MINUTES OF THE 2005 TRINATIONAL SARDINE FORUM

Ensenada, Baja California, México
November 14-15, 2005

Nancy C. H. Lo[1], Anne C. Allen[1], and Sharon Z. Herzka[2]

[1]Southwest Fisheries Science Center
8604 La Jolla Shores Drive
La Jolla, CA 92037
United States of America

[2]Departamento de Oceanografía Biológica
Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE)
Km 107 Carretera Tijuana-Ensenada
Ensenada, Baja California, México 22860

JUNE 2006

ADMINISTRATIVE REPORT LJ-06-

TABLE OF CONTENTS

INTRODUCTION 1

PLENARY SESSION HIGHLIGHTS
Regional Sardine Fisheries Reports
México
Gulf of California.....3
Bahía Magdalena 3
Ensenada 4
United States
California 4
Northwest.....5
Canada
British Columbia.....6

Introduction to Working Group 3: Industry trends and issues.....7

Focus Issue: 2006 Coast-wide survey.....9

WORKING GROUP REPORTS
WG 1: Regional Biomass.....13
WG 2: Stock structure, age structure and adult sampling.....39
WG 3: Industry trends and issues 40

CONCLUSIONS.....43

ACKNOWLEDGEMENTS.....44

REFERENCES 45

APPENDICES
Appendix I: List of Participants 46
Appendix II: English and Spanish Agendas.....51
Appendix III: Contributed Abstracts and Summaries.....67
Appendix IV: Spawning biomass estimates for the Pacific sardine (*Sardinops sagax caeruleus*) off Baja California, México, during April, 2002 and April, 2003.....97

INTRODUCTION

The 6th Trinational Sardine Forum (TSF) was held in Ensenada, Baja California, México, on November 14-15, 2005. The meeting took place at the Salón Casino, Centro Social, Cívico y Cultural Riviera (Riviera Social, Civic and Cultural Center) and at the Hotel Cortez, and was attended by 83 participants representing the fishing industry, scientists, governments, and academia from Canada, México, and the United States (Appendix I). Special thanks go to those individuals who helped with the local logistics, particularly Sharon Herzka, Orlando Amoroso, and Lic. Martín Gutiérrez. We also thank Quim.César Mancillas Amador, Municipal President of Ensenada, Dr. Federico Graef Ziehl, Director of the Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE), Dr. Axayáctl Rocha, Head of CICESE's Department of Biological Oceanography, Dr. Tim Baumgartner of CICESE and IAI-EPCOR, and Mr. Orlando Amoroso, SPPSOA, who provided the financial aid to make this Forum possible.

The Forum was inaugurated by City Council Member Ing. Nélida Pelayo Ponce, Coordinator of the Local Fisheries Commission. Two special guests made statements, including Dr. Federico Graef Zielh, Director, CICESE, and Dr. William W. Fox, Jr., Director, Southwest Fisheries Science Center, National Marine Fisheries Service. All speakers expressed the importance of understanding the oceanography, ecology, and biology of Pacific sardines and the impact of their extraction on sardine populations and industry. Each touted the benefits of the Forum as a venue for sharing academic experience, fostering international cooperation, identifying research priorities and exchanging ideas. In particular, Dr. Fox mentioned a newly established observing program: the Pacific Coast Ocean Observing System (PaCOOS), which extends the CalCOFI model and may involve Canada, México and the United States. The PaCOOS observing system will be built over the next decade (www.pacoos.org) and will target the California Current Large Marine Ecosystem. Its goal is to "provide the information needed for management of fishery resources, protected marine mammals, marine birds, and turtles, and to forecast the ecosystem consequences of fisheries removals, environmental variability and climate change". In addition, he mentioned that the upcoming 2006 coast-wide survey will provide an important data gathering opportunity.

Dr. John Hunter of Scripps Institution of Oceanography gave a brief history of the Forum and outlined the objectives at its inception. The main research goals of the first Forum in November 2000 were to: (1) improve knowledge of age structure and determine age-specific reproductive effort; (2) monitor shifts in maturity; (3) conduct coast-wide biomass surveys and add regional surveys to fill in knowledge gaps; and (4) identify movements (stock structure). In the last five years, substantial progress has been made in all these areas, except for age-specific reproductive effort (Hunter and Baumgartner 2001, 2002; Hunter and Pleschner-Steele 2003).

Some of the accomplishments highlighted by Dr. Hunter include fulfilling the central mission of the TSF: to hold regular informal meetings with participants from the three countries, provide a platform for sharing research results and planning collaborations,

present regional views of the fishery, and construct an integrated vision of the status of the Pacific sardine throughout its the geographic range. The Forum has also promoted the use of both traditional and new methodologies to examine Pacific sardine stock structure. In addition, since the first meeting, the goal of conducting a coast-wide inventory of the stock has been continually reiterated. It has not been possible to survey the entire range concurrently, and thus each country has worked with its own regional data. However, in April 2006 a coast-wide survey will be conducted that will hopefully establish a precedent and be repeated annually.

Dr. Hunter also emphasized the importance of defining the role of the Pacific sardine in the ecosystem, including the consequences of its variability in population size and geographic range. He suggested conducting workshops on specific topics such as the ageing workshop held previously, and organizing a formal fishery commission with representatives from the three nations.

The opening statements and historical overview of the TSF were followed by the two sessions: "Regional Sardine Fisheries Reports" and "Research Plans and Reports." Most of the scientific papers presented were oriented toward documenting patterns in the regional fisheries and understanding the reproductive capability, stock structure and migratory patterns of the Pacific sardine using various techniques. Posters were also on display around the meeting hall for the duration of the Forum. This year, there were two new features. The first was a session on "Contributed Papers," and the second a new working group on "Industry Trends and Issues," which was introduced by Orlando Amoroso and Martín Gutiérrez (Asociación de Armadores de Pelágicos Menores de Ensenada) toward the end of the first day.

In the evening, special guest Mr. Felipe Charat, of Maricultura del Norte, provided an overview of the company's tuna farming operating procedures. Of particular interest was the reliance of tuna farming on fresh sardines, which are fed to the tuna to obtain the high-quality product demanded by the Japanese market.

The second day of the meeting began with a presentation by Dr. Roger Hewitt, Director of the Fisheries Resources Division at the Southwest Fisheries Science Center. He discussed the focus issue of the Forum, a coast-wide survey to be held in April 2006 from Baja California to British Columbia. The survey is essential to obtain a clear picture of the overall biomass and reproduction patterns of the Pacific sardine along the west coast of North America, and to pave the road for future collaborations among the three countries. Participants were asked to provide recommendations on logistics and procedures for the survey to their working groups. After the focus issue presentation, the working group break-out sessions took place, followed by the plenary session in which working group results were presented. Finally, the Forum drew to an end with the promise of reconvening in the fall of 2007.

The executive committee of the Trinational Sardine Forum represents all three countries: Nancy Lo (United States), Sharon Herzka (México), Robert Emmett (United States), and Jake Schweigert (Canada). The committee members take turn organizing

and hosting the meeting. Next year's Forum will be held in Vancouver, Canada and will be hosted by Jake Schweigert and Bob Emmett.

PLENARY SESSION HIGHLIGHTS

Regional Sardine Fisheries Reports

México

Gulf of California
(Manuel Nevárez-Martínez, CRIP-Guaymas and Enrique Morales Bojorquez, CRIP-La Paz)

The Gulf of California has a large fishing industry and the catch of small pelagics is monitored monthly. Peak fishing occurs in winter and spring. The time series of landings show that the Pacific sardine catch mirrors the variability in total landings of small pelagics. In recent years, there has been a decrease in the availability of sardine that matches a decrease in the total landings of small pelagics in the Gulf. There are two competing hypotheses to explain the decline in catch: over-fishing and a change in the environment. The decline has been associated with a pattern of average temperature and abnormal winds. The winds have been weaker and less persistent, particularly between October and February. Strong winds during these months are important for generating upwelling along the coast of Sonora.

Bahía Magdalena
(Casimiro Quiñónez-Velázquez, CICIMAR)

The number of fishing trips for Pacific sardine out of Bahía Magdalena has declined in the last three years, from 991 in 2003, 858 in 2004, to 604 in 2005. During this time, 139,200 metric tons (mt) was landed, of which 83% was Pacific sardine (*Sardinops sagax*), 12% was thread herring (*Opisthonema spp.*), 2% anchoveta (*Cetengraulis mysticetus*), 2% round herring (*Etrumeus teres*), and 0.4% Pacific mackerel (*Scomber japonicus*).

The Pacific sardine was captured throughout the year, except for January 2004. From 2003-2005 interannual differences in CPUE were observed. The months of highest catch were April-October (>4,000 mt/month) in 2003, July-November (>3,000 mt/month) in 2004, and March-July (>4,000 mt/month) for 2005. The 2004 season was unusual in that few Pacific sardines were caught before July and those caught later in the summer were small. A variation in the overall sex ratio and in the proportion of adults with mature gonads was also observed. In 2004, there were more fish with mature gonads in the early months, and none were found to be mature in the later months.

In 2003 and 2005, the standard length (SL) of Pacific sardines caught increased throughout the summer. In 2004, however, a very different length and age distribution was observed. From February-May, age-1 fish were predominant. In June, two modes of

SL were identified with a break point at 150 mm SL, and age-2 fish were the most common. During the second half of the year 100% of the fish caught were <150 mm SL, and age-0 fish were dominant. This unusual size and age distribution was observed until April 2005, after which the lengths and ages followed a pattern similar to that documented in 2003.

The large abundance of age-0 fish in 2004 is an indication that they are from the Baja California stock. These results are presented in CalCOFI Reports volumes 45 and 46.

Ensenada – No presentation, but please see the abstract in Appendix III by Celia Eva Cotero.

United States

California
(Kelly O'Reilly, CDFG)

2004 Fishing Season

The fishing season for Pacific sardine off California takes place throughout the year, and the harvest guideline is based on the previous year's stock biomass estimate. There are two fishing sub-areas: the northern sub-area extends from 39ºN latitude up to the Canadian border. The southern sub-area is from 39ºN down to the Mexican border, which spans approximately the coast of California. The 2003 biomass estimate for northern Baja California and U.S. waters was 999,871 mt. Thus, the 2004 U.S. harvest guideline was set at 122,747 mt, split between the two sub-areas. The northern sub-area was allotted 40,916 mt and the southern sub-area 81,831 mt. This allocation scheme (one third in the northern area, two thirds in the southern area) was applied for the first 8 months of the year. After September 1, the unharvested portion was pooled and reallocated so that 20% was available to the north and 80% to the south. On December 1st, the total remaining unharvested catch was open to the entire coast. By the end of the year, 81% of the harvest guideline was landed.

California commercial landings from 1994-2004:

California landings have varied between 13,000 mt in 1994 to 58,000 mt in 2002. In 2004 the total landings were over 44,000 mt. During the same period, the market squid (*Loligo opalescens*) landings were much more variable than that of the Pacific sardine. Market squid are more valuable, and when they are available they are preferentially targeted by fishermen. In the last few years, the Pacific sardine landings have been much higher than those of either northern anchovy (*Engraulis mordax*) or Pacific mackerel (*Scomber japonicus*). These landing statistics do not include estimates of bait barge catches, so landings are somewhat underestimated. Because bait barge boats do not have to submit landings receipts, there is no way to monitor them at this time.

A breakdown of the catch by gear type is as follows: 99% of Pacific sardines caught were landed by round haul gear. Of this, 69% was landed by purse seine and 30% by

drum seine. In 2004, 53% of the total catch was landed in Los Angeles, 35% in Monterey and 11% in Ventura. All other areas comprised less than 1% of the landings.

2005 Fishing Season

In 2004, the Pacific sardine biomass estimate was 1,090,587 mt, and the U.S. harvest guideline for 2005 was set at 136,179 mt. As in 2004, one third was allocated to the northern sub-area, and two-thirds to the southern sub-area. From January to July 2005, 96% of the landings occurred in Los Angeles, 3% in Ventura, 0.8% in Monterey, and 0.1% in San Diego.

On September 1, the uncaught harvest allocation was pooled (85,000 mt) and reallocated, with 20% assigned to the northern sub-area and 80% to the southern sub-area. On December 1, the remaining allocation will be available coast-wide.

The harvest allocation rules for 2006 have changed. The FMP was amended with the goal of making the allocation distribution more equitable. Beginning January 1, 2006, 35% of the harvest guideline (118,937 mt) will be allocated coast-wide. On July 1, 2006, 40% of the harvest guideline plus any un-harvested portion from the initial allocation will be allocated coast-wide. Then, on September 15, 25% of the harvest guideline and any un-harvested portion from the previous allotment will be allocated coast-wide.

This is a very different scheme than those used in the past, but it should allow for more equitable distribution of the allocation. In 2004, 19% of the allocation was not harvested. If the quota from the previous year is not reached and the allowable quota for the following year is reduced, then this may indicate that factors other than fishing are reducing the biomass.

Northwest

(Jean McCrae, ODFW, and Michele Culver, WDFW)

Through mid-October of 2005, over 45,119 mt have been landed in Oregon and 6,892 mt in Washington. The September-through-November allocation for the northern sub-area was reached in mid-October and the northern fishery closed until December 1. This year, the first landings occurred in April, although the fishery did not start in earnest until mid-June, which has been the typical starting time in past years. As in the past, August was the peak harvest month and September the second highest.

In 2005, the main catch area was much farther north than in past years, during which the majority (59% - 75%) of the harvest activity occurred off Oregon, with the remainder occurring off Washington as far north as the mouth of Willapa Bay. This year, based on logbook data through mid-September, almost 2/3 of the harvest came from Washington. Vessels went as far north as the Canadian border to find larger-sized fish. In general, Pacific sardines were much smaller this year than they have been in the past. Larger fish began showing up toward the end of the season.

The Washington fishery continues to be managed under its "experimental" fishery designation; 16 permits were issued in 2005. The Oregon fishery is managed under the Developmental Fishery program; 20 permits were issued in 2005. The Oregon Fish and Wildlife Commission will consider in December whether to move the Oregon fishery out of Developmental Fisheries and into a limited entry system.

The websites for tracking each state's landings are as follows:
Oregon: www.dfw.state.or.us/mrp/finfish/cps.asp;
Washington: wdfw.wa.gov/fish/commercial/sardines/index.htm

Canada

British Columbia
(Christa Hrabok, DFO)

Pacific sardines supported a large fishery in Canada from 1917-1947, until the stock collapsed. In May 2002, sardines were de-listed by the Committee on the Status of Endangered Wildlife in Canada as a species of special concern. Historically, Pacific sardines have been distributed as far north as southeast Alaska, but have more recently been caught off Vancouver Island. This year the sardines moved away from Vancouver to the north coast area.

