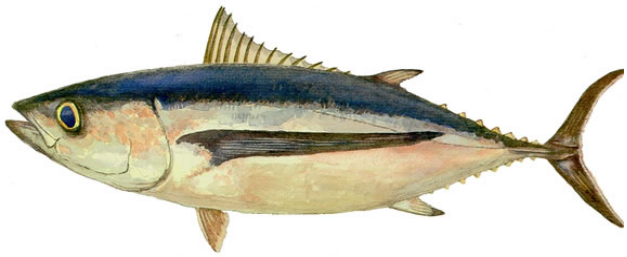
Pacific Islands Fisheries Science Center

Research, Fishery Monitoring, and Other Activities At the Pacific Islands Fisheries Science Center Related to Tuna and Tuna-Like Species During May 1, 2003 – April 30, 2004

A Report to the
55th Tuna Conference



National Marine Fisheries Service
Pacific Islands Fisheries Science Center

May 2004

NOAA Fisheries

Administrative Report H-04-07

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Research, Fishery Monitoring, and Other Activities at the Pacific Islands Fisheries Science Center Related to Tuna and Tuna-Like Species During May 1, 2003 – April 30, 2004

A Report to the 55th Tuna Conference

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May 2004

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INTRODUCTION

This report describes fishery monitoring and research related to tunas, billfishes, and other pelagic species conducted from May 1, 2003, through April 30, 2004, by the National Marine Fisheries Service (NMFS) at its Pacific Islands Fisheries Science Center (PIFSC). Summaries of activities and recent findings are provided for programs that monitor NMFS-managed fisheries in the western and central Pacific including domestic fisheries based in Hawaii, American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands (CNMI). Also described are PIFSC programs in data management, stock assessment, and biological, economic, and oceanographic research. Although most of the projects reported are carried out by PIFSC staff, many are by scientists of the NOAA-University of Hawaii Joint Institute for Marine and Atmospheric Research (JIMAR) sponsored by NMFS and working at the PIFSC.

PIFSC monitoring and research support the pelagic fishery management activities of the Western Pacific Regional Fishery Management Council and various multilateral arrangements for cooperation in the scientific study and management of tunas and other pelagic species including the Standing Committee on Tuna and Billfish (SCTB), the emerging Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific (WCPFC), and the Interim Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean (ISC).

Before the Pacific Islands Fisheries Science Center was created in April of last year, PIFSC scientists were part of the now-defunct Southwest Fisheries Science Center (SWFSC) Honolulu Laboratory and their activities were included in the SWFSC Director's report to the Tuna Conference. This year, separate reports for the SWFSC and PIFSC are being issued. Nevertheless, as indicated in both reports, the Centers collaborate extensively in many programs involving tuna and tuna-like species.

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May 2004
Honolulu, Hawaii

U.S. FISHERIES FOR LARGE PELAGIC FISH IN THE CENTRAL AND WESTERN PACIFIC OCEAN

The U.S. fisheries for pelagic fishes in the western and central Pacific Ocean are vital components of local and regional economies. Most pelagic fish stocks targeted by these fisheries appear to be healthy. Recent assessments indicate that the stocks of yellowfin (*Thunnus albacares*), skipjack (*Katsuwonus pelamis*), and albacore (*T. alalunga*) tunas targeted by U.S. fisheries in the central and western Pacific are not overfished, although the aggregate catch from some of these stocks may be approaching maximum sustainable yield. A recent meeting of the Standing Committee on Tuna and Billfish (SCTB) concluded that some tuna stocks in the equatorial regions of the Pacific are likely to be fully exploited, while the temperate regions remain underexploited. In the equatorial regions the Indonesian fishery has the greatest impact, particularly in its home areas, and the purse seine fishery also has a high impact on the status of tuna stocks. For bigeye (*T. obesus*) tuna, the SCTB recommended that there be no further increases in fishing mortality until assessment results are further confirmed. While the 2002 bigeye assessment indicated that the stock was not overfished nor was overfishing occurring, the 2003 assessment indicated that overfishing has indeed occurred. The SCTB's conclusions do not reflect a major shift in the nature of these fisheries; rather, they are the result of the growing use of improved population models that are more conservative than in years past.

PIFSC currently provides extensive fisheries monitoring support for Hawaii, American Samoa, Guam, and the CNMI. The prospect of increasing collaboration and cooperation among scientists of these U.S. areas and the many nations involved in tuna-related fisheries in the Pacific Ocean coupled with the regular sharing of data, stock assessments, and gear technology bodes well for PIFSC's ability to aide in the implementation of successful multinational fishery management policies for the highly migratory fish stocks within the region.

Hawaii-based Longline Fishery

The Hawaii-based longline fishery is the most productive and wide-ranging commercial fishery in Hawaii. Areas fished range from lat. 5^{o} to 35^{o}N and long. 145^{o} to 175^{o}W. The fishery is monitored and regulated through a mandatory federal daily longline logbook program, an observer program, an auction sampling program, and a State of Hawaii landings reporting system.

One hundred and ten vessels made 1,215 trips in 2003. All of these trips targeted tunas. These vessels set a record 29.8 million hooks, with over 50% of the effort being expended outside the U.S. Exclusive Economic Zone (EEZ) and 47% of the effort spent within the U.S. EEZ surrounding the Hawaiian Islands.

Landings by this fishery totaled 7,916 metric tons (t) worth an ex-vessel value of $38.6 million. The major components of the tuna landings were bigeye tuna (3,524 t, $24.9 million), yellowfin tuna (826 t, $5.2 million) and albacore (524 t, $1.4 million). Incidental catches of marlin (Istiophoridae), mahimahi (*Coryphaena hippurus*), opah (*Lampris guttatus*), wahoo (*Acanthocybium solandri*), pomfrets (Bramidae), and escolar (*Lepidocybium flavobrunneum)* also totaled 2,541 t worth $6.3 million.

