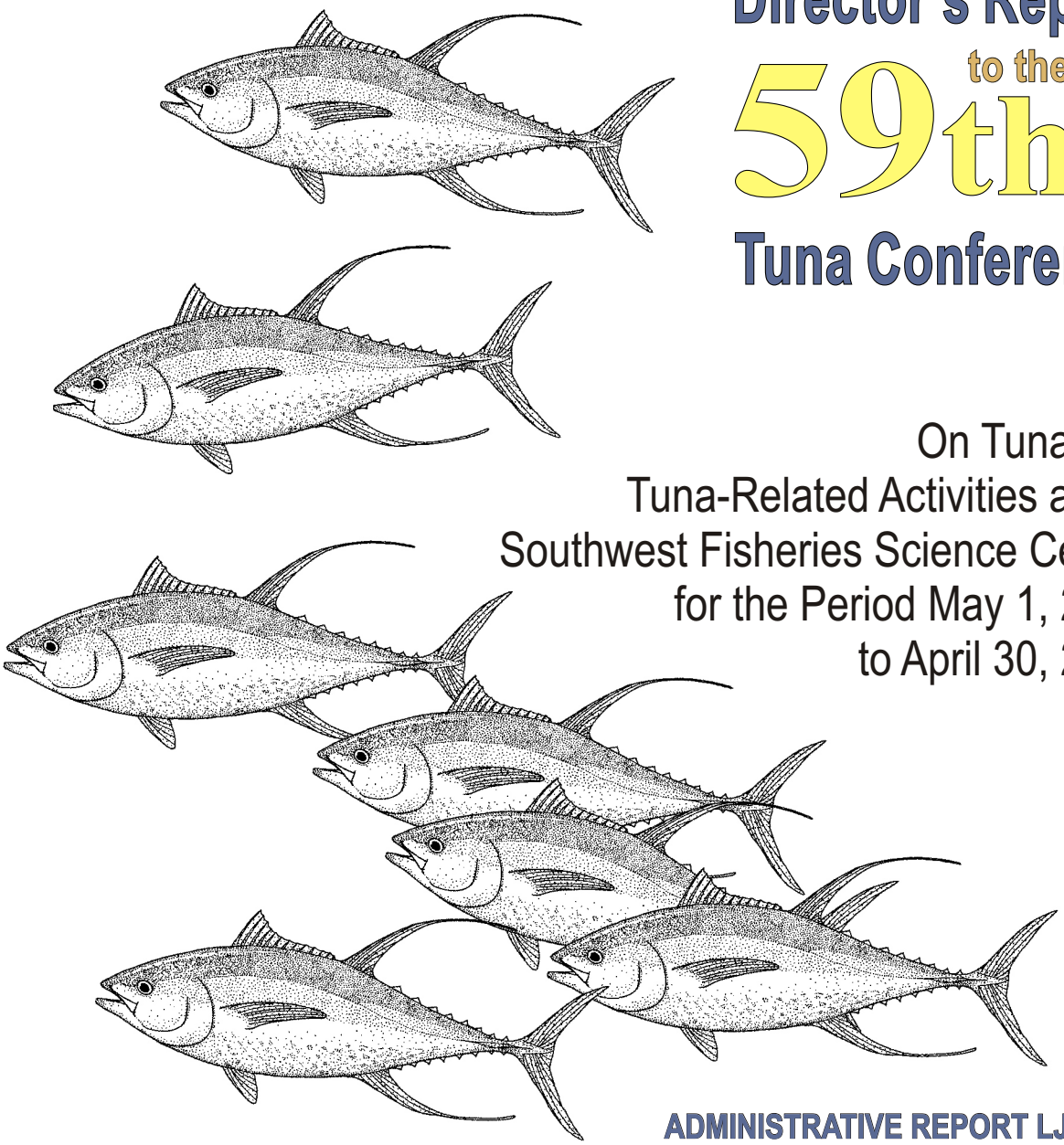
National Marine Fisheries Service
Southwest Fisheries Science Center

# Director's Report to the 59th Tuna Conference



On Tuna and
Tuna-Related Activities at the
Southwest Fisheries Science Center
for the Period May 1, 2007
to April 30, 2008

ADMINISTRATIVE REPORT LJ-08-01

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# DIRECTOR'S REPORT TO THE 59th TUNA CONFERENCE ON TUNA AND TUNA-RELATED ACTIVITIES AT THE SOUTHWEST FISHERIES SCIENCE CENTER FOR THE PERIOD MAY 1, 2007 TO APRIL 30, 2008

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**ADMINISTRATIVE REPORT LJ-08-01**

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## Introduction

This report summarizes research conducted by the Southwest Fisheries Science Center relating to tropical tunas, albacore, billfishes, oceanic sharks, and protected species associated with their fisheries, for the period May 2007 through April 2008. 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. In addition, Center scientists 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 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 2007–April 2008, 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.

In 2007, the size of the U.S. purse seine fleet fell to the lowest level (11 vessels) since the start of the treaty and continued a downward trend in fleet size that started in 1994. Preliminary estimates of the 2007 catch (72,204 metric tons, t) increased 6% from the 68,445 t caught in 2006. Skipjack tuna dominated the 2007 catch (83%), followed by yellowfin tuna (14%) and bigeye tuna (2%).

Purse seine sets on floating objects (logs and fish aggregation devices) in 2007 accounted for 79% of the total sets, a 1% decrease from the 80% recorded in 2006. Sets on free-swimming schools accounted for 19% of the sets, a 5% decrease over 2006 (20%). The overall catch rate was 28 t per day fished in 2007, a slight increase from 27 t per day fished in 2006.

