

**48th** Tuna Conference

On Tuna & Tuna-Related Activities at the Southwest Fisheries Science Center for the Period May 1, 1996 to April 30, 1997

> Administrative Report LJ-97-06

National Marine Fisheries Service Southwest Fisheries Science Center P.O. Box 271 La Jolla, CA 92038 DIRECTOR'S REPORT TO THE 48th TUNA CONFERENCE ON TUNA AND TUNA-RELATED ACTIVITIES AT THE SOUTHWEST FISHERIES SCIENCE CENTER FOR THE PERIOD MAY 1, 1996, TO APRIL 30, 1997.

This report describes research at the Southwest Fisheries Science Center relating to tuna, billfish, and other large pelagic fishes and protected species associated with their fisheries. The work was conducted from May 1996 through April 1997 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.

The Center continues to provide research support to the Western Pacific Regional Fishery Management Council, international working groups and committees, and the National Marine Fisheries Service's Southwest Region and Headquarters. The research, designed to meet both the long-and shortterm information needs of fishery managers, includes stock assessment and basic biological research to *improve the scientific basis for effective management;* socio-economic 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.

The Director's Report to the 48th Tuna Conference, the Tuna Newsletter, the Billfish Newsletter, and a list of other Center publications are available on the Internet at http://swfsc.ucsd.edu. This Administrative Report is issued as an informal document to ensure prompt dissemination of preliminary results, interim reports and special studies. We recommend that it not be abstracted.

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#### SOUTH PACIFIC AND WESTERN PACIFIC TUNA FISHERIES

Tuna Treaty Fishery Annual Report—Southwest Fisheries Science Center (SWFSC) scientists continued to monitor U.S. purse seiners fishing in the central and western Pacific under the South Pacific Tuna Treaty. The treaty was implemented in June 1988 and allows U.S. tuna fishermen to obtain regional licenses to fish in some 10 million square miles of rich fishing grounds in the western and South Pacific. Highlights of a paper (Coan et al. 1997) describing the 1996 U.S. fishery, which was presented at the annual treaty review meeting in March 1997 at Port Vila, Vanuatu, are as follows:

The treaty fishery operates between 10°N and 20°S latitude and 150°W and 14°E longitude. Fishing depends on environmental conditions and shifts east or west of 160°E longitude as conditions change. In 1996, fishing effort concentrated in the eastern area (75%), where vessels fished between Kiribati and Tuvalu and catches were mainly from schools associated with floating objects (56%, fish aggregating devices and logs). In contrast, fishing effort in 1995 was mainly in the western area (72%) between Papua New Guinea and the Federated States of Micronesia, and catches were mainly from free-swimming schools (66%).

The fleet was about 10% smaller in 1996 than in 1995 and spent 23% fewer days fishing. While the number of sets per trip and trips per vessel was essentially the same in the two years, the number of days per trip increased 6% in 1996, probably due to difficulties in finding fish.

Overall, catches declined for the second consecutive year-approximately 40% since 1994 and to the lowest levels since 1988. Skipjack tuna continued to dominate the catch, with 100,900 metric tons (t) in 1996, compared to a high of 177,400 t recorded in 1991. Yellowfin tuna catches decreased to 16,100 t in 1996, from a peak of 56,400 t in 1994. Bigeye tuna catches increased to a high of 9,100 t in 1996, from a low of 1,600 t in 1991, probably due to increased fishing on fish aggregating devices and logs.

The average size of fish in the catch decreased in the last two to three years. For skipjack tuna, the average fork length decreased to 51 cm (2.7 kg or 6 lbs) in 1996, compared to 57 cm (4.05 kg or 9 lbs) in 1993. The average fork length for yellowfin tuna decreased to 64 cm (4.95 kg or 11 lbs) in 1996, compared to 81 cm (9.9 kg or 22 lbs) in 1994. As with catches, catch rates in tons per day fished also declined, to 16.34 t per day fished in 1996, from a record high of 30.48 t per day fished in 1991. These trends may be related to cyclic changes in the environment or to changes in the abundance of the resources.

The fleet's reporting of bycatches and discards of the target species is becoming more routine; in 1996, approximately 75% of the trips reported this information. Tunas comprised the largest share of the reports (92% by weight), of which small skipjack tuna was the dominant species. Sharks were next in importance (5%), followed by others (2%), and billfishes (0.5%).

Data Collected on American Samoa's Emerging Longline Fishery—During its first three years of operation, the American Samoa domestic longline fishery increased its annual landings of albacore tuna from 2,000 lbs in 1994 to more than 50,000 lbs in 1996. This is an especially dramatic increase for a longline fishery consisting of three-man crews on 30-foot boats with no electric or hydraulic equipment on board. Based on the fishery's longline gear configuration, the Western Pacific Regional Fishery Management Council determined that American Samoa's longline fishermen must comply with existing federal longline permit and data submission regulations. Honolulu Laboratory staff subsequently began receiving federal longline logbook data in January from the Pago Pago field office of the National Marine Fisheries Service's (NMFS) Southwest Region.

Monitoring this emerging fishery has required changes to established survey and sampling methods and computer software used by the American Samoa Department of Marine and Wildlife Resources. Members of the Western Pacific Fisheries Information Network (WPacFIN) staff at the Honolulu Laboratory will design a new monitoring system and software to process data collected on this fishery. The new system is intended to integrate state data with federal logbook data for a comprehensive view of this growing fishery.