In 2005 the Department of Fisheries and Oceans Canada (DFO) is finishing the third year of a three-year sardine fishery management plan, and a total of 50 licenses were issued: 25 commercial and 25 communal commercial licenses. The total allowable catch (TAC) was set at 17,903 mt. The season is from July 10, 2005 through February 9, 2006. Consultations were held with First Nations to increase their participation levels. Participants in the fishery are required to fund a monitoring program, and to share the costs of stock assessment and managing the fishery through a joint agreement with DFO for $100,000.

<u>Fisheries activities</u>:
Of the 50 licenses available, 13 of the 25 commercial licenses were fished, and 5 of the 25 communal commercial licenses were fished. The catch for the season thus far is 3,200 mt. The largest total catch was in 2004, at 4,258.8 mt.

The majority of the fish were caught in the southern part of the northern-most area during September, and next biggest catch was in August. The west coast of Vancouver Island is usually the most successful fishing area, but this year large fishes were difficult to find, so there was more exploratory fishing and as a result many new fishing areas were discovered. Still, the total catch is much lower than 2004. Bycatch is usually less than 1% of the total catch rate. This year bycatch diversity increased, but was mostly dogfish and herring.

Length Frequencies July – October:

Small fish of 100 g were caught in all months. The largest fish this year were caught in Area 12 (Queen Charlotte Strait, northeast of Vancouver Island). In both 2003 and 2004 there was a large amount of big fish. However, in 2005 nearly of all the catch was comprised of small fish. The smaller fish were caught everywhere, but particularly inshore, and the larger fish, when found, were only offshore.

Industry Perspective:

Less than half the fishermen fished this year. The market was strong for big fish, but they were very hard to find. The industry's biggest concerns are: 1) the catch of small, 100 g fish, which seem to be 2-3 years old although they haven't been aged yet; and 2) the need to identify locations of spawning.

2006 Fishery Management Planning

There is a need to develop a new, integrated Fishery Management Plan that includes information on access to licenses, First Nation participation, use of the fish, scientific surveys, and a monitoring program.

Ongoing and future research by DFO includes: (1) industry surveys to assess abundance and distribution of fish; (2) age methodology studies; (3) diet studies; (4) trawl surveys for biomass estimates; (5) fat content monitoring (an industry concern); and (6) modeling studies to examine decadal-scale fluctuations.

Introduction to Working Group 3: Industry Trends and Issues

Mr. Orlando Amoroso announced the formation of a new working group focusing on fishing industry trends and issues in the evening of the first day. Mr. Felipe Charat, president of Maricultura del Norte, the invited speaker, then described the operation of his Pacific bluefin tuna (*Thunnus thynnus*) ranches and the role that Pacific sardine play in the industry.

The tuna are captured at sea via purse seine, and then transferred through open doors in the seine into a tow pen net. This net is 50 m in depth, with weights on the bottom to prevent a cone shape during towing. The net is towed at 1 knot per hour back to the pens at the mariculture facility. This can take up to three weeks, however towing at a greater speed causes stress to the fish. Observers check the condition of the fish everyday, and remove any dead fish to prevent attracting predators. The observers also estimate the weight of the fish they are towing. The density of fish per kilogram that can be maintained in each holding pen at the ranch is used to calculate the number of fish to transfer into each pen.

Once the fish are inside the pens, they are fed fresh sardines twice a day, six days a week. Maricultura del Norte is one of the few companies in the world to use only fresh sardine. They maintain strict standards to ensure the best possible tuna products.

To harvest the tuna, workers lift by hand each fish out of the water by the gills. It is killed quickly and humanely, and in such a way as to maintain the highest quality of meat by maintaining blood temperature and minimizing lactic acid. The amount of time from when a fish is lifted from the water to being auctioned off in Japan can be as little as 70 hours.

Tuna ranches in Ensenada produce approximately 500,000 t of bluefin tuna annually. To achieve this volume they consume sardine equal to the yearly catch of 2.5 sardine boat loads, and thus are not monopolizing the Ensenada sardine catch. The industry right now employs 1,000 people directly, and about 2,500 indirectly, and its annual revenue is approximately 80 million dollars U.S. One advantage that the Mexican tuna ranching industry has over other countries, such as Australia and those in the Mediterranean is the availability of fresh sardine at a low cost.

Mr. Charat praised the exchange of scientific information provided by the Forum, however cautioned the participants to remember that scientific knowledge can also be potentially harmful when used emotionally to obtain specific objectives.

Focus Issue: 2006 Coast-Wide Synoptic Survey

(Roger Hewitt, Southwest Fisheries Science Center)

The need for a coast-wide survey spanning the entire range of Pacific sardine was identified during the first Trinational Sardine Forum and it has been reiterated at each succeeding TSF. This synoptic survey is planned for April-May 2006, spanning from Baja California to British Columbia.

The objectives of the survey are to: 1) describe the spatial distribution of eggs, larvae, and adults; 2) obtain measurements of instantaneous egg production and adult fecundity required for estimating spawning biomass; 3) collect environmental data that may be useful for describing spawning habitat, and 4) collect specimens for use in genetics and microchemistry, and for the evaluation of size at maturity, age, and fecundity.

The survey will include regularly spaced stations along a series of inshore/offshore transects based on an extended CalCOFI pattern. The pattern is set up for two ships to run for 30 days each. The R/V *David Starr Jordan* will travel from San Diego, California north to Cape Mendocino from April 1-30. The R/V *Oscar Dyson* will depart near Cape Flattery and sail south towards Cape Mendocino from April 7 through May 9.

Primary station observations will include pelagic trawls of adult fish, plankton net samples of fish eggs, fish larvae and zooplankton, and vertical profiles of temperature, salinity, oxygen and chlorophyll. Transect observations will include continuous egg pump samples, continuous multi-frequency acoustic surveys of adults and possibly juvenile fish, and continuous measurements of sea surface and meteorological conditions.

In addition, the R/V *El Puma* and the R/V *Altair* of México have been secured by Instituto Nacional de la Pesca (INP) for 20+ days to cover the area off Baja California.

Nine people will be required on each ship to conduct basic measurements, not including acoustic technicians and marine mammal and seabird observers. David Griffith of Southwest Fisheries Science Center is the survey coordinator, and will be the main point of contact throughout the cruise (david.griffith@noaa.gov). He will shortly release a cruise announcement that will include dates, port calls, personnel lists, and a description of operations. Soon thereafter he will provide a cruise manual with detailed protocols on operations.

Dr. Hewitt acknowledged that these are very ambitious cruises which the Southwest Fisheries Science Center cannot complete alone. His team is looking for collaboration, particularly because a CalCOFI cruise will be running concurrently and three ships will need to be staffed.

Recommendations for the coast-wide survey

Plenary Session:

1. Call for proposals for ancillary projects to the coast-wide survey.
2. Calibration between the R/V *David Starr Jordan* and R/V *El Puma* for CUFES samples are needed. The R/V *El Puma* does not have CUFES installed and needs to get one on loan from SWFSC.
3. Trawl samples and acoustics information are two other data sources for the Pacific sardine biomass estimates. All trawls will be taken at pre-determined stations at night regardless of the appearance of eggs to ensure unbiased estimates of biomass. A protocol for the acoustics is being worked out by David Demer with multiple frequencies to sample the upper 10 m when the sea is calm.
4. Questions were raised regarding the optimal layout of transect lines north of Cape Mendocino. The CalCOFI pattern is to be followed due to its simplicity. Ideally, this coast-wide survey will be conducted annually, however a July survey is also desirable. In the future, an airborne LIDAR may be added to the survey to complement side-scan sonar by detecting schools in the upper 30 m.

Working Group 1: Regional Biomass:

CANADA

1. Month of the year

Canadian researchers' participation requires the application for ship time a minimum one year in advance. In order for Canada to participate in a survey in April 2007 the application for ship time should be submitted in November, 2005. Canadian vessels can collect trawl and bongo samples, but do not have CalVET and CUFES. NMFS would need to provide both nets. Canada would be able to participate in a July 2007 survey, for 7-10 days of ship time, although this ship time would be a part of their regular survey.

2. Acoustic sonar and trawl surveys

Inter-calibration among the sonar systems and among trawl samples is necessary. During a 2005 survey off Canada, sonar was used to obtain estimates of relative abundance. As to the compatibility among multiple vessels, it is necessary to inter-calibrate the sonar for the different instruments, multi-beam, single beam, and the algorithm used. However, the compatibility may be constrained by the transducers that are already on each vessel. For trawl surveys, differences may exist in towing speeds and area covered by the trawl due to the area of the net opening. It is necessary to standardize the towing speed even if the same net-tow is used.

3. Sample and data processing

The funding for sorting and data processing of ichthyoplankton samples would have to come from an agreement with industry, for instance with Don Pepper. If Canada gets the funding, the work has to be performed by contracted personnel, as there is no expertise at the Department of Fisheries and Oceans. Sub-sampling is recommended to save money and time. The funding situation is also similar for México; the funding will

have to come from the industry and a small amount may be provided by the Mexican government.

MÉXICO

For the coast-wide survey, INP is likely to obtain ship time for the R/V *El Puma*, which belongs to the Universidad Nacional Autónoma de México (UNAM). The R/V *El Puma* will be used to do the trawling and ichthyoplankton sampling. Yanira Green Ruiz of INP, Mazatlan, will be responsible for processing egg and larval samples, including staging eggs and sorting larvae. Eva Cotero of CRIP-Ensenada will process the adult samples and estimate reproductive parameters. Carlos Robinson from the Fisheries Ecology Laboratory, UNAM is doing an acoustic survey this month, but is using an Isaac-Kidd net. The R/V *Francisco de Ulloa* is the vessel used for routine IMECOCAL surveys in January, April, July and October to collect data from CUFES and physical oceanography.

UNITED STATES

If funding is an issue, the coast-wide survey could be conducted every 2-3 years, as was initially recommended during the first Trinational Sardine Forum.

1. Sample and data processing

For the 2006 April cruise, we need to have a time table in place for processing the specimens and to build up the data files necessary for analyses. At the very least, the ichthyoplankton samples and trawl samples from Central California should be ready by June or July, and the adult samples need to be processed by July-August. An estimate of spawning biomass needs to be finished by the end of August in order to be used as an input in the September stock assessment. In addition to samples needed for biomass estimates, aging of adults from all areas needs to be completed to assess the population age distribution by area. It is recommended that Pablo Santos Angeles from CRIP-Guaymas or Casimiro Quiñónez-Velázquez from the Centro Interdisciplinario de Ciencias Marinas (CICIMAR) read the otoliths from Mexican waters. Moreover, samples of other species along the west coast, particularly small pelagics need also to be sorted, identified, and the information incorporated into a database.

2. Future July coast-wide survey

The biennial Pacific hake survey, conducted by the Northwest Fisheries Science Center (NWFSC) in July, can be considered as a platform to collect Pacific sardine trawls at night after finishing with the Pacific hake work (Lo et al. 2005). One of the original ideas of the Trinational Sardine Forum was to involve industry, and for the industry to provide ship time in kind. As an example, in this working group, it was recommended last year that Canada would survey the inlets, and that Canadian industry would provide the ships and money to do the survey. This was accomplished in 2005.

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

1. Maintain good records of oceanography throughout the survey because oceanographic conditions dictate otolith microchemistry and accurate oceanographic

data facilitate the otolith analysis.

2. Data to delineate the spawning grounds for Pacific sardine are needed to increase the resolution of genetic analyses, as there is likely to be mixing on the feeding grounds. The synoptic survey may not detect the ripple effect of warming water temperature on spawning, for it is believed that the Gulf of California population spawns in November-December, the Magdalena Bay population in February, Ensenada in March, and San Pedro in April. These are not necessarily separate stocks.
3. It is important to know the location and habitat of small Pacific sardines and the year classes to which they belong, so as to try to provide forecasts for fishermen.
4. Two very important issues are which specimens to save for subsequent analyses and how to handle the data management. Samples preserved in ethanol are useful for many things, but not for otolith microchemistry or reproductive histology. Prior to the coast-wide survey, a plan on what samples are to be collected and how they will be handled must be developed. The storage and analysis of such a large number of specimens will likely require additional funding.

Tim Baumgartner commented that planning for their portion of the coast-wide survey is underway, and that México will have 20 days of ship time. The point of contact for cruise information will be Enrique Morales Bojorquez. They don't yet know the area they will cover, but are pleased to be involved. Baumgartner also raised a concern about inter-calibrating the egg pumps. He suggests that people who work frequently with the egg pumps should work together to calibrate the CUFES aboard the R/V *Francisco de Ulloa* and the R/V *David Starr Jordan*. So far, they have been unable to successfully employ the overboard method aboard the R/V *Francisco de Ulloa*.

WORKING GROUP REPORTS

Working Group 1- Regional Estimates of Biomass of 2004 and Recommendations

CalCOFI AND IMECOCAL, April cruises, 2005

Objectives: To estimate spawning biomass of Pacific sardine from Baja California, México to San Francisco, CA, U.S.

Activities:

CalCOFI, April cruises, 2005

The 2005 CalCOFI survey was extended north to CalCOFI line 60.0 (San Francisco) in winter and spring. The R/V *New Horizon* cruise (April 15 - May 1) occupied the six regular CalCOFI lines (93.3 - 76.6) and the R/V *David Starr Jordan* cruise (March 28 - April 26) occupied 12 additional lines (83.3- 60.0). Therefore, the total number of lines occupied by both vessels was 18, with each line spaced 20 or 40 nm apart (Figure 1). Bongo samples were taken only at regular CalCOFI survey stations aboard both the R/V *New Horizon* in the south and the R/V *David Starr Jordan* in the north (Figure 2). On the southern 6 lines CalVET tows were taken only at regular CalCOFI survey stations. On the additional 12 lines CalVET tows were taken at 4 nm intervals on each line after the egg density from each of two consecutive CUFES samples exceeded 1 egg/min. Similarly, CalVET tows were stopped after the egg density from each of two consecutive CUFES samples was less than 1 egg/min. The threshold of 1 egg/min was reduced from the number used in years prior to 2002 (2 eggs/min) to increase the area identified as the high density area and, subsequently, to increase the number of CalVET samples. This adaptive allocation sampling was similar to the 1997 survey (Lo et al. 2001). For adult samples, the trawl survey was conducted aboard the R/V *David Starr Jordan* from March 28 to April 26 during the April CalCOFI survey (Figure 1). Adult Pacific sardines were dispersed or in small schools. We conducted trawling near the surface (0-6 fathoms depth) at night in potential adult Pacific sardine areas as identified by the presence of Pacific sardine eggs in CUFES collections. In total, 19 trawls were taken, of which 14 were positive for Pacific sardine. Among 251 female Pacific sardines randomly selected for histological analysis of maturity and spawning, 76 were immature and 175 were mature.