Regulations imposed on the Hawaii-based longline fishery on June 12, 2001, to reduce the incidental capture of sea turtles substantially affected the fishery throughout 2003. The NMFS-issued regulations prohibiting shallow-set longline gear and the use of light sticks and implemented a 10-swordfish (*Xiphias gladius*) per-trip catch limit, which eliminated the swordfish-target sector of the Hawaii-based longline fishery. Swordfish landings and revenue, once the largest component of the Hawaii-based longline fishery, dropped dramatically in 2001 and remained low at 136 t worth $660,000 in 2003. In response to restrictions on shallow-set longline operations, most of the Hawaii-based swordfish vessels went to California to avoid restrictions affecting the Hawaii-based vessels. Other swordfish vessels that remained in Hawaii converted to deep-set tuna longline fishing.

In 2000, the State of Hawaii and the Federal Government prohibited the finning and landing of sharks without the associated carcass. Sharks, once a major component of landings, declined to 156 t worth $100,000 in 2003.

Sociological Baseline of Hawaii's Longline Fishery

The longline industry has been heavily regulated with little understanding of the sociocultural impacts of those regulations and management. Project researchers intend to address this concern by meeting two main project goals:

(1) Compiling a comprehensive social profile of the longline fishing industry of Hawaii.

(2) Providing social profile information to decision-makers, so that they can better understand and manage the effects of regulatory impacts and implementation strategies.

Project researchers are conducting personal interviews and focus groups with longline captains, owners, crews, and family members, as well as key individuals in associated ancillary businesses (including fishing supply and support industries). Because the study is ethnographic research, not a survey, there is no questionnaire. The interview schedule is a highly flexible document that covers a broad range of topics; in practice, no interviewee is asked the same set of questions. Instead, the focus is getting people to address social and cultural aspects of longline fishing and the meaning of those aspects to their lives.

As of March 2004 project researchers have interviewed 211 individuals involved with Hawaii's longline industry, reflecting slightly more than 60% of Hawaii-based longline vessels. These 211 participants included 70 vessel owners and captains, slightly more than 70% of Hawaii's longline owners and captains, along with 141 crew members, over 40% of Hawaii's longline crew.

Vessel owners and operators are primarily Vietnamese, Korean, and Caucasian U.S. citizens (roughly one-third of each). Researchers have completed interviews with representatives from all Vietnamese-operated vessels, approximately 60% of Korean-operated vessels, and approximately 50% of Caucasian-operated vessels. Vessels are concentrated in three distinct locations within the Port of Honolulu; researchers also plan to analyze differences across these three locations. The majority of crew members, about 80 percent, are Filipino. Finding local crew is reportedly not easy, and most vessel owners supplement Filipino crew with Micronesians or other local laborers, who are paid a percentage of the vessel's earnings after each trip rather than a set salary. Vessel owners continue to seek new opportunities for expanding the pool of available reliable crew.

We have developed a set of qualitative/quantitative data bases. Data entry is ongoing and expected to be completed by October 2004. An additional 50 or 60 interviews will be completed; these will include key individuals in the distribution chain for longline-caught pelagic fish, including representatives of the United Fishing Agency's auction, wholesalers, and retailers.

American Samoa Longline Fishery

The American Samoa longline fishery targets albacore for sale to the canneries in the port of Pago Pago. The fishery operates mostly within the EEZ of American Samoa, although some larger vessels have agreements to fish in the EEZ of neighboring islands. Data used to monitor this fishery include mandatory federal longline logbooks and an offshore creel survey.

The American Samoa domestic longline fishery has recently undergone extraordinary growth, particularly in the fleet composition of large (>50 ft long) vessels that have fueled a fifteenfold increase in fishing effort from 1999 to 2003. Prior to the sudden expansion, most longline fishing around American Samoa was accomplished through a fleet of smaller (about 30 ft long) open-decked catamarans known as *alia*. To illustrate this expansion, only 23 vessels made up the fishery in 1999, making 2,102 sets (ca. 912,742 hooks) yielding 32.38 fish/1000 hooks, but in 2003, 50 vessels participated in this fishery and set 13.9 million hooks to land a total catch of 5,022 t. The landings consisted primarily of albacore (3,899 t), yellowfin tuna (496 t), bigeye tuna (242 t), and wahoo (193 t).

Other Pelagic Fisheries

Hawaii

There are four non-longline pelagic fisheries in Hawaii.

(1) The aku boat fishery, also known as the pole-and-line skipjack tuna fishery, caught 461 t in 2003. The catch consisted primarily of skipjack tuna. Only two vessels participated full time in this fishery in 2003, and most of this catch was sold to local fish markets.

(2) The troll fishery, which targets yellowfin tuna and whose 2003 catch data has been combined with the handline fishery data below.

(3) The handline fishery (i.e., deep-sea handline, ikashibi, and palu-ahi) catch statistics combined with the troll catch statistics shows that for 2003 the catch consisted primarily of yellowfin tuna (34%), mahimahi (16%), bigeye tuna (12%), wahoo (11%), and skipjack tuna (10%). Yellowfin tuna dominated these Hawaii fisheries. The total catch of all species combined in 2003 was 1,902 t. Since 2000, there has been an increase in the number of handline/troll fishers who reportedly have begun to deploy and maintain their own private fish aggregating devices (PFADs) for personal use. This PFAD fishery has not yet been monitored nor described as a separate fishery.

(4) The distant water albacore trolling fishery is not based in Hawaii but fishes on the high seas and occasionally lands its catch in Honolulu. Composite catch statistics for this fishery are compiled by the SWFSC.

Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands (CNMI)

Small-scale and artisanal troll and handline fisheries in these U.S. territories exist in the form of relatively small vessels targeting tunas. The catch for these fisheries is predominately skipjack and yellowfin tunas. The vast majority of the catch is marketed and consumed locally, but there have been some exports of fish through Guam and Hawaii. Composite catch statistics for 2003 showed that an estimated 285 t of pelagic fish were caught in these territories.

