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Director's Report to the to the Tuna Conference

On Tuna & Tuna-Related Activities at the Southwest Fisheries Science Center for the Period May 1, 1995 to April 30, 1996

# Administrative Report LJ-96-05

National Marine Fisheries Service Southwest Fisheries Science Center P.O. Box 271 La Jolla, CA 92038

# THE DIRECTOR'S REPORT TO THE 47th TUNA CONFERENCE ON TUNA AND TUNA-RELATED ACTIVITIES AT THE SOUTHWEST FISHERIES SCIENCE CENTER FOR THE PERIOD MAY 1, 1995, TO APRIL 30, 1996.

This report describes research at the Southwest Fisheries Science Center (SWFSC) relating to tuna, billfish, and other large pelagic fishes and protected species associated with their fisheries. The work was conducted from May 1995 through April 1996 by staff at the Center's La Jolla Laboratory in California and Honolulu Laboratory in Hawaii. It is not meant to be a comprehensive account, but rather an informal summary of research highlights and relevant papers published since last year's Tuna Conference in May.

The Center continues to provide research support to the Western Pacific Regional Fishery Management Council, international working groups and committees, and NMFS' Southwest Region and headquarters. The research is designed to meet the information needs of fishery managers both in the long- and short-term, and includes stock assessment and basic biological research to improve the scientific basis for effective socio-economic management; research for analyzing management alternatives, especially for limited-entry regimes; biological and technological research to eliminate or minimize interactions between fisheries and protected species; and mathematical modeling to improve our understanding of fishery interactions and fish movements, and to help predict some of the consequences of management actions.

During the year, the Tuna Newsletter and the Billfish Newsletter came online, and can now be reached directly at the Web sites http://swfsc.ucsd.edu/tunanews.html and http://swfsc.ucsd.edu/billfish.html, respectively. These publications, as well as a copy of this report and a list of other Center publications, are also available online through the Center's new home page at http://swfsc.ucsd.edu by clicking the "Publications" button.

#### SOUTHWEST CENTER HOSTS THIS YEAR'S TUNA CONFERENCE

This year, the SWFSC hosts the 47th International Tuna Conference on May 20-23, 1996, at the University of California Conference Center at Lake Arrowhead, California. Sponsors are the U.S. National Marine Fisheries Service (NMFS) and the Inter-American Tropical Tuna Commission. Norman Bartoo, Alan Jackson, and Rand Rasmussen of the SWFSC are the co-chairs for this conference.

The theme for the Conference is "Sustaining Tuna Fisheries—Issues and Answers." It is designed to address questions such as, How can the world's tuna resources continue to support an increasingly industrialized and multinational fishery into the 21st century? Stock enhancement and aquaculture—a solution to over fishing? Fisheries monitoring and stock assessment requirements of the new FAO agreement on straddling fish stocks and highly migratory fish stocks—are the data good enough? Management of fishery inputs versus outputs—are we up to the challenge? The burgeoning developing world—can the resource meet the potential demand of these new and emerging markets?

It is hoped that the papers presented and accompanying discussions about these topics, all of which focus on the future sustainability of the fisheries, will lead to a greater understanding of the issues and problems ahead, and also help pave the way to more innovative and effective solutions to those problems and a strong international commitment to address them.

### WESTERN PACIFIC TROPICAL TUNAS

WPYRG Meeting Held in August—Pelagic Fisheries Resources Division (PFRD) staff at the La Jolla Laboratory attended the fifth meeting of the Western Pacific Yellowfin Research Group (WPYRG) in Noumea, New Caledonia, August 21–23, 1995. The WPYRG meeting accomplished several objectives including updating catch statistics for all tropical tunas caught by the fisheries in the central-western Pacific Ocean, reviewing the progress of research tasks, and establishing objectives for the next few years. These objectives will address the questions: (1) How do reproductive, foraging and environmental factors affect catchability of yellowfin tuna? (2) What are the local interactions between large- and small-scale fisheries? (3) How will the planned recalculation for separating previously lumped catches of mislabelled bigeye tuna with yellowfin tuna affect new stock assessment reanalyses of these stocks? The following papers were presented by Center participants, who also led sessions.

• "U.S. fisheries catching tropical tunas in the central-western Pacific Ocean, 1993–1994," by A. Coan and D. Prescott. Total yellowfin, bigeye, and skipjack tuna catches, sizes of fish caught, and daily fishing activities for U.S. fisheries operating in the central and western Pacific were presented. Total catch for these fisheries was more than 210,000 t in 1994, with skipjack tuna accounting for more than 70% of the catch and yellowfin tuna 25%.

• "Bigeye tuna catch in the U.S. tuna purse seine fishery of the central-western Pacific," by A. Coan, G. Sakagawa, and D. Prescott. Results were presented of a study to determine the amount of bigeye tuna that has historically been reported as yellowfin tuna landings from U.S. purse seiners fishing in the central and western Pacific. A high proportion of bigeye tuna was found in landings from sets associated with floating objects, especially when these sets involved fish of less than 9 kg. Lower proportions of the catch were bigeye tuna in sets on free-swimming schools.

• "Does schooling behavior affect estimates of movement parameters from tagging data?" by P. Kleiber. A model was used to assess effects of schooling behavior on estimates of fishing mortality, natural mortality, advection, and diffusion from tagging experiments. There was little effect of schooling on mortality estimates. Movement parameters (advection and diffusion) had wider confidence limits with schooling but were unbiased. As expected, the goodness of fit to schooling data was poorer than it was to non-schooling data.

The WPYRG agenda included a review of fisheries, update of databases for the period 1970 to 1994, and consideration of advances in biological and stock assessment research.

South Pacific Commission Meeting Held-Also while in Noumea, PFRD staff attended a meeting of the South Pacific Commission's Standing Committee on Tuna and Billfish, where the committee reviewed progress and plans of the Commission's program and offered advice. They also worked with staff of the South Pacific Commission in modifying a model for analyzing tuna tag release and return data near the Solomon Islands where fish aggregating devices (FADs) are present. Work on the model was completed and tests with data were performed. The results showed that FADs significantly affected the catchability of purse seiners, but not of pole-and-line vessels. However, the results were significantly sensitive to outlier data points, so additional work on the model is being continued to incorporate a more robust estimation procedure for handling outliers.

**Tuna Treaty Data Compiled**—In October, South Pacific Tuna Treaty data collected from licensed U.S. purse seiners for the period August 1 to October 1 were compiled and submitted to the Forum Fisheries Agency on schedule, as required by the Treaty.

As of this writing, not all landings data for the 1995 U.S. purse seine fishery in the central-western Pacific had been tabulated, but the preliminary data indicated that landings in 1995 were about the same as they were in 1994, but with less fishing effort. Estimated preliminary totals were 140,300 metric tons (t) of skipjack tuna and 32,100 t of combined yellowfin and bigeye tunas. Fifty-four vessels participated in the 1995 fishery and recorded 150 fishing trips. A more detailed report of this fishery will be available in issue No. 121 of the *Tuna Newsletter*, which will be distributed just prior to the Tuna Conference.

Logbook Forms to be Revised—New logbook forms for U.S. vessels licensed to fish under the South Pacific Tuna Treaty are being developed to reflect changes in reporting requirements.

