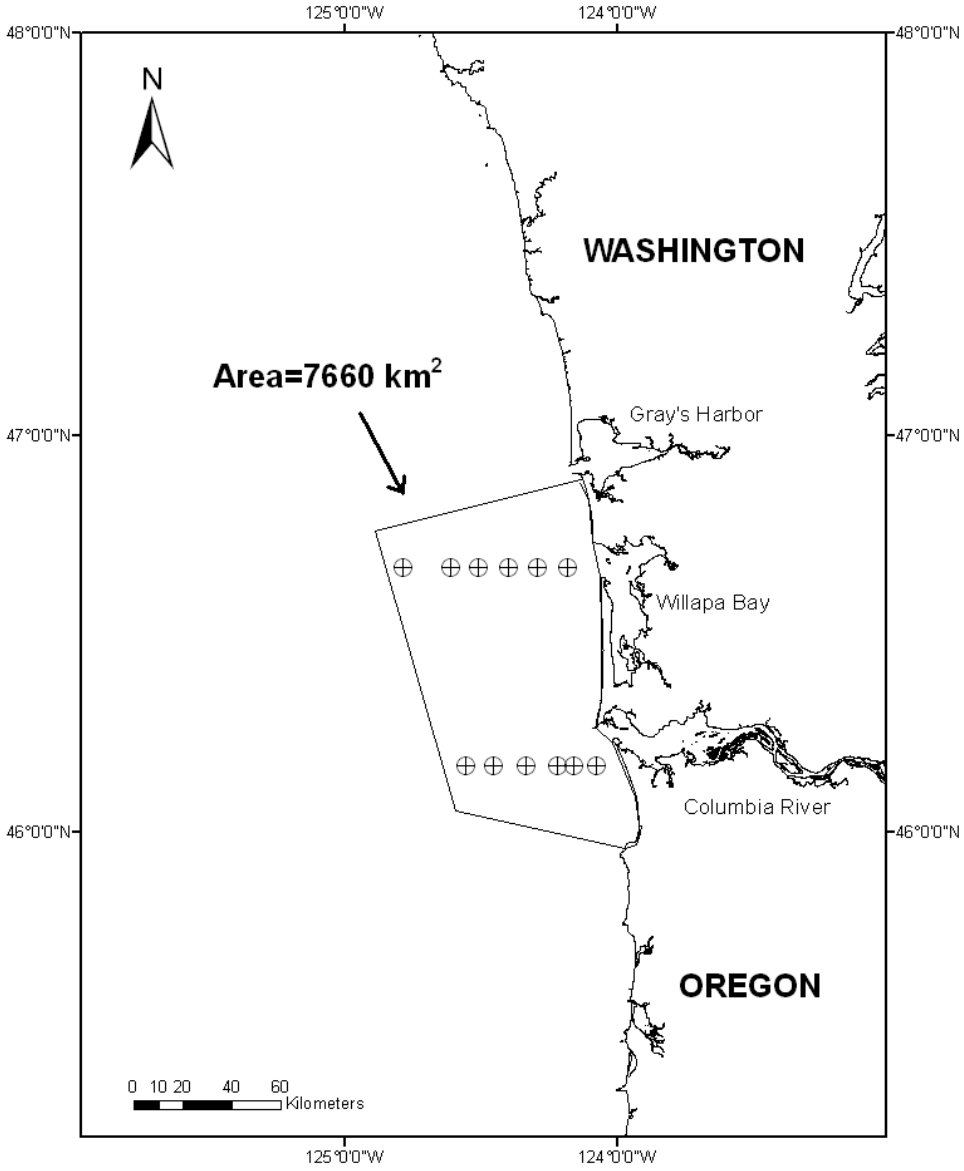


Figure 4. Location of the 12 surface trawl locations that were sampled from May through August 1998-2011 during the Predator/Forage Fish Surveys. In 2011 only the Willapa Bay line was sampled.

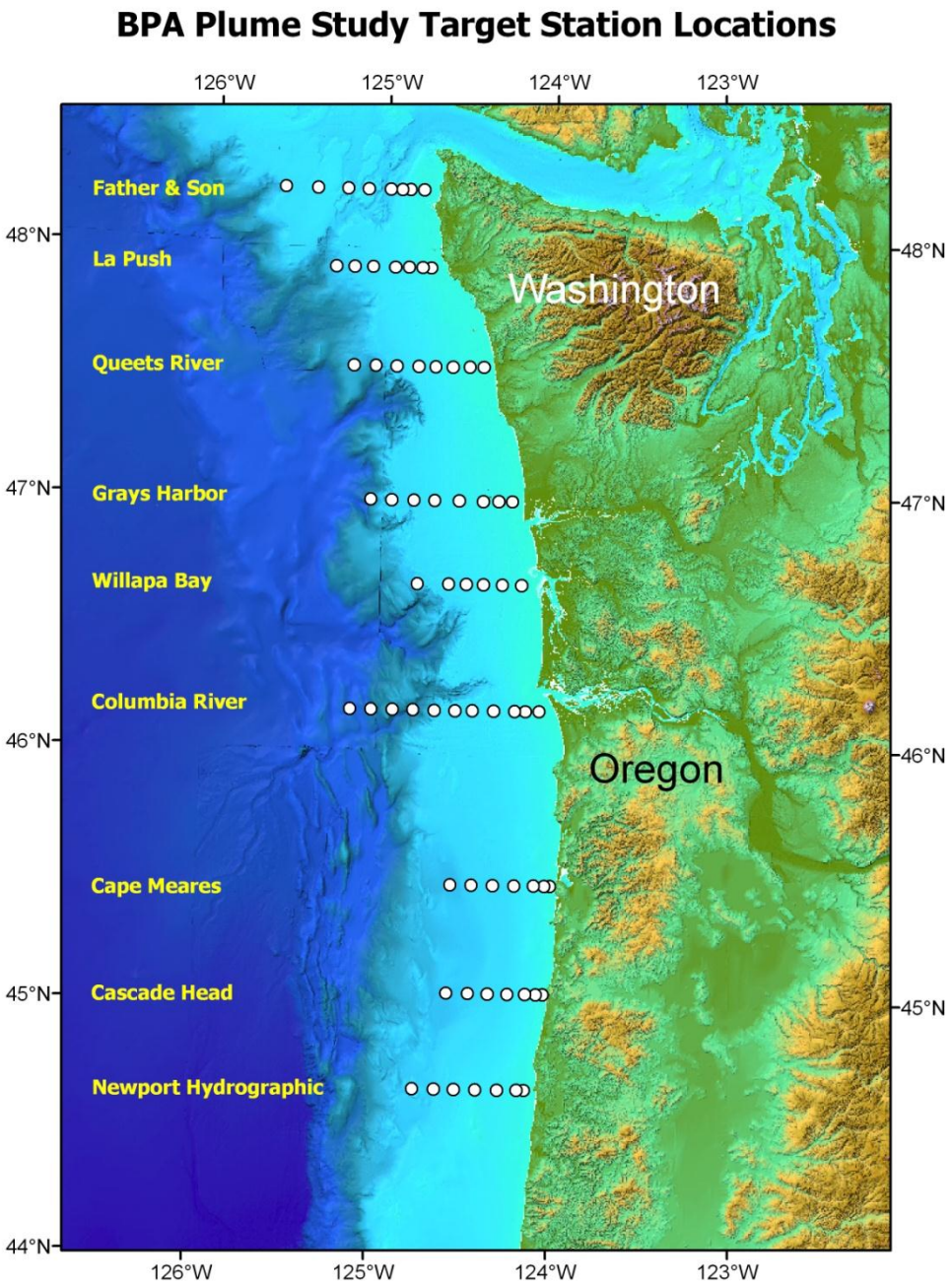


Figure 5. Station location sampled by surface trawl during the day in May, June, and September 2011 for the BPA Columbia River Plume Survey

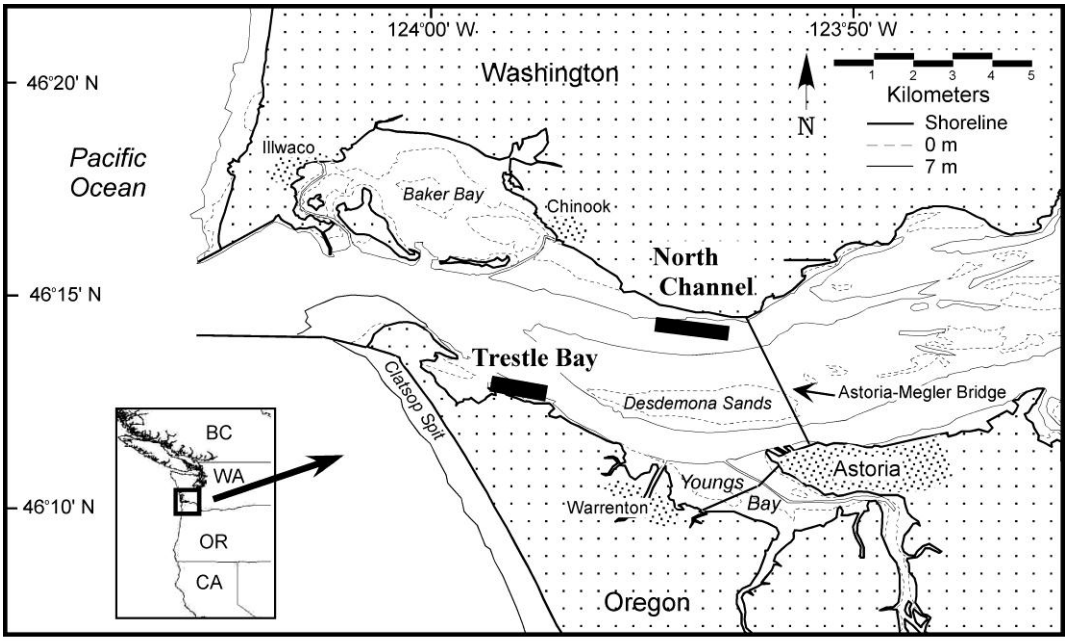


Figure 6. Two locations (black rectangles) where purse seines were used to collect Pacific sardine and other fishes monthly from May-July and September 2011 in the Columbia River estuary.

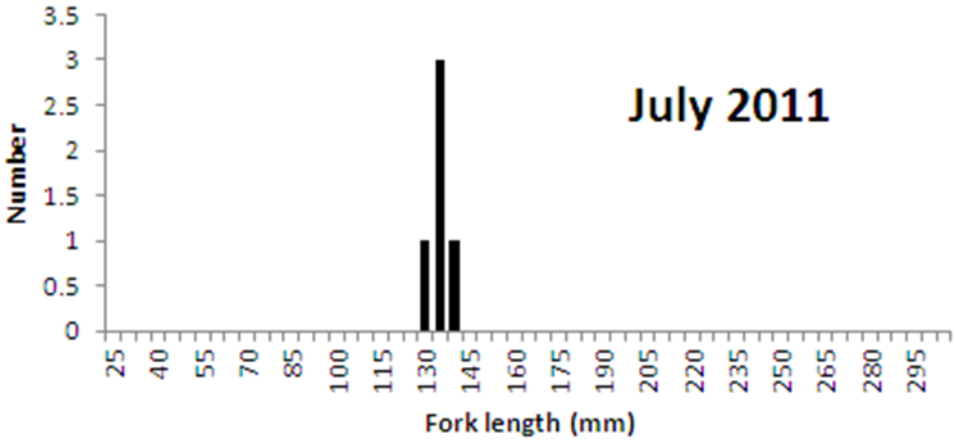


Figure 7. Length frequency of Pacific sardines captured off Willapa Bay, July 2011. No sardines were captured in May, June, August, or September.

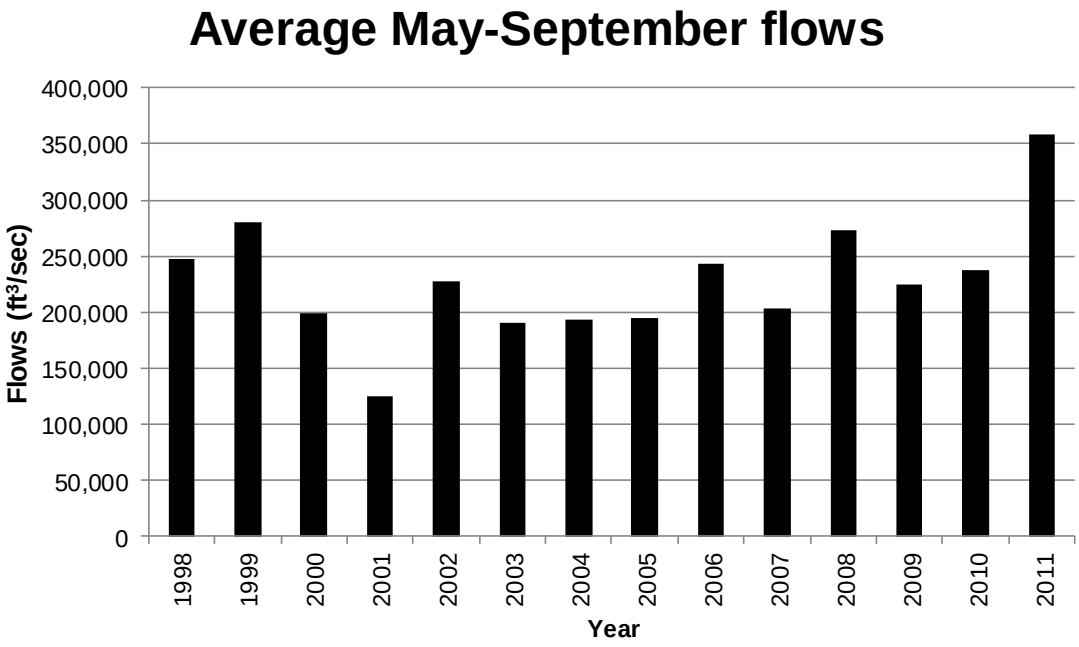


Figure 8. Average May through September Columbia River flows recorded at Beaver, OR.

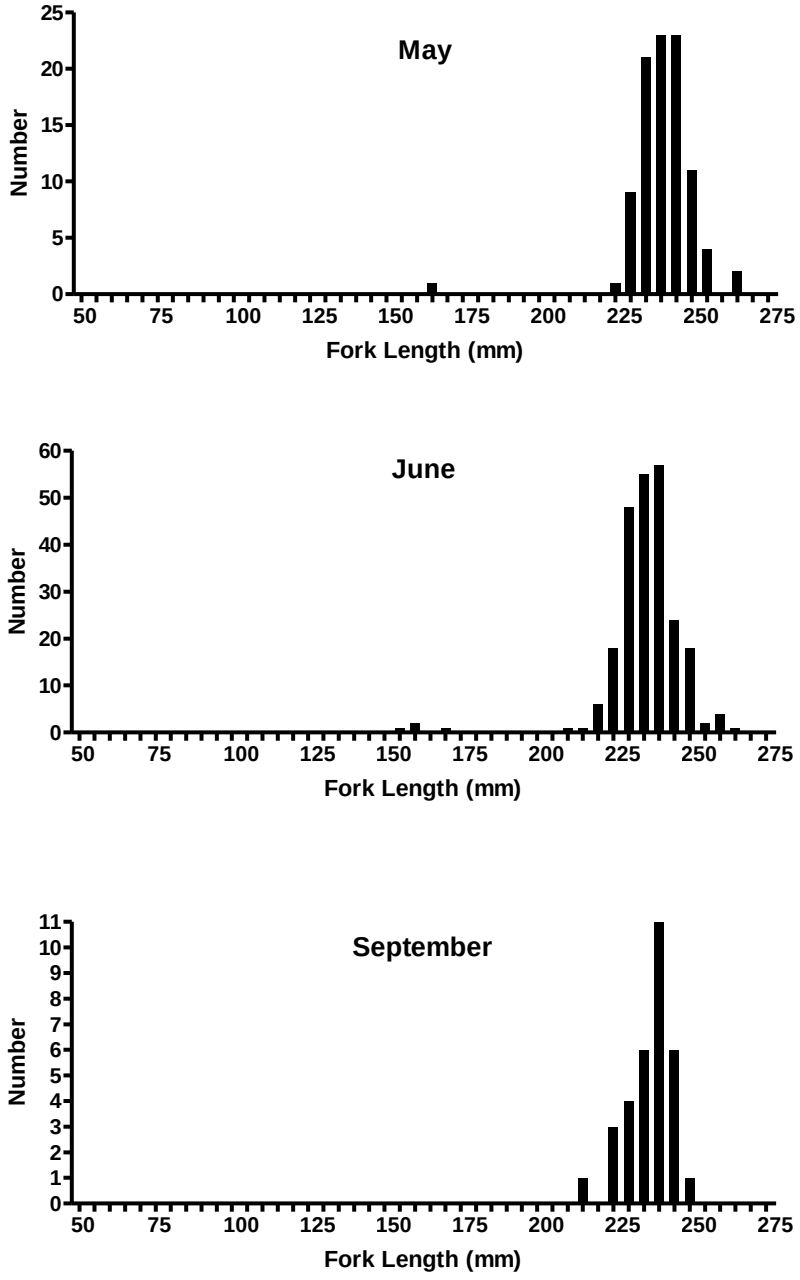


Figure 9. Length frequency of Pacific sardines captured during daytime surface trawling off Oregon and Washington during the BPA Plume 2011 surveys.