WPacFIN Staff Provide Technical Support to Island Fisheries Agencies—WPacFIN staff continue to update the longline fishery monitoring system maintained by the Guam Department of Commerce. Longline vessels fishing outside the Exclusive Economic Zone bring their catches to Guam, where the fish are weighed and graded before being transshipped to Japan. Longline data from these vessels provide important information for tuna stock assessments. These data are kept current and include essentially 100% coverage of this longline fishery.

Currently, databases are being adapted to include data from a newly established length-frequency sampling program on Guam. In addition, WPacFIN staff members have developed and implemented the first modules of a data processing system that will allow the Guam Division of Aquatic and Wildlife Resources to input offshore fisheries creel survey data. These data, which have not been processed since 1992, provide important fisheries statistics for the Honolulu Laboratory.

WPacFIN staff have also been involved in analyzing fisheries monitoring program data from the Northern Mariana Islands Division of Fish and Wildlife. Staff members, during a March onsite visit to the Marianas, assisted in the improvement of sampling programs, including a commercial landings receipt book program. Landings, effort, and value data from the receipt book program continue to be the mainstay of the offshore fisheries monitoring program.

WPYRG Meeting Report Published— In November, the "Report of the Fifth Meeting of the Western Pacific Yellowfin Tuna Research Group" was published in partnership with the South Pacific Commission. The purpose of the report, which is available from the Pelagic Fisheries Resources Division at the La Jolla Laboratory, is to apprise tuna scientists and managers of progress in research, developments in the fisheries, and current condition of the tropical tuna stocks of the central and western Pacific Ocean.

For 1995, the combined fleet information reviewed at the group's meeting indicated that the yellowfin tuna stock in the central and western Pacific remained healthy<sup>1</sup>. The yellowfin tuna catch was estimated at 370,300 metric tons (t) in 1994, down from a historical high of 397,600 t in 1993. There is growing concern that this level of catch might be adversely affecting the production of an associated and less abundant species, bigeye tuna, whose catch has recently decreased. Immature yel-

lowfin and bigeye tuna are difficult to distinguish and are caught together in surface schools. Consequently, statistics on yellowfin tuna catches include an unknown amount of mislabeled bigeye tuna. The amount is suspected to have grown with increased reported catches of yellowfin tuna and significantly reduced recruitment to the adult bigeye tuna stock.

## **INDIAN OCEAN TUNA FISHERIES**

1996 Second Quarter Fishery Data Updated—Data from the Seychelles Fishing Authority on the tuna purse seine fishery in the western Indian Ocean for the second quarter of 1996 were updated in March. The data, based on logbook returns from fishing vessels, are summarized in Lotus spreadsheets and cover the period 1983 to the present.

An average of 34 vessels (14 Spanish, 14 French, and a combined 6 Belizean, Liberian, Mauritian, and Panamanian vessels) participated monthly in the tuna purse seine fishery in the western Indian Ocean during the second quarter of 1996, compared to 46 vessels recorded for the same period in 1995. The number of vessel-days fished in the second quarter of 1996 was 2,471, down 27% from the previous year. Catches of skipjack, yellowfin, and other tunas (mainly bigeye and albacore) totaled 39,873 metric tons (t), down 38% from the previous year. The species composition was 57% skipjack, 31% yellowfin, and 12% other tunas. The catch rate for all tuna species was 16.1 t per day fished, down 15% from the previous year. Catch rates for skipjack and yellowfin tunas were 9.2 t and 5.0 t per vessel-day, respectively, compared to 11.0 t and 4.9 t per day fished for the previous year.

For the first two quarters of 1996, 48 purse seiners logged 5,622 vessel-days of fishing and caught 86,824 t of tuna, down 37% from the previous year. The species composition of the catch was 51% skipjack, 36% yellowfin, and 13% other tunas. The catch rate for all tuna species for the second quarter of 1996 was 15.4 t per day fished, down 19% from the previous year. Catch rates for skipjack and yellowfin tunas were 7.8 t and 5.6 t per day fished, respectively, compared to 10.9 t and 5.2 t per day fished for the previous year.

#### PACIFIC ALBACORE FISHERIES

Study Completed on Albacore Catch Patterns and Environment—Pelagic Fisheries Resources Division researchers and Dr. Tim Barnett of Scripps

<sup>&</sup>lt;sup>1</sup>More current information, based on U.S. fleet data only and indicating a declining trend, has prompted re-examination of the all-fleet data to see if these mimic U.S. fishery results. The subject will be examined and discussed at a meeting of the Western Pacific Yellowfin Tuna Research Group scheduled for June 1997.

Institution of Oceanography completed a statistical spatial analysis of albacore historic catch and effort data and sea surface temperature anomaly data to develop statistical predictors of fishery distribution. The results of the analysis were presented at the November meetings of the Western Fishboat Owners Association and the American Fishermen's Research Foundation in Reno, Nevada, in a paper "Albacore catch patterns in the U.S. troll fishery and their predictability: a statistical analysis," by N. Bartoo and T. Barnett. The analysis identified several spatial fisheries patterns which were correlated to specific sea surface temperature anomaly patterns and can be used in pre-season fishery predictions. In approximately 50% of the historical fishing years, one or two basic large-scale ocean temperature patterns were found to be associated with predictable regions of high catch rates. The remainder of the years did not show significant correlations between temperature and areas of high catch.

