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Southwest Fisheries Science Center

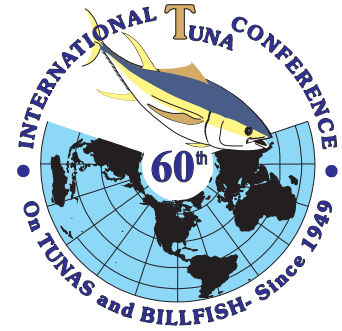
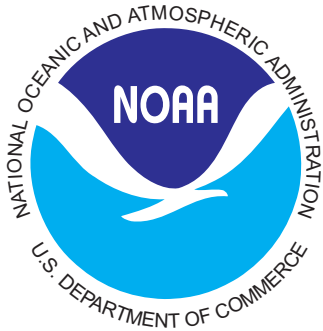
# Director's Report to the **60th** Tuna Conference

On Tuna and  
Tuna-Related Activities at the  
Southwest Fisheries Science Center  
for the Period May 1, 2008  
to April 30, 2009



**ADMINISTRATIVE REPORT LJ-09-02**

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**DIRECTOR'S REPORT TO  
THE 60<sup>th</sup> TUNA CONFERENCE ON  
TUNA AND TUNA-RELATED ACTIVITIES  
AT THE SOUTHWEST FISHERIES SCIENCE CENTER  
FOR THE PERIOD MAY 1, 2008 TO APRIL 30, 2009**

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**May 2009**

**ADMINISTRATIVE REPORT LJ-09-02**



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## **Introduction**

This report highlights Southwest Fisheries Science Center activities during the past year relating to tropical tunas, albacore, billfishes, oceanic sharks, and protected species associated with their fisheries. The Center's biological, economic, and oceanographic research was focused on supporting the information needs of international scientific working groups and committees, the Pacific Fishery Management Council, and the National Marine Fisheries Service. Major tuna-related activities included stock assessments, socio-economic research, research on interactions between fisheries and protected species, and mathematical modeling of fish movements and fishery interactions. The data collection and analysis were aimed at maintaining healthy U.S. and world fisheries, populations of protected marine species, and fish habitat, and ensuring that the most effective fishing regulations and international treaties are carried out supported by best available science. Center scientists also were active in tuna-related international fora such as the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean and the Scientific Committee of the Western and Central Pacific Fisheries Commission.

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## **I. SUPPORTING U.S. OBLIGATIONS OF INTERNATIONAL AGREEMENTS**

The U.S. is party to a number of international agreements for the conservation of highly migratory species (HMS) in the Pacific Ocean. As such, it is obligated to collect fishery statistics from U.S. HMS fisheries and to participate in advancing fishery science for species of interest. Scientists at the Southwest Fisheries Science Center (SWFSC) have been tasked to fulfill this obligation. In this section, brief descriptions of some of the contributions and activities during the past year, May 2008–April 2009, are described.

**Monitoring the Purse Seine Fishery in the Western-Central Pacific Ocean** – The National Marine Fisheries Service (NMFS) collects and manages data from the U.S. purse seine fishery for tropical tunas in the western-central Pacific as part of U.S. obligations under the South Pacific Tuna Treaty. Information from U.S. vessels licensed to fish under the treaty is collected by the NMFS Pacific Islands Regional Office (PIRO) in American Samoa and transmitted to the SWFSC in La Jolla, California, where information from logbooks and landings and biological data from port sampling are processed.

The size of the U.S. purse seine fleet increased in 2008 to 30 vessels from 22 vessels in 2007. Preliminary estimates of the 2008 catch (157,848 metric tons, t) increased 78% from the 88,736 t caught in 2007. Skipjack tuna dominated the 2008 catch (81%), followed by yellowfin tuna (15%) and bigeye tuna (4%).

Purse seine sets on floating objects (logs and fish aggregation devices) in 2008 accounted for 49% of the total sets, a decrease from 69% of total sets recorded in 2007. Sets on free-swimming schools accounted for 51% of the sets, an increase from 31% in 2007. The overall catch rate (CPUE) was 29 t per day fished in 2008, a slight decrease from 33 t per day fished in 2007.

Biological samples collected from the tuna catch provided estimates of sizes of fish caught on a species by species basis. Length measurements were taken from 65,213 yellowfin, skipjack, and bigeye tunas, an increase of 10% from the 59,446 fish sampled in 2007. Preliminary estimates of average fork lengths (FL) of fish sampled in 2008 are 74 cm for yellowfin, 55 cm for bigeye, and 54 cm for skipjack.

**Contributing to the Work of the WCPFC Scientific Committee** – The Scientific Committee (SC) of the Western and Central Pacific Fisheries Commission (WCPFC) held its fourth session in Port Moresby, Papua New Guinea, August 11-22, 2008, to review results of stock assessment research on HMS stocks of the western-central Pacific Ocean region, results of bycatch research, and other issues. Center scientist Gary Sakagawa participated in the meeting as a member of the U.S. delegation, led by Christofer Boggs of the NMFS Pacific Islands Fisheries Science Center (PIFSC), and as a representative of the International Scientific Committee (ISC). The priority species for the SC's stock assessments are yellowfin tuna, bigeye tuna, skipjack tuna, and South Pacific albacore. The SC also conducts oversight review of the work on North Pacific stocks prepared by the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC).

The SC estimated that the catch of the priority tuna species in the WCPFC area for 2007 was 2.4M t, the highest annual catch recorded. Skipjack tuna comprised 72% of the catch (1.7M t),

while yellowfin tuna was 18% (431,800 t), bigeye tuna was 6% (143,100 t), and South Pacific albacore comprised 4% (95,200 t). The SC concluded that the abundance of both yellowfin tuna and bigeye tuna has been declining and overfishing is likely occurring. With current levels of high fishing mortality and average recruitment levels, the stocks are projected to continue to decline in abundance. The SC, therefore, recommended a minimum of 30% reduction in fishing mortality for both species from the average level for 2003-2006. For skipjack tuna, the catch is at record high and the stock is in good condition. The current high catch is sustainable provided recruitment does not persistently fall below the long-term average. For South Pacific albacore, there is uncertainty that the current catch, which is primarily of adults, is sustainable and the SC recommended that catches remain at current levels.

The SC also reviewed stock assessment results of North Pacific stocks prepared by the ISC and of other South Pacific stocks prepared by members or contractors. The findings and recommendations for these stocks are contained in the report of the SC meeting and available on the WCPFC website.

**Exchange of Fishery Data for the U.S.-Canada Albacore Treaty** – The U.S. and Canada have a reciprocal fishing and port access agreement, the U.S.-Canada Albacore Treaty, for albacore in the North Pacific Ocean. The treaty allows controlled fishing access for U.S. and Canadian albacore troll vessels in each party's Exclusive Economic Zone (EEZ) and albacore landing privileges in designated ports. Monitoring of the U.S. fishery is performed by the NMFS Southwest Regional Office (SWRO) with the Center staff providing support for processing, summarizing, and reporting the fishery data. In December 2008, the parties met for their annual consultation to review provisions of the treaty and to review exchange of fishery data. Center staff did not participate but provided preliminary statistics from the 2008 U.S. albacore troll fishery, including estimates of catch and effort within the Canadian and U.S. EEZs for the data review. Results of the consultation included new limitations on numbers of vessels allowed to fish within each other's EEZ, and additional requirements for vessel markings, maintaining accurate catch and effort records, exchanging of fishery data, and provisions for recording historical catch should international management catch measures be adopted. The consultation also resulted in the exchange of updated fishery data for 2007 and preliminary fishery data for 2008.

**Contributing to the Work of the ISC** – The U.S. is a member of the ISC, along with Canada, China, Chinese Taipei, Japan, Korea, Mexico, the Inter-American Tropical Tuna Commission (IATTC), North Pacific Marine Science Organization, Secretariat of the Pacific Community, and Food and Agriculture Organization of the United Nations. The purpose of the ISC is to enhance scientific research and cooperation for conservation and rational utilization of species of tuna and tuna-like fishes which inhabit the North Pacific Ocean, and to establish the scientific groundwork for the conservation and rational utilization of these species in the region through a multilateral regime. The ISC is organized into five Working Group—statistics, bycatch, Pacific bluefin tuna, albacore, and billfish—that meet intercessionally and report to a Plenary body. The overall chairman of the ISC is Gary Sakagawa of the SWFSC. Results of the ISC are made available to participating members and to HMS regional fisheries management organizations of the Pacific Ocean.