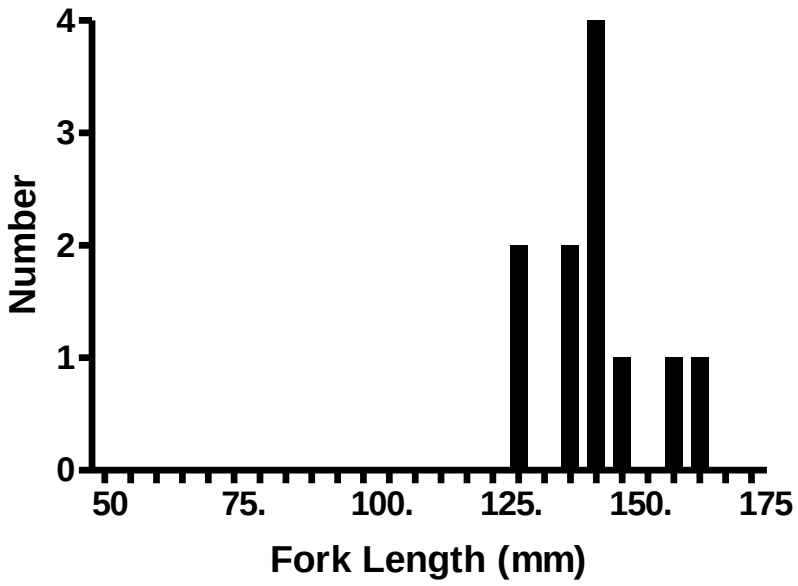


Figure 10. Length frequency of Pacific sardines captured during daytime purse seining in the lower Columbia River estuary in September 2011.

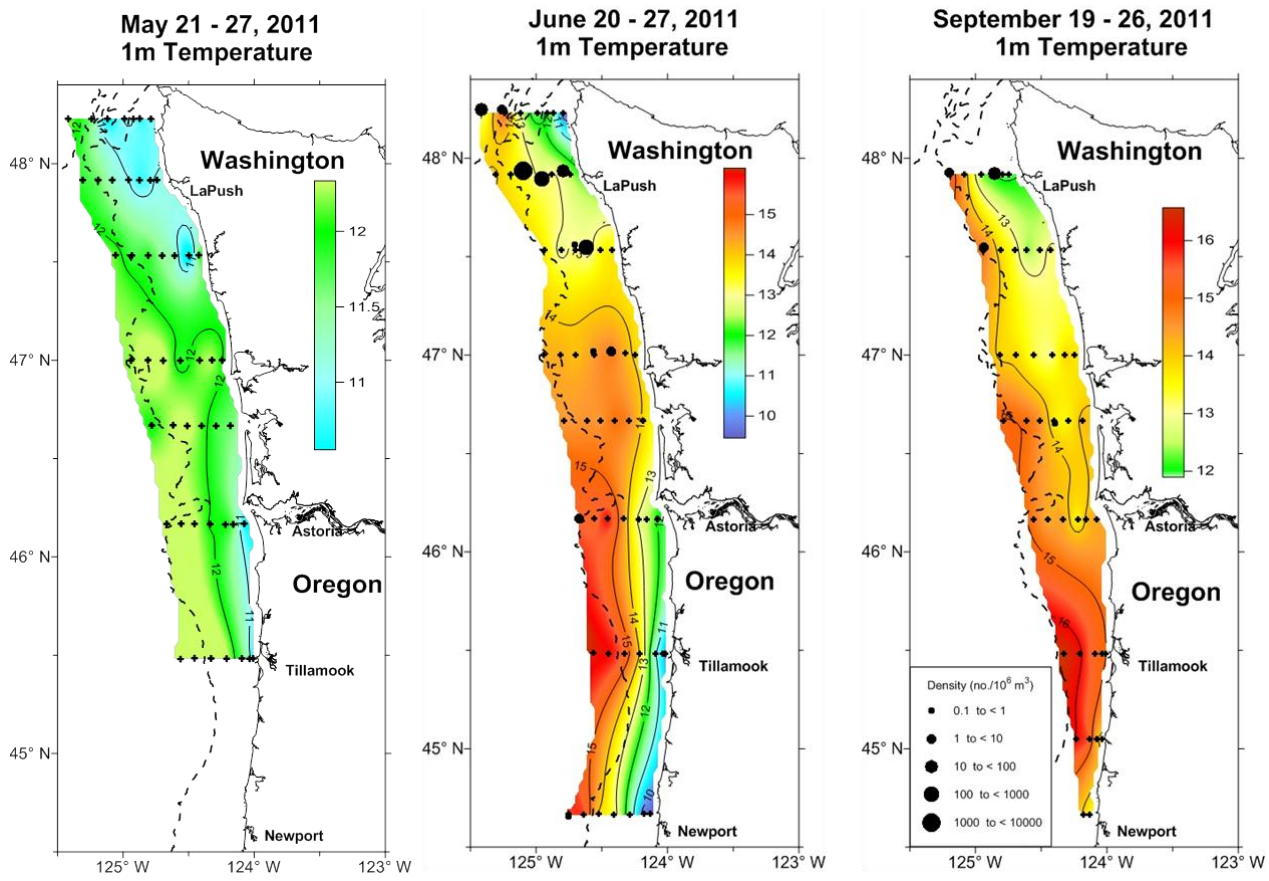


Figure 11. Densities of Pacific sardines captured during daytime surface trawling in May, June and September 2011 off Oregon/Washington during the annual BPA Plume Survey and associated sea surface temperatures.

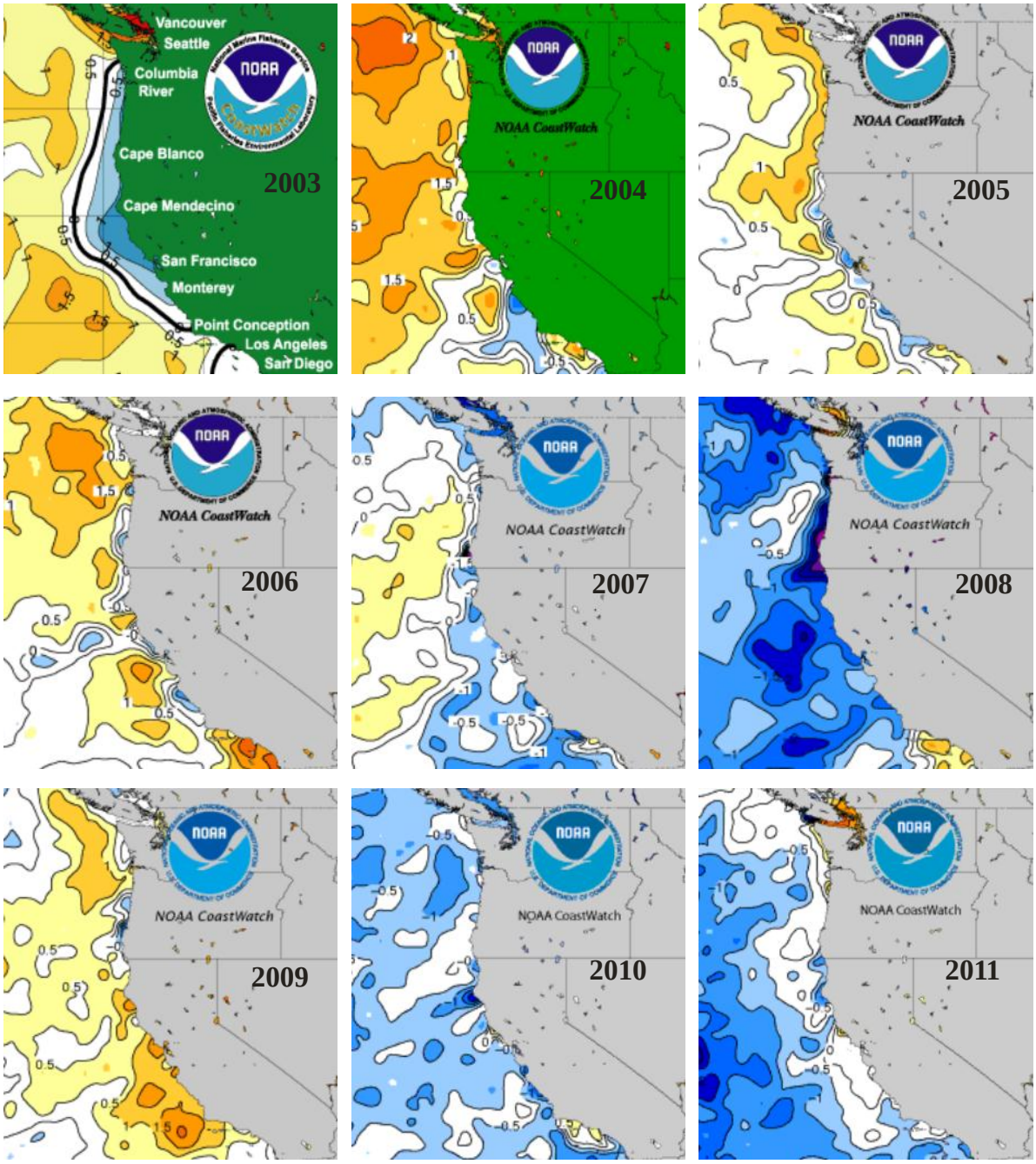


Figure 12. June sea surface temperature anomalies from 2003-2011.

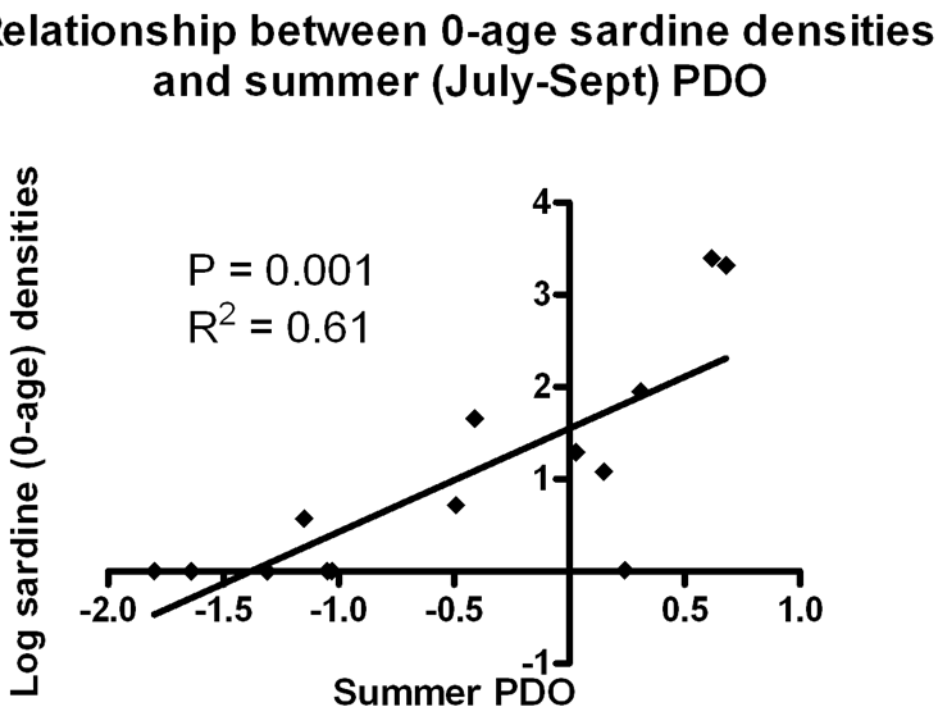


Figure 13. The relationship between 0-age sardines densities found off Oregon/Washington in September and average summer (July-September) Pacific Decadal Oscillation (PDO).

3. Canadian Trawl Survey of Pacific Sardines off West Coast of Vancouver Island During Summer of 2011

Biomass estimates and sampling associated with the summer Canadian trawl survey off the west coast of Vancouver Island, 2011 update

Survey Objectives

The summer west coast of Vancouver Island surface trawl survey is conducted to collect information on sardine 1) distribution, 2) abundance, 3) size and age structure, and 4) species associations ~ sardine diet and predation.

Summary Objectives

This report provides a brief update on Pacific sardine observations from the 2011 WCVI trawl survey with an emphasis on regional distribution, catch densities, biomass estimates, and fish lengths. Information on sardine length frequencies from commercial purse seine July and August fishing in or near WCVI inlets along with monthly July, August and September SST anomalies off the coast of British Columbia is provided.

Survey background

Summer surveys directed at collecting information on sardines off the West coast of Vancouver island (WCVI) started in 1992 (McFarlane and MacDougall 2001). Fishing is conducted using a mid-water trawl towed near the surface (e.g. <30 m) using floats on the headlines at average speeds approximating 4.0 to 5.5 knots. Since 2006, sampling has been conducted at night (Schweigert et al. 2009). Surveys are conducted to observe biological trends of sardines related to regional distribution, abundance, morphometrics, species associations and oceanographic conditions.

The 2011 survey was conducted between July 19 and August 1 and sampling sites were based on intersections of a regional 10 x 10 km grid extending approximately 2 to 52 km from shore with a range in latitude of 50.7-48.5° extending southward to 10 km from the U.S. border. The region was further subdivided into 8 sub-regions to aid in the planning of sampling coverage across the region and for future exploration of possible stratification schemes. Assignment of sampling stations was done by applying proportional probabilities to possible stations so that each sub-region would receive approximately equal sampling intensity. This was planned by assuming that 70 coastal stations would be sampled over the region.

In 2011, 68 coastal stations were sampled and 41 of the tows had sardines. Relatively high catch densities occurred off Brooks Peninsula and southward throughout the region at varying distances from shore, whereas many of the tows lacked sardines further offshore and in the southeast corner of the region (Figure 14).