1995 Fisheries Summary Completed—A summary of the 1995 U.S. North and South Pacific albacore troll fisheries (SWFSC Admin. Rep. LJ-96-07) was distributed in August to subscribers, including more than 400 members of the Western Fishboat Owners Association who cooperated in submitting logbook information. Highlights of this summary are as follows:

The 1994-95 South Pacific fishing season began in late December 1994 and lasted through early April 1995. Twenty-one vessels participated in the fishery. Total U.S. South Pacific albacore catch for the 1994-95 fishery was 2,072 metric tons (t), compared to 530 t in 1993-94 and a peak catch of 5,540 t in 1990-91. Catch rates for the South Pacific troll fishery increased to 150 fish per day in 1994-95, compared to 86 fish per day in 1993-94. The average fork length of fish caught during the 1994-95 season was 70 cm (7.9 kg or 17 lbs), compared to 66 cm (6.7 kg or 14.8 lbs) for the 1993-94 season.

The 1995 U.S. North Pacific albacore fishing season began in April and lasted until late October. Approximately 600 vessels participated in the fishery. Total North Pacific albacore landings from U.S. troll vessels have increased annually since 1991, reaching 10,978 t in 1994. Total landings for 1995, however, decreased to 8,200 t. Catch rates for troll vessels declined to 48 fish per day, compared to 60 fish per day in 1994. The average fork length of fish caught during the 1995 season was 69 cm (6.8 kg or 15 lbs), compared to 71 cm (7.4 kg or 16 lbs) for the 1994 season. SWFSC Observer Collects Albacore Fishery Data—NMFS has placed observers aboard U.S. troll vessels since 1990 in an effort to augment port sampling of the U.S. troll fishery. During the 1996 North Pacific albacore season, an observer from La Jolla's Pelagic Fisheries Research Division accompanied the U.S. troll vessel *Wendy Seaa* on a 60-day trip, to monitor trends in size and age classes of fish, areas of catch, and fishing effort. The observer collected size composition data from 14,285 fish during the trip. The average daily catch was 330 fish, with fish averaging 65 cm in fork length (5.6 kg or 12.4 lbs). The vessel unloaded 89 t of albacore caught in the offshore area near 44°N latitude and 151°W longitude.

Albacore Vessels Advised of New Logbook Requirements-During the year, all vessels were notified by the NMFS Southwest Region of the permit and logbook requirements of the High Seas Fishing Compliance Act, which the United States implemented in March 1996. Under the act, all U.S. vessels fishing the high seas (outside the U.S. 200-mile Exclusive Economic Zone) are required to obtain a permit and to submit logbook information for each fishing trip. Operators of U.S. albacore troll vessels, which will be at sea when the new logbook requirement takes effect in the summer of 1997, were advised to use the current North Pacific albacore logbooks and submit them to the SWFSC at the end of the 1997 fishing season. Additional logbooks can be obtained from the Western Fishboat Owners Association or the Pelagic Fisheries Resources Division at the La Jolla Laboratory.

American Fishermen's Research Foundation Activities—During the year, Pelagic Fisheries Resources Division staff participated in meetings of the board of directors of the American Fishermen's Research Foundation, to provide advice on proposed research to be sponsored by the foundation and to identify proposed research for the 1996-97 South Pacific fishery and the 1997 North Pacific fishery. Cooperative arrangements for fishery data collection, tagging, and observer participation also were discussed.

Fifteenth North Pacific Albacore Workshop Announced—The 15th North Pacific Albacore Workshop will be held December 3-5, 1997, in Nanaimo, British Columbia. A preliminary agenda and preworkshop assignments are being developed. The contact persons for the workshop are Drs. William Shaw of the Pacific Biological Station, Nanaimo (e-mail shawb@pbs.dfo.ca), and Norm Bartoo, SWFSC (e-mail norm@wallyworld.ucsd.edu). gear conflicts at Cross Seamount and arrived at an agreement to promote better communication on the fishing grounds. No new fishery regulations were initiated.

Swordfish Biology-Age and Growth--Complementary age and growth studies using several hardparts (otoliths, fin rays, vertebrae) were continued. Honolulu Laboratory scientists completed examination and analyses of daily microincrements for 15 putative young-of-the-year, yearling, and age-1+ swordfish. Otolith daily microincrement counts were evaluated as an age estimator for larger immature and subadult fish of ages-1+ to -2 with the objective of corroborating the annular nature of bands seen in anal fin ray cross-sections for fish of this age range. Preparation of anal fin ray cross-sections continued, with emphasis on small (100 cm eve-to-fork length, EFL) and very large (200 cm EFL) fish for the time period (September-December), which were least represented in the swordfish hardpart collection. Marginal increment analyses of anal fin ray cross-sections for about 300 swordfish, collected during March 1994-July 1996 by Southwest Region observers, were also completed, and further analyses of fin rays for fish of all sizes continue (current sample size 500 fish). A collaboration was initiated with John Kalish of the Australian National University to evaluate bomb carbon ages using vertebrae of very large swordfish. In the future, otolith microincrement studies will be expanded to corroborate fin ray ages for age-3 fish, if possible. Examination of the whole otolith scan electron microscope photo library will resume, and the use of whole otoliths as ageing structures for swordfish will be reevaluated.