The 8<sup>th</sup> Plenary meeting of the ISC was held in Takamatsu, Japan, July 22-27, 2008, and hosted by the Japan Fisheries Agency and local prefectural agencies. Scientists from Canada, Chinese Taipei, Japan, Korea, Mexico, and the United States participated. A representative of the Scientific Committee of the WCPFC attended as an observer. Christofer Boggs of the PIFSC led the U.S. delegation at this meeting. The delegation consisted of fishery scientists and fishery management experts from NMFS and a scientist representing a non-governmental organization (NGO).

Participants reviewed results of work performed by the ISC Working Groups since the 7<sup>th</sup> meeting. Considerable progress was made in understanding the status of the stocks by the working groups. A Pacific bluefin tuna (*Thunnus orientalis*) stock assessment, involving application of a complex Stock Synthesis 2 (SS2) model and major advances in parameter specification and estimation for the species, was completed. Analysis of biological reference points and production of “Kobe” diagrams were advanced for North Pacific albacore (*T. alalunga*). An assessment of the geographic center of population abundance of striped marlin (*Tetrapturus audax*) in the North Pacific Ocean was produced for use by the WCPFC in deciding whether the stock should be designated as a northern stock under WCPFC rules.

The participants concluded that it was important that the current fishing mortality rate for Pacific bluefin tuna not be increased. For albacore, a full, updated stock assessment is planned for 2010. Until then, the participants advised that the results of the last assessment still hold, i.e., fishing mortality rate should not be increased above recent levels. Similarly for striped marlin, the participants concluded that the 2007 advice still holds and fishing mortality should be reduced.

Miscellaneous matters were also reviewed by participants, including biological research needs and plans for a workshop to prepare a plan to coordinate multi-species sampling for biological studies. In looking ahead, the participants agreed to prioritize and accelerate work on the ISC database and website in order to improve the interface among the ISC working groups and between its partners and constituents. Work is continuing on preparation for upcoming stock assessments for swordfish (scheduled for 2009) and albacore (scheduled for 2010). The participants also accepted an offer from the Fishery Agency of Taiwan to host the 9<sup>th</sup> ISC meeting in Kaohsiung, Taiwan, in 2009.

## **II. SUPPORTING PACIFIC FISHERY MANAGEMENT COUNCIL ACTIVITIES**

Center scientists Stephen Stohs, Suzanne Kohin, and Kevin Piner served on the Highly Migratory Species Management Team of the Pacific Fishery Management Council over the past year. The team met several times in 2008 and early 2009 to review fishery information, complete assignments from the Council, and evaluate provisions of the fishery management plan for U.S. West Coast HMS fisheries. The main HMS issues facing the team and Council over the past year have been: (1) continuing development of a fishery management plan amendment to allow U.S. West Coast-based shallow-set swordfish longline fishing on the high seas; (2) considering alternatives to existing management measures for the recreational shark fisheries; (3) providing recommendations to the delegations of the WCPFC and IATTC for international fishery management; (4) developing proposals for improved recreational fishery data collection; and (5) preparing the 2008 Stock Assessment and Fishery Evaluation (SAFE) Report.

### **III. HIGHLY MIGRATORY SPECIES DATA COORDINATION**

A data coordination team has been working since 2002 towards better coordination of the collection and maintenance of HMS data at PIFSC, PIRO, SWRO, and SWFSC. The team is co-chaired by staff from PIFSC and SWFSC. The team did not meet in 2008 but coordination of HMS data summaries for regional fisheries management organization submissions continued. The team created the HMS data portal (<http://swfscdata.nmfs.noaa.gov/HMS/Default.htm>) in 2005. The data portal describes HMS data sets, collection, management, and reporting activities. The site contains an HMS data catalog with metadata descriptions and summaries of each data set maintained by the members. Meeting minutes, data submissions and guidelines, minimum suggested requirements for data collections, and data management policies are also available on the site. The site is still undergoing development to update metadata, add fisheries, and enhance displaying of data.

The team has also been working closely with the national Fishery Information System (FIS) project at NMFS headquarters. A representative of the SWFSC and PIFSC staff is on the FIS Program Management Team. FIS funds numerous projects that contribute toward improving fisheries dependent data that are collected and maintained by the agency. Staff members from SWFSC and PIFSC are leading several of these projects to improve data collection and management systems in their respective regions.

A representative from SWFSC chairs an FIS Professional Specialty Group that is developing a reconciliation tool to aid fisheries data managers in reconciling various fishery data that NMFS collects. The first version of the tool was used to reconcile logbook and landings data. The current version incorporates other types of fisheries data sets (observer data, permits data, biological data, etc.). The use of the tool will improve data quality in regional databases by enabling the correction of errors in species, gear identification, unloading tonnages, etc., and allow for selecting the best available data to be used in reporting procedures. The tool is currently being transferred to the Office of Science and Technology at NMFS headquarters, whose staff will distribute it to various regional programs.

HMS information technology specialists at the SWFSC are also improving data collection methods. A representative from SWFSC chairs an Electronic Monitoring Committee under the National Observer Program. The Committee is responsible for researching, assessing, and inventorying electronic data collection and monitoring projects being developed by regional observer programs. Electronic calipers and handheld computers are being used by port samplers in Oregon and Washington to collect length measurements of albacore from U.S. troll and baitboat landings. Future plans are to expand the electronic collection system to other programs and to enhance the transfer of data from the field computers to the centralized HMS database. SWFSC staff members have also developed an electronic logbook software application that is currently being used in the Pacific albacore troll and pole-and-line fishery. The application will be more widely used by the fleet in 2009.

The SWFSC HMS team continued development of its HMS database in 2008. An application for web-based data entry and data management has been developed and is being used by Center

data managers. Since the application is web-based, data entry does not have to occur on-site. The application is being expanded to provide data entry capability for all HMS fisheries data sets. In addition, legacy data sets are being migrated into the centralized Oracle database system. The database will interface with other databases maintained by the agency and its partners to ensure national coordination of fisheries data being maintained in different regional programs.

#### **IV. ADVANCING TUNA AND BILLFISH RESEARCH**

The SWFSC research on tunas and billfishes in the Pacific Ocean has largely been focused on better understanding the biology and ecology of the animals to support needs for assessing the effects of fishing on the population or stock. Described below are studies that have been completed or are ongoing by Center staff. These studies are carried out largely in cooperation with stakeholders and in collaboration with colleagues both in the U.S. and abroad.

**Monitoring the U.S. Albacore Troll Fishery** – U.S. troll vessels have fished for North Pacific albacore since the early 1900s and for South Pacific albacore since 1986. North Pacific albacore fishing areas range from Vancouver Island to the coast of Baja California and from the U.S. West Coast to approximately 160°E. The fishing season begins in late April and can last into mid-November. The size of the troll fleet for a season ranges from 500 vessels to over 1,000 vessels. About 620 U.S. troll vessels fished for North Pacific albacore in 2007.

Fishing areas for South Pacific albacore extend eastward from the east coast of New Zealand to approximately 110°W and between 30°S to 45°S. This fishery begins in late December and continues until early April of the following year. The international troll fleet in the South Pacific consists of 5 to 50 vessels. Factors such as increased fuel costs, lower ex-vessel prices and reduced availability of fish have contributed to a decrease in participation in the South Pacific troll fishery in recent years. Eight U.S. troll vessels fished for albacore in the South Pacific during the 2006-2007 season and caught 270 t of albacore, a significant decrease from 601 t caught the previous season. Bycatch species are sometimes reported in vessel logbooks and include yellowtail, dolphinfish and skipjack, as well as yellowfin, bigeye and bluefin tunas.

The Center routinely collects, manages, and reports the following information for use in stock assessments and for monitoring the U.S. albacore troll fisheries in the Pacific: (1) landings data obtained from U.S. West Coast states and canneries in American Samoa; (2) logbook data collected from albacore troll and baitboat fishermen; and (3) length frequency data obtained through port sampling of U.S. albacore troll and baitboat vessels operating in the Pacific Ocean.

The SWRO provides logbooks to fishermen, who record fishing information and return the logbooks to the Center. Beginning in April 2005, logbooks have become mandatory under the requirements of an HMS Fishery Management Plan. Length frequency data are collected through a Pacific States Marine Fisheries Commission contract to Washington, Oregon, and California state fisheries agencies and from the NMFS office in American Samoa. Data collected during the 2007 season were analyzed by SWFSC staff and summarized in a report issued in July 2008 (Childers and Betcher 2008, LJ-08-05). Highlights of the report are given below. A summary of data collected during the 2008 season will be available in August 2009.