The daily egg production of Pacific sardine off California from San Diego to San Francisco was estimated to be 1.916/0.05m^2 (CV = 0.416). The spawning biomass was estimated to be 621,266.08 metric tons (mt, CV = 0.54) for an area of 253,620 km^2, using the daily specific fecundity (number of eggs/population weight g/day) of 15.64. For the years prior to 2002, the daily specific fecundity used was 23.55. In 2002, 22.94 was used, and in 2004, 21.86. In 2005, trawl samples were taken in both high and low density areas to ensure the accuracy of estimates of adult reproductive parameters (Figure 1). The area (253,620 km^2) is smaller than those in previous years: 2004 (320,620 km^2) and 2003 (365,906 km^2). Estimates of the female Pacific sardine reproductive parameters were (EPM program of Chen et al. 2003): *F*, mean batch fecundity, 55,710.71 eggs/batch

(CV = 0.04); S, spawning fraction, 0.131 per day (CV = 0.17); and W_f, mean female fish weight, 166.99 grams (CV = 0.02). The average interval between spawning (or spawning frequency) was about 8 days (inverse of spawning fraction or 1/0.131), and the daily specific fecundity was 21.86 eggs/gm/day. The estimates of spawning biomass of Pacific sardine in 1994 - 2005 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, and 600,000 mt respectively. Therefore, the estimates of spawning biomass have been fluctuating and increasing since 1994.

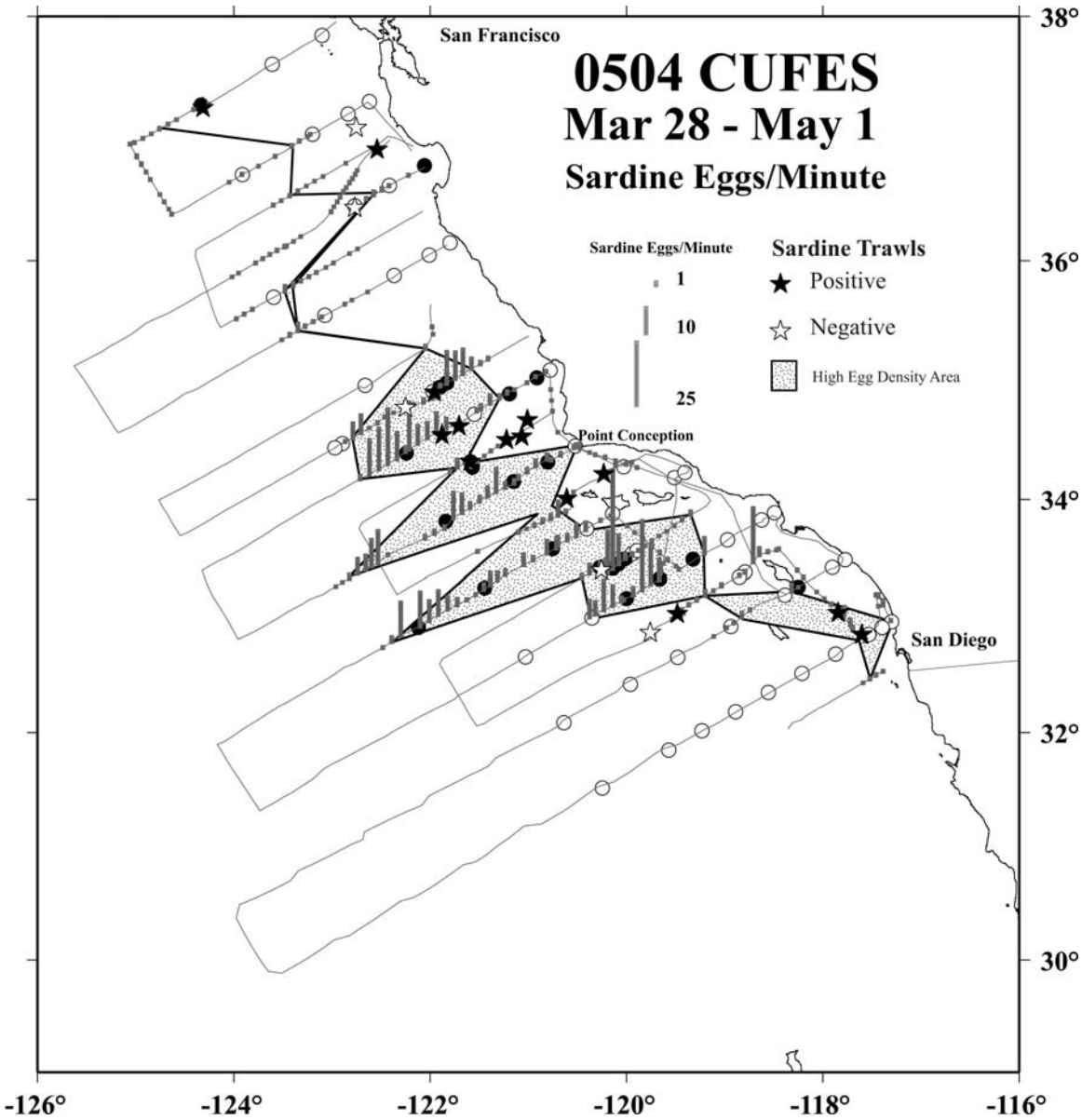


Figure 1. Pacific sardine eggs from CalVET (or Pairovet; solid circle denotes positive catch and open circle denotes zero catch) and from CUFES (stick denotes positive collection) and positive trawl samples (stars) in March-May 2005 survey. Region 1 is stippled area.

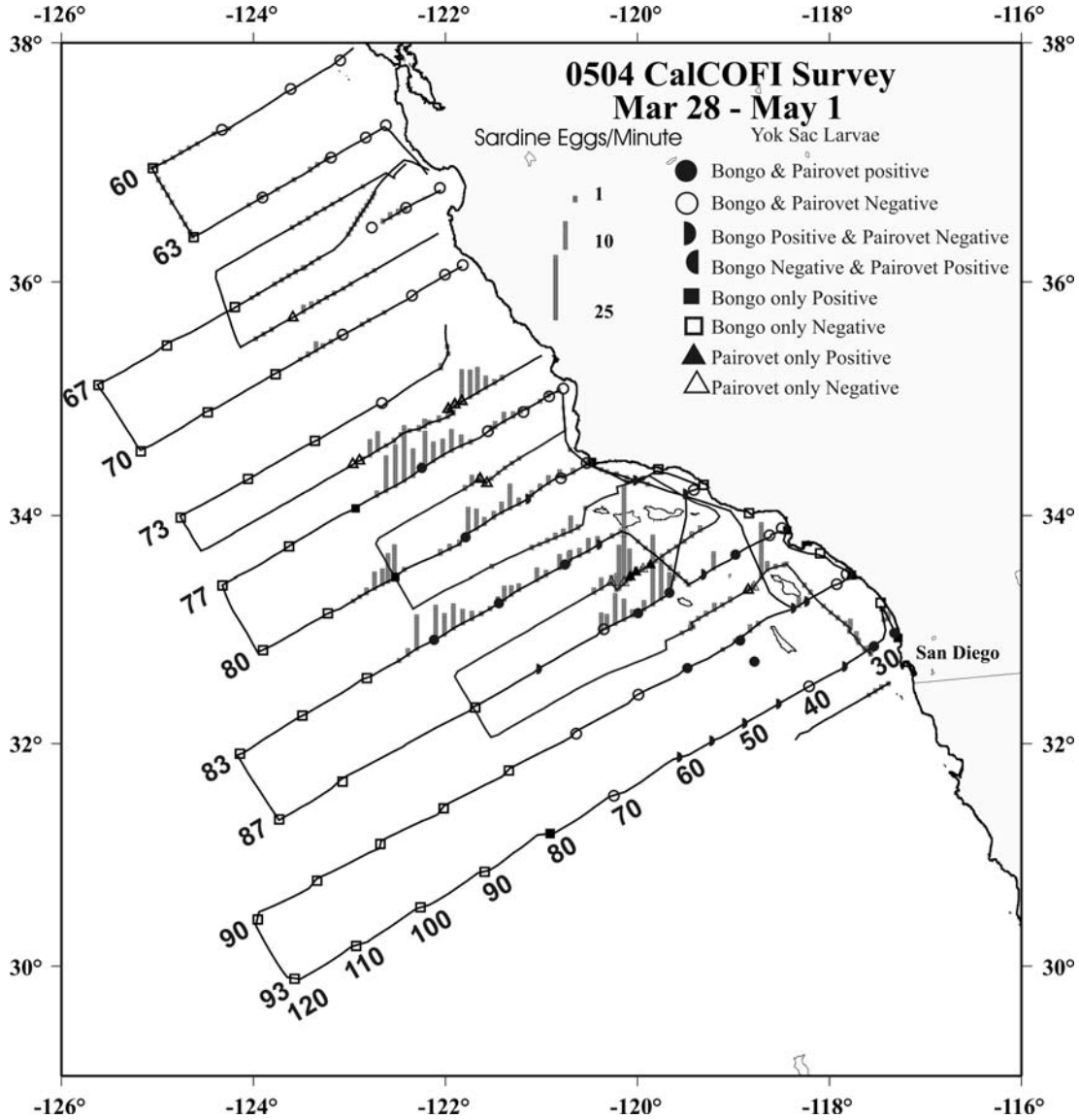


Figure 2. Pacific sardine yolk-sac larvae from CalVET (or Pairovet; circle and triangle) and from Bongo (circle and square) in April 2005 survey. Solid symbols are positive and open symbols are zero catch. The numbers on line 93 are station numbers.

Northwest winter (February, March) trawl and acoustic surveys

Twenty of forty-nine trawl samples were positive for Pacific sardine. No July cruise was conducted in 2005 (see abstract of Macewicz for more details).

Aerial Surveys

Beginning in March 2004, a statistically designed aerial survey was conducted off Central California. In addition to the fixed grid that the pilots fly over, they are also allowed to search over schools freely, in a similar manner to the flying pattern used

during their routine operation to search for schools for commercial boats. The data from this survey will be used to obtain fishery-independent estimates of recruits, which will be compared with the estimates of recruits made during routine spotter pilot surveys. As of now, three pilots have conducted seven surveys (Figure 3). The initial analyses indicated that the estimate of tonnage/block was 236 and 76 for 2003 and 2004, respectively, based on the strip-transect method (Buckland et al. 1993) and 31 and 6.28 based on the generalized linear model.

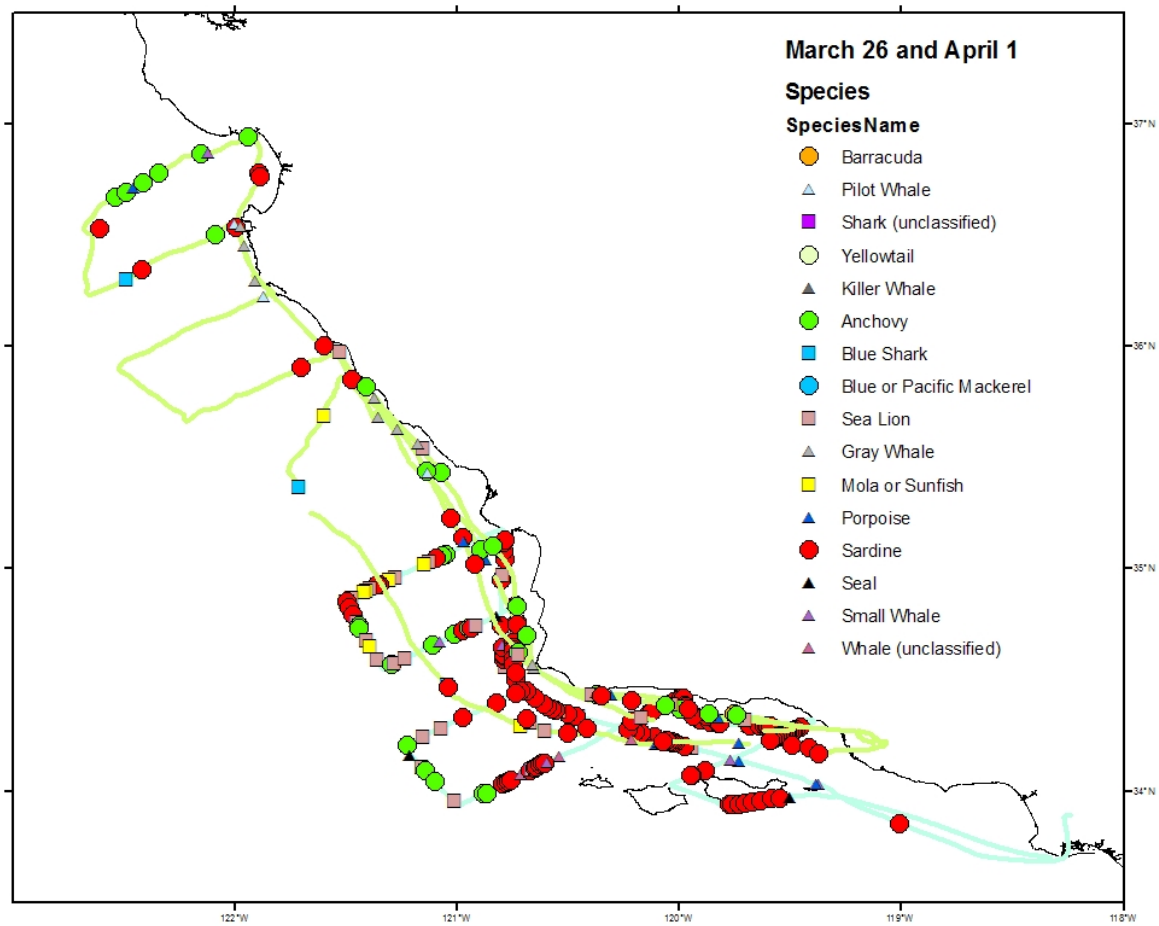


Figure 3. Sightings of different fish and marine mammals from one aerial survey in March and April, 2005.