Sex Identification--A pilot test was conducted for the presence of vitellogenins in muscle tissue of swordfish sampled at the Honolulu fish auction (Admin. Rep. H-96-11). The purpose of the research was to explore the development of an assay to determine the sexual identity of dressed swordfish at auction. Preliminary results were encouraging but only partly successful because the polyclonal antibody that was used was not species-specific and cross-reacted with other proteins. Blood and muscle tissue specimens were collected during a March-April research cruise on NOAA ship Townsend Cromwell for development of a swordfish-specific, monoclonal antibody assay by Dr. Nancy Denslow's laboratory at the University of Florida, Gainesville.

*Swordfish Size at Maturity*--Body size at 50% sexual maturity was estimated as 79 (95% CI = 5) cm

EFL for 416 male swordfish and as 143 ( $\pm$  3) cm EFL for 601 female swordfish caught by the Hawaiibased longline fishery during March 1994-July 1996.

Swordfish Tagging--Development and testing of methods for the external attachment of pop-up archival tags to monitor swordfish movement continued throughout the year at the Honolulu Laboratory. Researchers developed a tag anchor that successfully retained dummy archival tags in caged southern bluefin tuna. Research cruises on Townsend Cromwell explored methods for catching more swordfish in viable condition for tag and release, but this work was hampered by bad weather and ship breakdowns. Several conventional tag recoveries were made, bringing the total to four out of the 422 swordfish tagged so far in the Hawaii-based longline fishery. Researchers will be attempting to expand this conventional tagging program, but many of the most active participants were absent from the fishery in 1996.

Effects of Environmental Variation on Swordfish Catch Rates—In another study, output from a wind-driven ocean circulation model was used to identify oceanographic features that characterize Hawaii's swordfish fishing grounds, and research continued on the application of TOPEX satellite altimetry data to describe the spatial and temporal dynamics of mesoscale features in the swordfish fishing grounds and their links with fishery catch rates. Links between Hawaii longline catch rates and large-scale features such as the Kuroshio Extension Current dynamics are also being addressed. This research will be continued with satellite altimetry data, cruise data, and fishery data to describe the environmental dynamics of the swordfish fishing grounds and their impact on the fishery. Results include (1) a set of computer programs and analytical methods which permits routine processing of TOPEX altimetry data to produce vector maps of ocean circulation, and (2) current vector maps produced with this algorithm showing the relationship between swordfish catches and eddies and meanders.

An oceanographic cruise on *Townsend Cromwell* was conducted at the subtropical front in May 1996 to identify physical and biological factors which are the basis of the swordfish fishing grounds. Results showing that the swordfish fishery targets a region where subarctic water converges with subtropical water were presented at the recent swordfish symposium. A follow-up cruise will be conducted in May 1997. Fishery monitoring developments—Staff from the Fishery Monitoring and Economics Program of the Honolulu Laboratory continue to collect, compile, and summarize the federal logbooks for domestic U.S. longline fishing vessels based in Honolulu. Staff members have been working closely with fishermen to alleviate problems in accurate logbook recording of fish identification, fish caught, and fish kept. A new category, "sharks finned," was added to the logbooks in 1996 to provide more detailed information on shark landings in terms of product form. Developments concerning shark finning will be monitored throughout 1997.

Data from the Hawaii-based domestic longline logbooks are maintained in a database system which allows the generation of various reports, summaries, and secondary data sets. Program staff also monitor the Honolulu fish markets and brokerage houses to obtain information on average weight and prices of individual species. Such information, along with detailed size composition, is critical in the preparation of the Honolulu Laboratory's annual longline fishery status report.

The fraction of swordfish shorter than 29 inches CKL (cleithrum-keel length) that are landed by Hawaii-based longliners was estimated using length-weight relationships applied to NMFS landings statistics. A CKL of 29 inches is being evaluated by the International Commission for the Conservation of Atlantic Tunas as a possible minimum allowable size for swordfish landed in the Atlantic, where high catches of small swordfish are of great concern. The Honolulu Laboratory analysis showed that during recent years fewer than 6% of swordfish landed in Hawaii have been shorter than 29 inches CKL. This figure is much less than that in the Atlantic, indicating that management measures for swordfish must be developed and applied on a stock-specific basis.

In another study, analysis of the spatial and temporal distribution of catches of juvenile swordfish from observer and logbook data was conducted to describe juvenile swordfish habitat and juvenile discard rate. Results were presented at the recent swordfish symposium.

Members of the WPacFIN staff continue to assist Hawaii Division of Aquatic Resources staff in their efforts to streamline and improve the monitoring of Hawaii's fisheries. Division and WPacFIN staff are working to cross-validate data from alternate sources to improve the overall quality of monitoring data, to streamline methodologies, and to integrate NMFS and state fisheries information.