**Summary of U.S. North and South Pacific Albacore Troll Fisheries** – U.S. troll vessels in the North Pacific landed 11,436 t of albacore in 2007, compared to 12,524 t landed in 2006. Annual catches over the last 10 years averaged 11,553 t. The most productive fishing areas in 2007 were in Pacific Northwest waters off Washington and Oregon. U.S. catches of South Pacific albacore decreased from 601 t in the 2005-2006 season to 271 t in the 2006-2007 season. South Pacific catches averaged 1,312 t over the past 10 years. The total catch for the 2006-2007 season has decreased 84% from four seasons ago.

CPUE in the North Pacific fishery decreased from 87 fish per day in 2006 to 73 fish per day in 2007. Total effort decreased from 22,303 days fished in 2006 to 22,218 days fished in 2007. CPUE for the South Pacific fishery decreased from 62 fish per day in the 2005-2006 season to 60 fish per day in the 2006-2007 season. Total effort decreased from 1,310 days fished in 2005-2006 to 873 days fished in 2006-2007.

A total of 31,086 albacore were measured during the 2007 North Pacific season. The average fork length (FL) of albacore in 2007 was 70.1 cm (15.5 lb or 7 kg), compared to 68.1 cm (14 lb or 6.4 kg) in 2006. A bimodal size-class mode, with peaks at 64 cm and 76 cm FL (3- to 4-year-olds), was present in the North Pacific length frequency samples.

During the 2006-2007 South Pacific season, a total of 101 albacore were measured. The average FL of this sample was 63 cm (11.5 lb or 5.2 kg), compared to an average FL of 71 cm (16 lb or 7.4 kg) from the 2005-2006 season. Because of the low sample size, dominant size-class modes were not distinguishable in the sample.

**Cooperative Research with AFRF** – SWFSC scientists are working with the American Fishermen's Research Foundation (AFRF) on monitoring programs and other research efforts to improve knowledge of the biology and migration of North Pacific albacore in the waters off the U.S. Pacific coast. The cooperative research includes:

***North Pacific Albacore Biological Data Sampling Program*** – Since 1961, a biological data collection program, or port sampling program, has been in place for collecting size data from albacore landings made by the U.S. and Canadian troll fleets at ports along the U.S. Pacific coast. State fishery personnel collect the biological data by following sampling and data processing instructions provided by the SWFSC, where the database is maintained. In recent years, with AFRF support, fishermen have collected biological data during selected fishing trips. These data are collected to augment data collected through the port sampling program. Following procedures established by SWFSC scientists, fishermen provided length data from eleven trips during the 2007 season. The sample information provided by the fishermen was found to be generally similar to that collected through the port sampling program.

***North Pacific Albacore Archival Tagging Project*** – The Center and AFRF have been working together to use archival tags to study migration patterns and general life history strategies of subadult (ages 2-5) North Pacific albacore. Archival tag data provide detailed information on migratory behavior and distribution. Since 2001, 552 archival tags have been deployed along the U.S. West Coast and northern Baja California, Mexico. During 2008, one tagging trip was

conducted in the northern fishery area off the Columbia River, where 48 tags were deployed. Recovery rates have been very low, with only 22 archival tags recovered to date. Two tags were recovered in 2008, both aboard longline vessels operating in the central Pacific.

Preliminary data from the recovered tags demonstrate a wide range of behaviors of juvenile albacore. Most fish were at liberty for over a year and have provided over 5,000 days of data. Daily location estimates refined with state-space models and the minute-by-minute depth and temperature data are providing new insights into the vertical and horizontal movements and feeding behavior of albacore; these data are impossible to obtain without this technology. Tag returns indicate that the tagged fish ranged from the southern tip of Baja California to Vancouver Island and from the coast of North America to the eastern coast of Japan. Most fish demonstrated a diurnal pattern of daytime diving (routinely to depths of 250 to 300 m) while remaining near the surface at night. However, area- and season-specific behaviors were observed from the tag data. During summer and fall months near the U.S. West Coast off Oregon and Washington, the mean daytime swimming depth of juvenile albacore was roughly 20 m and greater than 85% of their time was spent in the top isothermal layer of the water column. During summer months off Southern California and northern Baja California, Mexico, mean swimming depths were similar; however, albacore tended to spend more time diving through the thermocline during the day. In contrast, off the west coast of Japan in May one fish spent only 20% of its time during the day in the upper isothermal layer with a mean daytime swimming depth of 150 m. Regional and seasonal differences in behavior and feeding periodicity determined from peritoneal temperature changes are being examined with respect to oceanography in order to learn more about the ecology of juvenile albacore throughout their range.

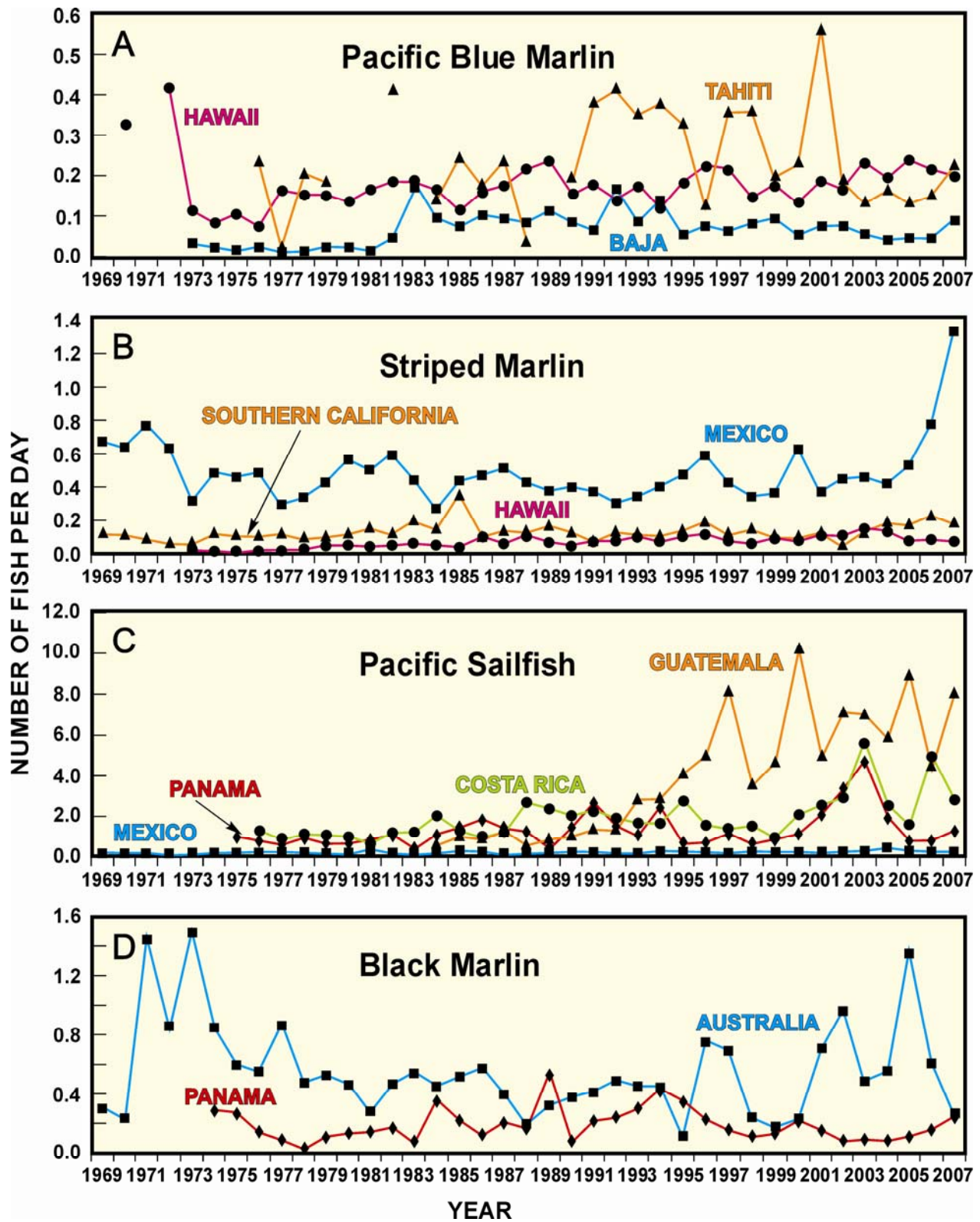
**Cooperative Research with Billfish Anglers** – The SWFSC and billfish angling community have been working together since 1963 to study various aspects of billfish biology and obtain an index of angler success in the Pacific Ocean. These efforts have created one of the longest time series available for recreational billfishing, charting trends in relative abundance for key species. The research includes recreational and commercial fishery monitoring, stock assessments, biological research into the life history and ecology of specific billfish species, and determining the economic importance of billfish resources. Two major components of that research are the International Billfish Angler Survey and the Billfish Tagging Program.