Guam is host to distant-water purse seiners and foreign longliners that fish primarily outside Guam's EEZ and transship through Guam. This fishery is not monitored directly by PIFSC. There is also a small fleet of primarily recreational trolling boats that are either towed to boat launch sites or berthed in marinas and

fish only local waters, either within Guam's EEZ or occasionally in the adjacent EEZ of the CNMI.

In American Samoa the increase in commercial longline effort has coincided with a decline in the troll fishery. In 1996, when the longline fishery was just getting started, 35 troll boats landed 56,562 pounds of skipjack tuna and 36,551 pounds of yellowfin tuna. By 2001, with the longline fishery now dominating catches, 18 troll boats landed 15,126 pounds of skipjack and 5,513 pounds of yellowfin tuna.

The major domestic commercial pelagic fishery of the CNMI is a small-boat, one-day troll fishery. In the past few years, the number of boats in the CNMI has rapidly increased, with about 70% of them being used in the commercial fisheries.

FISHERY MONITORING AND DATABASE MANAGEMENT

Pelagic Fishery Data Management

Data management staff at PIFSC continued to improve data management systems for the Hawaii-based longline fishery and other U.S. pelagic fisheries in the western and central Pacific. Major advances were made in the management of observer data for this fishery. Staff of PIFSC, JIMAR, and PIRO's observer program developed, tested, and implemented a comprehensive integrated system for data entry, editing, validation, and access using Oracle database technology. The NOAA Fisheries Pacific Islands Region Longline Observer Data System enables efficient management of observer data and ensures that they are readily available for critical analyses including assessments of incidental take levels for sea turtles and other protected species. The system Web site (http://www.pifsc.noaa.gov/lods/html/lods.html) provides complete system descriptions and documentation including information about system updates, reference codes, observer manuals, data forms, and tools for data quality management.

PIFSC staff continued to collaborate with staff of PIRO, SWFSC, and Southwest Region in executing the HMS Data Coordination Plan. In particular, significant progress was made in developing metadata for a wide range of U.S. pelagic fisheries in the central and western Pacific in support of the HMS Data Portal being developed under the plan.

PIFSC and affiliated JIMAR staff also participated actively in the NMFS-wide Fishery Information System (FIS) program, including several of the FIS Professional Specialty Groups (PSGs). The FIS fosters collaboration between fishery data management staff in all the NMFS Regions, Science Centers, and regional fishery information networks in the development and sharing of data management tools and technologies. The PSGs address a range of topics including

data management system design and integration, metadata, permit and vessel registries, reconciliation of parallel reporting systems, and electronic reporting. More information is available at the FIS Web site (http://www.st.nmfs.gov/fis/).

Western Pacific Fishery Information Network (WPacFIN)

The second WPacFIN Document Imaging and Archival System (DIAS) training workshop was held at PIFSC in Honolulu, December 1-5, 2003. One to three representatives from each island agency attended. The newly hired computer specialist from the Western Pacific Regional Fisheries Management Council (WPRFMC) also attended. DIAS was developed as a tool for agencies to scan images of important scientific and administrative documents for archival and future retrieval. DIAS will allow each fisheries office to permanently store images of their documents in digital form and in a database to reduce document storage requirements and facilitate their possible disposal as well. In addition, DIAS will prevent paper document loss from deterioration, termites, storms, and accidental disposal. This workshop focused on creating image forms for fisheries and scientific data collections. DIAS is already in use at the Hawaii Division of Aquatic Resources (HDAR) and the Guam Bureau of Statistics and Plans.

A third WPacFIN-DIAS training workshop, DIAS III, was held at PIFSC for administrative staff from the Pacific Islands Regional Office (PIRO), PIFSC, and WPRFMC January 21 and January 22, 2004. This accelerated workshop focused on administrative records such as purchase orders, personnel records, travel orders, and time and attendance forms. DIAS is based on a generic database design and can be used for virtually any type of document. The WPacFIN Web site (http://wpacfin.nmfs.hawaii.edu) continued to undergo significant improvements. New NOAA Web site standards are currently being applied, and a redesign has been implemented for most of the island Web pages. Enhancements also improve automated updating of graphics and tables when new data are received from island agencies. When the central WPacFIN webmaster receives data updates from island agencies, the new data, graphs, and tables are typically available on the WPacFIN Web site within 24 to 48 hours.

Central WPacFIN programming support focused on two major projects: 1) creating automated and updated Fisheries Management Plan (FMP) Plan Team annual reporting modules for the island agencies and 2) modifying processing systems and procedures for HDAR to accommodate their new online Oracle-based Commercial Marine Licensing System. Various central WPacFIN staff made several site visits to the Oahu HDAR office and single week-long visits to each of the American Samoa, Guam, and CNMI fisheries offices. Significant progress was made in all areas, and the projects will continue in the months to come.

Blue Marlin Longline Logbook Catch Rate Analysis

Blue marlin (*Makaira nigricans*) catch rates (catch-per-set) in the Hawaii-based longline fishery from March 1994 through June 2002 were analyzed by the integrated use of three independent types of data: observer reports, commercial logbooks, and auction sales records. The study was conducted because official statistics compiled from the logbooks in this fishery are known to be biased by billfish (Istiophoridae) misidentifications and because other uses of these data (e.g., population estimates generated by stock assessment models) could also be affected.

The objective of the study was to present corrected catch rates for blue marlin in the Hawaii-based longline fishery. The initial step entailed fitting a generalized additive model (GAM) to environmental and operational data gathered by fishery observers during 8,397 longline sets deployed by commercial vessels. The GAM included nine significant predictors and explained 41.1% of the deviance of observed blue marlin catch rates. The GAM coefficients were then applied to the corresponding predictors in the logbooks to estimate catches for use in evaluating the accuracy of data from unobserved sets (N = 87,277 longline sets on 8,437 trips; 95.4% of unobserved effort). This was done by regressing the logbook catch data on the predictions and using the residuals to identify trips with systematic misidentifications. Logbooks from questionable trips were checked against sales records from the public fish auction in Honolulu. These checks revealed that the large majority of the misidentifications consisted of striped marlin, (*Tetrapturus audax*) reported as blue marlin, with lesser numbers of shortbill spearfish (*T. angustirostris*) logged as blue marlin, and blue marlin logged as either striped marlin or black marlin (*M. indica*). Correction of 5.2% of the unobserved trips indicated that the nominal total for kept blue marlin throughout the study period was inflated by at least 24.6%. A separate estimate obtained by use of the GAM and observer data indicated that the nominal catch of blue marlin was inflated by 29.4%. There was no evidence of widespread underreporting of marlins.