Development of Oracle Database for Pelagic Fisheries—The Honolulu Laboratory has established a goal to convert all of its fishery and research data in flat files to a relational database using the Oracle database management system. Having this information on-line will provide researchers easy access to the data and afford access to summaries of the data to other users, such as the Western Pacific Council. Development of the database access software was made possible by funding from JIMAR's Pelagic Fisheries Research Program. The development group is composed of staff members from the Stock Assessment Investigation, Information and Technical Services group, and Fishery Management and Performance Investigation at the Honolulu Laboratory, and JIMAR staff.

JIMAR Socio-Economic Projects at the Honolulu Laboratory—The Center continued to make progress on grant projects awarded under the University of Hawaii's Pelagic Fisheries Research Program to principal investigators at the SWFSC's Honolulu Laboratory for socio-economic research on Hawaii pelagic fisheries. These grants are funded by a competitive process through the National Oceanic and Atmospheric Administration–University of Hawaii's JIMAR. Highlights of these projects follows:

HIFIVE Project—The Hawaii fleet, industry, and vessel economics (HIFIVE) project is completing its third year. The objective of this research is to provide fishery management information based on the economic characteristics and dynamics of the Hawaii longline and troll-handline fishing fleets. The project currently consists of two major components, a detailed cost-earnings analysis of the Hawaiibased domestic longline fishery and comprehensive information on the cost-earnings of the small boat pelagic fishery in Hawaii. Progress in 1996 centered on three areas: publication of longline vessel costearnings information of the longline vessels, completing initial economic analysis of longline fishing dynamics, and collection of basic information from the small boat pelagic fishery.

The longline cost-earnings information was published in two sources and was presented at the 1996 Hawaii School of Ocean and Earth Science Technology open house (poster) and the 1997 JIMAR external review (poster). This component of the project is completed, although updating some information for 1996 may be required to facilitate on-going economic analysis of the longline fishery. Detailed economic analysis of the longline fishery remains incomplete. Several papers have been prepared in draft form but have not yet been submitted for publication.

The troll-handline cost-earnings study was initiated in late 1995 with development of an information collection approach and instrument. The fishing community was informed of the project through an article in Hawaii Fishing News. Pretesting was initiated in early 1996 and full fielding with a staff of three is currently underway, with 575 completed interviews on all islands. A complete report of the fielding, and the cost-earnings results, has been completed and is under review. This component of the project collaborates with two additional JIMAR projects, a JIMAR visiting scientist project on the socio-anthropology of the distinction between recreational and commercial fishing in Hawaii (a thesis project at the University of Washington) and a Honolulu Laboratory recreational valuation project with the University of Maryland which began in mid-1996.

The HIFIVE project is currently funded to conclude in June 1997. Completion and publication of the current longline vessel economic dynamics research is anticipated, along with reporting of the troll-handline cost-earnings research. If a fourth year of funding is received, then the longline costearnings analysis will be extended into a spatial model of supply response, a comparison of set, trip, and vessel economic analysis for the longline fleet, and cost-earnings and patron activity analysis of the Hawaii charter-boat fishery. Charter boat fielding has already been initiated.

In a separate part of the basic HIFIVE project, Deane Neubauer of the University of Hawaii's Department of Political Science reviewed research on modeling fishermen's policy response frameworks by investigating methodologies utilized in other fields, such as forestry.

Collaboration between HIFIVE researchers and economics research project researchers of the University of Hawaii's Department of Agricultural and Resource Economics continued. This included collaboration on the writing of papers, analysis of data, access to confidential fishing vessel information, and joint fielding of dockside research.

Visiting Scientists—JIMAR visiting scientist funds were utilized for two pieces of sociological research directed toward pelagic fisheries in Hawaii. Julie Walker completed her master's thesis at the University of Washington's School of Marine Affairs on work and leisure in Hawaii's small boat fishery. This thesis identified different components of the fishing experience and developed an alternative framework from the recreational-commercial dichotomy. Walker then collaborated with the HI-FIVE project by conducting a study of charter fishing communities in Hawaii. This report investigated several charter fishing ports around Hawaii, identifying factors leading to cohesion, conflict, and differences within the community and their effect on charter fishing's role in fishery management.

Recreational Value Study—Marcia Hamilton collaborated with Prof. Ted McConnell of the University of Maryland on the preparation and field staffing of a study concerning the extent and economic value of recreational fishing in Hawaii. The project is funded separately through JIMAR. Pretesting was completed in the early spring of 1997, and full staffing to a large segment of Hawaii-registered small boat fishermen is scheduled for several waves during the remainder of 1997.

## EASTERN TROPICAL PACIFIC TUNA FISHERIES

Dolphin-Safe Research Program Activities—The Dolphin-Safe Research Program at the SWFSC's La Jolla Laboratory continues to focus on the development of acoustic and optical detection devices to replace dolphins as sighting cues for locating large yellowfin tuna in the eastern tropical Pacific Ocean (ETP). By concentrating on large yellowfin tuna not associated with dolphin, program staff hope to eliminate the need for the practice of "dolphin-fishing" in the ETP, during which dolphins are located, chased, and encircled with nets in order to capture the large yellowfin tuna which frequently associate with dolphins in this part of the Pacific Ocean.