**International Billfish Angler Survey** – In 2008, SWFSC researchers summarized the 2007 Billfish Angler Survey. Billfish anglers reported catching 3,786 Pacific billfish in 5,575 fishing days during 2007. The mean CPUE (number of billfish caught per angler day) for all billfish in the Pacific for 2007 was 0.68, which was high compared to the annual CPUE reported over the last 20 years but well below the 0.82 CPUE reported in 2006. Survey results extend back to 1969 and the CPUE time series were extended for each of the main species caught (Pacific blue marlin, striped marlin, Pacific sailfish, and black marlin) in the main fishing areas (Tahiti, Hawaii, Baja California, Mexico, Southern California, Guatemala, Costa Rica, Panama, and Australia). Figure 1 shows the CPUE time series by region for each of the main species. In 2007, billfish anglers reported high catch rates for striped marlin in the eastern Pacific. The mean CPUE for striped marlin caught off Mexico during 2007 was the highest on record.

Similarly, the catch rate in Southern California was high in 2007 compared to the average annual catch rate for the last 39 years.

***Recreational Billfish Tagging Program*** – The SWFSC’s Billfish Tagging Program has provided tagging supplies to recreational billfish anglers for 46 continuous years. Tag release and recapture data are used to determine movement and migration patterns, species distribution, and age and growth patterns of billfish. This volunteer tagging program depends on the participation and cooperation of recreational anglers, sportfishing organizations, and commercial fishers. Since its inception, over 57,700 fish of 75 different species have been tagged and released. Emphasis continues to be on the skillful tagging of billfish. In 2007, 841 billfish and 5 other fish species were tagged and released by a combination of 603 anglers and 142 fishing captains. In all, 471 blue marlin, 276 striped marlin, 27 sailfish, 61 shortbill spearfish, 2 black marlin and 4 unknown billfish were reported tagged and released. Table 1 shows the tagging effort for 2007 and the tag recoveries throughout the program’s history. The data include releases made by SWFSC scientists during research cruises in addition to the angler releases.





**Figure 1.** Catch per angler day is shown from 1969 through 2007 for Pacific blue marlin (A), striped marlin (B), Pacific sailfish (C), and black marlin (D).

**Table 1.** Summary of all fish tagged through the Billfish Tagging Program in 2007 with releases and recoveries for 1963–2007.

Species	Release 2007	Release Total	Return Total	Return Rate %
Striped Marlin	276	22,640	341	1.51
Pacific Blue Marlin	471	9,247	82	0.89
Sailfish	27	9,040	49	0.54
Billfish, unidentified	4	4,351	4	0.09
Black Marlin	2	3,383	69	2.04
Shortfin Mako Shark	0	1,985	64	3.22
Shortbill Spearfish	61	1,947	2	0.10
Blue Shark	0	622	14	2.25
Common Thresher Shark	0	562	17	3.02
Broadbill Swordfish	0	521	17	3.26
Yellowfin Tuna	0	348	24	6.90
Skipjack Tuna	1	99	2	2.02
Albacore Tuna	0	87	1	1.15
Bigeye Tuna	0	79	2	2.53
Bluefin Tuna	1	58	8	13.79
Hammerhead Shark	0	51	1	1.96
Atlantic Blue Marlin	0	43	0	0.00
Salmon Shark	0	33	1	3.03
Silky Shark	0	21	0	0.00
White Marlin	0	13	1	7.69
Basking Shark	0	7	0	0.00
Longbill Spearfish	0	3	0	0.00
Other Tunas	1	21	1	4.76
All Others	2	2,626	99	3.77
<b>Total</b>	<b>846</b>	<b>57,787</b>	<b>801</b>	<b>1.39</b>

**Swordfish Research** – Since 2006, NMFS has been studying swordfish in the Southern California Bight to examine migratory patterns, foraging ecology, and local stock structure. In 2008, researchers in the Fisheries Resources Division (FRD) teamed up with the Protected Resources Division (PRD) and the Southwest Region to launch a new initiative, Swordfish and Leatherback Utilization of Temperate Habitat (SLUTH). The overarching objective of SLUTH is to integrate studies of swordfish and leatherback sea turtles to inform management and conservation efforts. The endangered leatherback is taken incidentally in swordfish fisheries, and concerns about leatherback populations are currently shaping the management of swordfish along the U.S. West Coast.

In order to exchange information and identify key data gaps of the SLUTH program, a two-day workshop with scientists, managers, and industry representatives was conducted in May 2008 at the Scripps Institution of Oceanography in La Jolla, California. NGO representatives were not able to attend but expressed interest in future workshops. Biological and economic questions were discussed as well as ideas for research into potential policy options. The workshop report for this meeting was recently completed and was presented to the Pacific Fishery Management Council in April 2009 (Benson et al. 2009).

A research goal of SLUTH is to characterize and quantify the habitat overlap of swordfish and leatherback sea turtles in vertical and geographic space. To this end, FRD and PRD staff collaborated to conduct a pilot project in conjunction with the PRD Leatherback Use of Temperate Habitat (LUTH) survey. The survey was conducted off central California aboard NOAA Ship *David Starr Jordan* in August and September 2008. The objectives of this first cruise focused on the feasibility of using one platform to conduct research on both species. If possible, this would allow the same temporal and spatial data collection and strengthen conclusions about habitat overlap. During the cruise, rather than sample along a grid pattern, sampling was dynamic and executed to capture the characteristics of oceanographic features thought to be important leatherback or swordfish habitat. Sampling methods included using CTDs to characterize the water column, net tows to sample prey fields, and aerial surveys to document leatherback occurrence. Fishing via longline was used to determine patterns of occurrence of swordfish. During the cruise, four longline sets were conducted in three different areas. Swordfish were captured on two sets, both of which occurred on the warm side of a frontal system, and two animals were taken for sampling. Efforts were generally successful and provided an important proof of concept for this type of multidisciplinary research approach.

## **V. ADVANCING PELAGIC SHARK RESEARCH**

The SWFSC's shark research program focuses on pelagic sharks that occur along the U.S. Pacific coast, including the shortfin mako (*Isurus oxyrinchus*), blue shark (*Prionace glauca*), and three species of thresher shark: common thresher (*Alopias vulpinus*), bigeye thresher (*A. superciliosus*), and pelagic thresher (*A. pelagicus*). Center scientists are studying the sharks' biology, distribution, movements, stock structure and status, and potential vulnerability to fishing pressure. This information is provided to international, national, and regional fisheries conservation and management bodies having stewardship for sharks and other highly migratory species. Some of the recently completed or ongoing shark research activities being carried out at the SWFSC are discussed below.

**Abundance Surveys** – The blue, shortfin mako, and thresher sharks are all taken in regional commercial and recreational fisheries. Common thresher and mako sharks have the greatest commercial value and are also specifically targeted by sport fishers, especially off highly populous Southern California. Although the blue shark is targeted in Mexico, it has little market importance in the United States but is a leading bycatch species in the U.S. West Coast drift gillnet and high-seas longline fisheries. Although catches of adult blue, thresher, and shortfin mako sharks do occur, the commercial and sport catch of these species off Southern California consists largely of juvenile sharks.