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 38,045 yellowfin, skipjack, and bigeye tunas, an increase of 4% from the number of fish sampled in 2006 (36,597). Preliminary average fork lengths (FL) of fish sampled in 2007 are 63 cm for yellowfin, 50 cm for bigeye, and 49 cm for skipjack.

**Contributing to the Work of the WCPFC Scientific Committee –** The Scientific Committee of the Western and Central Pacific Fisheries Commission (WCPFC) is responsible for providing advice to that Commission on the HMS fisheries and resources exploited by the international fleet in the western-central Pacific Ocean. The Committee held its third session in 2007 to review results of research on the HMS stocks of the region, bycatch, and other issues. Center scientists Ray Conser and Gary Sakagawa participated in the meeting as members of the U.S. delegation led by Christofer Boggs of the NMFS Pacific Islands Fisheries Science Center (PIFSC). The major focus was on the status of the high-yield stocks of yellowfin tuna (426,726 t in 2006), bigeye tuna (125,874 t), skipjack tuna (1,537,521 t) and South Pacific albacore (67,530 t). Participants 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 advance into an overfished state. 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, no stock assessment was undertaken in 2007. Results of a 2006 stock assessment indicated that the effects of fishing on the stock were low (10%) and greater fishing mortality and yield is possible without threat to the sustainability of the stock as a whole. The Committee, however, noted that because the impact of fishing is high on the portion of the population vulnerable to longline gear and recent recruitment below average, this portion of the population is projected to decline further in the next two to three years.

**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 April 2008, the parties met for their annual consultation to exchange fishery statistics and to review other provisions of the treaty. Center scientists John Childers and Gary Sakagawa participated in this consultation and provided the following summary of U.S. albacore troll fishery statistics for 2006 and 2007.

***2006 Fishing Season*** – In 2006, 604 troll vessels participated in the U.S. albacore fishery. Catch and size composition statistics for this fishery have been processed and are complete. Catch and effort statistics, on the other hand, are incomplete with a few logbooks received in 2007 yet to be processed. Preliminary catch and statistics, however, were tabulated and summarized as follows:

The statistics indicate that the vessels made approximately 1,880 trips and fished 21,660 days in 2006. The total albacore catch was 12,520 t. The majority of this effort (90%) and catch (82%) was made within the U.S. EEZ. About 1% of the effort and catch was made in the Canadian EEZ and 9% of the effort and 17% of the catch was made in high-seas areas.

Port samplers measured 29,234 albacore from vessel landings in California, Oregon and Washington. Fishermen measured 400 albacore at sea. Sizes of fish ranged from 51 cm FL to 96 cm FL and averaged 68 cm FL.

Catch per unit of effort (CPUE) or catch rate for the fishery was 90 fish per day fished. Fishing extended from the North American coast out to 168°E longitude and between 30°N and 55°N latitude. The offshore fishing area (beyond about 135°W longitude) was relatively unproductive and did not receive significant effort, probably owing to high fuel cost. The highest catch areas were off Oregon and Washington, approximately in an area bound by the coast and 44°N to 47°N and 125°W to 129°W.

***2007 Fishing Season*** – In 2007, 638 troll vessels participated in the fishery. Processing of statistics for this fishery has not yet been completed. Preliminary statistics, however, indicate that the 638 vessels made approximately 2,100 trips. The catch was approximately 11,440 t, of which over 90% was made in the U.S. EEZ with approximately 97% of the effort. Approximately 42,300 albacore were measured for length composition by port samplers and 752 albacore were measured by fishermen.

**Contributing to the Work of the ISC –** The U.S. is a member of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC), along with Canada, China, Chinese Taipei, Japan, Korea, Mexico, the 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 the 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 Groups—statistics, bycatch, Pacific bluefin tuna, albacore, and billfish—that report to a Plenary body, which is led by Center scientist Gary Sakagawa. Results of the ISC are made available to participating members and HMS regional fisheries management organizations of the Pacific Ocean.

The 7th Plenary meeting of the ISC was held in Busan, Korea, July 25-30, 2007, and hosted by the Korea National Fisheries Research and Development Institute. Scientists from Canada, Chinese Taipei, Japan, Korea, Mexico, and the United States participated. A representative of the Scientific Committee of the WCPFC attended as a non-member. Center Director Bill Fox led the U.S. delegation to this meeting.

The ISC Plenary reviewed the results of work performed by the Working Groups since the 6th meeting. Considerable progress was made in stock assessment research and towards understanding the status of the North Pacific stocks. The ISC reached consensus on several important issues, including stock status and conservation advice, as well as governance and data management procedures. Based on assessments carried out during the past year, the ISC advised that fishing mortality rates for both albacore (*Thunnus alalunga)* and striped marlin (*Tetrapterus audax*) should be reduced. Previous ISC advice regarding Pacific bluefin tuna (*Thunnus orientalis*) fishing mortality rate was maintained, i.e., that it should not be increased above recent levels. Plans for undertaking a Pacific bluefin tuna assessment in the next year were approved. The next ISC Plenary was agreed to be held in July 2008 in either Japan or Chinese Taipei.