Two of three successive research cycles for the Dolphin-Safe Research Program have been completed, and completion of the third cycle is near. The first cycle answered affirmatively the initial question of whether large yellowfin tuna are ever unassociated with dolphins in the ETP and therefore might be available in commercially adequate numbers. The second cycle determined first, that locating such fish should be possible given the physical oceanographic environment of the ETP, and second, that the most appropriate medium- to long-range detection devices would be acoustic. Local detection could be improved over current methods by using newly developed and developing optical detection technologies (that is, light detection and ranging and enhanced video). During the third (and last) research cycle, specifications will be determined for the optimal acoustic system for locating large, unassociated yellowfin tuna in the ETP, and planning will be initiated for research surveys to determine distribution, abundance, and commercial potential of the resource.

1996 Dolphin-Safe Contract Proposals Awarded-Last year contracts were awarded to various researchers for investigations into both optical and acoustic methods of detecting tuna schools and the impacts to marine mammals from low-frequency, high source-level sonar. The research contracts included "Modeling the optical potential to detect schools of large yellowfin tuna in the eastern tropical Pacific Ocean;" "Development of an optimized environmental design for a low-frequency, tunatracking, towed array to detect schools of large yellowfin tuna in the eastern tropical Pacific Ocean;" and "Potential effects on marine mammals and tuna from an active, high source-level, low-frequency, towed array to detect schools of large yellowfin tuna in the eastern tropical Pacific Ocean." Research proposals approved for funding through the NMFS Saltonstall-Kennedy Grant Program included "Demonstration and evaluation of the streak tube imaging LIDAR (STIL) for use in bycatch reduction" and "Long-range tuna school detection." In addition to these contract awards, cooperative field studies of various optical detection methods continued during the year.

**Tuna-Dolphin Activities**—Tuna-dolphin projects completed during the year included a review of interactions between tuna purse seiners and dolphins outside the ETP, development of criteria for research proposals on tuna-dolphin separation or attraction methods, and a summary of NMFS dolphin-safe research projects conducted during 1992-96.

Results of a review of currently available literature regarding cetacean interactions with tuna purse-seine fisheries outside of the ETP (SWFSC Admin. Rep. LJ-96-20) indicated that the large-scale practice of setting purse-seine nets on cetaceans for the purpose of catching tuna occurs only in the ETP. Better data from each tuna fleet operating outside the ETP are needed, however, to show conclusively that such large-scale efforts do not exist.

Recommendations for improving research proposals directed at breaking the tuna-dolphin association for purposes of reducing fishery-related dolphin mortality were provided to interested researchers (SWFSC Admin Rep. LJ-96-17). Such proposals should show clearly that the proposed research is based on solid theory and a demonstrated understanding of past efforts, can be accomplished in a practical manner, will result in significantly lower dolphin mortality rates at no greater risk to the fishermen involved, compared to current practices, and will be tested in a scientifically, logistically, and economically feasible manner. The recommendations were developed from a workshop held at the SWFSC's La Jolla Laboratory in September 1995.

NMFS research projects conducted during 1992-1996 were selected based on their potential to improve understanding of the behavioral association between yellowfin tuna and dolphins and to develop new methods of locating and aggregating sexually mature yellowfin tuna not associated with dolphins. During that period, NMFS funded four specific research projects, conducted a research planning workshop, supported cooperative research on fish aggregating devices between NMFS and tuna vessel skippers, and funded studies on the potential for low frequency, longer range acoustic systems and enhancements to existing radar systems to detect yellowfin tuna schools in the ETP. NMFS also conducted a workshop on methods to separate or attract tuna and dolphins, completed a report on recent use of fish aggregating devices, estimated tuna bycatch in the ETP, and reviewed the dolphin-fishery interactions outside the ETP.

A contract also was awarded during the year for background preparation for two workshops on the potential effects of fishery-induced physiological stress on the population dynamics of ETP dolphins. It is hoped that the results from these workshops will provide a basis for developing a research plan to evaluate the possibility that fishery-induced stress may be affecting abundance and reproductive success in ETP dolphins affected by the tuna purseseine fishery.

#### SHARK RESEARCH

Annual Shark Abundance Survey Completed—A collaborative survey to index shark abundance within the Southern California Bight was conducted August 10-29, 1996, aboard NOAA research vessel *David Starr Jordan*. Survey objectives were to (1) collect data on shark abundance for population indexing, (2) tag and release live and healthy sharks, (3) collect biological data and samples, including reproductive organs, muscle and heart tissue, stomach contents, and whole specimens, for several ancillary studies, and (4) collect data on bycatch species.

Forty-four longline sets were made within the Southern California Bight, involving a total of 6,211 hooks. Thirty-three sets were made using wire cable leaders during daylight hours, and 11 sets with monofilament nylon were made during nighttime hours. Total catch was 205 shortfin mako sharks, 689 blue sharks, 74 pelagic stingrays, and one swordfish. One California sea lion and one common mola were foul-hooked (snagged) during fishing operations; both were released without harm. Overall catch rate of sharks was 14.4 sharks per 100 hooks. Catch rate for shortfin mako sharks averaged 4.0 per 100 hooks but was more than double– 8.5 per 100 hooks–in the most productive survey areas.