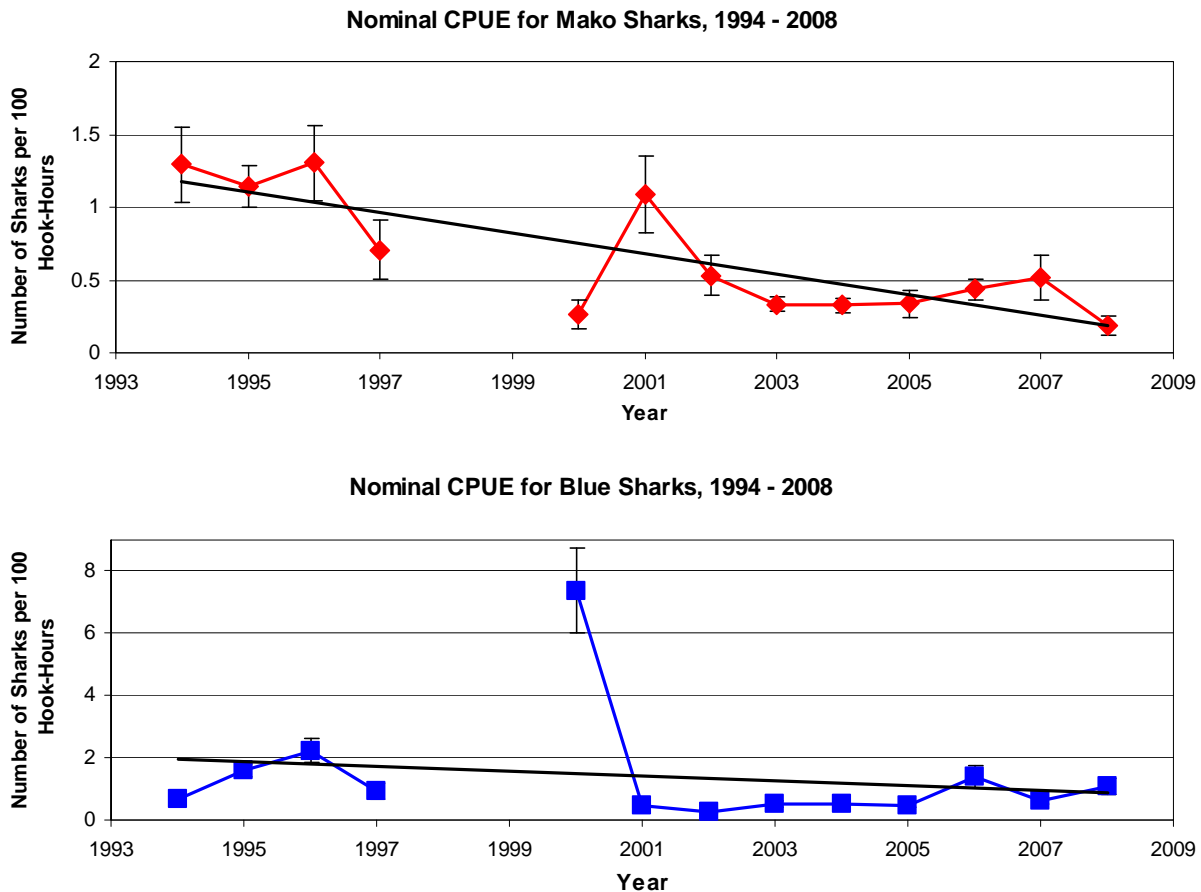
To track trends in the abundance of juvenile and subadult blue and shortfin mako sharks and neonate common thresher shark, surveys are carried out in the Southern California Bight each summer. Efforts to determine abundance trends from commercial fishery data have been complicated by changes in regulatory restrictions, fishing methods and areas over time. These changes have resulted in wide swings in both catch rate and catch distributions that are difficult to interpret. Therefore, consistent, fishery-independent sampling was needed, with slightly

different survey strategies required for the more oceanic shortfin mako and blue shark compared to the more coastal common thresher shark.

Offshore longline surveys from relatively large research vessels have proved most effective for sampling and estimating the abundance trends of the more oceanic species (shortfin mako and blue sharks). For mako sharks, the surveys have enabled the SWFSC to obtain a valuable abundance index, which can be linked to a historical time series of logbook and landings data from a former experimental shortfin mako longline fishery in the Southern California Bight in 1988-1991. Abundance trend information is also obtained for the blue shark, which is compared to that obtained from observers in the California/Oregon drift gillnet and U.S. and Japanese high-seas longline fisheries.

Surveys for neonate thresher sharks are conducted using small commercial driftnet and longline vessels. Initial studies demonstrated that neonate threshers are rarely encountered in waters deeper than about 90 m. Therefore, surveys are conducted in the shallower nearshore waters between Point Conception, California, to the north and the U.S.-Mexico border to the south. The primary purpose of the surveys is to produce a relative abundance index for the West Coast population by periodically sampling 0-year pups (neonates) in their nursery grounds off Southern California. Once the core nursery area was defined, representative areas were identified and are now sampled annually. The resulting neonate index of abundance should mirror adult abundance because adult population and recruitment should be tightly linked in K-selected species such as sharks. This study complements the fishery-dependent data available through the nearshore setnet fishery and pelagic driftnet fishery to provide measures of relative and absolute abundance of common thresher shark for stock assessment models.

**Juvenile Mako and Blue Shark Survey** – In 2008, the SWFSC conducted its fifteenth juvenile shark survey since 1994. Working aboard F/V *Ventura II*, the team of scientists and volunteers fished a total of 6,007 hooks during 29 daytime sets inside seven focal areas within the Southern California Bight. From the catch data, the index of relative abundance for juvenile sharks, defined as catch per 100 hook-hours, was calculated for the seven target survey areas. Survey catch totaled 40 shortfin mako, 233 blue sharks, 1 common thresher, 5 pelagic rays (*Pteroplatytrygon violacea*), and 1 bat ray (*Myliobatis californica*). The cruise was conducted in two legs with 85% of the shortfin mako sharks caught during the second leg when higher water temperatures were encountered. The overall survey catch rate was 0.184 per 100 hook-hours for shortfin mako and 1.090 per 100 hook-hours for blue sharks. The nominal CPUE for blue sharks was somewhat higher than in 2007; however, there is a declining trend in nominal CPUE for both species over the time series of the survey (Figure 2).



**Figure 2.** Catch per 100 hook-hours for shortfin mako (top) and blue sharks (bottom), 1994-2008.

In addition to obtaining an index of relative abundance, secondary objectives of the cruise were to deploy satellite tags, continue age and growth studies, and collect biological samples. Five ancillary sets were conducted either at night or outside the survey focal areas during which 6 shortfin mako, 43 blue sharks, 1 common thresher, and 1 spiny dogfish (*Squalus acanthias*) were caught. Over the course of all sets, 40 shortfin mako, 258 blue sharks, and 1 spiny dogfish were tagged with conventional tags for movement and stock structure data; a DNA sample was collected from 44 shortfin mako, 261 blue sharks, and 1 spiny dogfish; and 32 shortfin mako and 231 blue sharks were marked with oxytetracycline (OTC) for age and growth studies. Three blue sharks and 9 shortfin mako were tagged with pop-off satellite archival (PAT) and radio position transmitting tags (SPOT) in a cooperative project with TOPP (Tagging of Pacific Pelagics) to define the habitat-use patterns of these species in the California Current System (see below).

**Neonate Common Thresher Shark Survey** – The common thresher shark pre-recruit index and nursery ground survey was initiated in 2003 to develop a fisheries-independent index of pre-recruit abundance and has been conducted in each year since. Common thresher sharks are the most valuable shark taken in commercial fisheries off California and are frequently caught by recreational fishermen. In 2008, the SWFSC team worked aboard the F/V *Outer Banks* and

sampled in the California Bight from Point Conception to the Mexico border. Forty-eight longline sets were made in relatively shallow nearshore waters. Over the 18-day cruise, shark catch totaled 300 common thresher sharks, 2 spiny dogfish, 28 soupfin sharks (*Galeorhinus galeus*), 2 leopard sharks (*Triakis semifasciata*), and 5 brown smoothhound (*Mustelus henlei*). Nearly all of the common thresher sharks caught were injected with OTC for age and growth studies, tagged with conventional tags, and released. In addition, pop-off satellite tags were deployed on three common thresher sharks.