In April, logbook forms currently in use in U.S. large pelagic fisheries were reviewed to identify

common data elements, to determine whether the common elements and others should be required under the U.S. High Seas Fishing Compliance Act of 1995, and to determine what data forms should be used for fisheries that currently do not require reporting of logbook data. The work was done in coordination with NMFS headquarters and Southwest Regional Office staff.

Tuna Length Frequency Data Examined—During the year, staff of the La Jolla Laboratory's PFRD gained access to length-frequency information collected by Forum Fisheries Agency observers aboard U.S. purse seiners under the Tuna Treaty. Comparisons between these samples and port samplers' length frequencies will be conducted as requested by the Western Pacific Yellowfin Tuna Research Group at its last meeting.

#### **INDIAN OCEAN TUNA FISHERIES**

Consultation Held on Indian Ocean Tunas-The 6th Expert Consultation on Indian Ocean Tunas was held in Colombo, Sri Lanka, September 25-29, 1995. Attending the consultation were 51 scientists from national institutions of 20 countries and representatives from international tuna commissions and the Food and Agriculture Organization (FAO). The consultation was organized by the FAO Indo-Pacific Tuna Development and Management Programme to review progress of research, developments in the fisheries, and the status of the stocks of Indian Ocean tuna and tuna-like species. The chief of PFRD attended and served as moderator for a session involving status of the stocks. Although data for assessing the status of the stocks were either not available in usable form or inadequate for the consultation to assess the current condition of the stocks, the meeting, nonetheless, was successful in promoting information exchange among researchers, updating information on the fisheries, and identifying research needs for performing a stock assessment.

The consultation noted, among other things, that there is an urgency to complete an up-to-date stock assessment because the tuna fisheries in the Indian Ocean are expanding. Since 1982, total catch of tuna and tuna-like species has steadily increased—doubling every five years—with growth and expansion of coastal and high-seas fisheries. In 1993, the total catch was approximately 981,300 t, of which 690,300 t (70%) was principal tuna species (yellowfin, bigeye, albacore, southern bluefin, and skipjack) and the rest was neritic tuna species, seerfishes, and billfishes. Increased catches of yellowfin tuna and skipjack tuna are the primary causes for this upward trend. Southern bluefin tuna catches, on the other hand, have fallen markedly, from 34,700 t in 1983 to 4,300 t in 1993, and catches are severely restricted for conservation purposes.

While most available catch-per-unit of effort (CPUE) indices, which are standard measures of fishery performance, indicated an increasing or stable trend over recent years, technological innovations and new fishing practices have likely increased fishing efficiency over the years. It was recommended that analyses be undertaken to adjust CPUE indices for improvements in fishing efficiency, and that this be a priority in an up-to-date assessment of stock condition.

1994 Fishery Summary Completed—Last June, the Center completed an update of fourth quarter 1994 Seychelles Fishing Authority data on the tuna purse seine fishery in the western Indian Ocean. The data, based on logbook returns from fishing vessels, are summarized in Lotus spreadsheets and cover the period 1983 to the present.

The number of vessels participating monthly in the purse seine fishery in the western Indian Ocean during the fourth guarter of 1994 averaged 45 (17 French, 17 Spanish, and a combined 11 Belizean, Liberian, Mauritian, and Panamanian vessels), virtually the same as the average number of vessels recorded for the same period the previous year. The monthly average number of vessels participating during the entire year of 1994 was 42, down from 50 vessels the previous year, primarily due to the complete disappearance of the Japanese fleet from this fishery. The number of Japanese purse seiners declined in 1993 from 11 in January to 1 in December. No Japanese seiner has participated in this fishery since January 1994. The number of vesseldays-fished in the fourth quarter of 1994 was 3,311, up 5% from the previous year. The number of vessel-days-fished for the entire year of 1994 was 12,130, down 16%.

Purse seine catches of skipjack, yellowfin, and other tunas in the western Indian Ocean in the fourth quarter of 1994 totaled 74,900 metric tons (t), up 2% from the previous year. The species breakdown was 64% skipjack, 23% yellowfin, and 13% other tunas. For the entire year of 1994, the catches totaled 271,900 t, down 2%, and were composed of 55% skipjack, 34% yellowfin, and 11% other tunas.

The catch rate for all tuna species for the fourth quarter of 1994 was 22 t per vessel-day, down 3% from the previous year. Catch rates for skipjack and yellowfin tunas were 15 and 5 t per vessel-day, respectively. For the entire year of 1994, the catch rate for all tunas was 22 t per vessel-day, up 16%, with skipjack and yellowfin tuna catch rates of 12 and 8 t per vessel-day, respectively.

### HIGHLY MIGRATORY PELAGICS MANAGEMENT SYMPOSIUM TO MEET

SWFSC staff from La Jolla's PFRD participated in the first meeting of the Program Committee for the Symposium on Management of Highly Migratory Species in the Pacific Ocean, which is being organized by the National Coalition for Marine Conservation to take place in Monterey, California, in the fall of 1996. The purpose of the symposium, which will be open to the public, is to identify gaps in monitoring, scientific understanding, and conservation and management of highly migratory fish stocks of the Pacific Ocean; to examine U.S. perspectives toward managing migratory fish stocks in the U.S. Exclusive Economic Zone and on the high seas which take into account the various expectations and cultural diversity of other Pacific Rim nations; and to develop a U.S. strategy for advancing international cooperation in conserving and managing Pacific highly migratory species through an ocean-wide convention.

#### PACIFIC ALBACORE

1994 Fisheries Summary Completed—A summary of the 1994 U.S. North and South Pacific albacore troll fisheries (SWFSC Admin. Rep. LJ-95-15) was distributed in August to subscribers, including over 400 Western Fishboat Owner Association members who cooperated in submitting data. Highlights of this summary are as follows:

The 1993-94 U.S. South Pacific albacore fishery extended from 130° W to 180° W between 35° S and 45° S. The fishery began in December 1993 and ended in April 1994. Participation in the fishery decreased from 47 vessels during the 1992-93 season to 14 vessels. Poor catches in recent years and warmer than normal sea surface temperatures are responsible for the decreased participation. Total landings for the 1993-94 season decreased to 603 t from 1,028 t landed in the 1992-93 season. Catch rates for the 1993-94 South Pacific season, however, increased to 79 fish per day, compared to an average catch rate of 45 fish per day for the 1992-93 season. The average fork length of fish caught during the 1993–94 season was 66 cm (6.7 kg or 15 lbs) compared to 63 cm (5.9 kg or 13 lbs) for the 1992-93 season.

The 1994 U.S. North Pacific albacore fishery began in May 1994 north of Midway Island and ended in November 1994. More than 600 troll vessels participated in the fishery. Vessels fishing in the offshore areas near the International Date Line, and northeast of Hawaii, gradually moved east as the season progressed. Total albacore landings for the 1994 North Pacific season increased for the third consecutive year to 10,535 t. Catch rates also increased to 60 fish per day from 38 fish per day in 1993. The average weight of albacore caught during the 1994 North Pacific season was 7.4 kg (16 lbs) compared to an average weight of 6.8 kg (15 lbs) during the 1993 season. Results of the 1995–96 North and South Pacific fisheries are still pending.