<u>IMECOCAL</u>
Abstract by Tim Baumgartner (See Appendix IV for full text)

The Daily Egg Production Method (DEPM) was used to estimate spawning biomasses of the Pacific sardine off northern and central Baja California with data collected from IMECOCAL cruises during April, 2002, and April, 2003. The DEPM analyses were restricted to the area of spawning stock that is a southern extension of the stock found off Alta California (U.S.A.) so that comparisons can be reasonably drawn between biological parameters of the two regions. Ichthyoplankton data used in this

study were obtained from egg densities collected by the CUFES (Continuous Underway Fish Egg Sampler) system and CalVET net tows from the R/V *Francisco de Ulloa*. The adult parameters were estimated from biological sampling of the landings made from the area around Ensenada. The estimate of spawning biomass off Baja California for 2002 is significantly higher than that for 2003, and is associated with correspondingly higher egg production and larger spawning area of the targeted stock. Our mid-range estimates of the spawning biomasses are approximately 48,000 ± 30,500 metric tons for April, 2002 and 9,200 ± 5,900 metric tons for April, 2003.

One of the goals of this study has been to identify the uncertainties in the DEPM that result from the current practices in the ichthyoplankton collection and analyses from the IMECOCAL cruises, and from the limitations in collection of the adult reproductive parameters. Based on the analyses in this study we strongly recommend that the IMECOCAL surveys integrate a procedure of adaptive sampling with CalVET net tows based on the occurrence of Pacific sardine eggs in the CUFES samples. It is also imperative that steps be taken to ensure annual adult samples from the offshore areas to provide more realistic estimates of the adult reproductive parameters.

NWFSC Biomass Surveys off Northern Oregon and Southern Washington

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

Activities:

Egg surveys

Egg surveys were conducted from only 1994-1998.

Adult surveys

Since 2001, no offshore survey has been conducted to capture adults in June because locations and timing of spawning were unknown. Effort was concentrated on the following three nearshore trawling surveys off Oregon and Washington:

1. BPA Columbia River plume study - daytime surface trawl from northern Washington to Newport, Oregon in May, June, and September.
2. Predator/baitfish study off the Columbia River - night surface trawl surveys off the Columbia River every 10 days from late April through early August.
3. Lower Columbia River purse seine survey - every 2 weeks from April through September.

In past years a monthly purse seine study in the Columbia River estuary documented use of the estuary by sub-yearling and yearling Pacific sardines (item 3). Vessel problems caused this project to be canceled in 2004. This project was not carried out in 2005 (see below).

This section reports the preliminary estimates of biomass of Pacific sardine based on July samples from night surface survey trawls during a predator/baitfish study off the Columbia River from Willapa Bay, Washington, down to Tillamook Head, Oregon, in 1999-2004 (Figure 4). The survey area was approximately 20,000 km^2, from above Gray's Harbor to Cape Falcon and out 35 nm. Night surface trawls were conducted every 10 days from late April through July. During each survey, 12 surface trawls were conducted: 6 on 2 lines (Willapa Bay and the Columbia) at 6 distances from shore, 0-10, 10-20, 20-30, 30-40, 40-50, and 50-60 km, which constitute six strata. A 264 rope trawl with a mouth opening of 360 m^2 was used. The net sampled down to 20 meters depth. Total volume within the survey area was calculated using the depth of the net fished times the survey area, for a total of 4×10^{11} m^3.

Pacific sardine population estimates in the Columbia River region were calculated using the same method as in previous years (volume swept methodology). Sardines captured during the Predator/Forage Fish Survey are usually most abundant in July. As such, only July information is used to make population estimates. We usually have three 2-day surface trawl surveys off the Columbia River in July. However, in 2005 only two surveys were conducted because of poor weather conditions in mid-July. For each cruise the mean number/m^3 was calculated using the number captured divided by the volume swept. Total density in the study area was calculated by multiplying mean Pacific sardine/m^3 by the volume (4×10^{11} m^3) of the study area. Average weight of sardines captured was calculated from mean length. In July 2005, unlike 2004, only one size class was evident.

The Pacific sardine biomass estimates for 2005 ranged from 29,996 metric tons (mt) in early July to 20,054 mt in late July (Table 1). These estimates are much less than the late July estimates in 2004 (96,247 mt). However, wide fluctuations in population estimates can be expected because Pacific sardines have very patchy distributions, and show large movements both within and outside the study area.

The length/frequency data (Figure 5) indicate an abundance of small Pacific sardines. Average length in July 2005 was much smaller than previous years (Table 1). Many of these were probably one-year-olds in 2005. Large numbers of 0-age sardines were captured in fall 2004 off the Oregon/Washington coast. These 0-age Pacific sardine appeared to have over-wintered in Oregon/Washington coastal waters during winter 2004-2005. There were no indications that older Pacific sardines were over-wintering off Oregon. Many 0-age Pacific sardines were captured in September 2005 off Oregon (BPA survey; Figure 6). We suspect that these sardines will over-winter in Oregon/Washington coastal waters.

Large Pacific sardine (>220 mm FL) were only found in May, June, and September and were not very abundant. We suspect that many larger sardines may have migrated farther north, out of our study area, in 2005.

The ocean was again very warm in spring 2005 (Figure 7). Warm ocean conditions in May/June appear to be conducive for successful spawning and recruitment of Pacific

sardine off the Oregon/Washington coast. Spring surface temperatures in 2004 and 2005 were warmer than temperatures in 1998, an El Niño year.

These data indicate that Pacific sardines successfully spawned off Oregon May/June 2005. New recruits from this year's spawning will probably add significant biomass to the Pacific sardine population in the California Current.

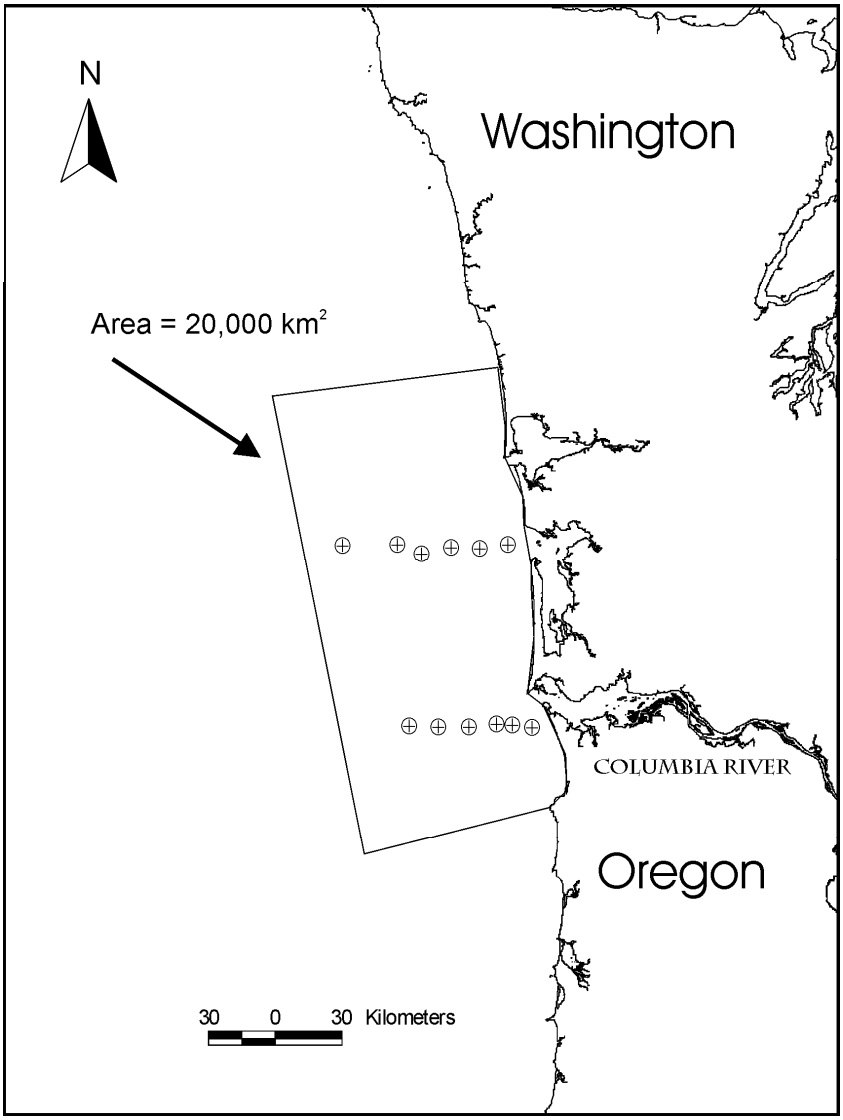


Figure 4. Location of the 12 surface trawls sampled at night approximately every 10 days from late April through early August, 1999-2004.

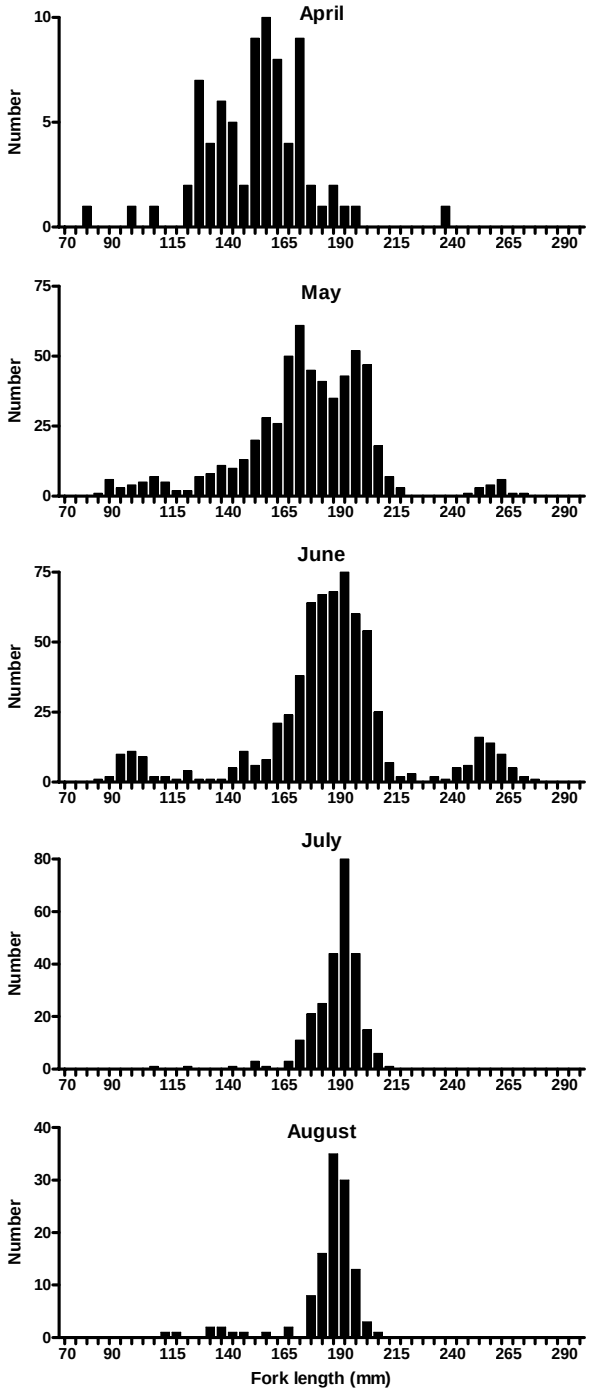


Figure 5. Length frequency of Pacific sardine captured off the Columbia River in 2005.

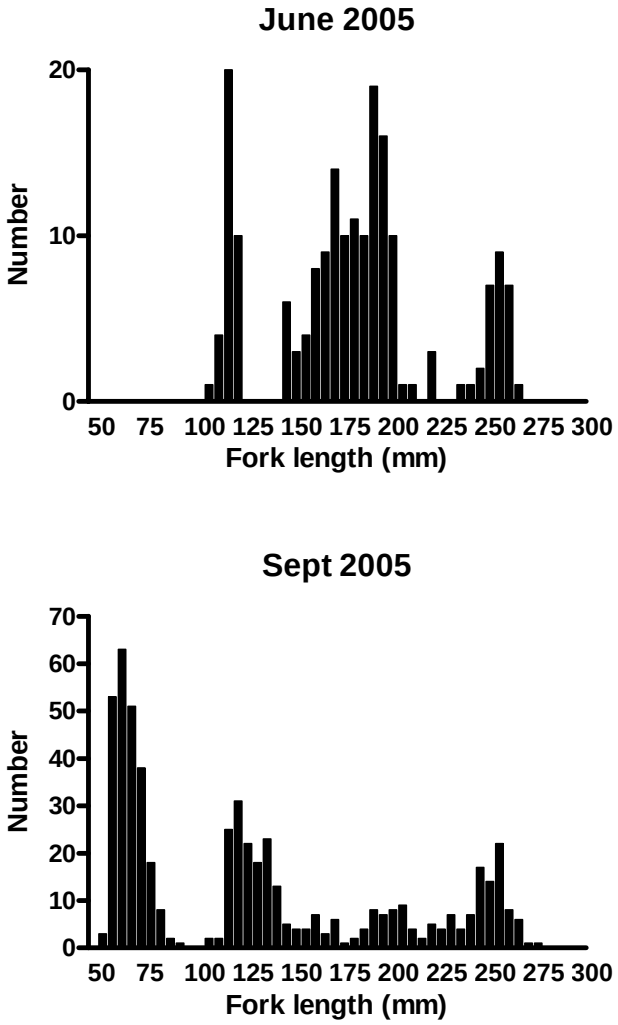


Figure 6. Length frequency of Pacific sardine captured off Oregon/Washington.