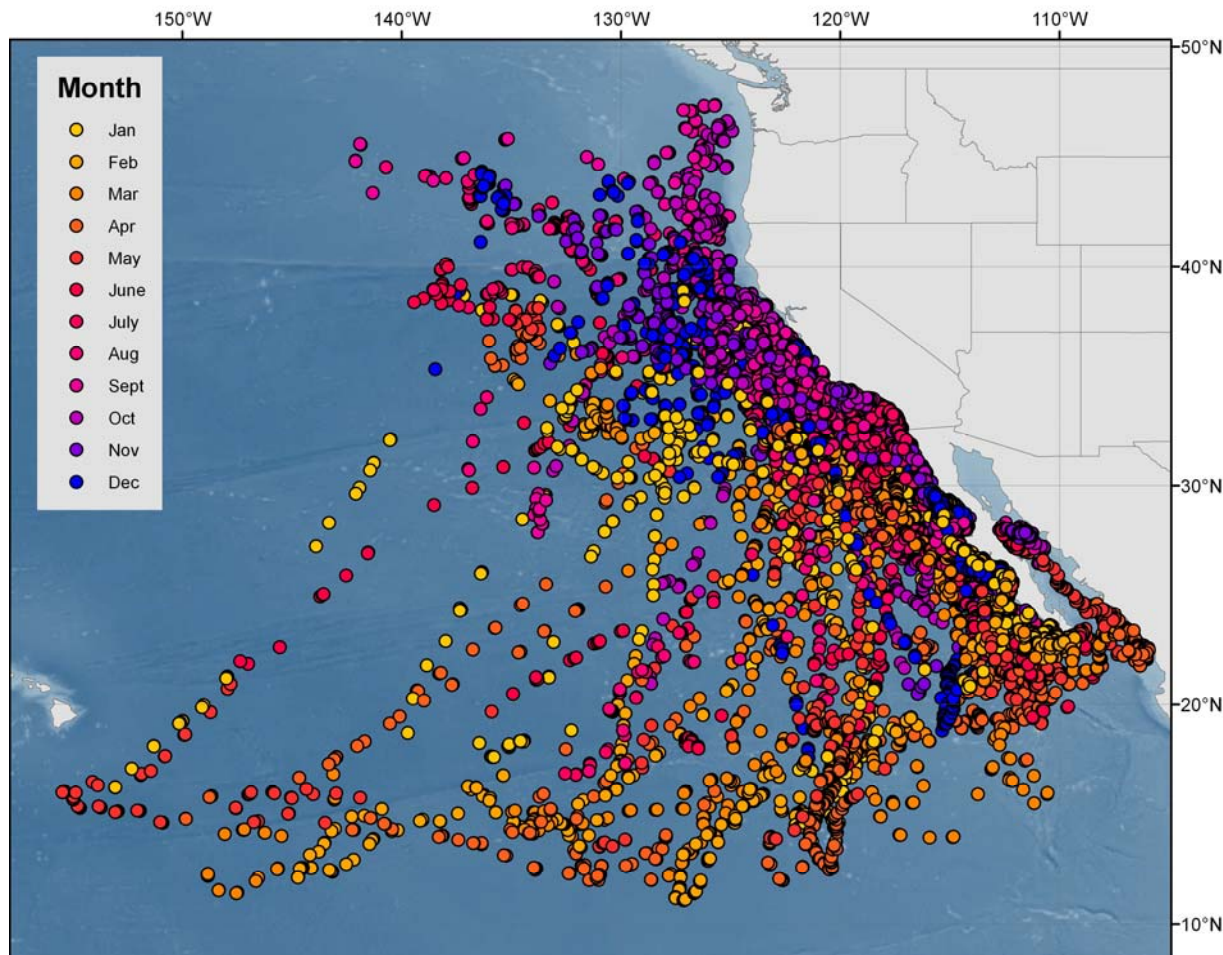
The distribution of common threshers is very patchy and areas of high abundance are not consistent across years. In all years, a large percentage of the catch has been neonates, which were found in all areas surveyed. In addition to providing important information on abundance and distributions, the thresher shark pre-recruit survey enhances other ongoing research at SWFSC, including age and growth, feeding, and habitat utilization studies.

**Migration Studies** – Since 1999, NOAA has been using satellite technology to study the movements and behaviors of blue, shortfin mako and common thresher sharks. In recent years, tag deployments have been carried out in collaboration with the TOPP program ([www.topp.org](http://www.topp.org)), Mexican colleagues at CICESE (Centro de Investigación Científica y de Educación Superior de Ensenada), and Canadian colleagues at the DFO (Department of Fisheries and Oceans) Pacific Biological Station in Nanaimo, British Columbia. The goals of the project are to document and compare the movements and behaviors of these species in the California Current and to link these data to physical and biological oceanography. This approach will allow us to characterize the habitats the sharks most frequently utilize or prefer and subsequently to better understand how populations might shift in response to changes in environmental conditions on short or long time-scales.

Overall, during the juvenile shark abundance surveys conducted in the summer of 2008, 9 makos, 3 threshers, and 4 blue sharks were tagged with PAT tags and/or SPOT tags. Since 1999, a total of 77 makos, 66 blue sharks, and 27 common threshers have been satellite tagged through these collaborative projects.

SPOT tag deployments went particularly well in 2008. Five of six SPOT tags deployed on blue and mako sharks in 2008 were still transmitting in early 2009 after more than 200 days. In addition, three satellite tags deployed in 2007 on mako sharks were also transmitting a year and a half after being deployed. These longer-term and multi-year records provide an incredible opportunity to examine seasonal movement patterns and regional fidelity (Figure 3). The longer tracks reveal that some mako sharks make an annual migration to the North Equatorial Current and interestingly, animals returned to the same general regions as in the previous year. The migrations are relatively directed with animals spending an average of four weeks south of 18°N before returning to the waters off Mexico and California. The exact reason for this migration remains to be determined. Analysis of the data on blue sharks tagged by CICESE in 2006 was recently completed by a master's degree student at CICESE in Ensenada, Mexico.





**Figure 3.** Mako shark movements recorded by radio position transmitting tags (SPOT) from 2002 through 2009 (n = 42).

**Feeding Ecology Studies** – With the reauthorization of the Magnuson-Stevens Fishery Conservation and Management Act there is a move towards ecosystems management. This approach requires information on ecological relationships among species, one of the most important being trophic links. To determine the trophic relationships of highly migratory species in the Southern California Bight, the SWFSC has been investigating the foraging ecology of a range of species since 1999. Species examined include swordfish, sharks (blue, shortfin mako, common thresher, bigeye thresher sharks) and tunas (see below). Sharks and swordfish are collected by observers of the drift gillnet fishery each year and other HMS are sampled during sportfishing trips. Recent results on studies involving swordfish and tuna are provided below.

**Broadbill Swordfish Stomach Content Analyses** – Since 2007, SWFSC scientists have been studying the feeding behavior of the broadbill swordfish. Sixty-four stomachs were collected by fishery observers over two fishing seasons from 2007 to 2008 within the U.S. EEZ between the U.S.-Mexico border and Point Conception. Swordfish sampled ranged in size from around 120 to 200 cm eye to fork length (EFL). Of the stomachs examined, 98% contained food representing at least 26 taxa. The most important prey overall was the jumbo squid (*Dosidicus gigas*), which was present in 82% of the stomachs and ranged in size from around 20 to 70 cm

mantel length (ML). Preliminary data reveal that there is a direct relationship between swordfish EFL and squid ML with larger swordfish able to feed on larger jumbo squid. Other important prey included the boreopacific gonate squid (*Gonatopsis borealis*) and teleosts of the family Paralepididae (Barracudinas).

In comparing swordfish to other large pelagics foraging in the Southern California Bight (blue, mako, common thresher, and bigeye thresher sharks) there are some distinct similarities. For swordfish, mako, and blue sharks, cephalopods are the most important prey taxa, with jumbo squid being one of the dominant species. Similar to bigeye thresher sharks, swordfish target prey associated with the deep scattering layer in addition to epipelagic schooling fish, indicating that they can forage broadly through the water column. Swordfish and bigeye thresher sharks exhibit similar diel vertical migrations. While swordfish can feed on a variety of prey taxa, jumbo squid, which has been particularly abundant in Southern California during recent years, was the most important prey item.