It is concluded that this study significantly improved the accuracy of logbook data for blue marlin by the use of statistical procedures that detected systematic misidentifications rather than random variation and that the results should contribute to improved management and understanding of the ecology and distribution of blue marlin. It is inferred that self-reporting could yield accurate marlin catch data if species identifications were improved because there was no apparent underreporting problem. Finally, it is recommended that logbook data accuracy be paid serious attention in the contexts of both stock assessments and large-scale, long-term retrospective studies of the effects of fishing.

Recreational MetaData Project

The Recreational MetaData Project was initiated to document and compile sources of pelagic recreational and sports fishing information in Hawaii over the past 50 years. Until now, there has been no centralized, systematic documentation of Hawaii's recreational fishery, though information does exist in the form of previous studies, surveys, tournament and club records, newspaper articles, and fishermen logbooks. These sources have been organized into database formats, so that they are easily accessible to researchers and fishery managers.

The sources of information fall into two categories: literature and catch records. The literature consists of nearly 80 documents including published and unpublished papers, technical reports, books, surveys and project summaries. PDF copies of the literature and associated tables are available on the PIFSC Web site. The catch records have been provided by various clubs, tournaments, and fishermen, and contain some or all of the following: date, time, boat, species, number, weight, tackle used, area, condition of fish, and tag number. Annual catch records from 33 tournaments, provided by seven clubs and three tournament organizers, and daily catch records from two harbors specializing in charter boat fishing have been incorporated into the database. The tournaments, which range in size from 6 to 260 boats, are held at approximately the same time each year. Though one tournament provided 42 consecutive years of data, the mean is 6 non-consecutive years. This database is available to scientists and other interested parties upon request.

MARINE TURTLE RESEARCH

Survivorship, Migrations, and Diving Patterns of Sea Turtles Released from Commercial Longline Fishing Gear, Determined With Pop-up Satellite Archival Transmitters

The objectives of this research are twofold: 1) to provide estimates of delayed mortality and morbidity in sea turtles following interactions with longline fishing gear and 2) to compare the movements and behaviors of sea turtles caught and released from longline gear to free-swimming controls. To do this, pop-up satellite archival tags (PSATs) were deployed on longline-caught and free-swimming hard-shelled turtles in the eastern tropical Pacific, the North Pacific, and the South Atlantic oceans.

PSATs Deployed in Costa Rica

We have worked in collaboration with local commercial fishermen and a nongovernmental organization (NGO) known as the Programa Restauracion de Tortugas Marinas (PRETOMA) on the Pacific Coast of Costa Rica since November 2001 to attach PSATs on marine turtles incidentally captured in longline fishing gear. Despite the use of circle hooks, the incidental capture of

juvenile olive ridley turtles in the EEZ of Costa Rica is extremely high (ca. 8 turtles/1,000 hooks). The majority of captured turtles are landed and released alive; however, about 10% are released with hooks remaining in their gastrointestinal tracts or flippers. We have successfully tagged 10 sea turtles (9 olive ridleys, 1 green) incidentally captured in longline fishing gear (longline caught), and 5 sea turtles as free-swimming "controls" to which the behaviors of longline-caught turtles could be compared.

Horizontal movements of turtles were similar for longline-caught and control turtles both in terms of directionality as well as in minimum distance traveled (4.6 vs. 7.7 nmi, respectively; $p>0.15$). PSATs were retained an average of 56 and 60 days for control and longline-caught turtles, respectively (range: 35 to 113 days). Dive behaviors varied considerably among individual turtles, rendering the data more useful for descriptive rather than statistical analyses. For example, lumping data together resulted in an earlier erroneous conclusion that longline-caught turtles remained deeper than free-swimming controls. This was based on a significantly deeper dive profile of a single turtle. Closer investigations into individual dive behaviors indicated a high degree of individual variation.

Our results suggest that turtles' median daily depths appear more highly correlated to oceanographic conditions than to condition (i.e., control vs. longline caught). Two longline-caught and two control turtles were tracked over 2 consecutive years. The longline-caught turtles had both the deepest and shallowest median depths. We believe this is due to the fact that the turtle with the deepest distribution was tracked during 2002 and 2003 as compared to the other turtles that were tagged the previous year. The sea surface temperature (SST) during this time period was approximately 3^{o} C warmer in this general area. Chlorophyll concentrations were also different from one year to the next, which could account for different depth distributions noted among tagged turtles. We have found evidence to suggest that turtles apparently compensate their dive behavior to stay within a similar range of ambient temperatures.

Our results indicate that olive ridley turtles usually survive their encounter with longline fishing gear at least for the first 2 months after release. Turtles in this study that were incidentally captured in longline gear (and for which we received some response from the satellite tag) all survived a minimum of 3.5 weeks, and most survived a minimum of 6 weeks post-release before the tag was shed.

In the one case for which we have data indicating a mortality, the turtle was tagged after it had been resting on the ocean surface and thus served as a control. Perhaps as a result of "natural causes," we speculate that after approximately 5 weeks at liberty, the turtle sank to the bottom and remained on a coastal shelf or on a seamount at approximately 900 m for 4 days before the PSAT released to the surface. The PSAT performed exactly as programmed, which we feel validates the utility of PSATs to identify delayed mortality.

PSATs Deployed in the North Pacific Ocean

Since September 2002, California-based longline fishery observers have placed 13 PSATs on loggerhead turtles in the North Pacific. Of these, 6 PSATs have already transmitted recorded data; 1 failed to report. The remaining tags are presumably still on turtles and should report within the coming months. PSAT retention on North Pacific loggerheads was significantly longer than on olive ridleys in Costa Rica. Average number of days at liberty for loggerheads was 88.3 (range: 30-192 days). However, we have been disappointed with the quantity of data received both regarding geolocation and dive behavior.