A total of 556 blue sharks and 164 shortfin make sharks were tagged and released for population and movement studies. Necropsies were conducted on 52 blue sharks, 31 shortfin mako sharks, and one swordfish. Heart, liver, gonad, and muscle tissue were collected for a variety of studies, including reproductive condition, DNA analysis, heavy metal and DDT concentrations, and biochemical analysis. Stomachs were collected for feeding pattern studies. Fifty-three pelagic stingrays were collected for ageing and growth studies. Four whole blue sharks were collected for observer shark identification and anatomy training. Physiological studies of swimming energetics were conducted on four shortfin mako sharks and six pelagic stingrays in a variablespeed water tunnel aboard the vessel.

Shark Demographics—The manuscript "A demographic method with population density compensation for estimating productivity and yield per recruit of the leopard shark (Triakis semifasciata)," was published in spring 1997 (Au and Smith 1997). The paper describes a procedure, using the leopard shark as an example, for obtaining estimates of a population's intrinsic rate of increase that depend on the level of total mortality borne and resulting decrease in population size. The method is tailored specifically to elasmobranchs. It uses age at female maturity, maximum reproductive age, and average fecundity, and incorporates concepts of density dependence from standard fisheries population modeling. The results indicate that the leopard shark may be more susceptible to overexploitation than previously thought. Rates of increase for this shark and five other species of sharks were obtained using the new simplified demographic method which compared favorably with published values obtained through traditional demographic methodology.

Also during the year, a manuscript was completed that uses the above method to measure the relative ability of different sharks to rebound from fishing pressure. A review draft of the manuscript, "Intrinsic rebound potentials of 26 species of Pacific sharks," was completed in May 1997. Using a threestep procedure, the effect of an approximated maximum sustainable yield level of fishing pressure on the intrinsic productivities of various species was examined, with each species being constrained by its own combination of three core life-history variables-age at maturity, maximum reproductive age, and average fecundity. The results revealed an interesting pattern along the productivity continuum with regard to adult shark size and certain life-history traits and strategies. Species with lowest "rebound" rates tended to be late maturing, medium-to large-sized sharks, while those with the highest values tended to be small coastal, early maturing species. Sharks with mid-range values were mostly medium- to large-sized pelagic sharks with low- to mid-range first ages at maturity.

## **BILLFISH INVESTIGATIONS**

Two components of the billfish investigations by the La Jolla Laboratory's Pelagic Fisheries Resources Division are the International Billfish Angling Survey, which tracks changes in recreational angling catch and effort, and the Cooperative Billfish Tagging Program, which provides information on the distribution, migratory patterns, and growth rates of billfishes of the Pacific and Indian Oceans. The results of billfish research conducted by the Center are published annually in the Billfish Newsletter. The goal of the billfish research program is to provide information for the conservation and rational management of billfish resources in the Pacific and Indian Oceans.

Results of the 1995 International Billfish Angler Survey—SWFSC scientists have collected angler catch and effort survey data through the Billfish Angler Survey annually since 1969. The information developed from this survey is used to measure trends in angler catch rates. The survey data are collected from cooperating international and national agencies, sportfishing clubs, and individual anglers. Trends in the catch rate of billfish, or catch in number of fish per angler-day, are monitored for major billfishing areas throughout the Pacific. Trends by area are important in understanding the impact of fisheries on billfish resources, such as recorded off northern Mexico in the mid-1980s with heavy longline fishing. Changes in long-term trends can also be used to identify emerging problems resulting from environmental, economic, or other causes.

Billfish anglers responding to the Billfish Angler Survey for 1995 reported catching 3,318 billfish during 6,521 days of angling in the Pacific and Indian Oceans. The overall success rate was 0.51 billfish per angler-day, or an average of 1.96 fishing days to catch a billfish. The 526 survey respondents reported catching 1,453 striped marlin, 1,020 sailfish, 609 Pacific blue marlin, 169 spearfish, 62 black marlin, and 5 swordfish for the Pacific and Indian Oceans.

The total number of angler-days reported for 1995 (6,521 days) decreased 1.0% from 1994. The current overall catch rate of 0.51 billfish caught per angler-day is higher than the prior four-year average (1990 to 1993) of 0.43 billfish per angler-day, and nearly the same as the preceding five-year period's (1985 to 1989) average of 0.54. This five-year period had the highest reported catch rate since the 1969 to 1971 period. The lowest catch rates occurred in the mid-1970s, averaging about 0.38 billfish per anglerday.

Cooperative Marine Game Fish Tagging Program—Since 1963, scientists from the Center's Billfish Tagging Program have utilized tag release and recapture data to help determine migration, distribution, and growth patterns of billfish. Their studies rely on the continued participation and cooperation of recreational anglers, commercial fishermen, and affiliated research agencies.

The Billfish Tagging Report cards received in 1996 indicate 1,147 billfish were tagged and released by 758 anglers and 254 fishing captains. This is 5% less than the 1,210 billfish released in 1995. Increased tagging was noted for blue marlin off Hawaii, striped marlin off Southern California, and sailfish off Mexico. However, there was a notable decrease in tagging of swordfish–only 13 swordfish were tagged and released in 1996, compared to 73 in 1995 and 51 in 1994.

Although the focus of the Billfish Tagging Program is on billfish, a variety of other species have been tagged. A total of 44,380 individual fish from 79 separate species have been tagged and released since 1963. There have been 625 recoveries, for an overall recovery rate of 1.41%. Billfish account for 90% of the releases and 75% of the recoveries. Striped marlin account for 44% of all fish tagged, while sailfish account for 16%, blue marlin 10%, and black marlin 8%. Of the billfish, swordfish and black marlin have the highest rates of return (2.36% and 2.07%, respectively), followed closely by striped marlin with a 1.64% return rate.