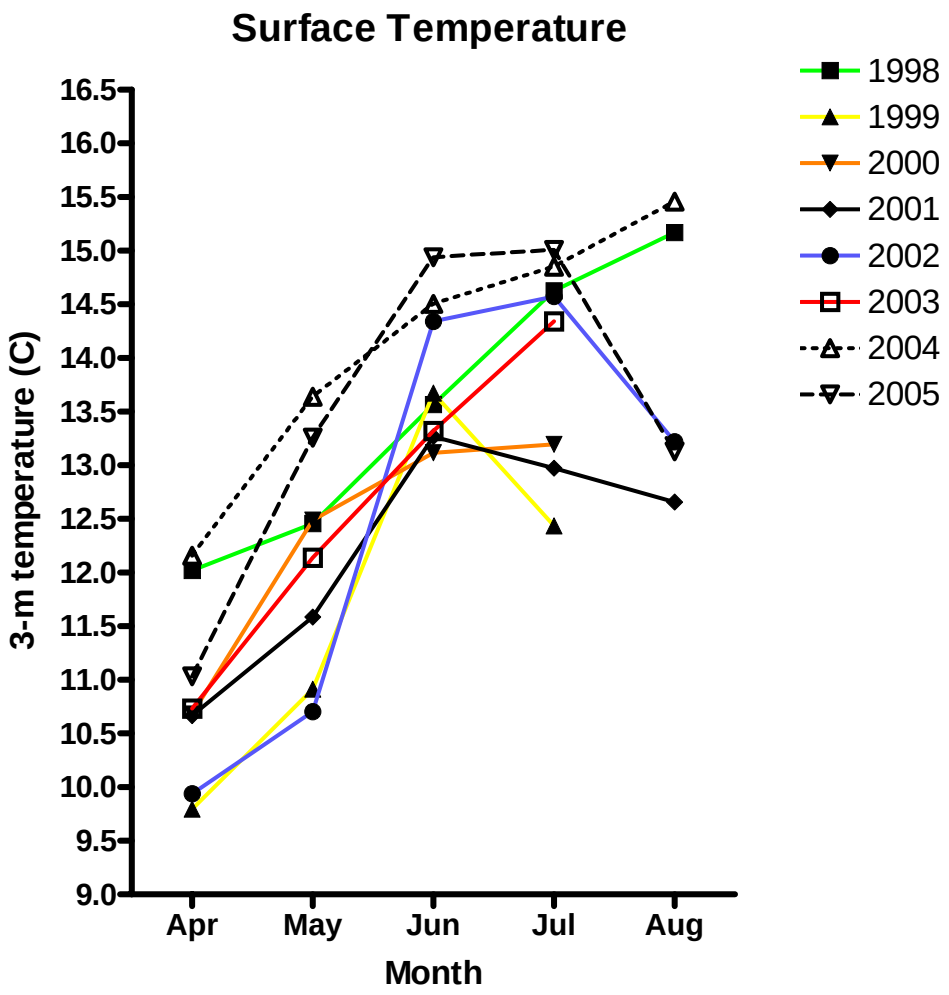


Figure 7. Average monthly surface temperatures (3 m depth) off the Columbia River.

Table 1. Statistics on Pacific sardine captured off the Columbia River region since 1999.

Number of Pacific sardine off S Washington/N Oregon

Year	Early July	Mid July	Late July/Early August
1999	16,738,383	10,282,076	667,488,503
2000	644,545,899	766,670,243	no trawls after 22 July 2000
2001	35,637,249	162,221,196	235,583,259
2002	544,696,457	48,770,214	non taken
2003	26,997,079	2,177,182,868	193,544,001
2004	30,713,861	208,021,190	454,430,085
2005	**410,664,790**	**No Trawls**	**271,509,680**

Average fork length (mm) of Pacific sardine

Year	Early July	Mid July	Late July/Early August
1999	246	239	235
2000	237	243	
2001	233	241	242
2002	247	247	
2003	251	249	237
2004	108 and 256	135 and 251	143 and 245
2005	**189**	**No Trawls**	**190**

Average weight of Pacific sardine (g) calculated from average length

Year	Early July	Mid July	Late July
1999	154	143	137
2000	140	149	
2001	133	146	148
2002	156	156	
2003	165	160	140
2004	22 and 248	41 and 236	48 and 220
2005	**73**	**No Trawls**	**74**

Biomass of Pacific sardine off S Wash/N Oregon (metric tons)

Year	Early July	Mid July	Late July/Early August
1999	2,585	1,471	91,200
2000	90,129	114,467	
2001	4,740	23,612	34,904
2002	85,229	7,607	
2003	4,448	542,448	27,049
2004	7,118	14,561	96,247
2005	**29,996**	**No Trawls**	**20,054**

Canadian Trawl surveys

Objectives: To provide information on the distribution of presence and absence of Pacific sardine, biological parameters, and feeding behavior, and to estimate a minimum biomass of Pacific sardine off Vancouver Island from the July cruise each year since 1996.

Activities:

Surveys of Pacific Sardine Abundance in B.C. Waters during 2005

Four independent research surveys were planned between August 4 and October 5, 2005 to assess the relative abundance of Pacific sardine in British Columbia waters, including the annual trawl survey conducted by Fisheries and Oceans Canada (DFO), and three surveys conducted with vessels chartered from the sardine fleet using commercial purse seine vessels.

The annual DFO trawl research cruise was not conducted (given in Figure 8 for reference) as the ship, R/V *W.E. Ricker*, was under repair. Instead, a comparative day/night trawl survey aboard the commercial vessel *Frosti* was conducted on the west coast of Vancouver Island (WCVI). Set track lines were surveyed offshore of Nootka and Barkley Sounds (Figure 9). The track lines were trawled during the day and night off Nootka Sound first and then at Barkley Sound. The trawls were repeated to complete another day/night series off Nootka Sound followed by a daytime series off Barkley Sound. The final night time survey could not be completed.

In total, 53 sets were made over a 9 day period: 8 day and 14 night sets off Barkley Sound; 16 day and 15 night sets off Nootka Sound. Initial findings indicate that Pacific sardine schools tend to aggregate in the daytime with catches being fewer, but larger. At night Pacific sardine appear to disperse with many smaller schools being encountered (Figures 9 & 10).

A total of 6,180 fish were sampled. Fish were weighed to the nearest gram and measured for fork lengths to the nearest millimeter. Fish were also sampled for sex and maturity with otoliths and stomachs extracted for future laboratory analysis. Weights ranged from 60 to 280 grams with the largest fish caught at Nootka Sound. Fork lengths ranged from 95 to 300 mm with the largest fish being caught at Nootka Sound (Table 2). Length frequencies for both Nootka and Barkley Sounds are shown in Figure 11.

Ages ranged from one to seven years old in both the Nootka and Barkley areas (Figure 12). Females tended to be older in the Nootka area while there was a pretty even mix of ages and sex in the Barkley Sound area. There was a large contingent of age two fish in both areas, with it being more predominant in the Nootka Sound area.

In general, jack mackerel (*Trachurus symmetricus)* and Pacific herring (*Clupea pallasi)* were the predominant bycatch species in sardine trawl catches. Salmon species,

particularly chinook salmon *(Oncorhynchus tshawytscha)*, but also coho salmon *(Oncorhynchus kisutch)*, pink salmon (*Oncorhynchus gorbuscha)*, sockeye salmon (*Oncorhynchus nerka)* and chum salmon (*Oncorhynchus keta)* were commonly caught. Other species captured along with Pacific sardine included: ocean sunfish, (*Mola mola)*, blue shark (*Prionace glauca)*, soupfin shark (*Galeorhinus zyopterus)*, Pacific hake (*Merluccius productus)*, euphausiids (Euphausiacea), jellyfish (*Scyphozoa* spp.*)*, yellowtail rockfish (*Sebastes flavidus)*, and spiny dogfish (*Squalus acanthias).* Bycatch estimates are presented in Table 3.

Pacific sardine spawn off the coast of California and then make an annual migration north to the coast of British Columbia in summer to feed. The extent of the migration into Canadian waters varies annually but on average appears to be about 10 percent of the total coast-wide population. Understanding the factors that affect the timing and degree of migration into British Columbia would provide the sardine industry with more consistent harvesting opportunities and market stability. An annual scientific survey to estimate the biomass of Pacific sardine in British Columbia could also help to better estimate the migration rate. Unfortunately, the hydro-acoustic technology required for such a survey is not currently available in the sardine fleet. As a result, a one-year feasibility study was proposed to develop guidelines for conducting future hydro-acoustic surveys to assess Pacific sardine biomass in the Canadian zone using scientific acoustic equipment.

The surveys were conducted utilizing standard sonar and sounding equipment and plotters to capture the size and location of surveyed Pacific sardine schools. When a school was encountered, the vessel sounder and sonar attempted to assess the dimensions of the school and to estimate relative fish density. The survey vessels made seine sets to collect biological samples in inshore and offshore areas as fish availability permitted.

The three industry-sponsored Pacific sardine surveys, WCVI Inlets, Northern Index Sites, and WCVI Offshore Encounter/Response Survey, were conducted between August 4 and October 5, 2005 (Figure 13). The surveys are described below.

<u>WCVI Inlets</u>: A 16-day survey of the major inlets on the west coast of Vancouver Island, from Areas 23 to 27, the offshore areas at the mouths of the inlets and in Area 12 (east side at the north end of Vancouver Island) was conducted along defined transects to obtain relative abundance and biological data.

<u>Northern Index Sites</u>: A 12-day survey of northern index sites was conducted to assess the relative abundance and northern distribution of Pacific sardine. The index sites ranged from Areas 6 to 12.

<u>WCVI Offshore Encounter-Response</u>: An 8-day encounter-response survey was conducted to assess large concentrations of Pacific sardine and determine the feasibility of obtaining acoustic assessments of total biomass. The survey attempted to map out school dimensions and qualitatively assess fish density.

In total, 37 sets were made during the course of the three surveys with 33 biological samples being retained during the combined 36 days of survey time. Total Pacific sardine catches ranged from 4 metric tons (mt) to 50 mt (Figures 14 & 15). Fish were sampled on-board for fork and standard lengths, weight, sex, and maturity. Frozen samples were also preserved for otolith and stomach data. A Scientific Committee on Oceanic Research (SCOR) net was used to collect plankton samples and a Seabird-19 was used for CTD casts.

Standard lengths of 3,348 fish ranged from 150 mm to 270 mm and fork lengths ranged from 162 mm to 287 mm with the largest fish being captured in Rivers Inlet, Area 9. The average standard length was 197 mm and the average fork length was 211 mm. Weights of 3,294 fish ranged from 43 g to 340 g with the heaviest fish being caught at the most northern site in Area 6. The average weight was 118 g.

Male to female ratios were examined over the entire coast in relation to length. Males tend to be more heavily represented in the small size range. South of Estevan Point, Vancouver Island, the male to female sex ratio was 46:54. North of Estevan Point the ratio was almost 50:50 and in the north mainland coast it was 48:52 (Figure 16).

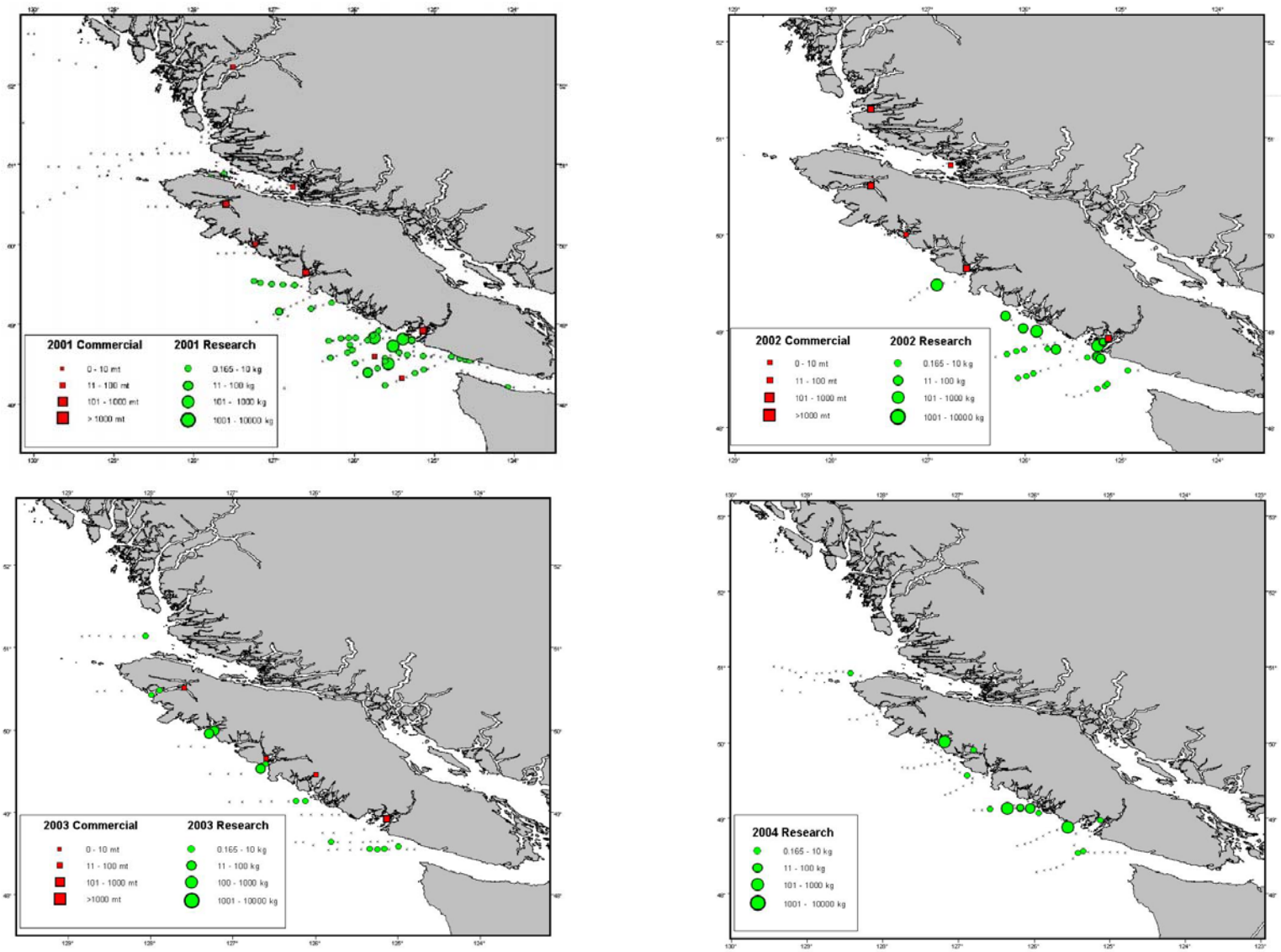


Figure 8. Distribution of relative abundance of Pacific sardine in trawl research surveys 2001-2004 off the west coast of Vancouver Island (Green = Research catch; Red = Commercial catch).