Since the 7th Plenary meeting, Center scientists have continued their involvement in ISC research activities, including participation in ISC Working Group meetings and in particular bolstering ongoing stock assessment efforts for Pacific bluefin tuna, striped marlin, and North Pacific albacore. In this context, cooperative work has continued on compiling U.S. fishery data and information on life history parameters for Pacific bluefin tuna, which was presented at a December 2007 Working Group meeting and ultimately for inclusion in stock assessment modeling efforts scheduled for 2008. At the most recent Billfish Working Group meeting held in January 2008, Kevin Piner presented collaborative research that addressed spawning distribution of striped marlin in the North Pacific Ocean. In February 2008, Paul Crone presented results at an Albacore Working Group meeting regarding joint research that focused on model 'transition' development from a virtual population analysis (VPA) to the Stock Synthesis 2 (SS2) model. Finally, in July 2008, presentations will be made to the Albacore Working Group and ISC Plenary body on progress related to both critical time series (e.g., length/age distributions, relative indices of abundance, etc.) and alternative assessment model development.

## II. SUPPORTING PACIFIC FISHERY MANAGEMENT COUNCIL ACTIVITIES

Center scientists Suzanne Kohin and Stephen Stohs currently serve on the HMS Management Team of the Pacific Fishery Management Council. The team met several times in 2007 and early 2008 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 issues facing the team and Council over the past year have been (1) development of a response to the overfishing declaration for yellowfin tuna in the eastern Pacific Ocean and advice for the IATTC and WCPFC; (2) continued consideration of an exempted fishing permit for a single vessel to conduct longline fishing for swordfish within the U.S. West Coast EEZ without jeopardizing protected species; (3) development of alternatives to allow U.S West Coast-based shallow-set swordfish longline fishing on the high seas; (4) characterization of the recent U.S. albacore fishing effort; (5) providing recommendations to the Council on HMS data collection and research needs in support of the management plan; and (6) preparation of the 2007 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. During August 2007, the team met to discuss progress on resolving issues that were identified at its last meeting and to discuss new issues. Significant progress had been made on developing a data portal (http://swfscdata.nmfs.noaa.gov) for describing HMS data sets, collection, management and reporting activities and for allowing public access to summary information. 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 further development to update metadata, add fisheries and enhance displaying of data. Special working groups have been organized to develop data management and collection guidelines and are continuing work on enhancing the data catalog. Significant progress was also made in establishing deadlines and protocols for submission of data to regional fishery management organizations. The next annual meeting of the HMS data coordination team is scheduled for August 2008 in Honolulu, Hawaii.

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. The team is currently working on funding projects for 2008. These projects are directed toward further developing a national permits system, a “one stop shop” for landings statistics for the U.S., and to provide support for the InPort metadata system. FIS continues to encourage all NMFS Regions to populate InPort with metadata on their data collections. A pilot one stop shop project was developed to consolidate and compare landings data for six major species from the Pacific Coast Fisheries Information Network (PacFIN), Alaska Fishery Information System (AKFIN), and NMFS Northeast and Southeast 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 next version (currently under development) will incorporate other types of fisheries data sets (observer data, permits data, biological data, etc.). The use of the tool will enhance 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.

HMS information technology specialists at the SWFSC are also improving data collection methods. 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 HMS data system. Specialists have also developed an electronic logbook software application that is currently being used on several troll and baitboat vessels. The application is available to the entire fleet and, it is hoped, will be used by more vessels in 2008. Funding is being sought to enhance and modify the application based on feedback from vessel captains.

The SWFSC HMS team continued to process and load HMS data into the Center's new HMS database in 2007. An application for web-based data entry and data management is being used by Center data managers and is undergoing enhancements. The application is being expanded to provide data entry capability for observer data which will be entered by SWRO staff. The observer data will be used to interface with a national bycatch and discard data system to prepare a national bycatch and discards report. Both the HMS database system and the proposed national system are in Oracle. Harpoon, longline, purse seine and gillnet fishery data and other observer data and data summary applications will be added to the HMS database in 2008.

## IV. ADVANCING TUNA AND BILLFISH RESEARCH

The SWFSC research on tunas and billfishes in the Pacific Ocean has largely been focused on better understanding of 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 600 U.S. troll vessels fished for North Pacific albacore in 2006.

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 2005-06 season and caught 600 t of albacore. 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 2006 season were analyzed by SWFSC staff and summarized in a report issued in July 2007 (SWFSC Admin. Rep., La Jolla, LJ-07-05). Highlights of the report are given below. Summary of data collected during the 2007 season will be available in August 2008.

**Summary of U.S. North and South Pacific Albacore Troll Fisheries** – U.S. troll vessels in the North Pacific landed 12,524 t of albacore in 2006, compared to 8,413 t landed in 2005. Annual catches over the last 10 years averaged 11,842 t. The most productive fishing areas in 2006 were in Pacific Northwest waters off Washington and Oregon. U.S. catches of South Pacific albacore decreased from 725 t in the 2004-05 season to 601 t in the 2005-06 season. South Pacific catches averaged 1,447 t over the past 10 years and have decreased 64% over the past three years.

CPUE in the North Pacific fishery increased from 47 fish per day in 2005 to 90 fish per day in 2006. Total effort decreased from 25,298 days fished in 2005 to 21,663 days fished in 2006. CPUE for the South Pacific fishery remained at 64 fish per day in the 2005-06 season, while effort decreased from 1,494 days fished in 2004-05 to 1,266 days fished in 2005-06.

A total of 29,630 albacore were measured during the 2006 North Pacific season. The average FL of sampled albacore in 2006 was 68 cm (14 lb or 6.4 kg), compared to 70 cm (15.5 lb or 7 kg) in 2005. A single size-class mode, centered at 66 cm FL (3-year-olds), was present in the North Pacific length frequency samples.