PSATs Deployed in the South Atlantic Ocean

In January 2004, while participating in an experimental fishery in Brazil to modify fishing gear to reduce sea turtle-longline interactions, we tagged a loggerhead turtle that had been previously caught in commercial longline gear and maintained in captivity in Southern Brazil for 2 months. A second loggerhead was tagged during a subsequent cruise in March 2004. That animal is still at large. We expect to receive data from the PSATs 8 months after their release. We anticipate future opportunities to tag longline-caught turtles in the Brazil longline fishery in the coming year. This work is being conducted in collaboration with a Brazilian NGO (Projeto TAMAR/IBAMA).

Fishing Experiments Aimed to Reduce Sea Turtle-Longline Interactions

These fishery experiments will identify bait or gear modifications that could significantly reduce the incidental capture of marine turtles in longline fishing gear. To date, we are leading research currently ongoing in Costa Rica, Ecuador, and Brazil.

Costa Rica

In collaboration with PRETOMA, we tested the effectiveness of blue-dyed bait in reducing sea turtle bycatch in their artisanal fishery. Two longline trips were held simultaneously from December 1 to December 15, 2003, in the Gulf of Papagayo to test the efficacy of blue-dyed bait as a potential sea turtle deterrent. Sets were randomly alternated between blue-dyed and untreated bait. The two boats fished in the same general area for the duration of the trips to reduce confounding variables that could influence turtle bycatch rates. The boats made 22 sets, 9 with blue dye and 13 with untreated bait. Catch rates were relatively high for both bait types, with a catch-per-unit-of-effort (CPUE) of 8.4 vs. 8.1 turtles caught for every 1,000 hooks deployed for untreated and blue bait sets, respectively ($t=0.096$, $p=0.92$). During both trips, 108 olive ridley turtles and 7 green sea turtles were caught. CPUEs recorded were similar to previously

recorded CPUEs during observer programs onboard the Papagayo Seafood fleet in this same general area. We believe we have sufficient data to determine that simply dyeing bait blue is not an effective means to reduce turtle bycatch in this longline fishery.

Brazil

In collaboration with Projeto TAMAR/IBAMA, we conducted experiments onboard a Brazilian government fisheries research vessel (R/V *Soluncy*) to test the efficacy of modified bait in reducing sea turtle interactions with longline fisheries. Two trips were conducted using blue-dyed bait as the experimental treatment. Although sample size was relatively small, blue dye was not deemed effective at reducing sea turtle bycatch. Future experiments are planned to test the efficacy of a large (18/0) circle hook onboard commercial fishing boats.

Ecuador

In collaboration with the Ecuadorian government, fishermen, scientists, and NGOs, we are involved in testing the efficacy of using modified fishing gear to reduce sea turtle-longline interactions by conducting an experiment with the Ecuadorian longline fishery. Work is currently underway comparing CPUE of targeted species (e.g., mahimahi, tuna spp.) and marine turtles caught on traditional J hooks vs. large (e.g., 15/0 or 18/0) circle hooks.

The exact number of experiments run will be determined by the logistical limitations of the program. However, given that the incidental capture rate of sea turtles is unknown, the experiment needs to be run until statistical determinations can be made about potential sea turtle reductions. In addition to the above-mentioned research, collaborators from Hawaii will contribute satellite tags to be placed on incidentally caught as well as free-swimming sea turtles.

Chemoreception in Sea Turtles: Implications for Longline Fisheries Interactions

The degree to which sea turtles are attracted to (and incidentally entangled in) fishing gear and bait is not well understood. A collaborative investigation is currently underway to characterize vision, hearing, and chemoreception (olfaction and gustation) in sea turtles to comprehensively assess potential sensory attractants and repellants. The ultimate goal is to develop modified gear or bait that will be effective for catching fish but either undetectable or repellant to sea turtles. Use of such bait could potentially decrease sea turtle injury and mortality from fisheries interactions.

Our research focuses on assessing the chemosensory abilities of loggerhead turtles. We conducted experiments at the NOAA-NMFS Sea Turtle

Facility in Galveston, Texas during November 2003 to investigate the behavioral responses of loggerhead turtles to various chemical stimuli. Our primary objectives were to develop an assay to effectively quantify the behavioral responses of sea turtles to chemical stimuli, determine if sea turtles use chemoreception to identify and locate food in the aquatic environment, and test chemical compounds that could potentially be used as turtle repellents.

We used a "choice tank" to assess behavioral responses of loggerhead turtles to chemical cues. All trials were conducted in complete darkness to eliminate visual cues. Experiments began with a turtle isolated in a central start chamber. After an acclimation period of 15 minutes, a bilateral flow of seawater was initiated. Seawater was pumped into opposite ends of the tank and exited through a large drain grate in the floor of the chamber. During chemical trials, a chemical was presented on one side of the tank but not the other. The turtle was then free to explore the tank, and the behavior of the turtle was monitored and recorded by an IR-sensitive video surveillance system. A control trial in which no chemical was introduced was also run for each turtle. Order of chemical and control trials was randomized. Data were analyzed using MANOVA to compare behavior during chemical trials with behavior of the same individual during control trials. Variables analyzed included proportion of trial time spent in the area of tank where the chemical was present and display of specific behaviors.

We used a food homogenate to test whether or not turtles showed signs of detection and attraction to food odors. Results show that turtles spent a significantly greater proportion of time in areas of tank where food odor was present, specifically in the central start chamber during food trials compared with control trials ($P = 0.014$, $N = 12$). Fluorescein dye flow characterization for our tank revealed that flow became more turbulent and flow speed increased above the drain grate in the central chamber. Many fishes and invertebrates display rheotaxis (i.e., orient into flow) in the presence of food odor, and we suspect that the turtles were exploring the currents and eddies in this section of the tank in an attempt to track the source of the food odor. Turtles also displayed an increased frequency of detection and searching behavior during food trials compared with control trials. For example, during food trials turtles would frequently stop swimming abruptly, put their nose to the tank floor, and then use their rear flippers to either back up or spin in circles in this nose-to-the-floor position. This behavior was displayed with significantly greater frequency during food trials compared with control trials ($P = 0.010$, $N = 12$).