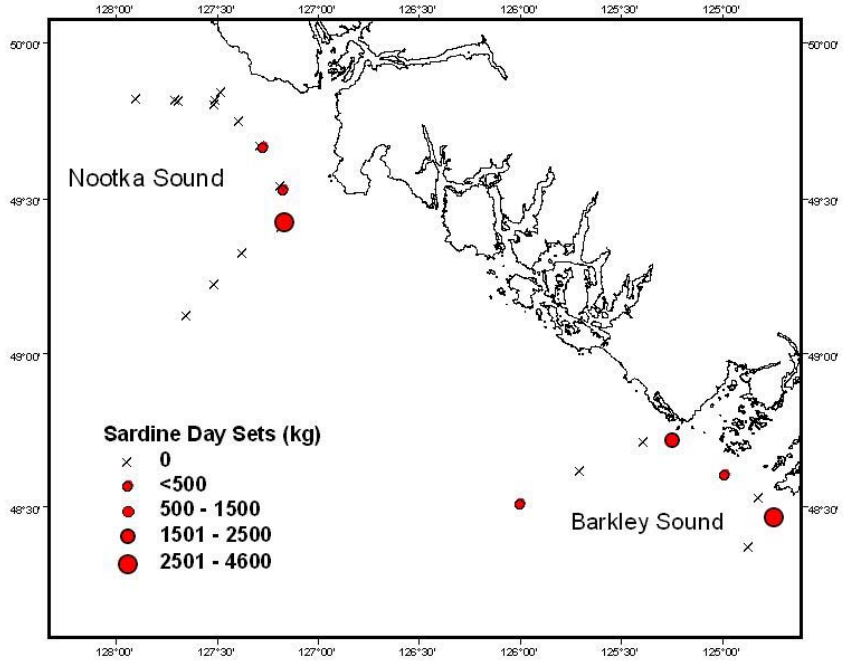


Figure 9. Set location and catch size along Nootka Sound and Barkley Sound transects for day cruises on the trawl research cruise aboard the F/V *Frosti*.

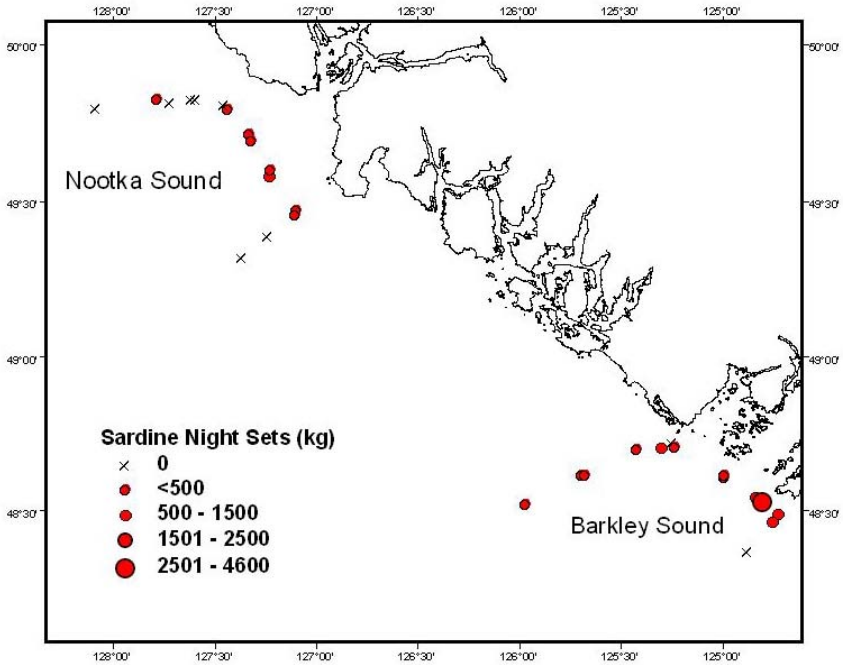


Figure 10. Set location and catch size along Nootka Sound and Barkley Sound transects for night cruises on the trawl research cruise aboard the F/V *Frosti*.

Table 2. Summary of Pacific sardine samples by sample type from the 2005 Pacific sardine survey conducted on the F/V *Frosti.*

set	location	time of day	# of sardines sampled	otolith pairs	stomach	full length	sex	maturity	weight
2	Nootka	Night	225	75	50	225	225	205	225
4	Nootka	Night	241	75	75	241	241	241	242
5	Nootka	Night	255	75	75	255	255	255	255
6	Nootka	Night	173	75	75	173	173	94	173
7	Nootka	Night	175	75	75	175	175	175	175
8	Barkley	Night	6			6	6	6	6
9	Barkley	Night	445	55	48	445	445	445	445
10	Barkley	Night	40			40	40	40	40
12	Barkley	Night	475	75	75	474	475	475	475
13	Barkley	Night	361	60	60	361	361	361	360
14	Barkley	Night	288			288	288	288	288
17	Nootka	Day	2			2	2	2	2
22	Barkley	Day	25			25	25	25	25
25	Barkley	Day	449	49	49	449	449	449	449
27	Barkley	Day	10	10	0	10	10	10	10
28	Barkley	Day	415	75	75	415	415	415	415
32	Nootka	Day	485	85	75	485	485	485	485
42	Nootka	Night	300	50	50	300	300	300	300
43	Nootka	Night	200			200	200	0	200
44	Nootka	Night	301	50	50	301	301	301	301
47	Barkley	Night	40			40	40	40	40
48	Barkley	Night	349	49	49	349	349	349	349
49	Barkley	Night	305			305	305	305	305
50	Barkley	Night	253	51	51	253	253	253	253
51	Barkley	Night	140			140	140	140	140
52	Barkley	Night	222	50	50	222	222	222	222

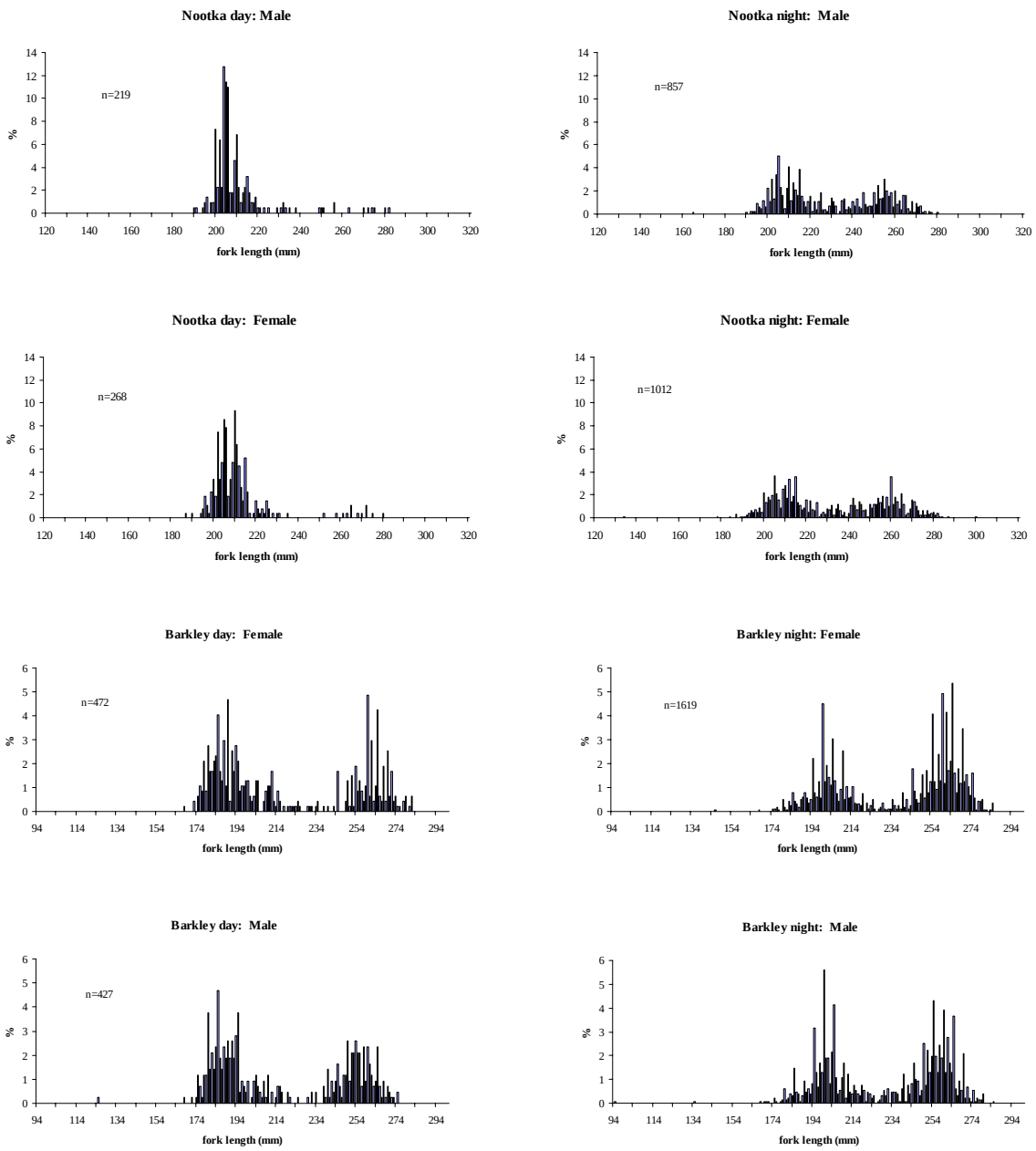


Figure 11. Comparing male and female Pacific sardine length frequencies for Nootka Sound and Barkley Sound for both day and night cruises on the trawl research cruise aboard the F/V *Frosti*.

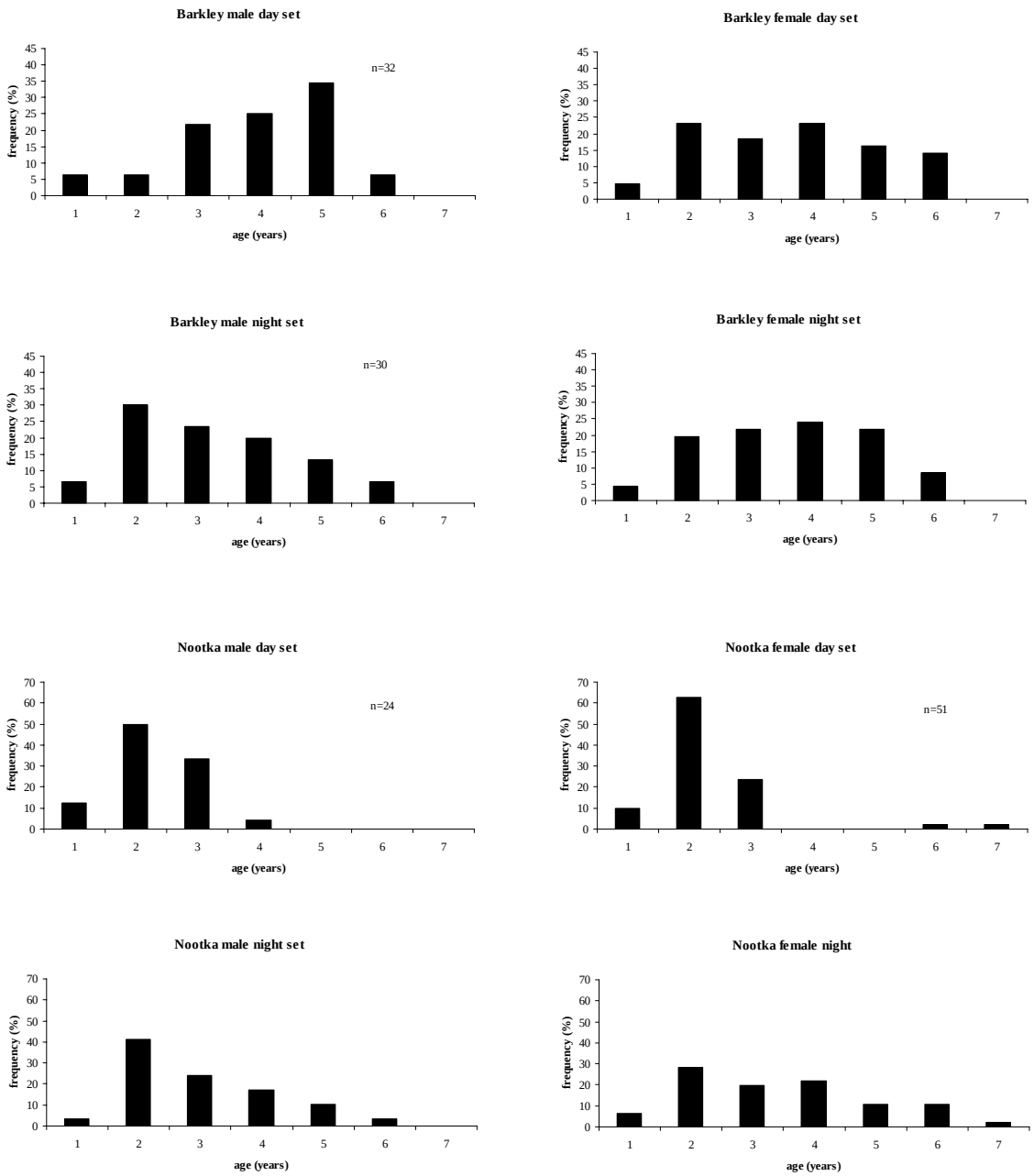


Figure 12. Comparing male and female Pacific sardine age frequencies along Nootka Sound and Barkley Sound transects for both day and night cruises on the trawl research cruise aboard the F/V *Frosti*.