During the 2005-06 South Pacific season, a total of 403 albacore were measured. The average FL of this sample was 71 cm (16 lb or 7.4 kg), compared to an average FL of 72 cm (17 lb or 7.6 kg) from the 2004-05 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 eight trips during the 2006 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 since 2001 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. The design of the long-term study was to deploy 500 archival tags in albacore over the period 2001to 2006 and more in subsequent years as required.

Through December 2007, 504 archival tags have been deployed. There have been 20 recoveries, most of which were at liberty for over a year and have provided over 5,000 days of data and nearly nine million samples of water depth, water temperature and body temperature from tagged fish. Daily location estimates from the tagged fish and the minute-by-minute depth and temperature data are providing new insights into the vertical and horizontal movements and feeding behavior of albacore, data which were 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 common diurnal pattern of repetitive deep diving (routinely to depths of 250 to 300 m) during the day while remaining near the surface at night. Refinements to the location estimates were made using state-space models combined with composite sea surface temperature data from satellite imagery. Analysis of the detailed time series data reveals that albacore spend most of their time in areas where surface water temperatures are 15° to 19°C. However, their vertical movements bring them into deeper waters with temperatures as low as 9°C. During dives, internal heat is conserved with visceral temperatures averaging 3° to 4° above ambient water temperatures with apparent feeding episodes discernable as transient visceral temperature changes.

Tagging efforts will continue in 2008. Ultimately, the data will help determine stock structure and improve CPUE standardization based on habitat use patterns, information critical to developing sound stock assessments regarding the status of this valuable marine resource.

**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 2007, SWFSC researchers summarized the 2006 Billfish Angler Survey. Billfish anglers reported catching 5,123 Pacific billfish during 6,045 fishing days during 2006. The mean CPUE for all billfish in the Pacific for 2006 was 0.85, which is just above the previous record of 0.82 set in 2003. With the 2006 data, there is a new high six-year average catch rate of 0.67 ± 0.17 billfish per angler day for the entire time series, which extends back to 1969. The lowest value (0.34) was reported for the late 1970s (1975-79) when billfish stocks were being impacted by large, international commercial fisheries. 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.

***Recreational Billfish Tagging Program*** **–** The SWFSC's Billfish Tagging Program has provided tagging supplies to recreational billfish anglers for 45 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, sport fishing organizations, and commercial fishers. Since its inception, over 57,000 fish of 75 different species have been tagged and released. Emphasis continues to be on the skillful tagging of billfish and bluefin tuna only. The tagging of other sport fish is not encouraged by this program. In 2006, 1,121 billfish and 15 other fish species were tagged and released by 807 anglers and 188 fishing captains. In all, 660 blue marlin, 220 striped marlin, 109 sailfish, 117 spearfish, 9 black marlin and 6 unknown billfish were reported tagged and released. Table 1 shows the tagging effort for 2006 and the tag recoveries throughout the program's history. The data include some releases made by SWFSC scientists during research cruises in addition to the angler releases.

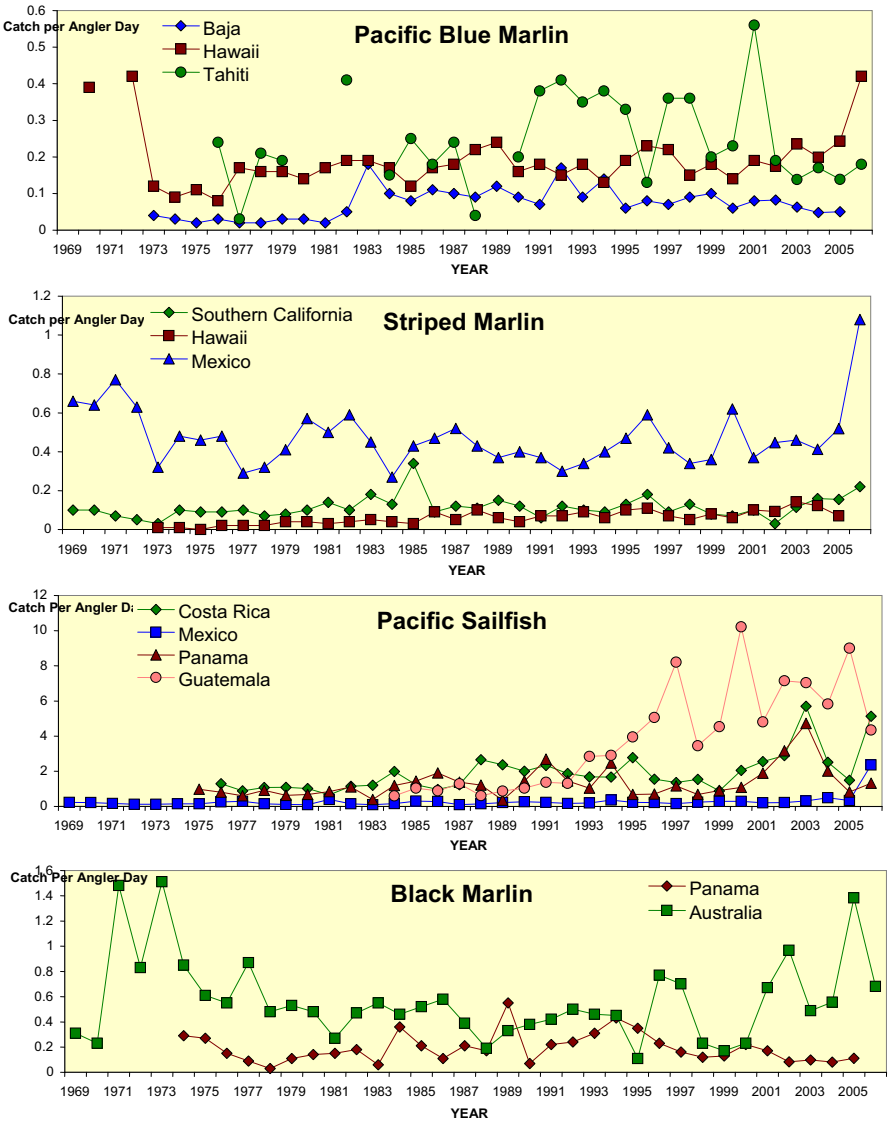


**Figure 1.** Catch per angler day is shown from 1969 through 2006 for Pacific blue marlin, striped marlin, Pacific sailfish, and black marlin.