In the absence of visual cues loggerhead turtles will respond behaviorally to the presence of food odors. Although sea turtles are thought to be primarily visual predators, our results show that chemosensory cues may also play an important role in aquatic food detection, and location and may be a factor in attracting sea turtles to longline fishing bait. Potential means of masking bait odor are currently being investigated, and analysis of chemical compounds that may act as turtle repellants is ongoing.

FISHERIES BIOLOGY AND STOCK ASSESSMENT RESEARCH

Billfish Research

Studies of Billfish Eggs

Colleagues at the SWFSC and the Scripps Institution of Oceanography have developed a species-specific multiplex PCR assay capable of identifying the early life stages of swordfish including the five Indo-Pacific species of Istiophoridae that co-occur in Hawaiian waters. This single-step PCR assay allows billfish species identification within 3 hours of sample acquisition. Although developed in the laboratory, this technique was tested at sea in May 2003 during a PIFSC Honolulu Laboratory research cruise onboard the NOAA ship *Oscar Elton Sette* off Kona, Hawaii. A 1.5-meter ring net with 500 micron mesh plankton netting was towed through the surface layer in areas of previous larval billfish catches. A total of 63 swordfish eggs and 8 shortbill spearfish (*Tetrapterus angustirostris*) eggs were identified out of 259 suspected billfish eggs that were removed from plankton catches and assayed using the multiplex PCR technique. Swordfish eggs were similar in appearance to previous descriptions of artificially spawned eggs in the Mediterranean. Shortbill spearfish eggs had distinctively different pigment patterns and were identified for the first time; a collaborative paper currently in review includes the first description of shortbill spearfish eggs. Billfish eggs were collected in surface waters 5 to 25 nmi off the Kona coast over a bottom depth of 1,000 to 2,500 m. This area overlaps the distribution of previous larval swordfish and shortbill spearfish captures off Kona and suggests that spawning activity could have occurred in the immediate vicinity. Future billfish egg collections and at-sea identifications using the multiplex PCR assay are planned off Kona in July and September 2004 to define the spatial and temporal dynamics of spawning in this region and to characterize the environmental features associated with billfish spawning habitat.

Stock Identification

A study to examine the possibility of using meristic variation as a natural marker of natal spawning sites was conducted on young-of-the-year (YOY) juvenile swordfish (47-99 cm eye-to-fork length, (EFL), $N = 214$) collected from equatorial to temperate waters within the central North Pacific. The assumption was made that YOY juveniles remain latitudinally adjacent to their natal sites. Juvenile specimens were obtained as bycatch from Hawaii-based tuna longline vessels. Meristic counts in this study were limited to total dorsal and anal fin elements. Meristic data were grouped geographically within latitudinal bands (0-7^{o} N, $N = 29$; 13-16^{o} N, $N = 38$; 20-22^{o} N, $N = 39$; and 28-34^{o} N, $N = 34$, and all specimens 0-37^{o} N, $N = 214$) to represent areas associated with the equator, North Equatorial Current, main Hawaiian Islands, the Subtropical Transition Zone, and the entire central North Pacific, respectively. The geographic extent of this

comparison also approximately coincides with the maximum latitudinal range of swordfish spawning (surface waters $\geq 24^{o}$ C) in the central North Pacific. The distribution and mean values for both dorsal and anal fin elements showed no significant differences among these latitudinal groupings, even when the two most distant sample groups were compared. No meristic counts for YOY juvenile specimens from other regions in the Pacific were available. For the western Atlantic, meristic counts for total dorsal and anal fin elements are reported for larvae and juvenile specimens (1-69-cm eye standard length) collected from the Gulf of Mexico, the Caribbean, and Florida. The distribution and means for both meristics are indistinguishable from those derived from the central North Pacific. Results suggest that these meristics offer little future promise as a natural marker of natal or nursery site origin.

Age and Growth

A swordfish age and growth study based on the enumeration of presumed daily growth increments within the sagittal otoliths of young swordfish (3.7 cm to 133.0 cm eye-to-fork length, EFL) is near completion. The estimated size of Hawaii fish at 365 days (age-1) is 96 cm EFL; this is considerably larger than the age-1 size estimate of ~80 cm EFL recently reported for swordfish studies off Taiwan. Due to the narrower width of outer otolith increments in older individuals and the greater difficulty of processing these samples for electron microscopy, our otolith ageing study was limited to fish no older than 1.75 yr.

Tagging Research on Tunas, Billfish, and Sharks

PSATs are being used to determine the movements and post-release survivability of swordfish, marlins, sharks, and tunas. To date we have deployed 144 pop-up satellite archival tags (PSATs) on 28 swordfish, 38 marlin (36 blue, 1 black, 1 striped), 23 tunas (14 bigeye, 3 yellowfin, and 6 albacore), 55 sharks (7 bigeye thresher (A*lopias superciliosus*), 32 blue (*Prionace glauca*), 8 oceanic white-tip (*Carcharhinus longimanus*), 4 shortfin mako (*Isurus oxyrinchus*) and 4 silky sharks (*C. falciformis*) in the central North Pacific Ocean. The objectives of the project are to determine horizontal and vertical movement patterns and rates of survival following release from longline and recreational trolling gear. Companion studies at Queens University are trying to quantify rates of morbidity and mortality in pelagic sharks and billfishes using a suite of biochemical assays to determine levels of stress from blood and (or) tissue samples. We hope to develop a cost-effective biochemical technique to sample large numbers of released pelagic fishes to investigate and thereby predict their chances of long-term survival.