**Foraging Ecology of Tunas in the Southern California Bight** – In an effort to collect biological data on the recreationally caught tuna and dorado that seasonally forage in the Southern California Bight (SCB), the SWFSC and the Sportfishing Association of California initiated a biological sampling program in 2007 working with the commercial passenger fishing vessels. Species collected to date include albacore (*Thunnus alalunga*), bluefin (*T. orientalis*), yellowfin (*T. albacares*), skipjack (*Katsuwonus pelamis*), and dorado (*Coryphaena hippurus*). A range of biological samples are collected from each fish caught, including stomach contents and tissue samples. Through the identification of stomach contents and the analysis of stable isotope ratios in tissues we can begin to develop an idea for both the daily and long-term feeding habits of tuna in the SCB. In 2007 for albacore (n = 116), fish comprised the dominant prey species by frequency of occurrence (89%), followed by cephalopods (18%) and crustaceans (16%). Preliminary results for 2008 show a shift in the composition of prey forage with cephalopods making up a higher percentage of the diet. This could be due to small changes in environmental factors favoring the recruitment of squid in 2008. By conducting studies over multiple years, the impacts of short-term environmental variation on available forage can be determined with implications for assessing habitat quality. This should help explain migration timing and patterns observed in highly migratory species within the SCB and northern Baja California, Mexico.

**Age, Growth, and Maturity Studies** – Age and growth of mako, common thresher, and blue sharks are being estimated from band formation in vertebrae. SWFSC scientists are validating aging methods for these three species based on band deposition periodicity determined using oxytetracycline (OTC). When the shark is recaptured and the vertebrae recovered, the number of bands laid down since OTC injection can be used to determine band deposition periodicity. In 2008, OTC validation studies on mako, blue, and thresher sharks were continued.

Since the beginning of the program in 1997, 1,959 OTC-marked individuals have been released during juvenile shark surveys. In 2008, 32 mako, 232 blue, and 253 common thresher sharks were tagged and marked with OTC. As of April 2009, recaptured OTC-marked sharks included 71 mako, 40 common thresher, and 31 blue sharks. Vertebrae were returned for only about half of the recaptures. Time at liberty ranged from 6 to 1,938 days, and the maximum net movement for an individual shark was 3,410 nmi. Analyses of band deposition patterns for returned



vertebrae were hindered by staff limitations in 2008; however, the studies are now progressing for both mako and thresher sharks.

In addition to the work with OTC-marked individuals, age and growth studies are being conducted with non-marked vertebrae using various visualization techniques to identify bands, and by length frequency analysis of the fisheries and survey catch data. The purpose is to expand and refine previous ageing studies using a larger sample size with accompanying information on sex and maturity stage.

**Survival after Capture and Release Studies** – Common thresher, mako, and blue sharks are captured in a number of West Coast commercial fisheries. The drift gillnet fishery is the commercial fishery which catches the greatest number of each of these species. While thresher and mako sharks are landed, almost all blue sharks are discarded. In addition, there is growing interest among recreational fishers to target thresher and mako sharks. Recreational fishers are often only interested in the challenge of the fight and will frequently release their catch. The survival rate of sharks released both from the drift gillnet fishery and by recreational anglers is unknown. Reliable estimates of removals (i.e., mortalities) are necessary in order to adequately assess the status of the stocks and determine the effects of the fisheries on their abundance.

**Blue Sharks Released by the Drift Gillnet Fishery** – In 2007, the SWFSC and SWRO began working on a project to determine the survivability of blue sharks caught and released alive by the California drift gillnet fishery. Blue sharks are the second greatest bycatch species in number behind the common mola in this fishery. Roughly 35% of the blue sharks caught are released alive, but their fate is unknown. During the 2007-2008 fishing season, 7 sharks in various conditions at time of release were tagged with PAT tags. During the 2008-2009 season, 3 additional blue sharks were tagged. The tagged sharks were tracked and results indicate that survivability is high; 9 of the 10 sharks survived for at least 30 days following tagging and the tenth shark survived for at least 17 days, after which it appears the tag was ingested by another animal. Final tagging efforts of smaller sharks and those of the poorest conditions will be conducted during the 2009-2010 season to conclude the study.

**Thresher Sharks Released by the Recreational Fishery** – A collaborative project was initiated by the SWFSC, SWRO Sustainable Fisheries Division, and Pflieger Institute of Environmental Research in spring 2007 to determine the survivability of thresher sharks caught and released alive by recreational fishermen. Anglers often hook the tails of thresher sharks and pull the fish backwards to the boat. When the fight time is long, the fish may be exhausted by the time it reaches the boat for release. A total of 28 thresher sharks were caught and released during the 2008 season, 26 of which had been tail hooked. PAT tags were deployed on 12 of the adult and subadult tail-hooked sharks. The tags were programmed to release after 10 days to determine survivability. Preliminary findings suggest a post-release mortality estimate of roughly 17% for the sharks tagged thus far (155-230 cm FL). All individuals with fight times less than 85 minutes survived the acute effects of capture as determined by the PAT records. The two largest individuals with fight times exceeding 105 minutes did not survive. These preliminary data suggest that large tail-hooked thresher sharks exposed to prolonged fight times have increased mortality rates when compared to smaller individuals which can be brought to the boat more quickly. Further tagging is planned for 2009 to increase the sample size and experiment with

alternative fishing techniques, including teasers with drop-back bait. In addition, the team is conducting physiological studies to assess capture stress associated with tail hooking.

### **Genetic Analysis of Highly Migratory Species**

**Silky Sharks** – Silky sharks (*Carcharhinus falciformis*) are an abundant pantropical species and comprise the bulk of the shark bycatch in global tuna fisheries. Despite their ubiquitous nature and relative abundance, little is known about their movement patterns, stock structure, and abundance trends. There is some evidence of declining abundance in both the Atlantic and Pacific, suggesting a need to take a closer look at this species. The SWFSC has been working with the IATTC, PIFSC, and other collaborators to collect samples throughout the Pacific in order to learn more about this poorly understood species.

To investigate whether distinct stocks exist within the Pacific Ocean, DNA sequence data from the mitochondrial control region and size polymorphisms at AFLP and microsatellite loci have been examined. Preliminary results suggest the existence of separate stocks north and south of the relatively cool zone of upwelling along the equator in the eastern Pacific. Obtaining samples from the western Pacific has been difficult, but what samples we currently have suggest another stock exists in the southwest Pacific. Additional samples from the western Pacific are anticipated in the next few months.

**Opah** – The opah or moonfish (*Lampris guttatus*) is found worldwide in tropical and subtropical waters. Though caught mainly as bycatch in pelagic tuna fisheries, opah command a high price in the market. Despite being known to science for over 230 years, the existence of two morphotypes was only recently discovered by PIFSC port samplers in Honolulu. The most conspicuous difference between these morphotypes is the relative size of the eye, leading to the labeling of the morphotypes as ‘big-eye’ and ‘small-eye’ opah. Genetic analyses performed at the SWFSC confirm that the two morphotypes are genetically distinct and are in fact separate species. Additionally, DNA sequence data provided by Bob Ward (CSIRO, Australia) suggests that there is yet another cryptic species of opah in the Southern Hemisphere, although additional samples are necessary to confirm this finding and describe spatial patterns. A description of this species complex is currently in preparation.

### **VI. IDCPA RESEARCH**

The SWFSC research conducted under the International Dolphin Conservation Program Act (IDCPA) during 2008 was focused on evaluating line transect methodology and the potential roles of the fishery and ecosystem in the apparent lack of recovery of depleted dolphin stocks in the eastern tropical Pacific Ocean (ETP). This lack of recovery follows a period of significant reductions in observed dolphin mortality in the ETP tuna purse seine fishery. Research activities included: (1) analysis of data collected during the 2007 survey designed to collect fine-scale ecosystem data and assess standard methods for collecting dolphin sighting data; (2) ongoing work on ETP dolphin stock assessments; (3) other data analyses, processing, and publication; and (4) a small purse seine vessel monitoring and observer program via contract.

**Analysis of *Stenella* Abundance Research-Line Transect and Ecosystem Survey Data** – In 2007, SWFSC conducted a *Stenella* Abundance Research-Line Transect and Ecosystem (STAR-LITE) cruise to survey marine mammals and their habitat in the ETP. The primary objective of the STAR-LITE cruise was to investigate line transect methods used on surveys in the ETP and to explore fine-scale spatial and temporal variability in the ecosystem using a multidisciplinary approach.

Sailing aboard NOAA Ship *McArthur II*, 29 scientists from five countries participated in the four-leg survey from August to December 2007. During the cruise there were a total of 1,031 cetacean sightings, 266 acoustic detections, and 7,135 seabird sightings. Biopsy samples were collected from 13 individuals of 3 species (*Pseudorca crassidens*, *Stenella attenuata*, and *Tursiops truncatus*). Environmental data were collected from 140 CTD casts, 269 XBT drops, 265 bucket samples for surface chlorophyll, 54 bongo net and 53 manta net tows.