**Table 1.** Summary of all fish tagged through the Billfish Tagging Program in 2006 with releases and recoveries for 1963–2006.

| Species | Release 2006 | Release Total | Return Total | Return Rate % |
|---|---|---|---|---|
| Striped Marlin | 219 | 22,283 | 339 | 1.52% |
| Sailfish | 109 | 8,983 | 49 | 0.55% |
| Pacific Blue Marlin | 657 | 8,717 | 81 | 0.93% |
| Marlin, unidentified | 6 | 4,312 | 3 | 0.07% |
| Black Marlin | 9 | 3,374 | 69 | 2.05% |
| Shortbill Spearfish | 117 | 1,885 | 2 | 0.11% |
| Shortfin Mako Shark | 105 | 1,791 | 81 | 4.52% |
| Broadbill Swordfish | 520 | 520 | 17 | 3.27% |
| Common Thresher Shark | 462 | 462 | 17 | 3.68% |
| Albacore Tuna | 87 | 87 | 1 | 1.15% |
| Bigeye Tuna | 79 | 79 | 2 | 2.53% |
| Bluefin Tuna | 57 | 57 | 8 | 14.04% |
| Hammerhead Shark | 55 | 55 | 2 | 3.64% |
| Whitetip Shark | 44 | 79 | 1 | 1.27% |
| Marlin, Atlantic Blue | 42 | 57 | 0 | 0.00% |
| Billfish, unidentified | 24 | 55 | 2 | 3.64% |
| Silky Shark | 21 | 24 | 0 | 0.00% |
| Sunfish | 17 | 21 | 0 | 0.00% |
| Tiger Shark | 15 | 17 | 2 | 11.76% |
| White Marlin | 13 | 15 | 1 | 6.67% |
| Triggerfish | 11 | 13 | 1 | 7.69% |
| White Shark | 8 | 11 | 0 | 0.00% |
| Whale Shark | 4 | 8 | 1 | 12.50% |
| Longbill Spearfish | 3 | 4 | 0 | 0.00% |
| Other Sharks and Rays | 20 | 595 | 16 | 2.69% |
| Other Tunas | 3 | 467 | 27 | 5.78% |

## 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 fisheries. Common thresher and mako sharks have the greatest commercial value and are also

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 sub-adult blue and shortfin mako sharks and neonates of 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 1988-91. 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 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 2007, the SWFSC conducted its fourteenth juvenile shark survey since 1994. Working aboard the NOAA ship *David Starr Jordan*, the team of scientists and volunteers fished a total of 5,759 hooks at 28 sampling stations in seven focal areas in 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 112 makos, 139 blue sharks, 14 pelagic rays (*Pteroplatytrygon violacea)* and one ocean sunfish (*Mola mola*). The overall survey catch rate was 0.556 per 100 hook-hours for mako and 0.666 per 100 hook-hours for blue sharks. The CPUE for mako sharks has

increased slightly since 2003; however, there is a declining trend in CPUE for both species over the time series of the survey (Figure 2).