Table 3. Summary of incidental catch by weight (kg) from the Pacific sardine survey on the F/V *Frosti* in August of 2005. Species with a catch weight of 1 kg and less are not shown.

set	sunfish	jack mackerel	blue shark	soupfin shark	pink salmon	chinook salmon	sockeye salmon	chum salmon	coho salmon	herring	hake	euphausid	yellowtail rockfish	jellyfish	dogfish
1	29.44	89.60	52.33		5.70										
2	9.90	68.04		25.07	1.90	40.35	2.98		2.34		952.54				
3															
4						20.42			26.41	36.40	30.00				
5				27.52	3.17	50.80		4.10	4.70	3.36	141.92				
6	6.74	2.34				31.91	2.07	11.65	4.86	trace	5.96				
7	5.17	1.91				139.00	2.56	50.92	10.78						
8				52.59					4.44						
9					12.99	30.16	3.55		8.29	281.63					
10		17.89			1.79	11.67	3.30		6.11			trace			
11						1.97			0.45	472.72					
12		2.33			1.04	9.55			27.71	438.40	2.78				
13						7.96	4.75		8.82	621.40	trace				
14					3.31	207.95	8.22		15.62						
15	11.82		2.68									3.81			
16		101.23				9.80	2.52		10.86						
17						24.63	5.68	5.72	18.57						
18					20.58	56.19	58.28		43.05					133.54	
19					5.25				12.34		0.86			700.00	
20					10.98	31.68	2.18	5.24	43.20					50.00	
21		5.90				1.90								trace	
22	5.00	143.34			1.86	66.66		16.14	38.94						1.74
23		58.60				14.22			45.44						
24		1.94							3.01						
25						13.78									
26		38.84				43.86			43.86						
27					3.55	10.25			25.54		trace				
28					trace	trace									
29		1.83				46.46			119.46						553.31
30	16.63	2.17												42.83	
31		2.09												27.17	
32		trace			trace	trace	trace	trace	trace						
33		25.31			1.70	50.51			40.10						
34		1.58			4.44	55.34	16.82		17.58					24.20	
35						48.76	4.94		11.89					3.70	
36					1.70	4.78			16.82					6.19	
37		536.68													
38		75.55	7.29										3.98	19.66	
39		22.13				27.87					0.65			24.49	
40		44.40				107.78		10.50		1.01	17.51	trace		4.63	
41		2.36		24.12	4.40	27.65		3.78	63.18	13.01	14.18				1.56
42					7.92	20.32				40.96	17.99				
43					7.04	7.27	2.64		10.83	108.07	7.21				
44		35.96			12.50		4.33		17.84		22.86				
45		15.84				13.45					13.06	26.15			
46		52.72										41.50		27.60	
47					1.58	30.89			16.63						
48		trace				12.92	2.50			63.80					
49									2.12	283.59	1.32				
50		trace				30.08	3.17		15.83	185.60					
51					trace										
52					0.93	18.79	6.02		7.44		1.12				
53		528.10			17.29	44.45	6.57		44.87	124.67	13.60				
Total	16.63	1344.89	7.29	24.12	59.50	500.86	46.99	14.28	265.13	820.71	109.50	67.65	3.98	180.47	1.56

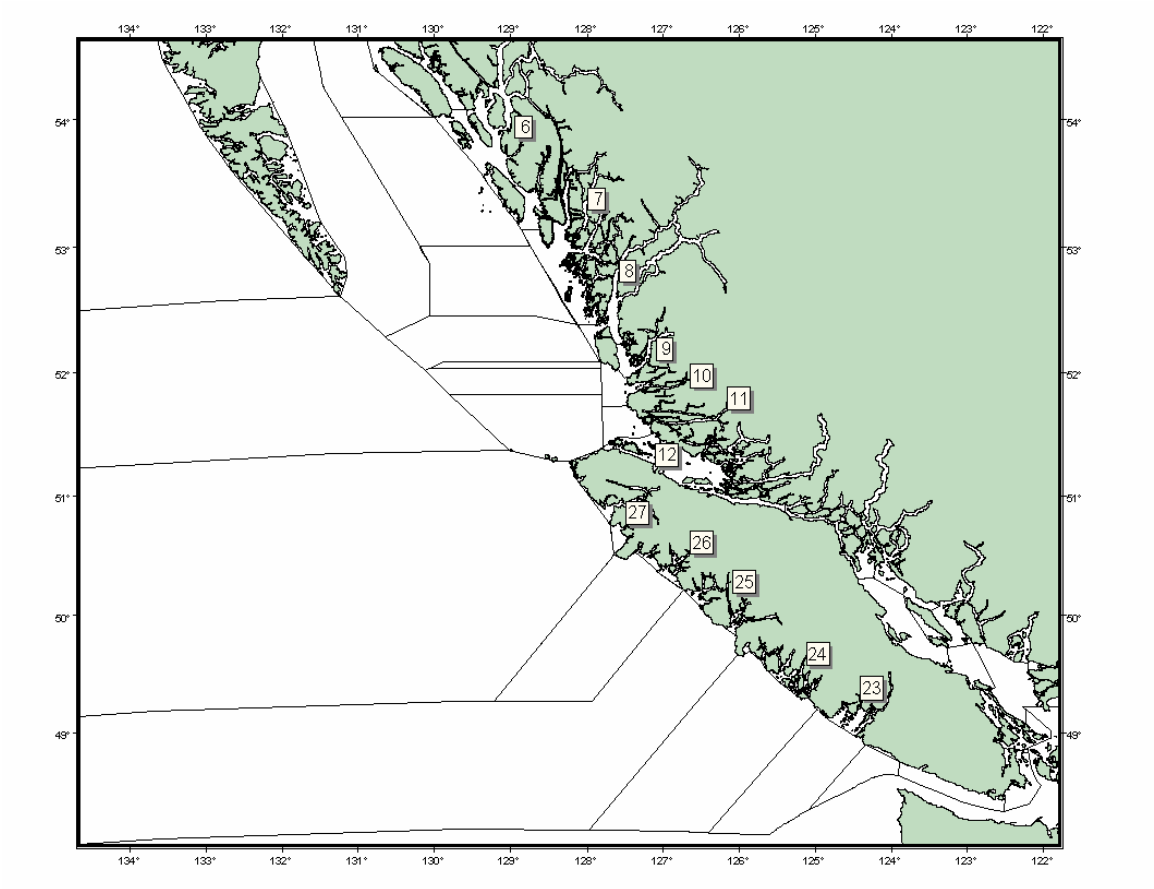


Figure 13. Management areas, denoted by numbers, on the British Columbian coast. The WCVI Inlets survey included areas 23-27 and the Vancouver Island coast in area 12, the Northern Index Sites survey included areas 6-12, and the WCVI Offshore Encounter-Response survey was conducted offshore from sites 23-27.

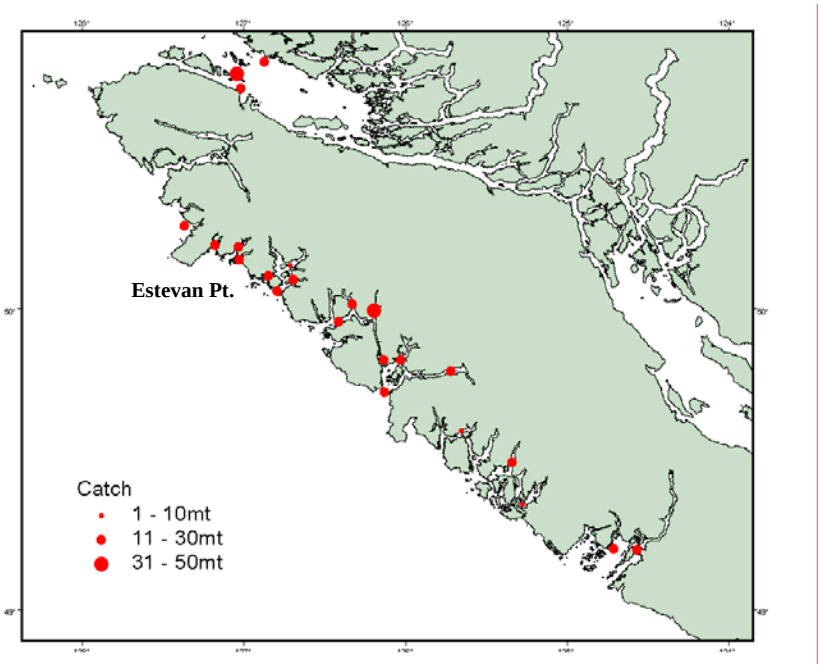


Figure 14. Catch size and location from the WCVI Inlet Industry survey.

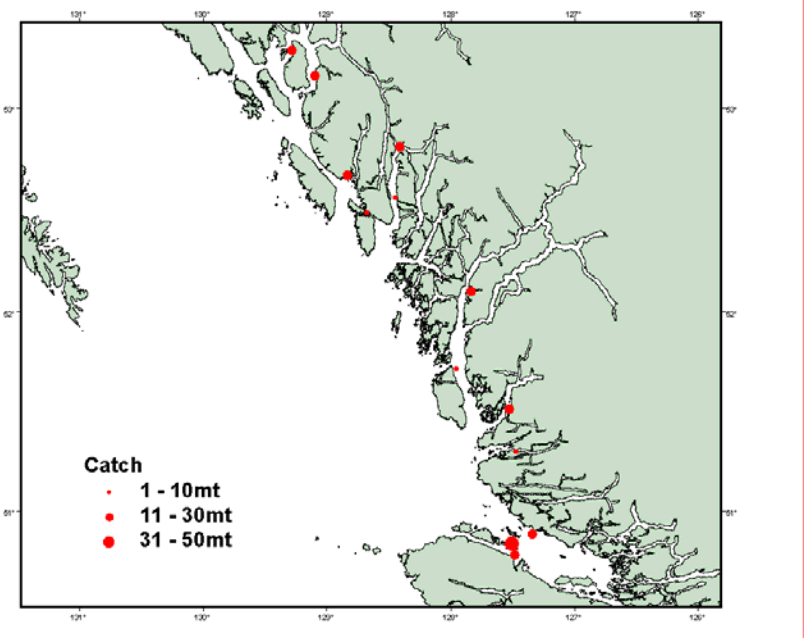
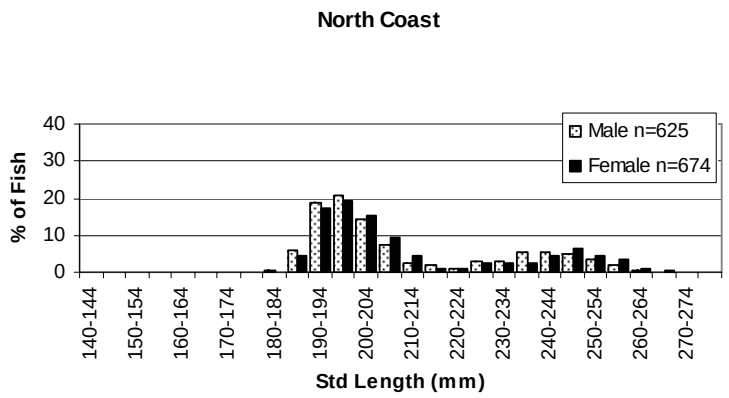
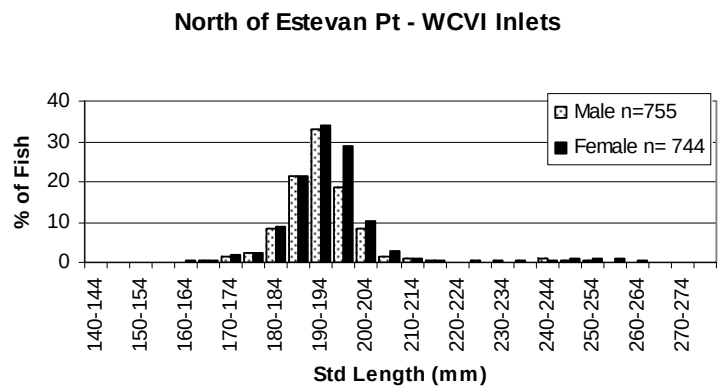


Figure 15. Catch size and location from the Northern Index Industry survey.





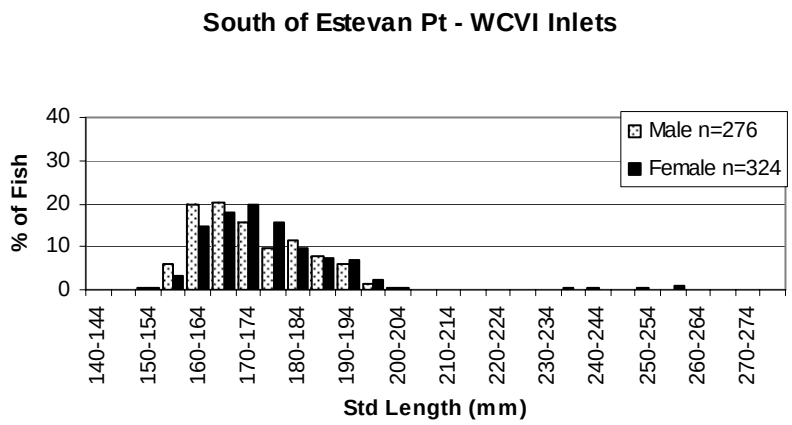


Figure 16. Comparing male and female Pacific sardine length frequencies along the entire coast for the three 2005 Industry sardine surveys.

IMECOCAL, January survey in South Baja California and Gulf of California

Objectives: To estimate spawning biomass of Pacific sardine in southern Baja California, México and in the Gulf of California, and to investigate the migration of Pacific sardine between the two (Hunter and Baumgartner 2002).

See report by Tim Baumgartner, Appendix IV.

Working Group 1 Future Plans and Recommendations

MÉXICO

1. Continue monitoring the fishery

   In Ensenada, sampling programs will be continued to monitor the fishery and obtain estimates of biological parameters each month: daily samples from the fishery catch and adult samples to get reproductive parameters. During the peak spawning period, sampling is intensified: 1-2 samples per day, around 30 fish per sample.

   In Bahía Magdalena, programs also exist to monitor the commercial catch from the fishery. Adult samples are taken for length and weight one day per week. For biological data, three samples per month are taken. During spawning season, the number of samples is increased and samples are also taken aboard commercial vessels. This year, however, no observers are sent to commercial vessels to collect samples in Ensenada. Some commercial captains do take samples for CRIP, but most of the sampling is done in port. The same type of monitoring is also done in the Gulf of California, which is coordinated and paid for by industry.

2. Increase the amount of ship time for IMECOCAL

   Dr. Cotero indicated that the ship time for IMECOCAL was reduced to 10 days for the last October cruise from the standard 21-22 days for each IMECOCAL cruise (January, April, July, October), and it will be the same this year. The vessel now does not go as far offshore, and the number of CUFES samples has been reduced from 800 to 400. The IMECOCAL survey emphasizes physical oceanography rather than biological samples. Nevertheless, more ship days for IMECOCAL are needed.

3. Lack of trawl surveys

   Due to the budget constraints and no access to the commercial fishery, very few adult samples have been collected. There is no trawl vessel based in Ensenada. Drs. Cotero and Baumgartner are working together to obtain adult samples along with ichthyoplankton for the biomass estimate. Eggs obtained using CUFES during IMECOCAL were counted by researchers at CRIP, Ensenada. Determining spawning biomass is not a primary objective of IMECOCAL, and the April cruise will be a special case.