WCVI survey catch densities and biomass estimates

Biomass estimates for the region (and by sub-region in past reports) were calculated using sardine catch densities (metric ton /km^3) and average sardine catch density extrapolated over the represented area's size and surface volume (Schweigert and McFarlane 2001; Schweigert et al. 2009; DFO 2011). Sardine catch weights were recorded for all tows and estimates of the volume of water swept during a tow were determined by multiplying the length and width dimensions of the trawl net mouth by the effective fishing distance covered during the tow (time between end of net deployment and beginning of net retrieval). The core area of the survey region is approximately 16,740 km^2 and catch densities are assumed to represent sardine distributions in the top 30 m of the region. Therefore the region's surface volume is estimated at ~ 502.2 km^3 (Figure 15, DFO 2011). Recent regional estimates of sardine catch density and seasonal biomass in the WCVI core survey region from night sampling in 2006 and 2008 to 2010 (no survey was conducted in 2007) show a declining trend, whereas the 2011 estimates are approximately double the 2010 estimates (Table 1, Figures 14 and15).

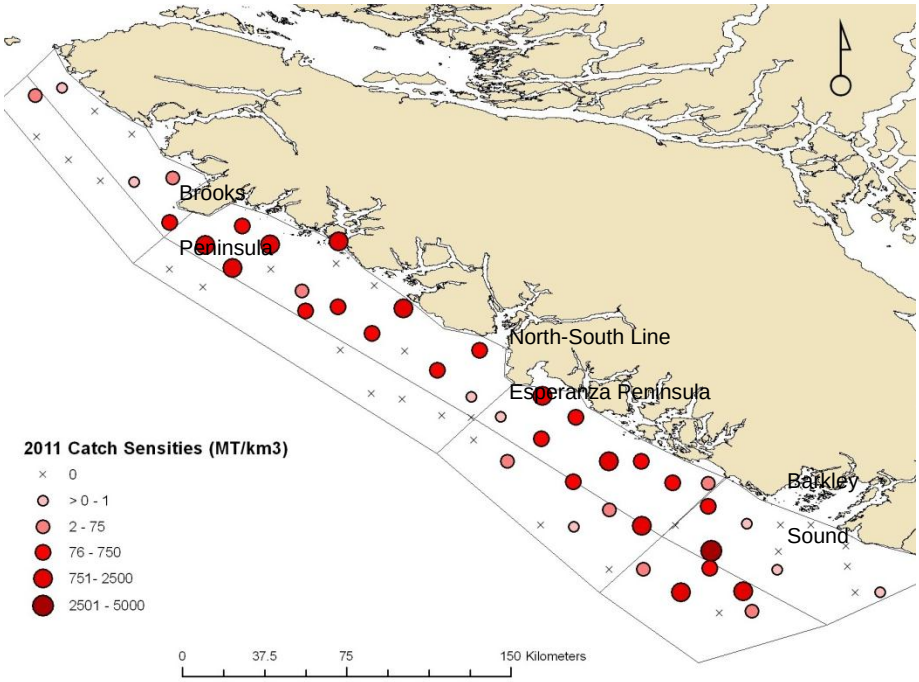
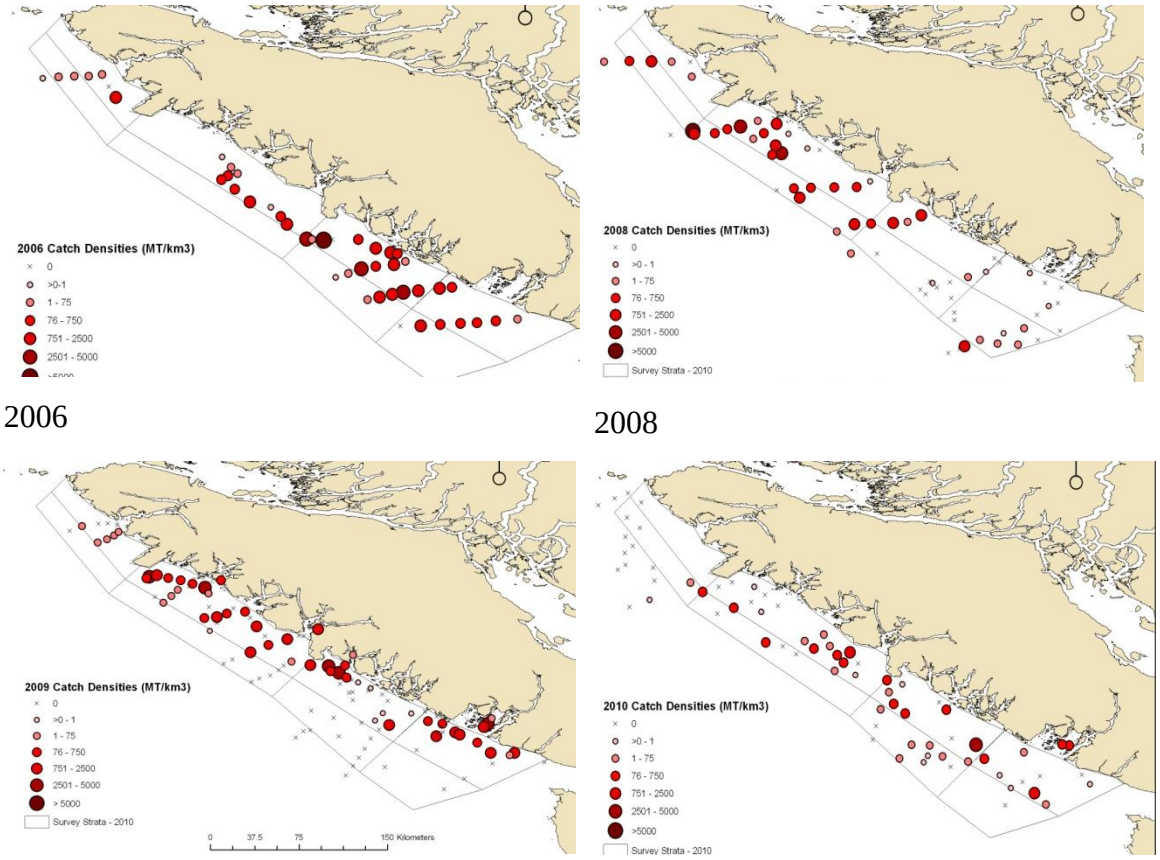


Figure 14. West coast of Vancouver Island 2011 surface trawl locations and approximate Pacific sardine catch densities for night sampling, occurring between July 19 and August 1.



2006 2008

2009 2010

Figure 15. West coast of Vancouver Island 2006, 2008-2010 surface trawl locations and approximate Pacific sardine catch densities for night sampling (DFO 2011). No survey occurred in 2007.

Table 1. West coast of Vancouver Island Pacific sardine catch densities and biomass estimates from night surface trawl surveys in 2006, 2008, 2009-2011, derived from treating the region as one stratum (DFO 2011). The size of the region represents 16,740 km^2 and surface volume estimates (km^3) result from multiplying the area by "0.03 km", thus the region's surface volume is characterized as 502.2 km^3 . No survey was conducted in 2007. Bootstrapping was done for 95% confidence intervals, LL= lower limit and UL= upper limit.

YEAR	**2006**	**2008**	**2009**	**2010**	**2011** *
WCVI SAMPLING					
Tows with sardines / total number of tows	42/45	44/71	53/109	40/72	41/68
Core survey region					
Tows with sardines/ total number of tows	41/44	40/60	47/95	37/57	41/68
SARDINE DENSITY (mt/km^3)					
Mean	759.9	420	378.3	163.2	301.0
95% LL	461.6	196.5	220.2	57.6	164.0
95% UL	1,105.60	736.4	557.8	309.7	459.0
CV **	0.23	0.33	0.23	0.39	0.27
BIOMASS (mt)					
Mean	381,617	210,924	189,977	81,964	151,162
95% LL	231,816	98,682	110,589	28,927	82,361
95% UL	555,232	369,820	280,127	155,541	230,051

* 2011 estimates are preliminary and have not been formally reviewed

** CVs presented above have been corrected from previously reported estimates

WCVI 2011 Biological Samples & Sardine Lengths

Sardines collected during the 2011 WCVI survey were measured for fork lengths (to the nearest millimeter), weight (to the nearest gram) and information on sardine sex, stomach contents, otoliths/age and predator size and stomach contents was collected (Table 2).

Table 2. Summary of biological samples taken onboard the W.E. *Ricker* July 19-August 1, 2011.

Sample Type	**# Tows Sampled**	**# Fish per Sample**	**#Fish Total**
Length	27	50-200	5146
Sex	27	100	2732
Weight	26	100	2338
Otolith/Age	15	75	1125
Maturity	14	100	746
Sardine Stomachs	15	30	450
Predator stomachs	45	1-30	370
Total number of sardine sampled: 5146			

In total, 27 length samples were taken (50-200 fish per sample sex combined), 13 from waters north of a seaward line off Esperanza Peninsula and 14 from waters south of this delineation (Figure 14). The range in fork length for most sardines was 22-28 cm, small proportions of fish were observed at 14, 15 and 20 cm, small proportions of fish were observed at 14-21 cm (<0.3% combined) and prominent modes were at 24 and 25 cm (Figure 16).

Sardines collected from July and August commercial purse seine catch samples from WCVI inlets were measured for fork length. In total, 242 sets were sampled (~100 fish per sample sex combined), 164 from waters north of a seaward line off Esperanza Peninsula and 78 from waters south of this delineation. Similar to sardines collected from the WCVI survey, the range in fork length for most sardines was 21-28 cm, small proportions of fish were observed at 13-20 cm (<0.3% combined) and prominent modes were at 24 and 25 cm (Figure 16).

Monthly Average Sea Surface Temperature Anomalies

Plots of monthly average Sea Surface Temperature anomalies for July, August and September taken from Fisheries and Oceans Canada SST internet archives (http://www.pac.dfo-

mpo.gc.ca/science/oceans/data-donnees/sst-tsm/index-eng.htm) are included to consider in association with the spatial distributions and densities of sardines observed during the 2006 and 2008 to 2011 WCVI surveys (Figures 14, 15, and 17). Average monthly August and September SSTs in 2011 were generally warmer compared to 2010. In the summer of 2011, relatively warm SST stemmed off northern Vancouver Island and progressed in a southwest direction, a unique pattern compared to the 2006 to 2010 observations. Whereas off the southeast corner of the WCVI (extending from the Juan de Fuca Strait) summer waters in 2011 remained relatively cool.

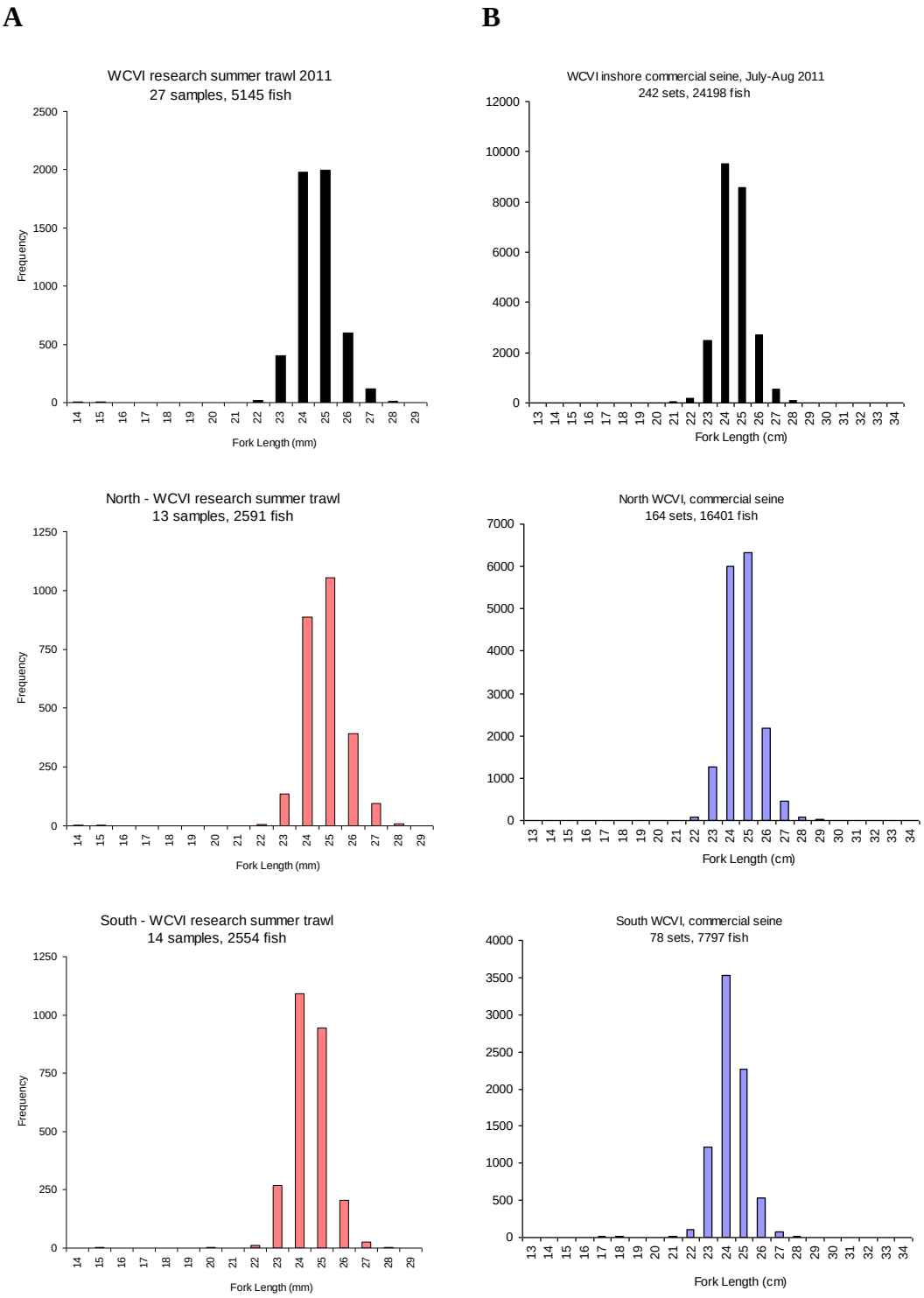


Figure 16. Fork length distributions representing sardines collected in 2011 from the WCVI summer surface trawl survey between July 19 and August 1 (A) and from commercial purse seine catches between July 5 and August 26. A perpendicular line seaward off Esperanza Peninsula delineates northern and southern groupings.