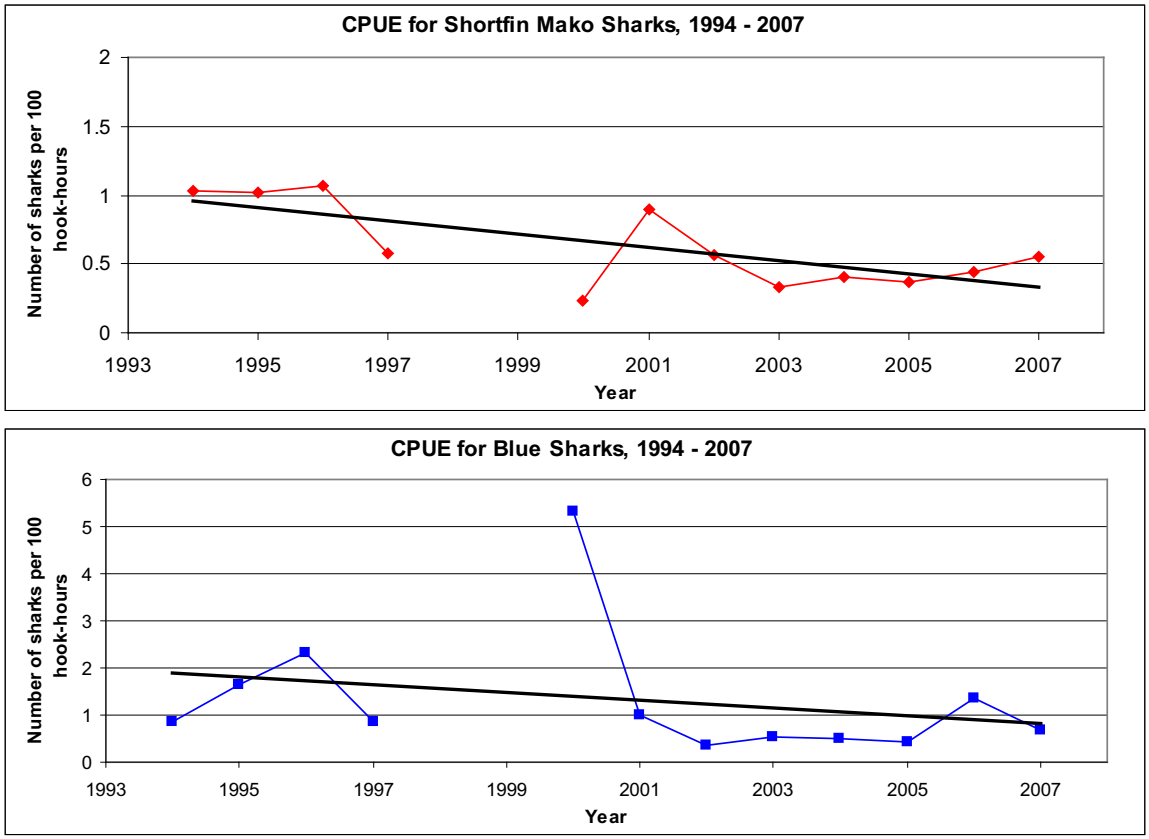


**Figure 2**. Catch per 100 hook-hours for shortfin mako (top) and blue sharks (bottom), 1994-2007.

An additional 10 days of ship time were used to conduct a hook comparison study in order to determine differences in selectivity with hook type. For this comparison, sets were made with alternating circle and J hooks in blocks which had high catch rates during the survey. Additional sets were made in other locations as time and conditions allowed. A total of 4,508 hooks were deployed of which 2,252 were 16/0 circle hooks and 2,256 were 9/0 J hooks. Circle hooks captured 28 blue sharks and 25 mako sharks, while J hooks captured 53 blues and 39 makos.

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. Over the course of the cruise, 215 blue sharks and 142 makos were tagged with conventional tags and biopsied for analysis of movement and stock structure. Of those, 166 blue sharks and 128 makos were marked with oxytetracycline (OTC) for age and growth studies. In addition, four blue sharks and 12 makos were tagged with pop-off archival transmitters (PAT tags) and near real-time satellite-linked radio transmitters (SPOT tags) to define their habitat-use patterns in the California Current System. The ocean sunfish was also tagged with a PAT tag. The satellite

tagging is being conducted in collaboration with the Tagging of Pacific Pelagics program (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. Thresher sharks are the most valuable shark taken in commercial fisheries off California and are frequently caught by recreational fishermen. In 2007, the SWFSC team worked with the F/V *Outer Banks* to sample in the California Bight from Point Conception to the Mexican border. Forty-nine longline sets were made in relatively shallow nearshore waters. Over the 18-day cruise, 137 common thresher sharks, 2 shovelnose guitarfish (*Rhinobatos productus*), 2 soupfin sharks (*Galeorhinus galeus*), 1 leopard shark (*Triakis semifasciata*) and 1 bat ray (*Myliobatis californica*) were caught. Roughly 65% of the thresher sharks caught were young of the year (<100 cm FL). Nearly all of the threshers caught were injected with OTC for age and growth studies, tagged with conventional tags, and released. In addition, PAT tags were deployed on four thresher sharks.

While it is still too early to develop a pre-recruit index, a number of interesting patterns are emerging across years. Depth-stratified sampling revealed that over half of the neonates were caught in shallow waters from 0 to 46 m and almost all individuals are caught shallower than 90 m. The distribution of thresher sharks 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 Tagging of Pacific Pelagics program (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.

While the majority of shark tagging is conducted during the abundance surveys in the Southern California Bight, in the summer of 2007 SWFSC scientists partnered with Dr. Sandy McFarlane at DFO to deploy tags on blue sharks off the coast of Vancouver Island. The tagging trip was conducted aboard the Canadian Coast Guard ship *Neocaligus.* The team was able to deploy both PAT and SPOT tags on 10 blue sharks larger than the size typically encountered in the Southern California Bight. These sharks should help to answer questions about connectivity of the population along the West Coast as well as provide further insight into the behaviors and migratory patterns of subadult and adult blue sharks in the California Current.

Overall, during the three trips conducted in the summer of 2007, 12 makos, 4 threshers, and 14 blue sharks were tagged with PAT tags and/or SPOT tags. Since 1999, a total of 68 makos, 62 blue sharks, and 32 common threshers have been satellite tagged through these collaborative projects. From the deployments in 2007, SPOT tags deployed on 12 makos and 12 blue sharks reported for at least four weeks and 12 tags were still reporting after eight months (Figure 3). Data have been obtained from 23 of the 27 PAT tags with three tags still due to report in May 2008. Two PAT tags have been recovered, providing detailed depth and temperature data. Analysis of the 2004-05 mako shark movement data was recently completed by a master's degree student at CICESE in Ensenada, Mexico.