Fishery Observer and Logbook Data Collection—An observer from La Jolla's PFRD spent 37 days monitoring catches at sea aboard a U.S. albacore troll vessel in the North Pacific. The SWFSC observer sailed with the 42-foot albacore troll vessel *Triggerfish* to collect fishery and biological data on the late-season, near-shore albacore fishery. The *Triggerfish* operated along the West Coast from Ilwaco, Washington, to Pt. Conception, California, within 100 miles of shore and logged only eight fishing days between September 14 and 28; the remaining time was lost to weather. The average catch was 30 fish per day fishing with fish averaging about 12.5 lbs and 65 cm fork length. In October, PFRD staff picked up logbooks from ten albacore troll vessels returning to San Diego, as part of the voluntary logbook program.

In November, logbook data for North Pacific albacore U.S. troll fishery and Japanese baitboat fishery were provided to staff at Scripps Institution of Oceanography (SIO) after standardizing measurements of Japanese baitboat data into effort in successful days fished and catch in numbers of fish. Correlations of environmental parameters will be examined in relation to catches. PFRD is working with Tim Barnett of SIO on a proposal to study the inshore-offshore availability of albacore off the Pacific Northwest, as affected by large-scale environmental changes.

North Pacific Albacore Research Plan—In September 1995, the Center's PFRD staff completed a draft North Pacific Albacore Research Plan, an assignment received from the 14th North Pacific Albacore Workshop. The draft was distributed for comments to the participants of the workshop. The completed plan will guide cooperating scientists in researching North Pacific albacore for the next three to five years.

American Fisheries Research Foundation Activities—Also during the year, PFRD staff met several times with the Board of Directors of the American Fisheries Research Foundation (AFRF) to talk about proposed research for the coming year, the 1995–96 South Pacific albacore season, arrangements for fishery data collection in 1996, technical advice on projects funded by the board for 1996, summary of tagging results of albacore in the South Pacific, and historical fishing conditions for albacore in the western North Pacific off Japan, as background for a possible AFRF exploratory albacore fishing effort in the western Pacific. SPAR Activities—PFRD Chief Gary Sakagawa attended the South Pacific Albacore Research (SPAR) workshop in Rarotonga, Cook Islands, in March 1996, and presented two papers by PFRD staff: "Fisheries data for longline vessels landing in American Samoa, 1993 and 1994," by SWFSC staff and "U.S. South Pacific albacore fishery, 1986–1995," by J. Childers and A. L. Coan, Jr.

Sakagawa also attended an annual meeting of parties to the South Pacific Tuna Treaty in Nadi, Fiji, in February 1996, where he presented a paper "The 1995 U.S. purse seine fishery for tropical tunas in the central-western Pacific Ocean," authored by A. L. Coan, Jr., G. T. Sakagawa, D. Prescott, and G. Yamasaki.

### CENTER PREPARES FOR INTERIM SCIENTIFIC COMMITTEE MEETING

In February and March, the SWFSC Pelagic Fisheries Resources Division staff at La Jolla were busy with preparations for the May 7–10, 1996, Interim Scientific Committee Meeting on North Pacific Tuna and Tuna-like Species, discussing the schedule of events, tasks, and other details with colleagues of Japan's National Research Institute of Far Seas Fisheries in Shimizu. A finalized document with agenda was completed March 1996.

In April, Honolulu Laboratory staff prepared presentations for the inaugural Interim Scientific Committee meeting in Japan, including a status overview report on Pacific swordfish and a presentation on North Pacific oceanography. The Honolulu Stock Assessment Investigation also contributed extensively to the U.S. Country Report which will provide an overview of pelagic fishery catch monitoring activities and research projects.



## SECOND INTERNATIONAL PACIFIC SWORDFISH SYMPOSIUM TO MEET

Honolulu Laboratory Swordfish Research Team members held three meetings to plan the Second International Swordfish Symposium which will be held in Honolulu, Hawaii, February 25-28, 1997. The symposium will provide a forum for review and synthesis of recent developments in biological, fisheries oceanography, and resource assessment research on swordfish in the Pacific Ocean, and will promote international scientific collaboration in assessments of Pacific swordfish. The team agreed to start the symposium with a plenary session including country swordfish fishery reviews and an expert panel discussion on stock assessment approaches and data needs. Working group sessions will follow with three themes: biological input to stock assessment, fisheries oceanography and habitat, and resource assessment and monitoring. Finally, a plenary session will be convened to discuss summary recommendations.

## HAWAII LARGE PELAGICS

Longline Fleet Summaries Completed—The annual report for the 1994 Hawaii-based longline fishery was completed in 1995 (Admin. Rep. H-95-08) and regular quarterly longline summaries were completed through the first quarter of 1996.

The annual report showed that the Western Pacific Regional Fishery Management Council (WPRFMC) moratorium prohibiting new entrants to the Hawaii-based longline fishery was replaced with a limited-entry program in 1994, and the NMFS Southwest Region (SWR) instituted a mandatory observer program to document interactions of longline gear with sea turtles. Vessel monitoring systems were placed on a number of vessels for use by the Coast Guard and NMFS Enforcement to determine if longline vessels are fishing in restricted areas. A total of 124 longline vessels were active out of 167 with limited-entry permits, about the same number as were active the previous year. Some vessels left the fishery toward the end of the year, but the total number of sets and hooks fished was similar from 1991-94. Swordfish catch reported on logbooks dropped by 46% to 43,345 fish in 1994, concurrent with a 33% decrease in CPUE on swordfish trips. Bigeye tuna catch increased by 33% to 54,803 fish. Sharks remained the most numerous catch but were down 26% to 114,656 fish in 1994.

Included in the annual report were eight years of size (weight) frequency distributions for swordfish, blue marlin, and striped marlin. Over the eight-year period, 165,538 swordfish and 15,053 blue marlin weights were included in the analysis. There appeared to be an upward size-class shift in the dominant mode for swordfish over the eight-year period. The dominant mode for blue marlin stayed at the 101-125 lb size-class except for 1990 when the mode was in the 126-150 lb size-class.

Preliminary quarterly reports for the following two years showed that in contrast to the 115 vessels that made 381 trips in the first guarter of 1994, only 103 and 98 vessels were active in the first quarters of 1995 and 1996, respectively. The total number of hooks set in the first quarter was similar in all three years but the number of swordfish-directed trips declined in 1995 and declined again in 1996. The numbers of tuna-directed trips and mixed-species trips increased from 1994 to 1996. First quarter swordfish catches were lower in 1995 and 1996 than in 1994, but first quarter CPUE for swordfish-directed trips showed improvement over 1994 levels. Mahimahi catch reached an all time high of 31,360 fish in the first quarter of 1995 making it the most numerous catch, followed by bigeye tuna (20,742 fish). First quarter shark catch dropped from most numerous to third most numerous in 1995 (17,289 fish). In the first quarter of 1996, shark catch was most numerous (29,230 fish), followed by bigeye tuna.

Honolulu Laboratory Submits Data for FAO Atlas—A 5-degree square (latitude by longitude) quarterly nonconfidential summary of Hawaii longline logbook catch and nominal effort data for 1991-94 was prepared and submitted to the United Nations FAO for use in compiling an atlas of Pacific tuna fishery data. Logbook data were converted from fish number to weight as required by the FAO by using average fish size statistics extracted from State of Hawaii commercial catch report data. A review of the draft FAO atlas was completed in April. In January, the Hawaii data submitted to FAO were tabulated and mapped for general distribution as a technical memorandum (NOAA-TM-NMFS-SWFSC-225).