4. Surveys in February-March, 2006 off western Baja California

   In addition to the coast-wide survey in 2006, México may conduct an ichthyoplankton survey on the west coast of Baja California from Ensenada to Bahía

Magdalena in February, after the regular January IMECOCAL. However, this is uncertain due to a lack of funding. One of the coordinators of the cruise is Tim Baumgartner. A tuna trawler may be chartered to do the survey during February for one month in Baja California and during March for one month in Baja California Sur from Punta Eugenia to Bahía Magdalena.

CANADA

1. A scientific workshop was again proposed to create a biological, economic and oceanographic model for Pacific sardine biomass estimates. Jake Schweigert has suggested that Don Pepper take the lead in organizing this workshop in 2006.

2. It is likely that the general abundance surveys done by purse seine beginning in 2005 (including inlets, and supported by industry) will continue on a yearly basis. This is in addition to the routine trawl survey that Sandy McFarlane conducts in July or early August.

3. Researchers plan to continue monitoring biological parameters of the population from the commercial catch and take samples.

U.S.A.

1. Extend the survey pattern offshore in California waters for the biennial Pacific hake survey conducted by the Northwest Fisheries Science Center. The survey runs from Point Conception to Canada to obtain trawl samples of adult Pacific sardine at night and to collect Pacific sardine eggs using CUFES and CalVET nets. The NWFSC may have time after the Pacific hake survey is over to take some trawls for Pacific sardine and northern anchovy.

2. Restore the Northwest trawl-acoustic surveys during February-March and in July in the future. The Northwest July survey was not conducted in 2005 due to the unavailability of ship time.

3. Organize a workshop to evaluate the Northwest trawl surveys conducted by SWFSC and to discuss the proper timing and the use of other survey methods such as LIDAR and acoustics during the coast-wide survey.

4. During the DEPM survey each April, it may be possible to ask coastal pelagic species observers to collect adult samples (March-May) in the Southern California Bight and Monterey to increase sample size.

WORKING GROUP 2: Stock Structure, Age Structure and Adult Sampling

Working Group 2 convened at the Hotel Cortez at 10:00 November 15, 2005. The overall discussion focused on: 1) new starts and accomplishments to date; 2) sampling logistics for the upcoming coast-wide survey; and 3) where to go from here in terms of students, research projects, and most importantly, funding.

First the group discussed the papers and posters presented the previous day, as well as the collected wisdom of the scientists present. Good starts have been made in the areas of otolith morphology, otolith microchemistry (elemental and stable isotope analyses), genetic comparisons of various populations, and the use of the stable isotope composition of Pacific sardine soft tissues as indicators of trophic structure and relationships. All of the studies have provided useful first steps in the understanding of regional differences in environment and its expression in Pacific sardine phenotype. To date, no single study has been able to compare differences throughout the full range of Pacific sardine distribution from the Gulf of California to British Columbia. Rather, work is progressing via smaller projects, often Masters and Ph.D. theses that will eventually be combined into a larger overview. It was agreed that the Trinational Sardine Forum is working well as a means of standardizing analytical approaches such that regional data can eventually be combined into a coast-wide synthesis. The working group approach has been important in developing a means of sharing samples and standardizing sampling and analytical protocols. Members of the working group have written joint proposals to various bi-national funding agencies with reasonable success.

In the case of otolith microchemistry, it is clear that there are regional signals, particularly in the Mexican portion of the study area, where temperature and salinity ranges can be more extreme and where oceanographic conditions are different. Laboratory studies that attempted to confirm the underlying hypothesis that otolith microchemistry reflects water chemistry and not temperature or diet have been mostly completed on captive Pacific sardine and bear out the basic assumptions, except that some trace elements such as phosphorous may be labile and can leave the otolith. The next step is to determine the degree of seasonal and yearly variation in different elemental and isotope signals to determine which approaches best reflect the region of birth so that their utility in tracking migration and in identifying natal stocks can be fully exploited with a minimum of cost and analytical time. Stable oxygen isotope signals that may reflect water temperature seem to be particularly promising, while some trace metal signals seem less easy to interpret.

Genetic analyses are underway that rely on mitochondrial DNA sequences and nuclear microsatellite markers. A preliminary study of microsatellite variability from three regions of the coast was presented with the surprising result that genetic variability at the northern extent of the range was quite large. This preliminary result is inconsistent with the idea that Canadian populations are extirpated under unfavorable climate conditions and were only recently repopulated. Confirmation of this result will be important in the coming year.

A central problem faced by all of the members of the working group is the identification of funds to carry out this work. Despite broad scientific interest and a consensus that it is critical to management, research on Pacific sardine stock structure tends to be more exploratory and is

often carried out in primarily academic institutions. To date, projects have been funded by small grants rather than broad institutional support. Finally, the problem of aging Pacific sardine otoliths to improve population dynamics studies was again agreed to be a particularly important need and one best supported by federal fisheries organizations rather than academia. However, no funding sources have been identified among the various national and state fisheries agencies.

Future Plans and Recommendations

The working group as a whole was very pleased with the progress made since the last meeting, and made the following recommendations for the future:

1. It is important to learn where the spawning grounds for the Pacific sardine are as this would greatly increase resolution obtained with genetic studies. Knowing the feeding grounds is not as useful, as there is likely mixing among potential subpopulations during the adult stage.

2. The group has been impressed with South African and Japanese fishery management. These nations seem to have a handle on the small recruits and can tell the fisherman that a year class is coming. We should pay attention during the trawl survey to the smaller fish and where the year classes are.

3. A goal for next year's Forum will be to lay out a fine scale sampling scheme once the genetics and the microchemistry are more worked out. This would help elucidate migration patterns more clearly and establish adequate sampling protocols. For instance, having port sampling stations or bait barge sampling throughout the entire latitudinal range would help us to learn where the recruits are.

4. A useful study would be to raise Pacific sardine from different regions in captivity and discover if gill raker and vertebral counts are genetically inherited or if they are functions of water temperature.

WORKING GROUP 3: Industry Trends and Issues
(Don Pepper, Pacific Sardine Association)

The industry working group focused on the role of the Forum and its relevance to industry. We posed the rhetorical question: what's in it for us? This provided us with the conclusion that there are tangible benefits in the form of scientific knowledge. The Forum is useful also because it avoids, indeed excludes, management and allocation issues.

The Forum gives industry "organized science," that is, science that is useful to industry. This is in the form of a biological model of the Pacific sardine stocks. From this it is hoped that a long-term predictive model that incorporates timing and distribution of stocks can be developed. Ultimately, industry's needs are simple: How many fish are there? Where and when are they located? And can we make a profit from fishing them?

The role of the Trinational Sardine Forum needs to be reviewed. At present, it is actually an informal arrangement that functions excellently (due to the professional attitude of the participants) which might be said to function in a semi-formal way given that it has a highly structured set of proceedings. However, it appears it is time for the Forum to evolve. There are various reasons for this. Primarily, as the Pacific sardine fishery develops there is a need for the industry to be comfortable in making long-term investments in the infrastructure necessary for a successful and stable fishery. This is especially true in the Canadian context. There is a common goal among government, industry and the Trinational Sardine Forum, which has to be a sustainable and profitable fishery.

From this, the challenge is to examine the mandate of the Forum to incorporate these long-term objectives. It is essential for industry and government to plan for the future. The Forum is a mechanism to provide this. It is hoped that the next session in Canada can address this problem. Given the success of the Forum to date, the industry participants are confident this can be achieved. The industry will be providing an impetus for a better Trinational Sardine Forum that builds upon the goodwill and success of its past achievements.

Future Plans and Recommendations

The working group members agree with Dr. Hunter in that a limit exists to how much can be done in the informal setting of the Trinational Sardine Forum, and they believe the time has come to move forward with a more formal arrangement. The following points were also put forth:

1. Orlando Amoroso (U.S.), Don Pepper (Canada), and Lic. Martín Gutiérrez (México) will work together to increase industry interest in next year's Forum in Canada.

2. What is really needed from the scientists is a predictive model that could suggest how many fish there are, what they're eating, where they are, and the age distribution, so that the industry can efficiently plan. The information should be specific for each of the three countries.

3. Industry deals with government, and by statute, has to look at the science first. So, industry participants want to be on top of the science and push it in the direction that is useful to them.

4. The technical methods for harvesting Pacific sardine have changed over the years, and it would be beneficial to have more discussion about this.

5. The industry participants would like a full day at the Forum devoted to their specific interests, the format of which will be worked out at a later time.

6. There should be a commercial side of Pacific sardine fishing being addressed at the Forum, and industry members should be invited to give talks on this issue.

7. There are banks and financial institutions supporting the industry in each country. In the future we should consider inviting them to the Forum. Increasing their awareness might increase their investment in the industry.

8. The U.S. has access to advanced technology, while México is at a technological disadvantage. Participants suggested that members of the industry be invited that can discuss and provide new technologies to the fleet.

9. Industry participants hope that with the Forum in Canada next year there will be good discussion and sharing of technology, without revealing trade secrets. For example, there has been research done on how a Pacific sardine rots, which is important information in the food industry to help improve sardine quality.

10. Tuna aquaculture is very advanced in México, and industry participants would like to see technical and operational issues on aquaculture presented more often.

11. The position of the industry participants from México is that there is room for scientific presentations at the TSF, but issues of management and quotas should be left for each country to pursue individually.

CONCLUSIONS

This two full day Forum was indeed a success. In addition to the regular sessions on regional Pacific sardine fisheries, research plans and reports, working group breakouts and a poster session, a session on contributed papers was added to increase the diversity of the Forum (see the program). Since our first Forum in 2000, substantial progress has been made in the areas regarding age structure, monitoring shifts in maturity, conducting coast-wide biomass surveys and regional surveys to fill gaps, and stock structure. In particular, the coast-wide survey, the focus issue of this Forum, will be realized in 2006. Another feature of the Forum is the newly formed working group on industry trend and issues.

The stock assessment of the Pacific sardine indicated a general decline in the stock productivity since the mid-1990s. Recruits (age 0) declined from 9.5 million fish in 1994-95 to a level between 3.5 and 6.5 million fish in recent years, although the biomass has been stable at around 1 million mt since the late 1990s. The commercial landings off Ensenada and the U.S. were similar to previous years. However, the catch in the Gulf of California is decreasing, and in Bahía Magdalena, the fishing effort has declined during 2003-2005. Similarly, off Canada, the catch in 2005 was much lower than 2004 and the fish was smaller (100 g). Much effort in 2005 was devoted to exploration and many new fishing areas in the northern part of Canada were discovered.

The coast-wide survey is to be conducted in April-May 2006. The Fisheries Resources Division of NMFS has secured ship time on two NOAA research vessels for this survey in addition to the regular CalCOFI survey in April. The INP, México, will also provide ship time, most likely on the R/V *El Puma* and the R/V *Altair* to cover the Baja California area. Although Canada is unable to provide ship time, they will provide sea-going personnel. The results of this survey will shed much light on the Pacific sardine off the west coast of North America in terms of the spatial distribution, the biomass, the size and age structure, and the verification of different population stock structures based on morphology, genetics, and microchemistry. In addition, we are likely to discover other biological characteristics of the population from Baja California to British Columbia, and will investigate linkages to oceanographic and environmental conditions.

The new working group on industry trends and issues was created to address the needs of the industry, and was well supported with many participants from the industry of the three countries attending (Appendix I). It is apparent that scientists from government and academia as well as industry representatives all have common goals: 1) better understanding of the status of the Pacific sardine population; 2) the location, timing and abundance of the fish; and 3) the ability to predict these factors in the future. One goal unique to industry is to find a way to make a profit from a sustainable population on a long-term basis. The industry representatives felt that the Forum needs to evolve and have a more formal structure to achieve these goals. However, these goals require the collaboration among all three nations as well as adequate funding and manpower in order to conduct extensive sea surveys, to develop a predictable economic, biological and oceanographic model, and to create a more formal Forum.

The 2006 Forum will be held in Vancouver, Canada in late October or early November. (http://swfsc.nmfs.noaa.gov/frd/Trinational/index.htm; if this link is no longer active, please visit http://swfsc.noaa.gov).

ACKNOWLEDGEMENTS

We thank Kevin Hill and William Watson of Southwest Fisheries Science Center for providing comments of early drafts of this report.

REFERENCES

Buckland, S. T., Anderson, D. R., Burnham, K. P., and J. L. Laake. 1993. Distance sampling: estimating abundance of biological populations. Chapman and Hall, London, Glasgow, New York, Tokyo, Melbourne. 446 pp.

Chen, H., Lo, N., and B. Macewicz. 2003. MS Access programs for processing data from adult samples, estimating adult parameters and spawning biomass using daily egg production method (DEPM). Southwest Fisheries Science Center, National Marine Fisheries Service, SWFSC Admin. Report LJ-03-14. 101 pp.

Conser, R., K. Hill, P. Crone, N. Lo, and R. Felix-Uraga. 2004. Assessment of the Pacific sardine stock for U.S. management in 2005: Pacific Fishery Management Council, November 2004. 135 pp.

Hill, K. T., Lo, N. C. H., Macewicz, B. J. and R. Felix-Uraga. 2006. Assessment of the Pacific sardine (*Sardinops sagax caerulea*) population for U.S. management in 2006. NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-386. 85 pp.

Hunter, J. R. and T. Baumgartner. 2001. Trinational Sardine Forum Proceedings. Interim report on the first meeting. Southwest Fisheries Science Center, National Marine Fisheries Service, SWFSC Admin. Rep., La Jolla, LJ-01-06, 25 pp.

Hunter, J. R. and T. Baumgartner. 2002. Proceedings of the 2001 Trinational Sardine Forum: An Informal Report of the Meeting. Southwest Fisheries Science Center, National Marine Fisheries Service, SWFSC Admin. Rpt. LJ-02-39, 98 pp.

Hunter, J. R. and D. Pleschner-Steele. 2003. Minutes of the 2002 Trinational Sardine Forum San Pedro, California, U.S.A December 5-6, 2002. Southwest Fisheries Science Center, National Marine Fisheries Service, SWFSC Admin Rpt LJ-03-05, 54 pp.

Lo, N. C. H., Hunter, J. R., and R. Charter. 2001. Using a continuous egg sampler for ichthyoplankton surveys: application to the estimation of the daily egg production of Pacific sardine (*Sardinops sagax*) off California. Fish. Bull. 99:554-571.

Lo, N. C. H., Macewicz, B. J., and D. A. Griffith. 2005. Spawning biomass of Pacific sardine (*Sardinops sagax*) from 1994-2004 off California. Calif. Coop. Oceanic Fish. Invest. Rep. 46:93-112.