PSATs were either directly harpooned with nylon or metal tag heads (swordfish, tunas, marlins, and bigeye thresher sharks) or placed through the dorsal fin (sharks) with a stainless steel cable harness. PSATs were programmed to release at 1, 2, 4, 8, and 12 months following deployment. Early detachment is

a continual problem. However, our new tether system with stainless steel ball-bearing swivels and arrowhead design augmented with spear gun flopper blades (to promote greater resistance) appears to be working well, and several colleagues have requested the design and materials. Tag head improvement is an ongoing project, and recently project personnel have collaborated with the SWFSC in this endeavor.

Of the 121 PSATs scheduled to report to date (waiting on 7 tags attached to blue marlin to reach their pop-off date or to report early), we have received data from 71 devices (60% overall reporting rate). Thirteen PSATs, or 11% of the devices reported on schedule and reached their pop-off date. In aggregate we have 527, 2138, 119, and 3,706 days of observations from swordfish, marlins, tunas and sharks, respectively (6,490 total days). There have, however, been sex- and species-related differences in PSAT reporting rates. For example, of 25 male sharks tagged, only 48% of PSATs have reported. Whereas of the 23 PSATs deployed on female sharks, 74% have reported. This difference appears to occur in blue, mako, oceanic white tip, and silky sharks and may also occur in bigeye thresher sharks, but they were all tagged in the water and gender was not determined. Deep-diving species, such as swordfish (32%) and bigeye thresher sharks (29%), similarly exhibited low PSAT reporting rates. We hypothesize that tag failure/damage may be caused by nuptial bites and deep oscillatory diving behavior, which may ultimately weaken and compromise PSAT housings over time. To further investigate PSAT reporting rates and possible explanatory factors of failures, project personnel have organized the construction of a metadata database that will incorporate PSAT information from several different researchers on many different species to explore for patterns and commonalities (e.g., comparing serial numbers of nonreporting tags).

Rates of shark survival (where tags did report) following release from longline gear appear to be over 90%. We have only one clearly confirmed mortality out of 29 tags reporting data from sharks (97% survival rate).

Vertical data from one blue marlin tag clearly indicate that the fish sank and died approximately 4 months after catch and release. The depth data indicate movements were relatively normal until 113 days after tagging when the fish apparently died and sank. There were no indications in the vertical data prior to sinking that suggested any abnormal behavior. We are confident that this case represents a mortality because the PSAT system worked as designed to detect a mortality (i.e., tag reached a “fail-safe” pressure release depth of around 1,136 m and jettisoned to the surface to start transmitting data). This blue marlin was caught on live bait, hooked in the mouth, and successfully tagged after a 25-minute fishing bout. As correlated by a steady rise in SST estimated by the PSAT, the fish moved due south and covered ca. 855 nautical miles in 113 days. Since this fish apparently died about 4 months after the initial ordeal (catch-tag-release), a logical extension is to suggest that it would be very difficult to attribute mortality to the tagging incident as other factors (e.g., predation, and disease)

could have contributed to the fish's death. Of the 28 swordfish tagged, only 9 have reported data (32%) with no indications of fish mortality from these tags.

PSATs have provided excellent data on vertical movement patterns. Swordfish have been shown to exhibit an oscillatory diel vertical movement pattern, where they swim shallow at night (< ~80 meters) but descend to ~80 – 1,000 meters during the day. Bigeye thresher shark, bigeye tuna (and occasionally blue and shortfin mako sharks) exhibit similar oscillatory diel vertical movement patterns whereas marlin, silky shark,and oceanic white-tip shark spend the majority of time (day and night) in the uniform surface layer (< 80 meters depth). Deep-diving behaviors, particularly at crepuscular times, have often prevented the light sensors on the PSATs from acquiring sufficient ambient light data to calculate geolocations. During the 1,015 days (in aggregate) PSATs remained attached to swordfish and bigeye thresher sharks, we received only 44 estimates of daily geolocations. It appears that extant light-based geolocation methodologies can be severely confounded by exceeding the limits of the light sensor. Therefore, only some pelagic species will be ideal candidates for this technology.

Light-based geolocation data, along with empirical data from mooring line and double-tagging studies suggest that it is highly unlikely that PSATs will be useful for deriving fine-scale movement patterns in relation to mesoscale oceanographic variability. However, the incorporation of SST into a Kalman filter (i.e., satellite-derived SST fields are matched to SST estimates recorded from PSATs and compared with an algorithm that determines most probable track) appears to significantly improve geolocation estimates. Colleagues from JIMAR's Pelagic Fisheries Research Program (PFRP) are continually investigating ways to improve upon the most probable tracks estimated by the Kalman filter. Colleagues at the NOAA Pacific Fisheries Environmental Laboratory have designed and constructed a "Live Access Server" whereby tracks estimated by the Kalman filter can be overlaid with a suite of oceanographic parameters to look for patterns and correlation. Yet for species that spend considerable time at depth, one needs to be careful with correlation from remotely sensed surface data because these may not be the causal factor(s) determining "movement" and potentially could be misleading. For example, density and distribution of the Sound Scattering Layer may be the driving factor in movement patterns for some pelagic fishes. Further, some movement patterns may reflect evolutionary processes (e.g., "homing" migrations). Therefore, with our team of PSAT collaborators with expertise in oceanographic correlations, data analysis and PSAT function, physiological modeling, biochemical correlates of delayed mortality, Kalman Filter development, habitat-based modeling and stock assessment, and visual capability of pelagic fishes, we intend to explore many different avenues of investigation that may help explain vertical and horizontal movement patterns of pelagic fishes that may uncover vertical and thermal niche partitioning in the pelagic ecosystem.

Life History and Ecology of Opah and Monchong

Studies on the life history and ecology of opah and monchong (*Taractichthys steindachneri*) in the North Pacific have continued with support from the PFRP. Particularly valued by the restaurant trade in Hawaii and the continental U.S.A. for their high- quality white flesh, these exotic deepwater fishes are generally harvested in small, but significant, quantities. Recent catch rate trends from 1994 to 2003 of deep tuna sets indicate an increased catch of both species associated with an increased catch of the target species, bigeye tuna. Since these fishes have historically been poorly studied, available information pertaining to their biology and ecology are virtually nonexistent.