Tag Recoveries in 1996—Eleven striped marlin, five blue marlin, one black marlin, one swordfish and one shortfin mako shark were recaptured in 1996. Unfortunately, the release information (Billfish Tagging Report) has not yet been received for the black marlin and shortfin mako.

Ten of the 11 striped marlin recaptured during 1996 were tagged and recaptured in the waters surrounding Hawaii. They varied in time at liberty from four to 217 days. The other striped marlin was released off San Clemente Island, California, and recaptured near Santa Catalina Island only 30 nmi away, after being at liberty for 369 days. None of the striped marlin recaptured this year moved between Hawaii and California or between California and Baja California Sur, Mexico, although such movements have commonly been observed in the past.

All five blue marlin were tagged and released off Hawaii. Time at liberty for these fish ranged from 16 to 1,503 days. The only swordfish recovery of the year was tagged near the Maher Seamount northeast of Hawaii, and recaptured 375 days later 394 nmi to the west. One black marlin and one shortfin mako shark were recaptured near Fiji, but the tag release information has not yet been received.

Recreational anglers world-wide are becoming more conservation minded through catch and release programs. Billfish tagging increases angler awareness of resource conservation and the importance of tag-recapture data to resource managers. Because billfish are large, highly mobile, and widely dispersed, it is difficult to determine the impact fishing has on their populations. When skillfully tagged and quickly released, billfish have an excellent chance for survival, and their recapture increases our knowledge of these magnificent fish. As tagging technology improves and tag design moves into high-tech archival and satellite tags, valuable new information will be available. This exciting new technology is certain to expand our understanding of billfish ecology and billfish resources worldwide.

## SCIENTIFIC MEETINGS ON TUNA AND TUNA-LIKE SPECIES

Center scientists continue to work cooperatively with colleagues from other nations on marine re-

sources of mutual concern, including tropical tunas, albacore, billfishes, and other large pelagic fishes. Following are highlights of selected meetings which took place during the year and in which Center scientists participated:

Organizational Meeting Held for New Scientific Committee—The inaugural meeting of the Interim Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean was held in Tokyo from May 7-10, 1996. Representatives from the United States, Canada, China, Japan, Korea, Mexico, Taiwan, the Inter-American Tropical Tuna Commission, the Pacific International Council for Exploration of the Sea, and the South Pacific Commission attended. The purpose of the meeting, hosted by the Japanese government, was to establish a new body to promote scientific research and cooperation for North Pacific tuna and tuna-like resources. Objectives and priorities were developed for the committee for a full range of scientific and administrative issues. Working groups were established for swordfish, bigeye tuna, northern bluefin tuna, and statistics. The Swordfish Working Group is chaired by Dr. Michael Laurs of the SWFSC's Honolulu Laboratory; the other groups are chaired by Japanese scientists. Science Director Dr. Michael Tillman leads the U.S. delegation for committee matters. The United States will host the next committee meeting in Hawaii, on a date to be determined in consultation with key participants.

Symposium on Pacific Highly Migratory Fish Meets-Scientists from the La Jolla and Honolulu Laboratories participated in the conference "Getting ahead of the curve--a symposium on managing highly migratory fish of the Pacific Ocean," in Monterey, California, from November 4-6, 1996. The objective of the symposium, which was sponsored by the National Coalition for Marine Conservation, was to provide a forum for the exchange of information on monitoring, scientific understanding, and conservation and management of highly migratory fish stocks of the Pacific Ocean. SWFSC scientists made presentations at the conference on recent and future trends in the pelagic fisheries, the status of Pacific billfishes and the assessment process, and the role of environmental variation on highly migratory fishes in the Pacific. A Center scientist also served on the planning committee for the event. The proceedings from the symposium will be published in late 1997.

Second International Pacific Swordfish Symposium—An International Steering Committee, including two SWFSC scientists, organized the second International Pacific Swordfish Symposium, which took place in Kahuku, Hawaii, March 3-6, 1997. The event, held under the auspices of the Interim Scientific Committee for Tuna and Tunalike Species in the North Pacific Ocean, provided a platform for the exchange of information on recent developments in biological, fisheries oceanography, and resource assessment research on swordfish in the Pacific Ocean. Two hundred symposium participants from seven countries heard thorough descriptions of swordfish fisheries presented by representatives from the United States, Japan, Mexico, Chile, Australia, and Reunion and a report by a representative of the International Commission for the Conservation of Atlantic Tunas. An expert panel was convened to discuss stock assessment approaches and data needs, and three concurrent working group sessions focused on specific themes: biological input to stock assessment, fisheries oceanography and habitat, and resource assessment and monitoring. A report on the various sessions will be published in late 1997.

Immediately following the symposium, NMFS hosted the first meeting of the Swordfish Working Group, a subsidiary body of the Interim Scientific Committee. Drawing upon results of the symposium, the working group considered priority objectives of the committee with respect to swordfish and identified actions, including data sharing and research, required to meet those objectives.

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Science Director Southwest Region

May 1997 La Jolla, California



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