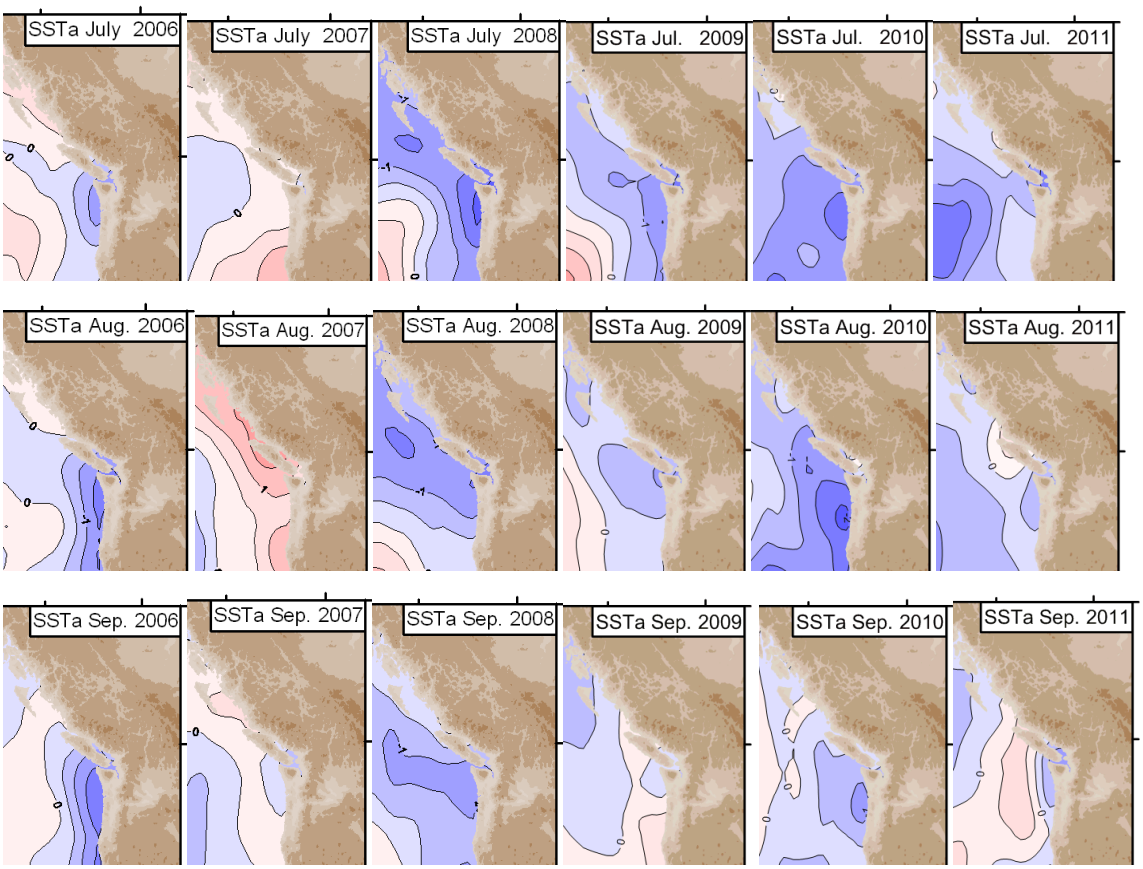


Figure 17. Mean sea surface temperature anomalies for waters surrounding British Columbia in June, August and September. Information from:

http://www.pac.dfo-mpo.gc.ca/science/oceans/data-donnees/sst-tsm/index-eng.htm

Accomplishments in 2011:

Canada

- 2011 Survey was conducted from July 19- August 1 on the *Ricker* with night trawling with acoustics.

Mexico

- Four IMECOCAL cruises (January, April, July, and October) start in north (Ensenada) to south hopefully at end of March, Tim Baumgartner will coordinate work with Manuel Navarro for acoustic operation

United States

- 2011 CCE and CalCOFI surveys in March and April
- Biomass estimates from acoustic data for 2008-2011 Northwest survey and CCE surveys was provided as one additional time series to 2011 Pacific sardine stock assessment.
- Aerial surveys off the Northwest and California by the industry
- An otolith workshop was held on Dec 10, 2011 in SWFSC.

Working Group 1 Plenary Session:

Possibility of integration of sardine trawls in the U.S. Hake Assessment survey

The timing and coverage of the U.S. hake survey is highly compatible to the study of sardine distribution and abundance. Targeted night trawl sets for sardines have not been implemented in past hake surveys, though some data sharing already exists. Working Group 1 discussed the integration of night time surface trawls to collect sardine data. Logistical challenges relating to gear type (specifically doors) were also discussed. Space to accommodate a second set of doors (for surface tows) is limited on the R/V *Shimada*. Colleagues involved in the hake survey (U.S. and Canada) will be invited to the 2012 Trinational Sardine Forum to contribute to further discussion with the goal of increased integration of collection of hake and sardine data from a single platform.

2012 Coast-wide sardine survey

The 2012 coast-wide survey offers a rare opportunity to standardize catchability of the CCGS (Canadian coast guard ship research vessel) R/V *W.E. Ricker* and the U.S. R/V *Shimada*. The goal is for the R/V *Shimada* to reach the most northern range as possible with spatial and temporal overlap with the *W.E. Ricker* survey efforts. A decrease in sampling density of the *Shimada* survey may be required to achieve this overlap. The *W.E. Ricker* survey will begin in late July 2012. Specific dates will be confirmed shortly after the 2011 Trinational Sardine

Forum. The timing of the Mexican survey is likely to begin on August 1st, 2012. Note, a joint sardine and hake acoustic-trawl survey will be conducted in July-August, and no parallel station coverage will be carried out by W.E. *Ricker* and R/V *Shimada*.

Standardization of biological sampling

Mexican colleagues identified their limited sampling capability. In particular, a fishing net and fish scale would need to be borrowed from U.S. colleagues. Exchange of sampling protocols among the three countries would be a logical first step to the standardization.

Tagging program Pacific Ocean Shelf Tracking Project (POST)

Bob Emmett plans to test surgical technique and subsequent survival on fish as a first step. Fish from aquarium experiments could be used for this purpose. It was suggested that tagging in the field be postponed until after the fishery to avoid early tag recovery from this source.

Future plans:

Canada

1. Continue acoustic data collection (38Hz and 120Hz)), beginning in 2011 with the CCGS *W.E. Ricker* platform. Analysis support from U.S. colleagues is welcome.
2. Conduct Inlet trawl survey: to obtain a representative biomass density.
3. Investigate the habitat mapping and the effect of oceanographic conditions such as sea surface temperature and chlorophyll concentrations.
4. Prepare for the methodology review for stock assessment in May 29-31, 2012.
5. Discontinue the aerial survey.

Mexico

1. Organize a meeting among CICES, CICIMAR, and CIBNOR in January, 2012 in Guaymas to prepare for the 2012 August coast-wide survey to collect ichthyoplankton, acoustic, and adult sampling data during their summer survey. Note: The January meeting was not held. There will possibly be an early survey in April 2012 depending on vessel availability.

United States

1. For future hake survey, trawl doors need to be reset. May invite hake folks to our working group in 2012 TSF in Seattle.
2. Tagging experiment on sardines using electronic acoustic receivers (first suggested at the 2008 TSF (Emmett and Lo, 2009)) to be done on a chartered boat in July. In June, fake

tags will be used for experiment. A total of 100 tags will be used for real release of sardines.

3. Early recruit survey. Possible use of Japanese surface trawl discussed during 2010 TSF (Schweigert et al. 2010).
4. Collect data from salmon surface trawls off Oregon during May-June-Sept 2012.
5. 2012 Coast-wide survey in spring and summer.

Working Group 2: Stock Structure, Age Structure, and Adult Sampling, John Hyde (SWFSC)

The Southwest Fisheries Science Center will conduct 2012 coast-wide surveys. Sound research plans are needed to generate robust datasets. A few points to consider based on discussion of the working group for augmenting survey data are:

- Collection of detailed CPUE data from Ensenada fisheries during the time of the survey
- Working with live-bait fishers to capture samples of the inshore sardine component
- Examining growth-at-age data for young sardines captured during the survey

After many years of tackling the stock structure question with assorted tools, most of the signal appears to be driven by ephemeral oceanographic conditions that are often unpredictable and highly variable. Questions were raised regarding whether there are two separate stocks in Bahía Magdalena. If they are not separate stocks, we need to include Bahía Magdalena in the stock assessment. Perhaps it would be a good exercise to use ROMS models to better predict the environment that eggs or juveniles may have experienced and use these results to analyze our data. To do this we will need to incorporate some behavior components (e.g., vertical migration) to drive the models in a realistic fashion. We can generate "virtual" otoliths using the ROMS models and compare these to empirical results. Coordinated oceanographic data collection and sampling of recruits and eggs would be a good complement to the survey.

Studies are planned in the Northwest to put electronic acoustic tags in sardines and use the Salmon POST (Pacific Ocean Shelf Tracking project) network to obtain information for movement patterns. This technique can be extended to fish in Mexican water such as Bahía Magdalena. This extended tracking study is likely to be expensive.

There is a general consensus that data on otolith ageing of young fish could be used for various U.S. projects, such as counting of daily rings could lead to birthdates, which is helpful for understanding potential movement and behavior given seasonal oceanographic conditions. These data could also be used to estimate growth rates, which when compared with archived samples can provide information on changes over time and signs of density-dependent growth. The CalCOFI samples preserved in ethanol since 1997 may be used to perform this kind of study, which would be a good graduate student project. We also need to conduct surveys to collect juvenile data which are lacking.

Regarding the possible inherent differences in the reproductive success of fish of different sizes, it's likely that large female fish produce more eggs of better quality over a wider spawning period than small fish. Thus it is worthwhile to conduct studies on the effects of fishing the big spawners on population sustainability. We should also examine the effects of the economic differences between one large fish and several smaller fish and how this compares to ecosystem value.

Working Group 3: Industry Trends and Issues, Mike Okoniewski (Pacific Seafood)

Mike Okoniewski, Working Group 3 leader, provided an opening statement. Afterward, attendees were encouraged to share their insight on the subject matter.

Mike Okoniewski began the working group by stating that the sardine industry in the U.S.A. is in a perilous state. Seasons have been so truncated due to low quotas that those businesses that rely heavily or entirely on sardines may not be able to continue.

Canada on the other hand has developed a robust business model which is allowing their fleet and processors to execute a fishery that is generally thought to be a success. It is hoped that Canadian attendees can offer comment on issues and successes relevant to their fishery. In general they have a long season and have increased quotas to their permit holders. Many former U.S.A. customers are now "shopping" in Canada. The Chair cannot comment on Mexico except to say that many of the former U.S.A. customers have taken their business south (and north) of our borders.

U.S. issues and trends are largely one and the same; the industry has been reporting large and numerous schools of sardines off the Oregon and Washington coast for the last decade. More recently similar amounts have been seen in Canada off west and north Vancouver Island. Fish sizes in the fishery seem to follow a spread in southern California of 30/70gr, Central California of 60/110gr, the Northwest of 110/190 gr and in Canada of 140/200+ gr. During the season boats in Monterey and Washington have often made 2 and even 3 trips in a 24-hour period. The 2011 July season this year only lasted 11 days and would have been much shorter if the Astoria boats had not had huge Columbia River runoff issues created by record snowpack.

There are several downstream effects of short seasons and low quotas in the U.S.A. The most obvious challenge is having enough fishing time to make any form of profit. Compounding this challenge are the following: 1) Attracting fleet to fish in an abbreviated season, 2) attracting skilled crew to work in a short season and 3) Customer retention when they realize you can no longer meet their needs.

The industry was (and is) convinced that there is a large amount of biomass that is currently being overlooked by the NMFS-sponsored sardine surveys. The industry launched an aerial survey in 2008 that was intended to be conducted in a coordinated and collaborative manner. No form of linkage or overlap ever really occurred.

In 2010 Dr. Usha Varanasi attempted to formalize the collaborative nature of these efforts through a sardine workshop that set forward goals and objectives which in part were intended to involve the sardine industry and their survey efforts in an overlapping manner. Part of the thought was to bring the Canadian research vessels into the overall effort and to introduce data from Canada into the model. As there appears to be an enormous amount of biomass in Canada at the same time as in the Pacific Northwest, the industry thought this would be an important component to quantify a "missing link" that might help to explain the vast difference in anecdotal reports to the NMFS surveys.

Industry believes that the science of sardine discovery is missing a key part of the overall picture. This has led to what may be a partial collapse of the U.S.A. industry. We also believe that the only affordable way to ground-truth this dichotomy is a tri-combo survey that uses aerial, acoustic-trawl, and Canadian swept trawl. Each of these survey methods offers clues, but unless conducted in a collaborative manner it may never be possible to put the puzzle together. In addition, these surveys need to be conducted at times when sardines are most heavily aggregated in their accustomed feeding zones. The acoustic-trawl vessel needs to have scientific sonar as well as a down sounder in order to quantify school volumes and dimensions. The aerial survey needs to overlap survey vessels so that they we can observe school behavior as the vessels approach and drive through schools. Simultaneous measurement of schools could occur from air and vessel. Acoustics could measure a portion of the schools that the camera cannot. In addition it is thought that acoustics could answer the question as to how many schools the camera and pilot are missing.

This basically comes full circle to where Don Pepper, former WG 3 Chair, left off in his summation report of the WG 3 from the 2010 Tri National Sardine Forum. Quote: "Central to the discussion was the impact of lower quotas on the industry. From the two countries' perspective the dominant issue was the need to improve scientific assessments." This still is industry's primary concern. For the U.S.A. industry this is becoming an act of desperation. If the quota does not increase soon some businesses will not survive.

Discussion:

While members of the industry have varied and broad notions of how to better the sardine market in the future, they share the common business perspective of investment with the purpose of attaining a return. Therefore, to ensure a future in harvesting, what the industry needs most at this time is confidence in the market and the security of future stock. Members of Working Group 3 noted the imperativeness of accurately predicted stocks to maintain a market and secure future production.

All attendees reiterated the industry's strong support for furthered science in the determination of sardine and other catch allocations. Many industry members, including Diane Pleschner-Steele of the California Wetfish Producers Association, believe the United States science is not measuring the biomass accurately, that there are more sardine than previous surveys have suggested, and that scientists need to further their examination in order to preserve both the future of the sardine and the industry. Future research needs to focus on reflecting accurate stock abundance and researching peak feeding seasons of the sardine coast-wide, as both timing and location are very important. While the industry has since found a market for small sardines, it is not as prosperous as the canning market. The industry needs to fish at peak times, when sardines are at their highest oil content, quality and quantity possible for that specific region. John Lenic, Canadian Pacific Sardine Association, indicated that science and

industry are making progress, and it is necessary to continue the cooperation and make improvement.

There are several ways the industry believes these issues can be addressed. One such argument advocates a redistribution of allocation based on each region's peak seasons. The industry argues that the allocation models were created incredibly conservatively and are no longer appropriate for today's needs. Overall, the industry argues that the United States needs to increase the quota and season length; but while there are truncated seasons, many within the industry believe the best allocation is to allow each region to catch at its specific peak harvest time.

Working Group 3 Plenary Session:

During the Plenary Session, conference members discussed the current issues and proposed future relationship between science and the industry. The past few years have seen a developing improvement in this relationship; however, both sides still battle with preconceived notions of the other. To best ensure the future of sardines and the sardine industry, science and the industry must find better ways to work collaboratively.

The possibility of industry supporting science became a dominant topic during the Plenary Sessions. Dr. Vetter, director of the FRD division at SWFSC, agreed that collaboration between government and the industry would prove widely helpful; however, there are serious issues with funding. To combat these issues, the United States could take the same approach as Canada in industry-funded science. However, it is obvious that this would create the need to completely revamp the structure of the U.S. government and industry relationship, a great undertaking in the very least. However, there is hope for the future sardine industry, as current examples, such as albacore, show a working relationship between U.S. industry and government. The albacore industry is comprised fairly equally of processors and fishermen and often carries out research programs with NOAA. One of the first steps towards this kind of relationship for sardines took place in 2008, with the industry's aerial survey.

Overall, the majority of the industry is more than willing to help support and fund U.S. science to provide more in-depth studies surrounding sardines. There are several models to choose from, both within the United States and from Canada and Mexico. However, the biggest challenge the sardine science and industry face at the moment is the next step in attaining a closer, more collaborative relationship with adequate funding.

SPECIAL SESSION: National Management Strategies of Sardine Population

Moderator: Robert Emmett (NWFSC)

The session was dedicated to examining different approaches used by the United States, Canada and Mexico in managing the sardine population of their areas. These national management strategies varied widely between the two groups and provided interesting alternative methods in the efforts of data collection and management. Note: Dr. Manuel Nevárez-Martínez (INAPESCA – CRIP), representative of Mexico, was unable to attend the Trinational Sardine Forum. Martin Hernandez-Rivas, CICIMAR-IPN gave a brief report on management strategies of Pacific sardine in Mexico.