**Progress on JIMAR Projects**—During the year, the SWFSC made good progress on grant projects awarded under the University of Hawaii's (UH) Tuna and Billfish Pelagic Fisheries Research Program (PFRP) to principal investigators at the Honolulu Laboratory. These grants are funded by a competitive process through the National Oceanic and Atmospheric Administration (NOAA)-UH Joint Institute for Marine and Atmospheric Research (JIMAR). A Pelagic Fisheries Research Program Symposium was held November 28–30, 1995, at the East-West Center in Oahu, Hawaii, and the annual UH-JIMAR program review was held February 6–7, 1996, with NOAA's Environmental Research Laboratory conducting the review.

Work was conducted on the second phase of a Hawaii fleet industry and vessel economics project including the study of the costs, earnings, and motivations of the Hawaii small-scale commercial troll and handline fisheries. A revised approach to information collection was completed and pre-tested by April 1996. Data have been collected from over 50 troll and handline fishermen so far. This project is a cooperative effort between the Honolulu Laboratory's Fishery Monitoring and Economics Program and JIMAR. Research began in January 1994 with a cost-earnings analysis of the Hawaii-based domestic longline fishery for 1993.

Vessel captains or owners of 100 of the 122 vessels that longlined in Hawaii in 1993 were surveyed successfully. Responses were coded and entered into a respondent survey database and merged to obtain a vessel-level survey database. In addition, a trip-level operations and revenue database was constructed from Federal longline logbook and State of Hawaii landings reports. This information was integrated with the cost survey database.

Another Honolulu Laboratory JIMAR PFRP project analyzed longline catch from swordfish in the Hawaii-based fishery operating between 15° and 45° N latitude in the central North Pacific from 1991 to 1994. The highest catch rates occurred in waters where the surface temperature was about 15-18° C and during two seasons: (1) the coolest time of year (spring) when these temperatures are found 500 nmi north of Hawaii, and (2) the warmest time of year (fall) when these temperatures are found about 1300 nmi north of Hawaii. The relationship between temperatures, temperature fronts, and catch rates is being studied to ascertain whether environmental changes help explain trends in fishery production. A preliminary analysis for the standardization of swordfish CPUE was completed in April and showed that surface temperature, temperature gradients, and latitude explained much of the variation in swordfish CPUE at a monthly, 1degree square (latitude by longitude) resolution. At this resolution, anomalies from the climatological averages (by month) did not explain much of the variation in CPUE. To obtain a finer resolution analysis, researchers are collaborating with University of Rhode Island researchers to categorize and map fine-scale temperature fronts.

For analyses of the effects of fishing areas on fishery performance, it was necessary to separate effort directed at swordfish from effort directed at tuna or at mixture of species on a set-by-set basis. Cluster analysis was used to classify longline sets in relation to species composition of the catches. Based on the proportions of eight species and species groups caught in longline sets over 4 years (1991-94), five types of sets were identified. The spatial distribution of sets and differences in fishing operations among clusters were then compared to reveal apparent differences in fishing strategies. A paper on this work ("Cluster analysis of longline sets and fishing strategies within the Hawaii-based fishery") was completed and submitted to Fisheries Research.

Another JIMAR PFRP project at the Honolulu Laboratory consists of the effects of variations in catch levels by Hawaii's combined pelagic fisheries for tuna and associated species on the performance of those fisheries. Transfer function time series analyses were used to look for impacts on local tuna abundance. Simulations of Hawaii pelagic fisheries with random variation and varying degrees of fishing pressure were used to test the behavior of the transfer function analyses. A paper on this was completed by X. He and C. Boggs for presentation at the upcoming Second World Fishery Congress: "Estimating fishery impacts using commercial fisheries data: simulation models and time series analysis of Hawaii's tuna fisheries."

A new JIMAR PFRP project was initiated in October by the Honolulu Laboratory in collaboration with the Commonwealth Scientific and Industrial Research Organization in Australia to deploy "pop-up" satellite transmitting archival tags (PSTATs) on swordfish in the Hawaii-based longline fishery. A critical element in this project is the development of a reliable external attachment method for the tags. An enlarged steel tag anchor for use in swordfish muscle was designed and tested, and the holding power of two existing tag anchors (conventional NMFS steel anchors and Billfish Foundation nylon anchors) was found to be about half as strong as the larger design in swordfish muscle. In February and March, 141 dummy PSTATs on southern bluefin tuna were released from a pole-and-line baitboat in the Great Australian Bight. Two kinds of intramuscular anchors were deployed: the large type designed for swordfish and the nylon type. Another 20 dummy PSTATs were deployed in a tuna farm in South Australia, and the fish bearing those tags have since been observed schooling and feeding normally.

Honolulu Laboratory scientists also collaborated with UH principal investigators in two other PFRPfunded projects. One of these projects involves examining the utility of satellite altimetry and ocean color data to identify environmental features and quantify environmental variability that may impact the distribution and abundance of marine resources (fish and protected species) in the central North Pacific. Results of altimetry data analysis show variability due to waves and eddies in the lee of the Hawaiian Islands, variations near the Kuroshio extension, and a region of very low mesoscale energy to the northeast of the islands. The seasonal evolution of these features has also been evaluated and shows an out-of-phase relationship between the high energy region south and west of the islands and the low energy region to the northwest. Sea surface heights from a variety of models were evaluated to address causes of interannual differences in the mesoscale energy fields. Work in progress is focused on developing analogous statistical descriptions of the fish catch from logbook data to quantify relationships between the mesoscale variability and the fisheries.

The other project is modeling yellowfin tuna movements and fisheries around the Hawaiian archipelago in order to design a tagging program sufficient to answer WPRFMC questions regarding interactions between Hawaii pelagic fisheries. Hypotheses have been developed for release sites, natural mortality, and movement of tagged yellowfin in the Hawaiian Islands. The advection-diffusion mathematical model was applied to simulated release-recapture data for two release sites frequently visited by fishers and abundant in yellowfin tuna: Cross Seamount and the Molokai/Maui region. Estimates of the effectiveness of parameter recoveries for each hypothesis were presented and showed that the best strategy involved releases at both sites.

The Honolulu Laboratory supplied monthly averaged fishing effort and catch data for longline, troll, and handline fleets operating near and among the Hawaiian Islands based on 1991-92 logbook reports and State of Hawaii commercial catch reports. The Honolulu Laboratory also completed summarizing one year of dockside sampling by the Fish Biology and Ecology Investigation to determine the unreported species composition of the offshore handline fishery for input into the releaserecapture modeling effort. This work was required to estimate the real catch of yellowfin tuna because approximately 80% of the offshore handline fishery catch is actually bigeye tuna.