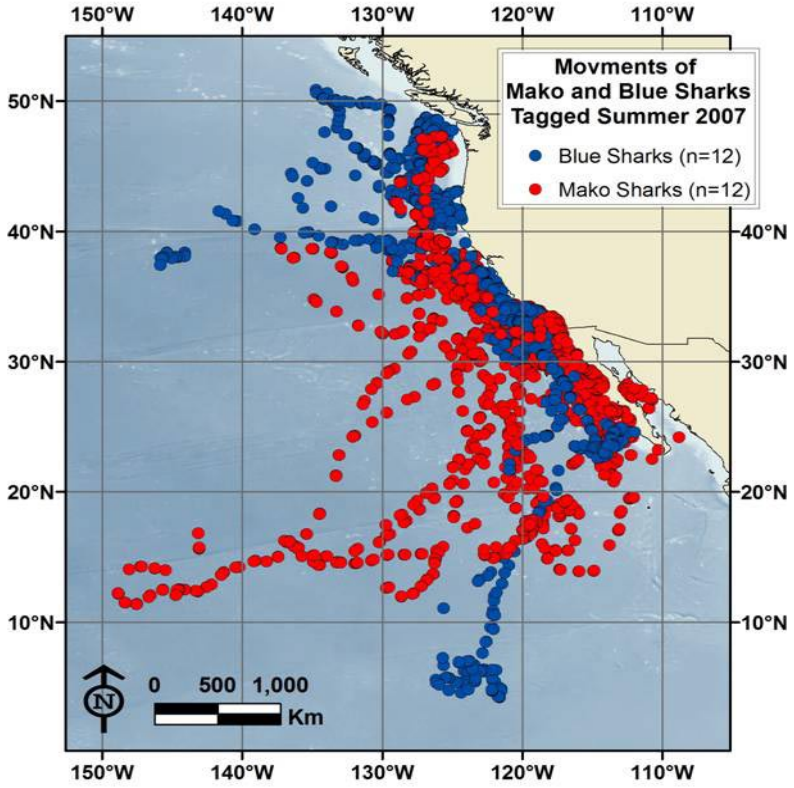


**Figure 3**. Movements of mako and blue sharks tagged during summer 2007. All mako sharks and four blue sharks were tagged in the Southern California Bight. Eight blue sharks were tagged off Vancouver Island in a collaborative effort with Department of Fisheries and Oceans, Canada.

**Feeding Ecology Studies** – Since 1999, the SWFSC has continued investigating the feeding ecology of the blue, shortfin mako, common thresher, and bigeye thresher sharks. All species are captured in the drift gillnet fishery for swordfish. Distinct diet differences among the species and across years have been identified.

***Mako Shark Predation on Jumbo Squid*** – Stomach content data from recent years reveal that jumbo squid (*Dosidicus gigas*) are an increasingly important component of the mako shark diet. SWFSC scientists have been examining stomachs of mako sharks caught in drift gillnet fishery off Southern California since 2002. Of 228 stomachs examined, 49 contained jumbo squid remains. Quantitative analysis of interannual variation in the diet reveals that the occurrence of jumbo squid in the diet has been increasing as jumbo squid become more abundant in the California Current. Mako sharks captured during the juvenile pelagic shark abundance survey are often covered with scars from the toothed suction cups of jumbo squid. These findings have been submitted for publication in CalCOFI Reports.

***Bigeye Thresher Shark Stomach Content Analyses*** – While the bigeye thresher is less frequently encountered in the drift gillnet fishery than the other pelagic shark species, stomachs of 26 bigeye threshers were collected by fishery observers between August 1998 and January 2007. Twenty-three of the stomachs contained food representing a total of 20 taxa. The six most important prey species were the barracudinas (*Paralepididae* family) followed by Pacific hake

(*Merluccius productus*), Pacific saury (*Cololabis saira*), Pacific mackerel (*Scomber japonicus*), northern anchovy (*Engraulis mordax*), and jumbo squid. Previous studies have suggested that species of the deep scattering layer may be important in the bigeye thresher's diet; however, it appears that off California midwater and epipelagic species are also important, as are some epi-benthic species. The large number and diverse taxa suggest that the bigeye thresher is an opportunistic feeder that forages over a broad range of habitats to exploit locally abundant prey. Detailed findings have been submitted for publication in CalCOFI Reports.

**Age, Growth and Maturity Studies –** Age and growth of mako, common thresher, and blue sharks are being estimated from ring formation in vertebrae. Critical to this method is validation with OTC, which lays down a mark at the time of injection. When the shark is recaptured and the vertebrae recovered, the number of rings laid down over a known time period can be counted. In 2007, we initiated OTC validation studies on blue sharks and continued OTC validation studies on mako and thresher sharks.

Since the beginning of the program in 1997, 1,368 OTC-marked individuals have been released during juvenile shark surveys. In 2007, 128 mako, 166 blue, and 115 common thresher sharks were tagged and marked with OTC. As of January 2008, recaptured OTC-marked sharks included 68 mako, 19 common thresher, and 2 blue sharks; however, vertebrae were returned for only about half of the recaptures. Time at liberty ranged from 7 to 1,938 days with net movements of individual sharks as high as 3,410 nmi. Examination of the band periodicity based on the OTC mark is ongoing 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*** – The SWFSC and SWRO have been 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 2007-08 fishing season, seven sharks in various conditions at time of release were tagged with PAT tags. The tagged sharks were tracked and preliminary results indicate that survivability is high; all seven sharks survived for at least six

weeks following tagging. The study will continue in the 2008-09 season with smaller-sized sharks tagged to determine whether size affects survival rates.

***Thresher Sharks Released by the Recreational Fishery*** – A collaborative project was initiated by the SWFSC, SWRO Sustainable Fisheries Division, and Pfleger 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. Four thresher sharks hooked by the tail by anglers were fitted with PAT tags and released. The tags were programmed to release after 10 days. Preliminary results indicated that in one case mortality occurred within hours of release. The sample size was small, and the survival rate is expected to be highest for smaller animals and when fight times are low. Further tagging is planned for 2008 to increase the sample size. In addition, the team will undertake physiological studies to assess capture stress and will experiment with various gear modifications to reduce tail hooking.