United States - Kevin Hill (SWFSC)

To calculate the U.S. harvest guideline (HG) for a given calendar year, the Pacific Fishery Management Council (PFMC) uses the harvest control rule defined in Amendment 8 of the coastal pelagic species fishery management plan (CPS-FMP; PFMC 1998[2]). The formula is intended to prevent Pacific sardines from being overfished and maintain relatively high and consistent catch levels over the long-term. The formula for calculating HG, presented at the bottom of Table 1, includes the following parameters: 'HG' is the total U.S. (California, Oregon, and Washington) harvest guideline for the coming calendar year, BIOMASS is the estimated stock biomass (ages 1+, July 1) from the current year's assessment, CUTOFF is the lowest level of estimated biomass at which harvest is allowed (150,000 mt), FRACTION (15%) is a percentage of biomass above the CUTOFF that can be harvested by the fisheries, and DISTRIBUTION (87%) is the average portion of BIOMASS assumed in U.S. waters. In addition, the PFMC adopted a maximum catch (MAXCAT) policy of 200,000 mt, which limits the fishery to taking no more than this amount regardless of population size. Using results from the final base model of 2011 (Hill et al. 2011), the harvest guideline for the U.S. fishery in calendar year 2012 was calculated to be 109,409 mt (Table 1).

The Magnuson-Stevens Reauthorization Act of 2006 required fishery managers to define an overfishing limit (OFL), allowable biological catch (ABC), and annual catch limit (ACLs) for

[2] PFMC (Pacific Fishery Management Council). 1998. Amendment 8: (To the northern anchovy fishery management plan) incorporating a name change to: The coastal pelagic species fishery management plan. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 200, Portland, OR, 97220. OR. (http://www.pcouncil.org/wp-content/uploads/a8fmp.pdf)

species managed under federal fishery management plans (FMPs). By definition, ABC must always be lower than the OFL based on uncertainty in the assessment approach. The PFMC's Scientific and Statistical Committee (SSC) recommended the '*P*star' approach for buffering against scientific uncertainty when defining ABC, and this approach was adopted under Amendment 13 to the CPS-FMP (PFMC 2010[3]). The ABC buffer depends on the probability of overfishing level chosen by the Council (*P*star). Uncertainty buffers and ABCs associated with a range of discreet *P** values, with calculated examples from the latest sardine assessment (Hill et al. 2011) are presented in Table 1. OFL is taken as the product of stock BIOMASS (ages 1+), F_{MSY} (18%; see Hill et al. 2011, Appendix 4), and the average DISTRUBUTION (87%) assumed for U.S. waters. ABC levels are the calculated product of BIOMASS, uncertainty BUFFER, F_{MSY}, and DISTRIBUTION (Table 1). The PFMC chose a *P*star value of 40% for setting ABC levels for 2011 and 2012. Effective harvest rates for OFL, ABCs, and HG, calculated over a range of biomass, are displayed in Figure 1. Calculated HGs, which have been the basis for PFMC management specifications since the year 2000, are more conservative than OFL or $ABC_{0.40}$ at all biomass levels. Calculated OFL and $ABC_{0.40}$ result in constant harvest rates of 15.7% and 14.3%, respectively, over the range of biomass levels. Exploitation rates for HG vary with biomass level, peaking at 11.8% when biomass equals 1.67 Mt, and dropping rapidly to zero as biomass approaches the cutoff level of 150,000 mt. Exploitation rate also decreases as the population exceeds 1.67 Mt due to the fishery being capped at 200,000 mt (Figure 1).

Table 1. Pacific sardine harvest control rules for the 2012 management year (Hill 2011).

U.S. Harvest Formula Parameters	**Value**			
BIOMASS (ages 1+, mt)	988,385			
*P*star (probability of overfishing)	0.45	0.40	0.30	0.20
$BUFFER_{Pstar}$ (Sigma=0.36)	0.95577	0.91283	0.82797	0.73861
F_{MSY} (stochastic, SST-independent)	0.18			
FRACTION	0.15			
CUTOFF (mt)	150,000			

[3] PFMC (Pacific Fishery Management Council). 2010. Measures for integrating new provisions of the Magnuson-Stevens Fishery Conservation and Management Act and National Standard 1 Guidelines into coastal pelagic species management. Amendment 13 to the Coastal Pelagic Species Fishery Management Plan. Partial Draft Environmental Assessment. Pacific Fishery Management Council, Portland, OR. (http://www.pcouncil.org/wp-content/uploads/F2a_ATT1_DRAFT_EA_JUNE2010BB.pdf)

DISTRIBUTION (U.S.)	0.87

U.S. Harvest Formulas	**MT**
OFL = BIOMASS * F_{MSY} * DISTRIBUTION	**154,781**
$ABC_{0.45}$ = BIOMASS * $BUFFER_{0.45}$ * F_{MSY} * DISTRIBUTION	147,935
$ABC_{0.40}$ = BIOMASS * $BUFFER_{0.40}$ * F_{MSY} * DISTRIBUTION	**141,289**
$ABC_{0.30}$ = BIOMASS * $BUFFER_{0.30}$ * F_{MSY} * DISTRIBUTION	128,153
$ABC_{0.20}$ = BIOMASS * $BUFFER_{0.20}$ * F_{MSY} * DISTRIBUTION	114,323
HG = (BIOMASS - CUTOFF) * FRACTION * DISTRIBUTION	**109,409**

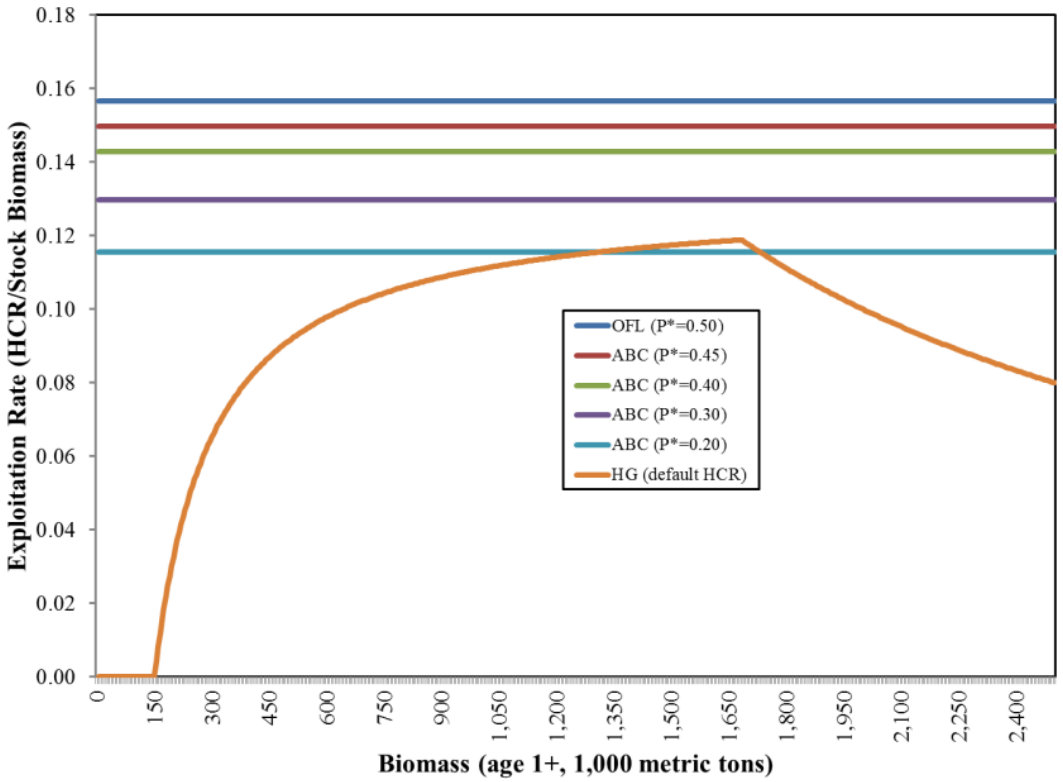


Figure 1. Effective exploitation rates for a range of sardine biomasses based on the U.S. harvest control rules for OFL, ABC, and HG (Table 1 above).

Canada - Jordan Mah (DFO)

For the Department of Fisheries and Oceans (DFO), Canada's broad mandate, consultation and engagement with First Nations, stakeholders and other governments, is critical to its management approach. The Department has a range of legal and policy-based commitments to consult and work collaboratively with First Nations (FN). One of the Department's strategic objectives is improved governance, including shared stewardship and co-management. This includes a greater role for First Nations and stakeholders in policy development and decision-making.

There is no single, agreed-upon definition of co-management. Normally, this refers to a partnership or arrangement where two or more parties share the responsibility and accountability for resource management. DFO is shifting from centralized, "top down" management to a model based on co-management and shared stewardship. This transition is gradually being integrated into our core business and is reflected in key policies and initiatives such as Fisheries Renewal, Wild Salmon Policy (WSP), and Pacific Integrated Commercial Fisheries Initiative (PICFI). Work spans most aspects of our mandate including fisheries management, oceans, habitat, enhancement, and science. Co-management can take many forms and operate at different scales/levels. DFO is current working on a "Co-Management Framework" to engage First Nations / stakeholders and better clarify the Department's approach to co-management. These consultations began in Fall 2011.

Co-management has a range of benefits including better and more informed decisions, increased transparency, improved relationships, and better outcomes for fisheries and the resource. While the aspirations of First Nations and stakeholders regarding co-management and shared stewardship are increasing, building a sustainable co-management takes time and resources. Relationships are essential and the outcome requires a significant commitment from all parties.

The Sustainable Fisheries Framework (SFF) is a toolbox of new and existing DFO policies to support sustainability and industries that rely on healthy fish populations. The aim is to provide planning and operational tools that achieve goals in a clear, predictable, transparent, and inclusive manner. New SFF policies include: Managing the Impacts of Fishing on Sensitive Benthic Areas; New Fisheries for Forage Species; and a Fishery Decision-Making Framework Incorporating the Precautionary Approach.

DFO has taken significant steps toward fisheries co-management in recent years. Such advances are found in the Integrated Fisheries Management Plans (IFMPs) for many fisheries including sardines, advisory bodies or committees for several fisheries, the strengthening of bilateral consultation with First Nations, support for First Nations capacity, and enhanced collaboration on science and stock assessment.

DFO management is directed by an assortment of government acts and agreements. Predominantly this includes the Fisheries Acts and associated regulations: Fishery (General) and

Regulations (authority for conditions of license); Pacific Fishery Regulations (1993) (i.e., licenses, open times); The Aboriginal Communal Fishing License Regulations; British Columbia Sport Fishing Regulations; The Oceans Act (i.e., Marine Protected Areas), court decisions (e.g. *R v. Gladstone* 1996, *R v. Sparrow* 1990); treaty agreements; the International Commitments; Pacific North Coast Integrated Management Areas Initiative; and the Sustainable Fisheries Framework.

Management decisions are based on the best available scientific information. We apply a precautionary approach and take into consideration aboriginal food and social and ceremonial fisheries. We promote economic prosperity, apply an ecosystem approach to fisheries management, apply transparent decision-making measures and foster shared stewardship.

With regard to stock conservation, we aim at only harvesting available biomass on a sustainable basis by applying decision rules. The ecosystem process is aimed to protect the sardine stock and habitat, manage ecosystem impacts, and maintain environmentally sustainable fisheries.

Consultation is an open and transparent process for discussions on harvest management issues. It provides harvest opportunities for all sectors: First Nations priority access for food, social, ceremonial (FSC) purposes, commercial opportunity in a manner that ensures long-term sustainability, recreational harvest, and monitoring fish stocks and fish harvest (monitoring programs, compliance and enforcement).

DFO's consultative role is maintained by a two-step process: (1) bilateral discussions with the First Nations, and (2) the advisement of the Sardine Integrated Advisory Board. Through bilateral discussions with First Nations, DFO determines FSC allocations, including the Aboriginal harvest of herring that occurs coast-wide, and projects are carried out through the agreements between FN and DFO. The Sardine Integrated Advisory Board supports inter-sectoral participation (consensus building among stakeholders) and is structured to achieve transparency, accountability, inclusive representation, and efficiency. The Board provides advice on development of fishing plans (includes harvest levels) and longer-term direction for fisheries, makes recommendations to resolve disputes, and shares fishery information for post-season reviews.

The Pacific Sardine Integrated Fisheries Management Plan (IFMP) provides a planning framework for the use of fisheries resource and the process by how a fishery is managed for a period of time. The guidance document describes the broad context of the fishery, stock assessment, policies, fishery overview, management issues, and performance measures. The document includes appendices with fishing plans by sector and fishery including Aboriginal, recreational, and commercial harvest plans.

The Sardine Management Fishery has developed greatly since its creation. From 1996 to 2001, the limited experimental fishery was established when stock size and production were determined sufficient to support a moderate fishery. From 2003 to 2007, the Department

developed a 3-year fishing plan to allow for the incremental approach to development, consistent with principles of the New Emerging Fisheries Policy. Since 2007, an annual Integrated Fisheries Management Plan (IFMP) has been developed to continue support of the fishery with 50 licences made available. In 2007 there was limited entry for 25 commercial participants. Since 2007, the fishery has remained consistent with New Emerging Fisheries Policy (NEFP) policies and other relevant Departmental policies.

The Fishery's management is based on a co-management structure. This includes the use of Joint Project Agreements (JPA's). JPA's are based on the principle of joint accountability as an agreement between associations representing license holders and the Department. Integrated Fisheries Management Plans (IFMPs) are developed each year with the objective to identify fishery issues/objectives and management measures to ensure an orderly, economically viable, socially/culturally beneficial and sustainable fishery. IFMP's are developed with stakeholder and First Nation input through the Sardine Integrated Advisory Board (SIAB).

The SIAB objectives are to improve decision-making by allowing greater involvement by interested parties and to provide formal advice and make recommendations on operational decisions related to sardine harvest in the Pacific Region. Membership consists of 5 communal commercial representatives and 5 commercial representatives: One commercial organization, three processor/buyer representatives, one First Nations representative, one recreational representative, one conservation representative, and other representatives from the provincial government in a technical capacity. The advisory board meets twice a year, prior to and after the fishing season.

Discussion:

In regards to collaboration with other countries, it appears that Canada plans to maintain their management strategy but is willing to collaborate within the science realm. Possible future scientific exchanges might include salmon, halibut and tuna. Only after the exchange of science might Canada open to collaboration in treaties and commissions. As for now, sardines seem a subject far from such collaboration.

Canadian migration rates are assessed through biomass estimates from a trawl survey divided by the total biomass from the U.S. stock assessment. DFO uses a 3-year average to obtain a stable estimate of migration rate, due to year to year fluctuations. Based on historical catch landings data, the total catch was highly variable. In 2002, when the emerging fishery began, the market still had a low demand for sardines. The sardine quota was provided using the harvest control rule with 10% migration rate. In 2009, with more trawl surveys the regional biomass was estimated from surveys and total biomass from annual coast-wide assessment. Until 2009, these estimates were very conservative, but in 2009 the industry requested harvest advice and wanted a new average/percentage. The estimates of migration rate are currently a running average of three years, but the new harvest control rule takes into account the average of three years and the current biomass estimate. The industry then decides the percentage they need from this allowable catch.

Mexico - Martin Hernandez-Rivas (CICIMAR-IPN)

Mexico plans to have an annual survey to assess sardine biomass (Pacific side of Mexico). Work is underway to develop a new harvest guideline, based on sardine biomass estimates similar to U.S. Biomass estimates and based on data from acoustic- trawl survey and age-structure data. The minimum legal size limit (150mm) may change or be removed depending on re-analysis, fishery, and area.

$$\textbf{HG: TAC} = (B - B_{min}) * \text{Fraction}$$

No temperature parameter will be included in the formula. Fraction may change with improved knowledge. The harvest control rule will be enforced once it becomes a federal law, most likely in Spring 2012. **Note**: the management plan was under revision as of April, 2012 and has not been officially approved.

Discussion:

Two stocks: Gulf and Pacific will be managed separately with two quotas. Commercial harvesting is mostly targeting the summer stock. Industry supports the science stock assessment by providing funding for the survey as in the management plan. The ship platform for survey cruises is the property of the government. Mexico is in the early stages of using the new acoustics equipment. Preliminary results from March 2011 are encouraging. Acoustics/net equipment is similar to that in the U.S.