**Pelagic Fisheries Oceanography**—In August, Honolulu Laboratory Ecosystem and Environment Investigation staff participated in the 21st General Assembly of the International Association for the Physical Sciences of the Oceans, held in Honolulu, and gave a presentation on recent research findings during the session on decadal and interdecadal variation in the ocean. In October, the first meeting of the Swordfish Working Group on Ecosystem and the Environment was convened. This is one of a number of discipline-oriented workings groups that are currently being developed to plan and coordinate Center research on swordfish. In April, the Honolulu Laboratory director participated in the first U.S.-Japan Earth Remote Sensing Conference on the Island of Hawaii, bringing the laboratory one step closer to having access to ocean color and other ocean measurements made by Japanese satellites.

The response of the ocean north of Hawaii to atmospheric conditions is being examined with ocean circulation models by the Honolulu Laboratory Ecosystem and Environment Investigation. High resolution (1/4-degree) maps of upwelling and downwelling features in the North Pacific produced from the Semtner-Chervin model provide the first picture of fronts on a basin-scale. For example, the subtropical front is clearly seen at 30° N as a strong narrow convergence front spanning the central Pacific and strongest north of Hawaii in the first and second quarters, while the subarctic front is seen as an upwelling front strongest in the second and fourth quarters. Equatorial and continental margin fronts and upwelling patterns are also clearly seen. There appears to be considerable interannual variation in the length and east-west position of these fronts reflecting interannual variation in the pattern of the large-scale circulation. While more work needs to be done to evaluate and possibly improve the formula used to compute these fronts, based on these preliminary maps, it appears that this depiction of high resolution upwelling and downwelling features will provide new insights into pelagic habitat.

Output from the Semtner and Chervin ocean circulation model is being used to examine annual variability in the strength of the subtropical front north of Hawaii, in the area and season that the longline fishery targets swordfish. The fisheries catches show that during the first quarter of the year, the region of highest swordfish catch lies between 28° and 32° N latitude, and model output shows this area is characterized as a region of convergence between southward transport of subarctic water from the north and northward transport of subtropical water from the south. During the five years (1991-94) for which both swordfish catch rates from the fishery and an estimate of southward transport from the model are available, 1994 is unique by having both very weak southward transport and low swordfish catch rates.

Eddy Studied in Conjunction with Billfish Tournament-In July and August, scientists from the Fish Biology and Ecology and Ecosystem Research Investigations conducted an oceanographic and biological survey of waters off the west coast of Hawaii Island in conjunction with the Hawaiian International Billfish Tournament (HIBT). The cruise collected juvenile billfish and tunas for genetic and ongoing life history studies and mapped ocean temperatures, salinity, oxygen concentration, and current patterns in and beyond the area of the tournament for comparison with tournament catch distribution and other biological features of the habitat. Results of the survey and satellite imagery of the tournament area were supplied to HIBT participants via the HIBT radio station. The region surveyed (ca. 60 nmi<sup>2</sup>) was characterized by a mesoscale cyclonic eddy with a particularly strong current running northward along the coast. A shearline of very low current velocities and a shallow (500-ft) thermal front was positioned about 11-12 nmi offshore and delineated the bounds of northward current.

Turtle Handling Guidelines Published—The Honolulu Laboratory published the results of last year's Workshop on Turtle Handling, Resuscitation, and Avoidance, which was held March 15-17, 1995. The report is entitled "Guidelines for Handling marine turtles hooked or entangled in the Hawaiian longline fishery" (see Balazs et al. in the publications list). Participants in the workshop included marine turtle biologists and veterinarians, NMFS at-sea observers, and representatives from the longline fishing industry. The report provides practical guidelines for improving the survivability of marine turtles taken incidentally in the Hawaii longline fishery and was prepared in response to the NMFS Biological Opinion (July 25, 1994) concerning interactions between the Hawaii domestic longline fishery and protected marine turtles. Workshop participants examined the background of the Hawaii longline fishery, the experiences of the NMFS observers, and marine turtle physiology. Participants prepared detailed recommendations for both fishermen and observers, covering fishing vessel operations, procedures for retrieving and releasing turtles, and methods for assessing and treating hooked or entangled turtles. Workshop guidelines include recommendations for determining longterm assessment of the effectiveness of turtle survivability measures and will be used to educate fishermen and to implement current regulations. The report identifies the rationale of the guidelines, their advantages and disadvantages, and detailed measures for implementation where appropriate.

Longline Observer Program Evaluated-In response to interactions of the Hawaii-based pelagic longline fishery with sea turtles, a mandatory observer program was established in 1994 to implement a stratified random survey designed by the Honolulu Laboratory (G. Dinardo, Tech. Memo., NOAA-TM-NMFS-SWFSC-190). In a report completed in March 1996, data from the first year of the observer program (February 23, 1994, to February 23, 1995) were analyzed to estimate the number of interactions (or "takes") and to investigate use of observer-collected data on gear configuration and fishing operations for mitigation and to improve the design of the observer survey (R. Skillman et al., Admin. Rep. H-96-02). The observer data were used to build models of take, and data on the number of hooks fished from the mandatory longline logbook program were coupled with these models to estimate the number of interactions in the fishery. Models included one with no use of the survey design (preliminary estimates released earlier by the SWR), two models based on species targeted by different fleet sectors, and one using three boat size-classes.

The latter model resulted in the best fit, and the estimated number of interactions for all turtles (and for each sea turtle species using the proportions by species recorded by the observers) did not exceed the limits for take or mortality as specified in the current Incidental Take Statement Pursuant to Section 7(b)(4) of the Endangered Species Act. A tree-based regression analysis indicated that latitude, moon phase, the proportion of albacore in the catch, and the proportion of swordfish in the catch (in that order) were the most important predictors of sea turtle interactions. Attempts are now under way to devise a double stratification design using both vessel size and latitude of fishing for conducting the observer program.

Possible Impacts of Longline Turtle Takes Explored—The Expert Working Group Meeting on the Status of Marine Turtles in the Pacific was convened by the Honolulu Laboratory in December. The Honolulu Laboratory Stock Assessment Investigation joined in the effort to assess the status of endangered or threatened marine turtles taken incidentally in the Hawaii longline fishery. The group assembled the best available information on the status and biology of these populations and used various numerical models, including J. Wetherall's TURTSIM turtle population simulator, to examine the potential impacts of Hawaii longline takes and their sensitivity to various biological assumptions and model parameters. Japanese loggerheads and several endangered Pacific populations of the leatherback were model parameters. Limited studies using the models were initiated at the meeting and analyses are continuing. Afterwards, the Honolulu Laboratory Stock Assessment Investigation worked to complete simulation studies of Japanese loggerhead dynamics and impacts of incidental take in the Hawaii longline fishery, which will be reviewed by meeting participants and incorporated in a report.

**Tracking and Tagging**—In August, the Honolulu Laboratory completed a study of the short-term movements and depth distribution of large (140–200 lb) yellowfin tuna caught by handline in waters near the island of Hawaii. Fish were tracked using ultrasonic transmitters for periods of 10 hours to 3.5 days. Surprisingly, these fast-swimming, highly migratory fish remained within about 12 nmi of the coast. Biologists are studying fish movements in order to provide fishery management advice regarding interactions between nearshore surface fisheries (i.e., handline) and offshore subsurface fisheries (i.e., troll and handline).