## VI. IDCPA RESEARCH

The SWFSC research conducted under the International Dolphin Conservation Program Act (IDCPA) during 2007 was focused on evaluating line transect methodologies 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) following a period of significant reductions in observed dolphin mortality in the ETP tuna purse seine fishery. Research activities included: (1) a 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.

***Stenella* Abundance Research-Line Transect and Ecosystem Survey –** 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 methodologies used on surveys in the ETP and explore fine-scale spatial and temporal variability in the ecosystem. The project took a multidisciplinary approach. Data on cetacean distribution, school size and school composition were collected to examine cetacean density. Oceanographic data were collected to characterize habitat and its variation over time. Data on distribution and abundance of seabirds, flying fish, and marine turtles will be used to further characterize the ecosystem. Skin biopsies of cetaceans provide a resource for investigations of stock structure and phylogenetic relationships. Photographs provide a tool to document geographic variation in dolphins and distribution of individual large whales.

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 2007, the SWFSC continued to publish and develop stock assessment models for both depleted and non-depleted dolphin stocks in the ETP. A paper using several stock assessment models to evaluate support for different hypotheses for the lack of ETP dolphin recovery was published in the journal Marine Ecology Progress Series (Wade et al., 2007). In addition, a paper describing reproductive patterns in ETP dolphins was revised in response to reviewers' comments and resubmitted to the same journal. A NOAA Technical Memorandum will be published in 2008 with new estimates of ETP dolphin abundance based on cruises conducted in 2003 and 2006. Work continues on models developed for at least three stocks of short-beaked common dolphins (these stocks were not depleted). All of the models described here are Bayesian models that are fitted to estimates of abundance from line transect methods and conditioned on historical estimates of mortality. The models are parameterized to consider hypotheses such as temporal changes in stock productivity and carrying capacity or underreporting of true mortality. This type of work will continue in 2008.

**Data Analyses, Processing and Publication –** The SWFSC's investigations of dolphin stocks historically depleted by the ETP tuna purse seine fishery (pantropical 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 2007 included: (1) direct work on depleted ETP dolphin stocks and (2) investigations of dolphin reproductive biology.

***Fetal Mortality –*** A study to estimate fetal mortality rates in three ETP dolphin species is in progress. Hundreds of fetuses collected from incidentally killed dolphins were used to fit survivorship curves for each species and the management stocks recognized for each. This work is expected to be submitted for publication during 2008.

***Dolphin Calf Mortality –*** Between 1973 and 2000, the shortage of calves in the kill remained at a relatively constant fraction of the kill, about 14%, for both stocks of pantropical spotted dolphins. On the assumption that suckling calves do not survive separation from their mother, the estimated calf deficit represents a negative bias of approximately 14% in the reported kill. This is a minimum estimate of unobserved calf deaths because it only includes separations in which the mother was killed.

Given that dolphins exhibit some of their fastest swimming during release from the net, calves waiting immediately outside or still inside the net may risk separation from their mothers as the school rushes rapidly away from the net. If this or any of the other scenarios regarding the manner in which permanent separation can occur without the mother being killed, then the 14% calf deficit is an underestimate of the actual number of orphaned calves.

Research completed to date indicates that dolphin calves are likely to have difficulty remaining associated with their mothers during high-speed swimming and rapid maneuvering (similar to that observed during chase and backdown in tuna purse seines sets), with quite severe difficulty

for calves from birth to about a year postpartum, and likely critical for calves 0-1 month postpartum.

***Vessel Response Behavior*** – The evasiveness of stocks that are frequently targeted by the tuna purse seine fishery (northeastern spotted dolphins, *S. attenuate*; eastern spinner dolphins, *S. longirostris orientalis*; and short-beaked common dolphins, *Delphinus delphis*) was greater in those sightings with more recent tuna purse seine sets in the vicinity, while no significant relationship was found for those stocks that are rarely set on. These results indicate that the purse seine fishery is affecting the behavior of dolphins, which might have consequences for their population dynamics.

***Dolphin Reproductive Biology*** **–** The SWFSC Protected Resources Division has developed a method to diagnose pregnancy status from the blubber attached to most cetacean skin biopsies. With sufficient samples, this allows estimation of pregnancy rates for entire populations. We have determined the relationship between progesterone levels and reproductive stages (pregnant or not pregnant) in seven species of delphinid (including *S. attenuata*, *S. longirostris* and *D. delphis*) using specimens incidentally killed in eastern Pacific purse seine and gillnet fisheries. While working with these animals for which pregnancy status is known through gross observations, we have conducted blind tests to estimate success rate of determining pregnancy using the progesterone quantification protocol alone. The method has been 100% successful in correctly identifying known pregnant dolphins (n = 64) and 99% successful in correctly identifying known non-pregnant ones (n = 234).

In 2007, we employed this method to estimate the proportion of pregnancies contained in a sample of female (immature and mature) pantropical spotted dolphin biopsies collected in the ETP. In total, we found 25 pregnant females out of the 212 females sampled, approximately 11.8%. Through this preliminary study we also found that the proportion pregnant in our sample varied with respect to location, with greatest values in the north at the mouth of the Gulf of California (25.0%, n = 29) and smallest along the Mexican coast near Acapulco (3.5%, n = 40).

**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). During 2006 and 2007, the IATTC sampled 297 unloadings of Class 4 and 5 vessels in international ports. 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 2008.

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# 59th Tuna Conference Notes

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