CONCLUSION

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

In addition to the regular sessions most often utilized in the TSF, including regional Pacific sardine fisheries, research plans and reports (including many contributed papers), and working group discussions, 2012 also saw the introduction of the special session on national management strategies. U.S. and Canadian management of sardine is currently carried out through quota setting on commercial catches based on the harvest guideline. Mexican management, on the other hand, maintains a legal minimum length of 150mm to ensure the stability of the sardine population in Mexico.

2011's focus issue concentrated on the upcoming 2012 coast-wide spring and summer sardine surveys, similar to the measures taken in 2008. While the 2012 spring coast-wide survey will be conducted by the SWFSC and IMECOCAL, the summer coast-wide survey will be synchronized as much as possible between the three countries. Current plans have Canada performing a trawl-acoustic survey in July-August, a U.S. ichthyoplankton-acoustic-trawl survey from San Diego to U.S. Canada border in June-July, an aerial survey off Washington and Oregon and possibly off California, and a Mexico IMECOCAL ichthyoplankton-acoustic-trawl survey in August, 2012. The exchange of trawl-acoustic operation protocols among three countries should enhance the understanding of survey operations and possible differences in data collection. The results of these surveys will further shed more light on Pacific sardines off the west coast of North America in terms of their spatial distribution, biomass, size and age structure, and may elucidate different population stock structures based on morphology, genetics, and microchemistry. It is also hoped that such a comprehensive survey will aid in the discovery of other biological characteristics in the population from Baja California to British Columbia and will investigate linkages to oceanographic and environmental conditions.

The Pacific sardine stock assessment indicates a general decline in the stock productivity since the late-1990s and early 2000s with around 1-million mt. Recruits (age-0) declined from 15 billion fish in 1997-99 to a level of 3 billion fish in fishing year 2008 (July 1, 2008-June 30, 2009), with the strongest 2003 year class of 21 billion fish. The spawning stock biomass has been declining from 1 million mt in early 2000 to 0.7 million mt in the 2011 season. The commercial landings of U.S. peaked at 2007 with 127,788 mt and have been declining since. The total landings in 2011 were 43,695 mt, primarily due to decline of the spawning stock biomass in recent years. The commercial catch off B.C., Canada has been increasing from 1.7 thousand mt in 2000 to 22 thousand mt in 2010. The commercial catch off Ensenada has been stable with annual total catch being around 50 thousand mt (Hill et al. 2011). The harvest guideline (HG) proposed for 2012 (109,409 mt) is lower than the 2007 HG (152,564 mt), but higher than the quota allocated in 2008-2011. Since 2008, the commercial catch of the U.S. fishery has been close to the HG issued under federal management.

The Forum concluded with closing remarks from Dr. Russ Vetter *(SWFSC)* and Dr. Nancy Lo *(SWFSC)*. Beverly Macewicz, SWFSC, gave a short presentation announcing the retirement of Nancy Lo at the end of 2011 after 35 years of service at the SWFSC. Nancy Lo acknowledged the opportunity that TSF provided her to serve on the executive committee from 2005 to the present along with executive committee members Sharon Herzka (Mexico), Robert Emmett (U.S.), and Jake Schweigert (Canada). Nancy Lo encouraged the continuation of open dialogue among all sectors interested in the sustainability of Pacific sardines to prevent the replay of the population collapse in the 1950s. The 2012 Trinational Sardine Forum will be held in Seattle, Washington in late November. Please visit http://swfsc.noaa.gov/tsf.aspx or http://swfsc.noaa.gov for more information. An otolith workshop was held after the forum on December 10th (Appendix V).

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ACRONYMS

CCGS	Canadian Coast Guard Ship
CDFG	California Department of Fish and Game
CIAD	Centro de Investigación en Alimentación y Desarrollo
CICESE	Centro de Investigación Científica y de Educación Superior de Ensenada
CICIMAR-IPN	Centro Interdisciplinario de Ciencias Marinas - Insitio Politecnico National
CIBNOR	Centro de Investigacion biologico del Noroeste
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 (INP)	Instituto Nacional de la Pesca
IPN	Instituto Politécnico Nacional
IVQ	Individual Vessel Quota

NEFP	New Emerging Fisheries Policy
NMFS	National Marine Fisheries Service
NWFSC	Northwest Fisheries Science Center
ODFW	Oregon Department of Fish and Wildlife
PICFI	Pacific Integrated Commercial Fisheries Initiative
PSC	Pacific Seafood Co
SAFS	School of Aquatic and Fishery Sciences, University of Washington
SARDI	South Australia Research and Development Institute
SIO	Scripps Institution of Oceanography, University of California San Diego
SWFSC	Southwest Fisheries Science Center, National Marine Fisheries Service
UBC	University of British Columbia
WDFW	Washington Department of Fish and Wildlife
WSP	Wild Salmon Policy

APPENDIX I

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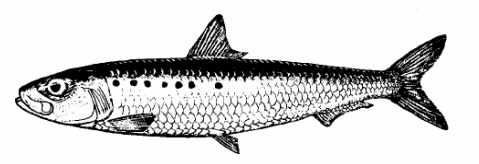
APPENDIX II

ENGLISH AGENDA

12th Annual

TRINATIONAL SARDINE FORUM
FORO TRINACIONAL DE LA SARDINA





2011

PROGRAM

Sumner Auditorium, Scripps Institute of Oceanography

La Jolla, CA, U.S.A.

December 8th and 9th, 2011

http://swfsc.noaa.gov/tsf.aspx

WEDNESDAY, DECEMBER 7th

The Jolla Shores Hotel

18:00-21:00 Informal welcome gathering at the bar of the Shores Restaurant, La Jolla Shores Hotel, La Jolla

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THURSDAY, DECEMBER 8th

Summer Auditorium, Scripps Institution of Oceanography

8:00 Registration

9:00 ***Opening of the Conference***

Welcome- Nancy Lo *(SWFSC)*

9:10 Opening Remarks- Dr. Francisco Werner, Director *(SWFSC)*

9:20 ***Regional Sardine Fisheries Reports (20 minutes each)***

California- Kirk Lynn *(CDFG)*

9:40 Canada- Jordan Mah *(DFO)*

10:00 ***Break***

10:20 Oregon and Washington- Gregory Krutzikowsky (ODFW), Lorna Wargo (WDFW). Dale Sweetnam *(SWFSC)* to present

10:40 Bahía Magdalena- R. Félix-Uraga, F. N. Melo-Barrera, C. Quiñónez -Velázquez, E. Álvarez-Transviña, and R. García-Morales. *(CICIMAR -IPN, La Paz)(COFAA and EDI*)

11:00 Gulf of California and Ensenada- Manuel Nevárez-Martínez *(INAPESCA-CRIP Guaymas)*[*]

11:20 Stock Structure- John Hyde *(SWFSC)*

11:40 Biomass- Nancy Lo *(SWFSC)*

12:00 ***Lunch***

13:30 Stock Assessment- Kevin Hill *(SWFSC)*

13:50 Ecosystem- Andrés M. Cisneros-Montemayor and U. Rashid Sumaila *(UBC)*

14:10 ***Research Plans and Reports***

Biomass

West coast of Vancouver Island 2011 Sardine Trawl Survey and Aerial Survey Trials - Linnea Flostrand, Jake Schweigert, Jackie Detering and Vanessa Hodes *(DFO)*

14:30 Larval abundance of *Sardinops sagax* in the Sebastián Vizcaíno area during 1997-2003 IMECOCAL Cruises - Martín E. Hernández Rivas, Sylvia P. A. Jiménez Rosenberg, Alejandro Hinojosa Medina, Ricardo Saldierna Martínez and Gerardo Aceves Medina *(CICIMAR)*

14:50 A comparison of Pacific sardine (*Sardinops sagax*) abundances estimated using multiple fisheries-independent methods and a stock-synthesis model - David A. Demer, Juan P. Zwolinski, Kyle A. Byers, George R. Cutter Jr., Thomas S. Sessions, and Beverly J. Macewicz *(SWFSC)*

15:10 ***Break***

[*] Unable to attend the Forum

15:30 ***Ecosystem***

Ecosystem-Economic "eco^2" Model of the California Large Current Ecosystem - U. Rashid Sumaila *(UBC),* Andrés M. Cisneros-Montemayor *(UBC),* and Samuel Herrick *(SWFSC)*

15:50 ***Stock Assessment***

Population analysis of coastal pelagic species off the U.S.A. Pacific coast using age-structured statistical catch-at-age/length models - K. T. Hill and P. R. Crone *(SWFSC)*

16:10 The Impact of Spatial Structure Assumptions on Pacific sardine Assessment - Felipe Hurtado-Ferro *(SAFS),* André E. Punt*(SAFS),* and Kevin T. Hill *(NMFS)*

16:30 ***Age Growth***

Age and growth of Pacific sardine in California during a period of stock decline and geographical expansion - Emmanis Dorval *(SWFSC),* Jenny McDaniel *(SWFSC),* and Dianna Porzio *(*CDFG*)*

16:50 Weight of evidence approach to age-determination of sardine (*Sardinops sagax*) off southern Australia - T.M. Ward, A.J. Ivey and P.J. Rogers *(SARDI)*

17:10 ***Adjourn***

18:30 Dinner at the Fish Market restaurant, sponsored by the California Wetfish Producers Association

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FRIDAY, DECEMBER 9th

Sumner Auditorium, Scripps Institution of Oceanography

8:00 ***Research Plans and Reports (continued)***

Age Growth

Age and growth of Pacific sardine off the west coast of Baja, California in 2005 - Y. A. Green-Ruiz *(CRIP, Mazatlán- INAPESCA),* A. Cota-Villavicencio *(CRIP Ensenada-INAPESCA),* E. Cotero-Altamirano *(CRIP Ensenada-INAPESCA),* A. Verde-Hernàndez *(CRIP, Mazatlán- INAPESCA),* and Vianey Ibarra-Abrajan *(Servicio Social FACIMAR-UAS) (not presented)*

8:20 ***Oceanographic Conditions***

Size variability of Pacific sardine *Sardinops sagax* (Jenyns, 1842) and its relationship with the environment in Bahía Magdalena, BCS from 1982 to 2009 - Alvarez-Trasviña, E *(CICIMAR –IPN, La Paz. Becario PIFI-CoNaCyT),* R. Félix-Uraga, C. Quiñonez-Velázquez, and F.N. Melo-Barrera *(CICIMAR –IPN, La Paz. Becarios COFAA and EDI)*

8:40 Pacific sardine abundance and associated oceanographic conditions off northern Oregon and southern Washington in 2011- Robert Emmett (*NWFSC, Hammond),* Marisa Litz (*NWFSC, Newport),* Andrew Claiborne (*NWFSC, Newport),* and Paul Bentley(*NWFSC, Hammond)*

9:00 Interannual and decadal change of spring spawning of sardine in the IMECOCAL area. *Tim Baumgartner (CICESE)*

9:20 ***Stock Structure***

Discrimination of Pacific sardine (*Sardinops sagax*) subpopulations using $\delta^{18}O$ values of otolith cores to calculate larval rearing temperature - Sharon Z. Herzka *(CICESE),* Jorge A. Cerón *(CICESE),* Casimiro Quiñónez- Velázquez *(CICIMAR-IPN),* Paula Pérez Brunius *(CICESE),* and Timothy Baumgartner *(CICESE)*

9:40 Regional differences in Pacific sardine populations determined by otolith morphology - Barbara Javor, *(SWFSC)*

10:00 ***Break***

10:20 ***Special Session: National Management Strategies of Sardine Population-*** Moderator Robert Emmitt. Kevin Hill (SWFSC), Jordan Mah (DFO) and Manuel Nevárez-Martínez *(INPAPESCA-CRIP)*

11:30 ***Focus Issue: 2012 Coast-wide Survey-*** Moderator Russ Vetter. David Demer *(SWFSC),* Jake Schweigert *(DFO)* and Tim Baumgartner *(CICESE)*

12:30 ***Lunch***

13:45 ***Working Group (WG) Breakout Sessions***

WG1. Regional Biomass, Nancy Lo *(SWFSC)*

WG2. Stock Structure, Age Structure, and Adult Sampling, Russ Vetter *(SWFSC)*

WG3. Industry Trends and Issues, Mike Okoniewski *(Pacific Seafood)*

15:00 ***Break***

15:30 ***Plenary Sessions for reporting results of WG discussions***

17:00 ***Closing Remarks***

17:30 ***End of conference***

SATURDAY, DECEMBER 10th

Large Conference Room, SWFSC, 3333 N. Torrey Pines Court

8:00-17:00 ***Sardine Otolith Workshop***

POSTER SESSION ***December 8th & 9th***

Sumner Auditorium, Scripps Institution of Oceanography

Thermoregulation behavior of sardine, S*ardinops sagax caeruleus* (Jenyns, 1842) at different thermal fluctuations - Marcel Martínez Porchas *(CIAD)* and Mónica Hernández Rodríguez *(CICESE)*

Spatial and temporal length distributions off California from Daily Egg Production Method surveys conducted 1986-2011 - Beverly Macewicz, David Griffith, Nancy Lo *(SWFSC)*

Analysis of the potential application of an ecosystem-based management approach to the sardine fishery in the Gulf of California, Mexico – F. Huerta Orozco, G. Ponce Díaz and J. L. Castro Ortiz *(CICIMAR – IPN, La Paz)*

Posters will be displayed around the meeting hall for the duration of the forum.

WORKING GROUPS/CONTRIBUTERS/COMMITTEES

WORKING GROUPS:

The principal goal of the working groups is to promote coast-wide cooperation in producing information needed regarding the biology and dynamics of the population:

WG1. Regional Biomass, *Nancy Lo (SWFSC)*

WG2. Stock Structure, Age Structure, and Adult Sampling, *Russ Vetter (SWFSC)*

WG3. Industry Trends and Issues, *Mike Okoniewski (PSC)*

CONTRIBUTORS:

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Dr. Sharon Herzka (CICESE)
Dr. Timothy Baumgartner (CICESE)
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Stephanie Schott (SWFSC)
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EXECUTIVE COMMITTEE:
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Dr. Jake Schweigert (DFO)

APPENDIX III

CONTRIBUTED ABSTRACTS AND SUMMARIES

ORAL PRESENTATIONS

(In order of presentation)

WEST COAST OF VANCOUVER ISLAND 2011 SARDINE TRAWL SURVEY AND AERIAL SURVEY TRIALS

Linnea Flostrand[1], Jake Schweigert[1], Jackie Detering[1], and Vanessa Hodes[2]

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[2] Department of Fisheries and Oceans, Canada

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Summer surveys directed at collecting information on sardines off the WCVI started in 1997. Fishing is conducted in surface waters ($\leq$ 30 m) using a mid-water trawl towed at average speeds approximating 4-5 knots. Since 2006, sampling has been conducted at night. In 2011, the locations of stations were identified prior to the survey by randomly selecting sites along a 10x 10 km grid representing approximately equal sampling intensity in zonal divisions of the region. A total of 68 trawl tows representing an area of approximately 16,740 km^2 were sampled. Forty-one of the 68 tows collected sardines and positive sardine trawl catches were scattered throughout most of the region. Preliminary mean estimates of biomass for the region, depending on methods of zonal stratification, range from 143,000-151,000 metric tons, which is approximately twice the amount estimated for the region from the 2010 survey. Biomass estimates are based on extrapolating the average catch density (t/km^3) by stratum over an estimate of the stratum's spatial size (km^3) and then summing across strata. Most sardines ranged in fork length from 23-28 cm, with a prominent mode and average length ~ 24cm and average sardine weights by sample varied from 163-182 g.