Researchers from the Honolulu Laboratory continued to encourage the conventional tagging of swordfish by commercial longline vessels. In March, a Hawaii longliner recovered the third swordfish so far from releases made by Hawaii longline vessels and the R/V *Townsend Cromwell*. The fish was tagged in March of 1995 near Maher Seamount (approximately 30° N and 148° W). The swordfish was at liberty for a year but was recaptured only 344 nmi west of where it was tagged. A total of 417 swordfish have been tagged by commercial longliners and *Townsend Cromwell* since 1990. The other two recoveries moved eastward from their release by Hawaii-based fishermen north of the islands. One fish traveled almost to the coast of Mexico.

Swordfish Cruises—A series of swordfish cruises was conducted aboard the R/V Townsend Cromwell north of Hawaii during the past year. The work was part of an ongoing investigation of the ecology of pelagic billfish and tuna populations exploited by Hawaii fisheries. These longline cruises were designed to study the habitat utilization, hooked longevity, vulnerability to fishing gear, and viability for tag and release of swordfish. Physical oceanographic characteristics were also simultaneously measured. Bad weather, engine problems, and unscheduled interruptions (e.g., a search-and-rescue effort in March) greatly hampered the effort, but a limited amount of valuable data were gathered. Among the objectives were to test different day-night fishing times and types of hooks on swordfish condition and to develop techniques for handling swordfish for tagging with PSTATs. On the most successful cruise, a total of 18 longline sets were completed, catching mostly blue shark (126), albacore (35), and swordfish (15). Circle hooks caught 7 swordfish, all but one of which was caught in the jaw. This hook position causes less damage and may improve viability for release. Four other swordfish were caught on J hooks. Muscle samples were collected for genetic analysis by collaborators at other institutions.

Another swordfish cruise is scheduled for May 4–24, 1996, in waters north of the Hawaiian archipelago in the vicinity of the Subtropical Front. The purpose of the cruise is to characterize the physical and biological properties associated with the Subtropical Front to gain a better understanding of the regions that appear to be preferential habitat for swordfish in the central North Pacific Ocean.

Swordfish Age/Growth and Reproductive Studies—Work continues at the Honolulu Laboratory on processing swordfish age/growth and gonadal tissue samples to obtain parameters on swordfish vital growth and reproductive rates.

Swordfish otoliths (sagittae) from 90 specimens collected by longline observers during 1994-95

have been weighed, and results thus far indicate that otolith weight is closely related to fish length by the power equation, but likely differs for males and females. Sagittae were prepared for viewing on the UH scanning electron microscope and counts of surface microincrements and external ridges (presumed yearly features) on rostrums are being compared for small, young fish. Automated measurements of marginal increments and internal radii on swordfish anal fin ray cross sections have also been implemented.

Swordfish gonads collected by observers are being examined histologically to assess state of maturity. Analyses of month- and size-specific sex ratio data for longline observer program swordfish samples were provided for presentation at the Interim Scientific Committee meeting in Tokyo. Swordfish are usually gutted at sea, and even determining the sex of the catch is a daunting problem. A comprehensive series of swordfish muscle tissue specimens (both sexes, spawning and nonbreeding seasons) was sent to Jennifer Specker at the University Rhode Island. Specker assayed these specimens for vitellogenins as a means of identifying the sex of market carcasses from the Honolulu auction. Preliminary results indicate that the tilapia vitellogenin assay used is not sensitive enough to reliably indicate swordfish sex, but it may be feasible to develop a more specific assay.

Multiple regression analyses were conducted on length-weight data for swordfish measured (eyefork length, EFL) and marked aboard ship by the Hawaii Longline Observer Program and then weighed at the Honolulu Auction. Both month of collection and sex of fish significantly affect weight-at-length in a log-linear model fit to the data obtained thus far. Interestingly, male fish were heavier at a given EFL than females. Ultimately, a nonlinear model will be fit to the untransformed data for predictive purposes.

A large sample of swordfish weights from the Honolulu Auction, including both "tail-on" and "tail-off" samples, and comprehensive *Townsend Cromwell* research vessel data on swordfish lengths and weights were used to calculate conversion equations for the two different types of dressed weights (new and old) that have been used at the Honolulu Auction. The data collected to date provide sufficiently precise conversions between two types of dressed weights and "tail-on" weights. The new and old types of dressed weight differ by about 4% (of tail-on weight).

Swordfish 1994 Decline Examined—In March, Honolulu Laboratory and JIMAR staff held a consultation to review information and hypotheses regarding the decline in swordfish CPUE and catch that occurred in the Hawaii-based fishery in 1994 and the recovery of CPUE in 1995. A summary report of this meeting was presented to the WPRFMC Pelagic Plan Team, the Scientific and Statistical Committee, and the Council in March and April, and will be included in the final draft of the Pelagic Annual Report in June. At the consultation, researchers discussed trends in catch, effort, prices, and environmental conditions from 1991-95. Also discussed were (1) progress in standardizing CPUE to account for time, area, temperature, and temperature front effects; (2) an analysis to compare CPUE between participants that exited the fishery and those that remained; and (3) differences in the physical dynamics on the North Pacific Transition Zone in 1994. The summary report examines a variety of hypotheses to explain the decline in catch. An analysis of CPUE in relation to time, area, and sea surface temperature features indicated a statistically significant drop in CPUE from 1993 through 1994 followed by a return to more typical levels in 1995. There has also been a sustained drop in fishing effort targeting swordfish since late 1994. Various hypotheses for the temporary CPUE decline have been explored, including a decline in fish abundance; declines in availability or catchability caused by environmental factors; and changes in fishing operations, fishing areas, and fleet participation.

#### **BLUEFIN TUNA RESEARCH**

**Pacific Bluefin Tuna Research**—Staff at the Honolulu Laboratory have been investigating a possible link between bluefin tuna migration in the Pacific and sardine abundance. During the past year, Hawaii-based longline vessels reported sporadic catches on northern bluefin tuna north of the Hawaiian Islands. Given the high value of these fish and the possibility that they could be targeted by the fishery, staff reviewed the current research on their population dynamics. Tagging data suggest that northern bluefin tuna spawn only in the western Pacific and that a portion of the juveniles migrate to the eastern Pacific. During the past decade, catches of northern bluefin in the eastern Pacific have declined. One cause for this decline that has been proposed as a result of bluefin stock assessment studies is a decline in the proportion of bluefin that migrate out of the western Pacific. Several indices of the relative abundance of bluefin tuna in the western and eastern Pacific were examined. Apparently, fewer bluefin are migrating to the eastern Pacific since 1977. This period of reduced bluefin migration coincides with the period when a prey of bluefin, Japanese sardine, are abundant in the western Pacific. It is hypothesized that in years when sardines are abundant in the western Pacific, a higher proportion of bluefin stay in the western Pacific compared to years when sardines are scarce. Currently, sardines are declining in abundance in the western Pacific, and if this decline continues, an increase in bluefin migrating north of Hawaii and into the eastern Pacific may occur. In November, a paper was completed on trans-Pacific migration of northern bluefin tuna relating to climate-induced change in prey abundance.

Atlantic Bluefin Tuna Research-Staff of the PFRD in La Jolla attended a research planning workshop for Atlantic bluefin tuna tagging studies in Miami, Florida, in August. This was a continuation of work done by PFRD staff on rotational assignment at NMFS headquarters, Silver Spring, Maryland, during spring 1995. Two papers coauthored by SWFSC staff were presented-one on archival tagging and another on the use of a North Atlantic bluefin tuna movement model to test the efficacy of conventional tag experiments in measuring exchange rates across the Atlantic. Two subgroups met to discuss aspects of experimental design and analysis of archival tag data. A draft report of the meeting was prepared and will be edited and presented as a research proposal to the International Commission for Conservation of Atlantic Tunas.