The results of an analysis and simulation of passing versus closing survey modes (i.e., survey mode when there are no changes in course to approach a sighting versus when such course changes are made) will be submitted for publication to the Journal of Cetacean Research and Management (Schwarz et al., in prep.). Both empirical data and simulations were used to compare group encounter rates in the two modes and to better understand the mechanisms that might lead to an encounter rate bias in closing mode. As seen in similar studies, observers are able to identify to the species level less frequently in passing mode (81% vs. 57% of sightings), and point estimates of delphinid group size were 58% lower in passing mode than closing mode at distances between 1.0 and 5.5 km from the trackline. In addition, uncertainty in group size both within and between observers was higher in passing mode. Closing mode delphinid group encounter rates are generally 20% to 25% lower than passing mode delphinid group encounter rates. Simulations showed the lower encounter rates in closing mode are due to a loss in detection probability caused by the stop-start nature of the survey method. The closing mode encounter rate bias is greater when groups are in fewer and/or tighter clusters and when overall group density is higher.

This is the eleventh year of similar investigations conducted during the past 20 years, with previous cruises in 1986-1990, 1998-2000, 2003, and 2006. Using an ecosystem approach, we conducted research on physical and biological oceanography (dolphin habitat); midtrophic-level fishes and squids (dolphin prey); and seabirds, marine turtles and other cetaceans (dolphin commensals, competitors, and predators). Data and analyses resulting from STAR surveys form the basis for many international measures adopted to conserve dolphin stocks and manage the tuna purse seine fishery in the ETP.

**ETP Dolphin Stock Assessments** – During 2008, the SWFSC continued to analyze abundance data for stock assessment research for both depleted and non-depleted dolphin stocks in the ETP. A NOAA Technical Memorandum was published with new estimates of ETP dolphin abundance based on cruises conducted in 2003 and 2006. Gerrodette et al. (2008) reported estimates of abundance for 10 dolphin stocks in the ETP for ten years between 1986 and 2006. Revised estimates of abundance for previous years were based on new data on observer school size estimation bias and the addition of unidentified spinner and unidentified common dolphins. The 2006 estimates of abundance for northeastern offshore spotted dolphins were somewhat higher,

and for eastern spinner dolphins substantially higher, than estimates from 1998 to 2000. However, interpretation of these results is complicated by uncertainty due both to the size of the ETP study area and movements of spotted dolphins across stock boundaries (i.e., apparent increases in northeastern offshore spotted dolphins may be accounted for by western/southern animals moving into the northeastern stock area). Coefficients of variation and confidence intervals for the 2006 estimates are also larger than for other recent estimates. Further monitoring cruises, studies on spotted dolphin stock structure, and population models that integrate all available information are needed to assess recovery.

**Data Analyses, Processing, and Publication** – The SWFSC’s investigations of dolphin stocks historically depleted by the ETP tuna purse seine fishery (panropical spotted, and spinner dolphins) are conducted with an ecosystem approach. In addition to investigating the status and trends of these dolphin stocks, auxiliary projects are conducted to improve our understanding of their surrounding environment. Data analyses, processing, and publications in 2008 included: (1) investigations of dolphin reproductive biology; and (2) investigations of the ETP ecosystem and its change over time.

***Investigations of Dolphin Reproductive Biology*** – A doctoral dissertation (Kellar et al., 2008) was completed examining the pregnancy patterns of spotted dolphins in the ETP. One hypothesis for the lack of recovery of the spotted dolphin population in the ETP is that continued chase and encirclement by the tuna fishery negatively affects reproduction. Insufficient life history sampling in this region over the last decade makes traditional estimation of population reproductive rates impossible. The current reproductive patterns of these dolphins were examined using a molecular method to assess pregnancy state from blubber progesterone concentrations in biopsy samples. Blubber progesterone was quantified in 212 biopsies from female offshore spotted dolphins sampled between 1998 and 2003 in the northeastern tropical Pacific. These concentrations were found to be sharply bimodal with no value observed between 49 ng/g and 87 ng/g, a finding consistent with the concentration gap between known pregnant and non-pregnant dolphins. Given that high blubber progesterone ( $\geq 87$  ng/g) indicates pregnancy, we found that 11.8% of the biopsied females were pregnant. This is substantially lower than an estimate of the proportion pregnant found in the fishery kill over the same region (22.3%) between 1973 and 1992. To try to ascertain the potential cause of this discrepancy, the relationship between pregnancy and fishery exposure was analyzed, and we found that pregnant females were exposed to significantly less fishery activity than non-pregnant ones ( $P < 0.046$ ), suggesting that the fishery has an inhibitive effect on pregnancy. However, there are several caveats to this finding, and how this relationship might explain the discrepancy between these data sets is unclear. We also examined and modeled spatial patterns of reproduction and found that pregnancy was more aggregated than random ( $P = 0.020$ ), with the highest proportion pregnant in the mouth of the Gulf of California, an area with relatively low reported fishery activity. Because this is a first attempt at applying this technique to a wild population, we are careful in the interpretation of the results. However, it appears that it is a promising tool for assessing reproductive rates in populations of free-ranging cetaceans.

***Investigations of the ETP Ecosystem and Its Change over Time*** – During 2008, a study was completed that provides insight into the food web supporting dolphins and tunas in the ETP (Olson et al., in press). The ecosystem approach of STAR 2006 made it possible for

collaboration with an international team of researchers supported by the Pelagic Fisheries Research Program, University of Hawaii; the Inter-American Tropical Tuna Commission, La Jolla; CICIMAR-IPN, La Paz, Baja California Sur, Mexico; and others. Zooplankton samples collected by bongo net on board both the NOAA Ships *David Starr Jordan* and *McArthur II* in 2006 were utilized for stable isotope analysis of copepods. Simultaneously, yellowfin tuna were sampled on board purse seiners fishing in overlapping areas, encompassing much of the eastern Pacific warm pool and parts of several current systems. The approach was to examine broad-scale spatial relationships among the stable N isotope values of copepods and yellowfin tuna, and to quantify yellowfin trophic status in the food web based on the hypothesis that omnivorous copepods, primary-secondary consumers, represent a proxy for variations in  $\delta^{15}\text{N}$  values at the base of the food web. A significant inshore-offshore, east-to-west, gradient in yellowfin trophic position based on bulk isotopic analysis was corroborated using compound-specific isotope analysis of amino acids conducted on a subset of samples.

A paper on linking climate change to community structure was finished in 2008 and published in 2009 (Vilchis et al., 2009). Vilchis et al. analyzed the composition of larval fish species caught with surface net tows during SWFSC cruises to the eastern Pacific warm pool from 1987 throughout 2000. They found the spatial and temporal variability of larval fish species composition and abundance to be correlated with an east-to-west productivity gradient, and in the most productive regions in the east with ENSO warm and cold water events. They hypothesize changes in water column stratification caused by ENSO events either inhibit or facilitate vertical mixing and thus advection of nutrients from the deeper waters to the surface. Finally, they argue that the variability measured in the larval fish species composition and abundance in the eastern Pacific warm pool is a result of these changes in water column stratification and thus productivity.

**Port Sampling and Observer Program to Monitor Small Purse Seine Vessels** – In January 2006, SWFSC awarded a contract to the IATTC to expand the at-sea observer and in-port sampling programs currently implemented in the ETP tuna purse seine fishery under the Agreement on the International Dolphin Conservation Program (AIDCP). Sampling during 2008 was ongoing: 214 unloadings of Class 4 and 5 vessels were sampled in international ports. A total of 511 unloadings by these international vessels have now been sampled under this program, and sampling will continue in 2009. SWFSC and IATTC staffs are collaborating to analyze tuna species and size composition data along with other catch characteristics to explore the feasibility of using this type of data to identify if small purse seine vessels have harvested tuna in association with dolphins. The selected approach relies on marked differences in the species and size of tunas generally caught in dolphin sets versus other set types. We then use the length frequency data of vessels carrying onboard observers to build a classification algorithm for predicting the purse seine set type (dolphin sets versus non-dolphin sets) of a length frequency sample collected from a vessel of a size not required to carry observers.

Pending further refinements, this work has several potential applications, including using unusual length frequency data from small vessels to estimate potential unobserved dolphin mortality for inclusion in stock assessments and for consideration in management. A report of this analysis has been prepared, and if requested by AIDCP parties the report could be published during 2009.

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# Notes