In 2011, aerial survey trials were conducted over marine waters of the WCVI and Central Coast regions of British Columbia using a system called CASI (Compact Airborne Spectrographic Imager). Trials were coordinated by a technical team from ASL Environmental

Sciences Inc. and approximately 12 hours of continuous. CASI data were collected over two survey days in late July. Due to cloud cover, survey altitudes were frequently relatively low (1000-1500 feet), resulting in relatively narrow fields of view. In addition to the CASI records, digital photographs were collected approximately every 8 seconds. Survey efforts initially focused on ground-trothing observations where sardine schools were known to occur in order to calibrate equipment settings. The CASI approach is a novel approach for surveying sardine in British Columbia waters. The data collected from the CASI system have yet to be analyzed and the feasibility of conducting aerial surveys in British Columbia requires further evaluation.

LARVAL ABUNDANCE OF *Sardinops sagax* IN SEBATIAN VIZCAÍNO AREA DURING 1997-2003 IMECOCAL CRUISES.

Authors: Martín E. Hernández Rivas, Sylvia P. A. Jiménez Rosenberg, Alejandro Hinojosa Medina, Ricardo Saldierna Martínez y Gerardo Aceves Medina.

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Sebastian Vizcaino bay has been traditionally considered the center of spawning for Pacific sardine (*Sardinops sagax)*, several papers reported this area, as the major spawning ground during the low abundance periods and this shift to central California during high abundance periods.

In order to establish if the three stocks (c.f. Félix-Uraga) spawn in Punta Eugenia vicinity, we analyzed the larval abundance of Pacific sardine in an area of 35,678 km^2, Vizcaino priority region for conservation.

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

The tendency of the cold stock is to diminish while the temperate stock seems to be increasing from 2002 to 2003 period, following the tendency of SST.

Finally we calculated the larval index of sardine larvae by cruise, in same area.

A COMPARISON OF PACIFIC SARDINE (*Sardinops sagax*) ABUNDANCES ESTIMATED USING MULTIPLE FISHERIES INDEPENDENT METHODS AND A STOCK SYNTHESIS MODEL

David A. Demer, Juan P. Zwolinski, Kyle A. Byers, George R. Cutter Jr., Thomas S. Sessions, and Beverly J. Macewicz

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The abundances and distributions of the 'northern' stock of Pacific sardine (Sardinops sagax) in the California Current have been surveyed by the Southwest Fisheries Science Center during spring 2006, 2008, 2010, and 2011, and summer 2008, using acoustic-trawl (ATM) and Daily Egg Production (DEPM) methods. During summer 2009, 2010, and 2011, the fishing industry sponsored surveys of the stock using an aerial-photogrammetric method (APM). Here, the methods and results from the 2011 ATM survey are documented; and the six-year time series of ATM-estimated sardine abundance is compared to estimates from the DEPM and APM surveys. These fisheries-independent estimates are also compared to results from the stock-synthesis assessment model which incorporates information from the APM and DEPM method surveys, and fishery-landing data. Comparisons among the estimates and similarities in the apparent stock trajectory are discussed.

ECOSYSTEM-ECONOMIC "eco^2" MODEL OF THE CALIFORNIA LARGE CURRENT ECOSYSTEM

U. Rashid Sumaila[1], Andrés M. Cisneros-Montemayor[1] and Samuel Herrick[2]

1. University of British Columbia
2. Southwest Fisheries Science Center

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First, we build on our presentation on the BC Shelf part of the California Current Large Marine Ecosystem (CCLME) to extend the modeling work to the whole of the CCLME. This ecosystem-wide model will be used to investigate the multispecies issues related to the role sardine plays as forage in the CCLME. In this portion of the talk, we will focus on the data needs, both ecological (e.g., landings and biomass estimates) and economic (e.g., price, discount rates and cost of fishing) for not only sardine but other important species of the CCLME. The second part of the talk incorporates available data to present preliminary estimates of market or use values from the California Current Large Marine Ecosystem.

POPULATION ANALYSIS OF COASTAL PELAGIC SPECIES OFF THE U.S.A. PACIFIC COAST USING AGE-STRUCTURED STATISTICAL CATCH AT AGE/LENGTH MODELS

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Historically, Pacific sardine and Pacific mackerel inhabiting the California Current ecosystem represent two coastal pelagic species that have supported both commercial and recreational fisheries along the U.S.A. Pacific coast over an extended timeframe. These species generally represent transboundary stocks to some degree, with distribution extending south into waters off Mexico and north along the coast of Canada in any given year depending on oceanographic conditions. Management of these fisheries over the last several years has been based largely on results generated from formal, peer-reviewed stock assessments using a model framework that allows full integration of population size and age structure and auxiliary indices of abundance, with explicit parameterization both spatially and temporally. The *Stock Synthesis* modeling platform incorporates all relevant sources of variability and estimates goodness of fit in terms of the original data, allowing for final estimates of precision that accurately reflect uncertainty associated with the varied sources of data used as input in the development of the overall model. The current assessments include a broad range of data sources from the respective countries based on availability, including: catch time series; length and age distribution time series; and survey and fishery based indices of abundance. Pertinent areas of model development are discussed here, including initial baseline assumptions, treatment of input data, and parameterization issues regarding influential biological/fishery/survey processes (e.g., growth, selectivity, and catchability). Finally, we present newly adopted management requirements and legal mandates associated with stock status (quota) determinations for U.S.A. fisheries.

THE IMPACT OF SPATIAL STRUCTURE ASSUMPTIONS ON PACIFIC SARDINE ASSESSMENT

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The conventional model of the dynamics of the northern subpopulation of Pacific sardine (*Sardinops sagax caerulea*) is that it concentrates in a "core" area off southern California and northern Mexico during periods of low abundance, but expands its range to the north during periods of high abundance. The 2009 and 2010 assessments, conducted using the Stock Synthesis 3 (SS3) framework, use this model and assume a spatially-aggregated stock with constant growth across the entire coast and fleets with different selection patterns in the four areas included in the assessment (Ensenada, southern CA, northern CA and Pacific Northwest). However, seasonal length-dependent migration has been described in the literature, as well as the possible presence of two stocks, rather than one.

We use a simulation-based approach using an operating model including several hypothetical scenarios of spatial structure and seasonal movement, on which the performance of SS3 is evaluated to determine (1) how much error can arise because assessments of sardine are conducted using a spatially-aggregated stock assessment method when this assumption is violated, and (2) whether moving to a spatially-structured stock assessment could reduce this error. Specifically, our model considers the impact of (a) the presence of a southern (Mexican) subpopulation in the area in which the northern subpopulation is usually found, (b) movement of sardine between southern California and the Pacific Northwest, and (c) the occasional persistent presence in the Pacific Northwest of Pacific sardine, on the performance of SS3. The focus of this presentation will be on the initial results of the project.

AGE AND GROWTH OF PACIFIC SARDINE IN CALIFORINIA DURING A PERIOD OF STOCK DECLINE AND GEOGRAPHICAL EXPANSION

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The northern Pacific sardine (*Sardinops sagax*) stock ranges from northern Baja California (Mexico) to British Columbia (Canada), but the core spawning area of this stock is located off California. The stock is fully exploited throughout its range, with the Ensenada (Mexico) and California fisheries targeting smaller and younger fish (0-4 years old) and the Pacific Northwest fishery exploiting larger and older fish (4-8 years old). During the last decade the spawning stock steadily declined from a peak of 1,307,800 mt in 2000 to a low of 376,250 mt in 2010. This period of stock decline coincided with the expansion of the range of the population from California to the Pacific Northwest. Although a previous study estimated growth rate for Californian sardine collected during the mid-1990s, to our knowledge no studies have determined whether the decline in abundance and the northward migration have impacted growth processes within the California spawning stock. In this study we used the von Bertalanffy growth equation to model growth of sardines collected during the Southwest Fishery Science Center April DEPM (i.e., Daily Egg Production Method) surveys from 2004 to 2010. As Pacific sardine were aged by multiple readers, we developed mixed-effect models to account for age-reader effect on the estimation of the three parameters (*i.e.*, k, L_∞, t_0) of the growth equation. We used the parameter k-values to compare growth rate of cohorts that were born in the 1996-2002 and the 2004-2008 time periods. Preliminary results showed that there was no significant difference between growth rate of the 1994-2002 cohorts (k=0.25) and the 2003-2008 cohorts (k=0.28), suggesting no density dependence effects on growth. However, these rates were much slower than the growth rate previously estimated for fish collected in the mid-1990s (i.e., k = 1.19) a period when the sardine population was still recovering from the 1940s' collapse. We will discuss the implications of our results for modeling growth and understanding the impact of abundance and movement on the age structure and growth within the California spawning stock.

WEIGHT OF EVIDENCE APPROACH TO AGE-DETERMINATION OF SARDINE (*Sardinops sagax*) OFF SOURTHERN AUSTRALIA

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Annual growth increments in the otoliths of many pelagic fishes are difficult to read, perhaps because their high mobility results in them moving quickly between water bodies of different temperatures, which may confound the effects of seasonal changes in water temperature on metabolic processes and patterns of calcium carbonate deposition. Annuli in the sagittal otoliths of ~13,000 adult sardines from South Australia were examined by two readers and assigned readabilities ranging from 1-5, with 1 rated as excellent and 5 unreadable. Less than 20% of otoliths were rated as having readabilities of 1 or 2 (good). Estimates of average percentage error (APE) were high (11.37%). Readabilities decreased and APE increased with fish age. Relatively few reliable estimates of fish age were obtained for older fish. Age structures developed from fish that could be aged reliably were strongly biased towards younger fish. To address these high levels of imprecision and potential bias, we used a weight of evidence approach to develop a method for estimating the age of sardines from commercial catches and research surveys. The age of larvae and juveniles were determined by counting daily increments in sagittae. Interpretation of daily increments became increasingly difficult beyond the age of 150 days, due to narrowing and reduced clarity of increments near the outer edge. Estimates of the age of older juveniles may be negatively biased. Otoliths from adults were weighed (nearest 0.0001 g). Correlations between age estimates and measures of otolith weight were strongest for otoliths with high readability and lowest for otoliths that were difficult to read. These results suggest that much of the variability in the relationships between age and otolith weight resulted from errors in determining the number of annuli rather than errors in measuring the weight of otoliths. Regressions of otolith weight–age from otoliths with high readabilities were used to estimate the age of fish with readabilities of 3 or more. Fish in commercial catches taken from inshore waters, mainly southern Spencer Gulf, were generally younger than those taken in research samples obtained further offshore. Growth rates of larvae, juveniles and adults off South Australia are higher than those observed in oligotrophic waters found in other parts of Australia, where there are no large upwelling systems, and at the lower end of rates observed in the

productive boundary current systems off southern California and South Africa. Estimates of spawning biomass obtained using an age structured population model suggest that model are sensitive to errors estimates of sardine age. We are currently investigating both alternative methods for estimating the age of sardine and the benefits of using statistical methods (mixture analysis) to infer age structures from otolith measurements.

AGE AND GROWTH OF PACIFIC SARDINE OFF THE WEST COAST OF BAJA CALIFORNIA IN 2005 (not presented)

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In the northwest of Mexico one of the most important fisheries is that of small pelagics, with 64,414 ton in 2005, in which Pacific sardine (*Sardinops sagax*) are a major component (88%). In order to increase knowledge of this species and have benchmarks of population behavior useful as indicators in the management of the fishery, a study of age and growth was performed based on the analysis of otoliths of Pacific sardine captured by the commercial fleet on the west coast of Baja California in 2005. Of 383 sardines, 54% were female, 46% were males. Age-length data were analyzed on the population level. The minimum size in the sample was 141 mm and maximum was 216 mm. We identified 5 age groups (1 to 5): Age group 2 was dominant, with 52% of total, followed by groups 1 and 3. With this research updating the database INAPESCA of length and age composition of the sardine fishery of the west coast of Baja California, which have a direct application to age-structured models used to estimate the abundance of sardine in this area.

SIZE VARIABILITY OF PACIFIC SARDINE *Sardinops sagax* (Jenyns, 1842) AND ITS RELATIONSHIP WITH THE ENVIRONMENT IN BAHÍA MAGDALENA, BCS FROM 1982 TO 2009

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It is well established that environmental factors influence the development of organisms and in particular that the temperature causes changes in growth in response to ambient pressure on the metabolism. This has been verified by comparing temporal and spatial changes in length at age, identifying differences in the ontogenetic growth pattern. The present work assesses inter-annual variability of the average standard length (SL) on age-1 group fish caught in Bahía Magdalena, BCS, relative to the environment [Sea Surface Temperature (SST), Level Sea and the Pacific Decadal Oscillation (PDO)], during 1982 to 2009. The biological material is the result of monthly sampling of commercial catch, registering a total of 15.704 organisms with sizes between 105 and 225 mm SL and 0 to 8 years old. Significant differences in size structure between the sexes (P> 0.05) were not detected. Multiple regression analysis between the annual averages SL on environmental variables throughout the study period did not show any significant relationship. However, we identified three periods in which the annual changes of SL were negatively associated with the environment (P <0.05): a) from 1982 to 1995 with the sea level, b) 1996-2000 with the SST, and c) 2001 -2009 with the SST and sea level. Supported by evidence of the seasonal presence of two stocks of sardine in Bahía Magdalena (temperate and warm stocks) with different size structure, we analyzed the inter-annual variability of the average SL by stock in relation to environmental variables lagged one year. The SL of individuals of temperate stock was calculated using only the organisms captured from May to June of year **t** and was related with the environmental variables of the year **t-1** from January to June. For the warm stock, the SL was estimated using size data from November to January of year **t**, and related to environmental variables from July to December of year **t-1**. Multiple regression analysis for the warm stock identified a significant relationship between the annual average SL on sea level (P <0.05); while the inter-annual changes of SL of the temperate stock was significantly related on the sea level and the PDO (P <0.05). The results support the seasonal presence of two sardine stock in Magdalena Bay, which respond, for its latitudinal distribution, at sea level (warm stock) and the decadal oscillation (temperate stock).

PACIFIC SARDINE ABUNDANCE AND ASSOCIATED OCEANOGRAPHIC CONDITIONS OFF NORTHERN OREGON AND SOUTHERN WASHINGTON IN 2011

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We have conducted two surface trawl/oceanographic surveys off Oregon/Washington since 1998 and one in purse seine survey in the Columbia River estuary that collect juvenile and adult sardines. While one survey has reduced coverage because of vessel availability, the other has maintained its overall effort. However, the Predator Survey, which has been conducted data annually since 1998, had severely reduced sampling because of charter vessel availability. . However, our surveys do provide information on relative abundance, arrival to the area, size and oceanographic conditions. Preliminary data indicate that sardine did not successfully spawned and recruit off the Pacific Northwest in 2011. No 0-age sardines were observed in any of our surveys in 2011. However 1-year-old sardines were captured in the Columbia River estuary. Oceanographic conditions continue to be cool (e.g., La Niña is expected in 2012) and appear to be unfavorable for successful sardine recruitment. However how this recent recruitment failure in the Northwest will influence overall adult sardine abundance is presently uncertain.

INTERANNUAL AND DECADAL CHANGE OF SPRING SPAWNING OF SARDINE IN THE IMECOCAL AREA

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IMECOCAL (Investigaciones Mexicanas de la Corriente de California) is an interdisciplinary research program, begun in October, 1997, to regularly monitor ecosystem conditions in the southern region of the California Current system off Baja California. The sample design is based on the original CalCOFI grid extending from line 97 to line 137, and cruises are coordinated with CalCOFI to the degree permitted by ship scheduling. A CUFES system (Continuous Underway Fish Egg Sampler) was incorporated into the IMECOCAL quarterly surveys in January, 2000, to assess distribution and concentrations of coastal pelagic fish eggs over the sampling region in relation to conditions of the pelagic habitat.