## EASTERN TROPICAL PACIFIC TUNA FISHERIES

Dolphin-Safe Workshop Held-On September 20, 1995, the Dolphin-Safe Research Program of the Marine Mammal Division hosted a Separation/Attraction Workshop in La Jolla, California. The purpose was to review previous efforts in using separation/attraction methods to effect dolphin-safe fishing, and to evaluate the potential for future efforts into separation and attraction methods for eliminating encirclement of dolphins during purse seine sets on tuna-dolphin aggregations in the eastern tropical Pacific (ETP). The current goal of U.S. legislation is to reduce the mortality of dolphins involved in the fishery to rates approaching zero. An obvious way to reduce mortality would be to separate the tunas and dolphins prior to encirclement by the purse seine net. Numerous methods have been suggested to accomplish such separation, but preliminary tests have been unpromising in all cases.

The objective of the workshop was to discuss and evaluate prior separation/attraction efforts and promising future efforts. Workshop participants included experts in dolphin behavior and auditory physiology, tuna behavior and physiology, tunadolphin fishing practices, and overall ecology of the tuna-dolphin association. From these discussions, the Dolphin-Safe Research Program will produce a "Handbook of Considerations and Recommendations" for future research to develop practical separation/attraction methods for eliminating dolphins from purse seine sets on tuna-dolphin aggregations in the ETP. The handbook will strongly emphasize practical approaches and will include background information regarding the characteristics of dolphin-fishing, with details on animal behavior and physiology, school sizes and behavior, weather (e.g., wave heights, glare), and gear and equipment design (e.g., speed boat numbers and sizes, net skiff procedures and characteristics, length of time to set net, net size, vessel size, helicopter characteristics). In particular, the handbook will emphasize the characteristics of the tuna-dolphin association, fishing practices, and fishing environment that are peculiar to this system and which should be considered in any practical solution. The goal of the workshop was to produce a volume of practical background information that must be specifically considered and addressed in any future proposals for separation/attraction research. Providing interested researchers with this preliminary information should improve both the quantity and quality of practical separation/attraction proposals.

1995 Dolphin-Safe Contracts and Congressional Report Completed—In January, the La Jolla Laboratory's Marine Mammal Division completed the 1995 Annual Report to Congress of progress and activities related to the Dolphin Conservation Act of 1992, which mandates work on eastern tropical Pacific dolphin-safe research, yellowfin tuna stock assessment, and the bycatch issue.

Last year, the Dolphin-Safe Research Program at the SWFSC's La Jolla Laboratory began implementing the research program outlined by the planning workshop which was held in 1994. Contracts were awarded to various researchers, primarily from the military sector, to characterize the physical environment of the ETP and the target signatures of large yellowfin tuna under three detection modes: acoustic, optical, and radar. During calendar year 1995, the Center's Dolphin-Safe Research Program awarded and received final reports for three contracts for the major research projects recommended by the 2nd Dolphin-Safe Research Planning Workshop in 1994. The research contracts included "Acoustic propagation modeling of low frequency sound in the ETP," "Acoustic target strength modeling of schooled large yellowfin tuna," and "Enhancements to existing radar." Radar modeling results indicate that effective range of existing bird radars on tuna seiners could be improved substantially by simply increasing antenna size to larger dimensions. Radar detection of breezers did not prove too promising. Acoustic modeling results indicate that tuna detection within 20 km in the ETP should be quite feasible. These contracts provide definitive directions for future research within the Dolphin-Safe Research Program, in terms of which type of detection technology to pursue (acoustics) and the types less likely to be useful for location and detection at long ranges (radar and optical methods). Regarding the assessment of yellowfin tuna stocks, all evidence continues to indicate that the yellowfin stock in the ETP continues to be healthy. Concerning the bycatch issue, bycatch data are not collected by NMFS, but NMFS scientists participated in a peer-review of the Inter-American Tropical Tuna Commission's bycatch database, and the reviewers concluded that the data collection program is very well designed and run, but that some additional statistical experiments should be conducted to help in analysis of the data.

1996 Dolphin Safe Contract Proposals Being Developed—In March, staff with the Dolphin-Safe program in La Jolla worked with a number of contractors to develop proposals for investigating the following areas of study: (1) the optical potential of detecting tuna schools, (2) impacts on marine animals from airborne LIDARs (light detection and ranging systems), and (3) impacts to marine mammals from low-frequency, high source level sonar. The Center will be involved in field tests of an Office of Naval Research-funded LIDAR being developed by a private firm.

**Tuna-Dolphin Briefing Activities**—Over the past year, the staff was also active in various dolphin-safe issues related to the progress of the two dolphin-tuna bills which were introduced to Congress, providing information at weekly conference calls between the Center and the NMFS Southwest Regional Office, and providing information about the eastern tropical Pacific bycatch problem to environmental groups. In February, revisions were completed on a manuscript on tuna fishery bycatch, and the manuscript was submitted to *Fishery Bulletin, U.S.* 

In March, dolphin-safe personnel prepared and presented testimony at a hearing before the House Subcommittee on Fisheries, Wildlife, and Oceans. The hearing was called to debate the two bills before the House that proposed changes in the Marine Mammal Protection Act to lift embargo on imports of tunas from countries fishing both on and off dolphins in the eastern tropical Pacific. SWFSC staff summarized the current status of knowledge about dolphin abundance, bycatch, and potential for fishery-related stress in dolphins in the ETP.

36-year Summary Completed on ETP Dolphin Stocks Using Bayesian Model—Since the eastern tropical Pacific purse seine tuna fishery began in the late 1950s, an estimated 6.3 million dolphins have been taken as bycatch. Spotted, spinner, and common dolphins account for over 95% of the mortality. SWFSC staff working with staff at NMFS' National Marine Mammal Laboratory combined estimates of mortality over the 36 years of the fishery, relative abundance from observers on tuna boats over 20 years, and absolute abundance from 20 research cruises over 17 years. A Bayesian model was used to estimate the status and trends of seven stocks (management units) of these three species.

All stocks were shown to have declined since the fishery began. Two stocks, northeastern offshore spotted dolphins and eastern spinner dolphins, have declined to approximately one-fourth of their prefishery abundance and are declared "depleted" under the U.S. Marine Mammal Protection Act.

At present, the annual incidental mortality in this fishery is less than 0.2% of population size for all dolphin stocks. In theory, with such a low mortality rate, dolphin populations should be able to recover to their former abundance. However, this assumes (1) mortality will remain at a low level for the next 30 years, (2) there is no unreported kill, (3) effects of injuries are negligible, (4) effects of fishing activities are negligible, and (5) there have been no major ecosystem changes.

#### SHARK RESEARCH

**Progress on Developing Shark Abundance Index**—The Center's PFRD continues work on developing an index of abundance for pelagic sharks in the Southern California Bight—a project that began in 1993.