We present here the results from the CUFES surveys made during the Springtime cruises (centered on month of April) that are currently available for the period of 2000-2010. Results are presented as a series of total egg numbers encountered in each survey over the IMECOCAL region for Pacific sardine (*Sardinops sagax*), northern anchovy (*Engraulis mordax*) and Jack mackerel (*Trachurus symmetricus*). Each of these series varies over a range of three orders of magnitude, with significant interannual change in the earlier years (2000-2004). An abrupt shift to minimal values for all three species occurred in 2005, with low to moderate values for all three species persisting after 2005 without recovery to the higher values found during the early years of the series. Investigation of the strong interannual change in the period 2000-2004 indicate that the patterns in abundance and distribution of the three species over these years are consistent with the transition from La Niña to El Niño conditions that occurred between 2002 and 2003. However the cause of the decadal scale shift to lower values of egg numbers exhibited by all three species in the period 2005-2010 cannot be readily explained with the data available describing the overall ecosystem conditions. We discuss the possibility that this tendency to generally lower concentrations of eggs for all three species after 2004 may be associated with an apparent trend to earlier spawning in the California Current system in relation to the fixed IMECOCAL cruise dates.

DISCRIMINATION OF PACIFIC SARDINE (*Sardinops sagax*) SUBPOPULATIONS USING $\delta^{18}O$ VALUES OF OTOLITH CORES TO CALCULATE LARVAL REARING TEMPERATURE

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The implementation of management strategies for marine fishes relies on the identification of subpopulations as well as the characterization of their spatial and temporal distribution relative to environmental conditions. In the Pacific off North America, there are currently three spawning subpopulations of Pacific sardines (*Sardinops sagax caeruleus*). The spawning center of the northern (or cold) subpopulation is located off southern California and occurs in the spring at sea surface temperatures (SST) of 12-16°C. Spawning can also extend northward of Washington and Oregon. Spawning of the southern (or temperate) subpopulation can take place between spring and fall off central Baja California at SST of 17-22°C. Peak spawning also occurs in the Bahía Magdalena region in the winter and there is less intense spawning during the summer at SSTs > 23 °C.

The oxygen isotopic composition ($\delta^{18}O$) of the otolith carbonate of marine fishes has been successfully used as a natural tracer of stock structure and natal origin, as well as to reconstruct thermal history of individuals and infer migration patterns. Otolith $\delta^{18}O$ values permanently record the temperature and salinity under which the carbonate precipitated. The otoliths of individuals that have grown in waters with different temperature and/or salinity regimes can thus exhibit differing isotopic values. Further, if the isotopic composition of the water (δ_w) in a given area is known or can be estimated based on salinity, $\delta^{18}O$ values can be used to estimate the temperature of carbonate precipitation.

Our objective is to reconstruct the temperature to which individual sardines were exposed to during the larval and early juvenile period by subsampling carbonate extracted from otolith cores. We hypothesize that back-calculated temperatures derived from $\delta^{18}O$ values should reflect the rearing temperature of individual Pacific sardines and can therefore be used to discriminate among spawning populations and infer mixing based on adult sampling.

Sardines were sampled biweekly from the fishery operating off Ensenada, Baja California, between February 2008 and March 2009. For isotopic analysis, we selected sardines collected in late winter and early spring (February, March and April) and fall (September and October). Ages were estimated by counting seasonal growth rings. The sardines analyzed ranged from age 0 to age 4. Carbonate subsamples were extracted from the otolith core using a New Wave Micromill. Based on daily ring width measurements, the extracted carbonate cores integrate 50-70 days of the larval and juvenile early period.

There was wide variability in the values of $\delta^{18}O$ otolith cores, which is consistent with previous results obtained from whole-otolith isotopic analysis. However, sardines collected in late winter and spring had twice the range in isotopic values (-1.5 to 0.2‰) than those from the fall (-0.7 to 0.2‰). Because $\delta^{18}O$ values are negatively correlated with temperature, sardines collected in the fall were reared at lower temperatures. Preliminary estimates of each individual's rearing temperature were calculated using an assumed but representative δ_w. Rearing temperature estimates ranged from 12-21°C from sardines collected in February through April, which is consistent with the range of spawning temperatures of the cold and temperate subpopulations and could indicate mixing. In contrast, the rearing temperature of sardines collected in September and October was 13-17°C, which is consistent with the spawning temperature range of the cold subpopulation. Finally, back-calculated temperatures were compared with mean satellite-derived SST to evaluate the extent of potential spawning areas.

REGIONAL DIFFERENCES IN PACIFIC SARDINE POPULATIONS DETERMINED BY OTOLITH MORPHOLOGY

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Assessment of morphological features of otoliths from Pacific sardine captured nearshore between 1991 and 2007 revealed regional differences in recruits (age-0 to age-2) from northern California (Monterey), southern California (San Diego), northern Baja California (Ensenada), and southern Baja California (Bahía Magdalena and the Gulf of California). Beginning in mid-2008, sardine otoliths from San Diego have persistently demonstrated morphological features of southern Baja California fish captured in previous years, while Monterey sardine otoliths have changed to appear more like San Diego otoliths from previous years. One possible explanation could be a large cohort of mature sardine from Baja California joined the offshore seasonal migration to higher latitudes beginning in 2006 and 2007, but only returned as far south as the central and southern California spawning grounds where their offspring recruited to both Monterey and San Diego. The data suggest temperature plays a role in otolith morphology. The recent northward regional shift in morphotypes of San Diego and Monterey otoliths suggests a genetic component may also exist. Identification and interpretations of such regional population shifts can best be ascertained by cooperative sharing of data and collections between U.S. and Mexican fisheries.

APPENDIX IV

CONTRIBUTED ABSTRACTS AND SUMMARIES

POSTER PRESENTATIONS

(In alphabetical order)

Spatial and temporal length distributions off California from Daily Egg Production Method surveys conducted 1986-2011.

Beverly Macewicz, David Griffith, Nancy Lo

NOAA-NMFS-Southwest Fisheries Science Center

Pacific sardine (*Sardinops sagax*) spawning biomass has been assessed using data from daily egg production method (DEPM) research surveys since 1986. Although eggs and larvae were sampled during 1986-1988 and 1994-2011 to estimate daily and total egg production, adults were collected, adult parameters calculated and spawning biomass was estimated in 1986-1988, 1994, 1997, 2002, and 2004-2011 (Table 1). All surveys collected sardines off California within the standard DEPM survey area. The standard DEPM area extends from CalCOFI line 95 (near San Diego) to CalCOFI line 60 (just north of San Francisco). A few DEPM surveys extended south into Mexico (in 1994) or north to Canada (in 2006, 2008, 2010, and 2011). We examined egg and trawl locations and sardine standard length distributions (SL in mm) (Figure 2 and 3). On closer examination of eight consecutive surveys (2004-2011) in the standard DEPM area we found a significant number of smaller sardines in the 2005, 2006, 2007, and 2011 surveys, an indication that some recruitment occurred. We found few small sardines during 2008-2010 coupled with decreasing biomass

Thermoregulation behavior of sardine sacific, S*ardinops sagax caeruleus* (Jenyns, 1842) at different thermal fluctuations

Marcel Martínez Porchas[1] and Mónica Hernández Rodríguez[2]

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The aim of this experiment was to evaluate the effect of thermal fluctuations on thermoregulation behavior of *Sardinops sagax caeruleus*. Sardines were captured at Ensenada Bay during the fall of 2007-2008 and exposed for 20 days to a symmetrical winter cycle (S-WC) with a daily thermal fluctuation from 13 to 18 °C, the period of permanence at the highest and lowest temperature was 7 hours. Another group of organisms was exposed to a symmetric summer cycle (S-SC) with a fluctuation of 18-23 °C. Other sardines were exposed to two asymmetric cycles of winter and summer (A-WC and A-SC) in which the lowest and highest temperature remained constant during 10 and 4h respectively (10-5-4-5). None of the treatments had an effect on thermal preference of the sardines (≈18 °C). Neither the type of cycle (S or A) had an influence on their thermal limits; however, thermal fluctuation of the cycles (summer or winter) had an effect on the displacement of these limits. The intervals of thermal preference, delimited by the avoidance temperatures were: 13.5-19.6 °C and 16.1-22.5 °C for the cycles of W and S respectively. The tolerance intervals, delimited by the incipient lethal temperatures (LT_{50}) were 6.1-24.3 °C and 7.5-25.6 °C for W and S respectively. The intervals of resistance, delimited by the critical temperatures were 5.5-30.5 °C y 6.6-32.2 °C respectively. With base on these results, it can be concluded that the studied sardines are able to modify their thermal preference within an interval of 13.5-22.5 °C and are vulnerable to higher temperatures, considering that they avoided incursions in temperatures higher than 23 °C. This work is part of a project financed by Mexico's

Analysis of the potential application of approach Ecosystem based Management to the sardine fishery in the Gulf of California, Mexico

Huerta Orozco F., Ponce Díaz G. and Castro Ortiz J. L.

Centro Interdisciplinario de Ciencias marinas – IPN, Departamento de Pesquerías y Biología Marina. La paz Baja California Sur

Current trends in the Ecosystem-Based Fisheries management is focused on management decisions that bearing in mind the functionality of the ecosystem, being an integral part the target species. The sardine industry in the Gulf of California conducts its economic activities in the framework of regulations that seek to reconcile conservation and exploitation of commercial species, maximizing economic benefits, but until now the criteria are not explicitly considered the ecosystem approach. The aim of this paper is analyze the probability of introduce in sardine fishery the Ecosystem-Based Management, as well as the elements are taken into consideration. The "*legal framework*" of fishery was analyzed, considering on the application of the Ecosystem Approach, as well as the available information. We are considered the Principle Two of the "*Marine Stewardship Council"*. Indicating that although not adopted this approach in the management of the fishery, seems to meet the criteria of the Certification Process, showing that the bycatch is less than 1%, and although the area fleet operation overlaps with the distribution of some protected species, the operation of the fleet avoids negative interactions with them. As part of the analysis was explored the perceptions of players on the status of fishery, taking into account their points of view as experts through an assessment tool of the "*Seafood Watch*", was applied to the government, productive, academic and conservation sectors, and the results of evaluation, concluding that the sardine fishery is sustainable according Seafood Watch indicators. Cluster analysis allowing U.S. to identify that the academia and government obtained a higher similarity (0.95) in their responses.

APPENDIX V

OTOLITH WORKSHOP

December 10, 2011

Workshop title: Trinational Sardine Forum Otolith Workshop

Location: Large Conference Room, Southwest Fisheries Science Center (Torrey Pines Laboratory), La Jolla, CA, U.S.A.

Conveners: J. D. McDaniel, P. R. Crone, and E. Dorval

Participants: 23 participants from the following institutions/agencies:

- California Department of Fish and Game (CDFG, U.S.A.)
- Centro de Investigación Científica y de Educación Superior de Ensenada, Baja California (CICESE, Mexico)
- Centro Interdisciplinario de Ciencias Marinas (CICIMAR, Mexico)
- Department of Fisheries and Oceans (DFO, Canada)
- Scripps Institution of Oceanography (SIO, U.S.A.)
- South Australian Research & Development Institute, Aquatic Sciences (SARDI, Australia)
- Southwest Fisheries Science Center (SWFSC, U.S.A.)

Agenda:	Saturday, December 10, 2011
09:00-09:10	Welcome (Paul Crone –SWFSC)
09:10-09:20	Report on Pacific sardine Otolith Workshop 2010 (Paul Crone - SWFSC)
09:20-12:00	Lab introductions
12:00-13:00	Lunch
13:00-15:00	Ageing session
15:00-15:10	Break
15:10-16:00	Ageing session wrap up
16:10-17:00	Discussion and summary
17:00	Adjournment

Background:

The TSF's Pacific Sardine Otolith Workshop was held on Saturday, December 10, 2011 at the Southwest Fisheries Science Center (SWFSC-TPC/NOAA/NMFS) in La Jolla, CA, U.S.A. The Workshop included scientists representing sardine age and growth laboratories in the United States, Mexico, Canada, and Australia.

The primary objectives of this Workshop were to: (1) welcome Canada researchers to the Workshop as formal members, as well as recognize participation from Australia; (2) review the *Report of Pacific sardine Otolith Workshop* held on June 7-8, 2010 at the SWFSC-TPC; (3) present updated age/growth information and related research efforts by country; (4) conduct a working session that focuses on current sardine ageing methods and standardization between laboratories; (5) establish an ongoing sample exchange program between ageing laboratories; and (6) establish a Steering Committee charged with further developing the Workshop, i.e., structured along the lines of a technical Working Group, as included in most formal international fishery forums.

Summary:

The Workshop day was divided into two sessions, including presentations in the morning and the working session in the afternoon (see Agenda above). During the morning session, researchers from each country made brief presentations regarding their respective ageing (Pacific sardine and other coastal pelagic species) laboratory's objectives, methods, results, etc. The afternoon was used to conduct the working session, which incorporated a tractable experimental design for focusing on particular areas involved in the overall ageing preparation/analysis that warrant further clarification and standardization (e.g., identification of first annulus, edge classification, otoliths preparation, etc.).

During the Workshop, DFO, SWFSC, CICESE, CICIMAR, and CDFG submitted 5-10 sardine otoliths pairs (collected in their research/fishery region) for inclusion in the overall sample used in the working session. A total of 35 otolith pairs composed the sample analyzed during the afternoon period. Otolith pairs were distributed among 5 age-reading stations, with each station containing at least one pair from each research/fishery region or laboratory. Whole otoliths were prepared and analyzed following Yaremko (1996), while polished otoliths were analyzed using methods described by McFarlane et al. (2010). Finally, given time constraints, Conveners recommended that each laboratory strive to analyze all specimens from at least two stations. Finally, results from statistical analyses of the working session data set will be presented in the forthcoming Workshop (2011) report.

Actual discussion time was limited and thus, concentrated on priorities for the current year, including establishing an appropriate Working Group title, appointing a Steering Committee, and coordinating otolith exchanges. It was agreed that the Steering Committee should include one member per research laboratory. The following scientists were nominated and accepted to be members of the Committee: Jenny McDaniel (SWFSC, U.S.A.); Vanessa Hodes (DFO, Canada), Roberto Felix Uraga (CICIMAR, Mexico), and Dianna Porzio (CDFG, U.S.A.). Finally, in absence, Manuel Nevárez Martinez was nominated as the Instituto Nacional de Pesca (INAPESCA, Mexico) member and Sandra Rosenfield as the representative from the Washington Department of Fish and Wildlife (WDFW, U.S.A.). Nominated candidates unable to attend the Workshop will be contacted by the Steering Committee so that their nomination can be confirmed or alternative nominees can be recommended.

After considerable discussion, a name for the Working Group was not adopted. However, many agreed that, in the interim, the Small Pelagic Ageing Research Cooperative (SPARC) is an appropriate 'placeholder' title, given that The Working Group: (1) may extend its research work to include other small pelagic fish species; (2) may expand further and formally include researchers from other countries, as well as include informal participation from international colleagues in any given year; (3) meets or communicates regularly, establishes timely research projects, and provides technical consultation to management bodies.

Initial steps for the newly appointed SPARC Steering Committee will be to outline a research design for exchanging otoliths among laboratories and to coordinate the next Workshop (i.e., Working Group meeting), tentatively scheduled along with the next TSF (Seattle, WA in late 2012).

References:

McFarlane, G., J. Schweigert , V. Hodes, and J. Detering . 2010. Preliminary study on the use of polished otoliths in the age determination of Pacific sardine (Sardinops sagax) in British Columbia waters. Calif. Coop. Oceanic Fish. Invest. Rep.51:162–168.

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