In the past, attempts to standardize CPUE and determine abundance for shortfin mako and blue sharks in the driftnet fishery have been hampered by changing targets within the fishery and increasing regulations governing it, which has resulted in an ever-changing distribution of catch and effort over time. Pelagic shark landings in California peaked in 1982 as the driftnet fishery for swordfish and thresher sharks expanded, but have since declined. The catch of shortfin mako sharks fell from a high of 900 metric tons (t) in 1982 to only 100 t in 1985. Catches increased in 1986 and 1987 as a new commercial longline fishery developed for shortfin mako and blue sharks. This longline fishery was discontinued because of a high percentage of juvenile sharks in the catch and an excessive bycatch of blue sharks for which there was little demand.

The abundance index will be developed using historical logbook and landings data from the 1988-91 experimental longline fishery and current data from fishery-independent research vessel longline catches. Collaborative research cruises have been conducted aboard the NOAA ship David Starr Jordan and the California Department of Fish and Game vessel Mako since 1993 to help formulate this index and also tag and release sharks for movement and distribution studies. The first year of study was devoted to working out experimental procedures. In 1994, 47 longline sets were made during 31 days of sampling. A total of 215 shortfin mako sharks, 432 blue sharks, and 1 thresher shark were caught, and 114 pelagic rays also were taken. The overall catch rate for 1994 was 10.6 sharks per 100 hooks set. The highest catch rates occurred in July for make sharks (3.4 per 100 hooks) and in October for blue sharks (14.2 per 100 hooks). Sampling locations were selected from productive fishing areas known from skipper logbooks.

In 1995, 42 sampling sets were made during 30 days at sea. A total of 188 mako, 298 blue, and 9 thresher sharks were captured, with 46 pelagic rays also caught. The overall catch rate for 1995 was 6.8 sharks per 100 hooks. The highest catch rate for mako sharks was 2.9 per 100 hooks and the highest catch rate for blue sharks was 4.7 per 100 hooks.

The mako shark catch rates of 4.1 in 1994 and 2.9 in 1995 were lower than the average catch rate of shortfin mako sharks in the 1988–91 commercial fishery (6.1 per 100 hooks; 4-year average). This does not necessarily indicate a decline in relative abundance. Continued survey indexing is required to adjust survey catch rates to commercial fishery data and to determine distribution ranges for juvenile sharks.

Shark Demographic Analysis Developed—Staff of the La Jolla Laboratory's PFRD completed an analysis, using the leopard shark as an example, for obtaining mortality-dependent estimates of a population's intrinsic rate of increase (r)that requires only age at female maturity, maximum reproductive age, average fecundity, and standard fisheries concepts of density-dependence. This procedure returned rate of population increase values for this and five other species of sharks that compared favorably with published values obtained by the more standard life table method. An estimate of the leopard shark's r-value at the population size producing maximum sustainable yield was obtained and extended to adjust estimates of its yield per recruit for the effects of recruitment reduction under fishing pressure. The results indicated that the leopard shark may be more vulnerable to exploitation than previously thought. This method should be useful in assessing the status of shark populations for which few data exist.

Joint U.S.-Mexico Shark Research Planning—SWFSC staff met with Mexican scientists in early March about the Mexican shark research plan and areas of collaboration. The Mexican plan is being developed and will be formally available at the Mexico-U.S. planning meeting in June 1996. Areas of possible collaboration were identified and the PFRD staff will develop proposals for consideration at the April meeting.

Hawaii Sharks—During the year, staff at the Honolulu Laboratory began an investigation of the developing shark fin fishery in Hawaii. A JIMAR PFRP project was also initiated to estimate blue shark bycatch by the Hawaii-based longline fishery. A report was completed that is in review but will soon be available as a technical memorandum. The reports shows that the bycatch of blue sharks reported on logbooks is very similar to that estimated from observer data. About 500,000 blue sharks (total) were taken from 1991-95. Based on observer data the finning rate was about 25% in 1994-95, and a minimum estimate of bycatch mortality was about 40%.

Mike Seki of the Honolulu Laboratory Ecosystem and Environment Investigation collaborated with Skip McKinnell of the Pacific Biological Station, Nanaimo, British Columbia, to complete a draft manuscript describing "Shark bycatch in the Japanese high seas squid driftnet fishery in the North Pacific Ocean." The manuscript is currently undergoing internal review.

## ANGLER SURVEY AND BILLFISH TAGGING PROGRAM

Analyses of the 1995 International Billfish Angling Survey and the 1995 Cooperative Marine Game Fish Tagging Program were completed in March. Results will be published in the 1996 Billfish Newsletter. The Billfish Newsletter, an annual publication produced by the Center's PFRD, emphasizes recreational billfish angling and conservation of billfish resources in the Pacific and Indian Oceans and is provided as a service to the international angling community. The data presented are the result of the cooperation of billfish anglers, sport fishing clubs, and agencies affiliated with the SWFSC.

The number of tags both released and recovered increased in 1995, which was an excellent year. Survey response was good and indicated continued good fishing in most areas. The tagging program also came to cyberspace this quarter via the Internet. The *Billfish Newsletter*, along with PFRD's quarterly issue of the *Tuna Newsletter*, can now be found on the Southwest Fisheries Science Center's home page at http://swfsc.ucsd.edu.

**Results of the 1995 Billfish Angler Sur**vey—The Billfish Angler Survey provides estimates of billfish angling activity throughout the Pacific and Indian Oceans. The survey began in 1969 and provides an index of trends in billfish angling effort and catch for the international recreational fishing community.

Billfish anglers responding to the Billfish Angler Survey for the 1994 fishing year reported catching 2,671 billfish during 6,589 days of fishing in the Pacific and Indian Oceans. This is a decrease of 23% from the number of angler-days reported for 1993. The overall success rate was 0.41 billfish per angler day, or 2.47 days fishing to catch a billfish. This is similar to the 1990-93 catch rates of 0.42, 0.43, 0.57, and 0.40 billfish per day, respectively. The numbers of billfish reported caught by anglers included 587 Pacific blue marlin, 136 black marlin, 895 striped marlin, 874 sailfish, 171 spearfish, and 8 swordfish.

**Tagging Results for 1995**—The Billfish Tagging Report cards received in 1995 indicate a total of 1,178 billfish were tagged and released, 36% more than in 1994. Tagging increased for blue marlin and striped marlin in Hawaii and Baja California and for striped marlin in southern California.

Nineteen billfish tags were returned in 1995 from 5 blue marlin, 11 striped marlin, 2 swordfish, and 1 sailfish. A bigeye tuna tag and one mako shark were also recovered. All of the blue marlin were tagged and recaptured near Hawaii. The most notable returned data were from two blue marlin tagged near Kailua-Kona; they were at liberty for 706 and 559 days and traveled a net distance of 208 and 597 nautical miles, respectively. Two striped marlin tagged near San Clemente Island, California, were recovered 205 and 129 days later after traveling 2737 and 1506 nautical miles (respectively) toward Hawaii. The two swordfish traveled the other direction. Tagged just east of Hawaii, they moved 1852 and 899 nautical miles toward California in 610 and 287 days, respectively.

The success of the survey and tagging program is due to the cooperation of the anglers, fishing vessel captains, commercial fishers, and supporting agencies. Their support is sincerely appreciated.

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Science and Research Director Southwest Region

May 1996 La Jolla, California

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