The research activities for both the opah and monchong resources fall under two major projects: (1) a comprehensive shore-based biological sampling program designed to monitor landings and catch composition and to obtain the metrics (length, weight, and sex) and samples (ovaries, otoliths, and stomachs) required for a comprehensive biological and ecological assessment, and (2) an analysis of spatial distribution patterns, preferred habitat, faunal associations, and trophic relationships. The latter project involves the analysis and merging of industry, research, and environmental data sets, as well as analysis of capture depth information collected from vessels of opportunity.

Among the study highlights, it was discovered that opah exhibit sexual dimorphism, thereby enabling the determination of sex without having to cut into the peritoneal cavity to access the gonads; this determination has saved considerable time and energy, allowing substantially more data collection both shoreside and in the field. Complementary studies with live opah instrumented with PSATs have benefited from this finding by enabling the examination of the movement behavior of these fish by sex. For example, one tag reported after 4 months of liberty from a female opah in which it traveled over 1,000 kilometers, northwest from the main Hawaiian Islands to above lat. 31° N. With regard to age and growth, fin rays were deemed to provide the best opportunity for ageing these animals. Assuming that fin ray marks are formed annually, opah taken in the fishery are estimated to be between 1+ and 6+ years old. Both sagittal otoliths and fin rays are used for estimating age and growth parameters for monchong. If microincrements (on postrostrum or rostrum of sagittal otolith) are assumed to be daily indicators, monchong appear to grow rapidly in the first year; ages of 42-49-cm fork length fish ranged from ~1 year to 13.5 months; the oldest monchong sampled would be about 9 yr.

The project has been particularly successful in obtaining capture depth information for both opah and monchong as well as biological samples on cooperative commercial longline fishing trips. On four trips, 149 monchong and 70 opah were caught on 45 longline sets. Of these, 18 monchong and 4 opah were caught on the sections of longline instrumented with a series of time-depth-

temperature recorders (TDRs) and hook timers. Additionally, 16 opah (8 males and 8 females) were instrumented with PSATs upon capture and released.

ECOSYSTEM AND OCEANOGRAPHY RESEARCH

Oceanographically, there has been little study regarding the pelagic habitat in the American Samoa region or the spatial and temporal variability of the oceanographic climate. Current research undertakes the task of characterizing the pelagic habitat and fishing grounds occupied by the American Samoa longline fishery through the use of satellite oceanographic remote sensing and in situ shipboard surveys. Ultimately, the oceanographic assessment will be coupled with fishery information to develop a functional understanding of the spatial and temporal occupation and movement tendencies of large South Pacific albacore and the role of the environment on longline gear performance and catch. These data include albacore depth distribution and gear performance obtained from commercial longlines instrumented with TDRs and the set level catch information from the American Samoa fishery logbook program. In March 2004, nine PAT tags were deployed in the South Pacific around American Samoa with times at liberty ranging from 3 to 17 days with two tags still transmitting. Six of these tags were deployed on albacore and three on bigeye tuna. This deployment was made in close proximity and during the same time as a longline oceanography cruise aboard the NOAA ship *Oscar Elton Sette*. CTD profile casts were performed to quantify the subsurface physical components, and acoustic backscatter data were collected to analyze the subsurface biological component in this deployment area. The data from PSATs combined with the CTD and acoustic data will be used to describe the bigeye and albacore habitat in the American Samoa area. In addition, TDRs were attached to the longlines used to catch the animals used in the tagging studies in both areas to quantify the depths of the longline gears as well as additional information on the subsurface regions necessary in describing the bigeye and albacore tuna habitats.

INTERNATIONAL COLLABORATION

Several PIFSC scientists were involved in international fisheries research activities that included serving as U.S. delegates to the Preparatory Conference of the WCPFC and preparing for the 4th Meeting of the ISC for Tuna and Tuna-like Species in the North Pacific Ocean, which was hosted by PIFSC from January 26 to February 4, 2004. In addition to logistical planning, considerable effort was devoted to assembling catch and effort data to facilitate stock assessments conducted prior to the meetings. PIFSC personnel also attended the 12th annual North Pacific Marine Science Organization (PICES) in Seoul, Korea. One PIFSC scientist chaired the advisory panel meeting for planning of a PICES-sanctioned cruise for intercalibrating sampling gears of micronekton. Another PIFSC researcher participated in the 30th International Remote Sensing of the Environment workshop and assisted in a “Building the Foundation” leadership seminar series for Pacific Islanders. PIFSC is also continuing to participate in

enhancement of MULTIFAN-CL, which is now freely available to scientists of government and other public agencies. Other entities involved in this project are the Pacific Community's Oceanic Fisheries Programme, the United Nations Food and Agriculture Organization, Taiwan, and Australia.

Interim Scientific Committee (ISC)

The PIFSC hosted (in Honolulu) the fourth meeting of the ISC for Tuna and Tuna-like Species in the North Pacific. The ISC was attended by 33 participants from six countries and an international fishery management body. The plenary session was preceded by working group meetings on Pacific bluefin (*T. thynnus*) tuna, swordfish, marlins, and statistics; PIFSC staff served as chairs of the marlin and swordfish working groups. During the swordfish working group meeting PIFSC scientists presented a review of the U.S. swordfish fisheries in the North Pacific (in collaboration with SWFSC scientists), a summary of biological research conducted in support of stock assessment, a MULTIFAN-CL swordfish stock assessment (in collaboration with scientists from Japan), and an evaluation of the reliability of MULTIFAN-CL swordfish assessments. An analysis of blue marlin catch rates using a GAM was presented to the marlin working group. In collaboration with SWFSC staff, a catalog of U.S. catch-effort and size composition data was presented to the statistics working group. The plenary adopted the following assessment summaries. For Pacific bluefin tuna, recent F is greater than F_{max}, which has economic implication (too much fishing effort for the yield returned) and is also generally taken as an indicator of biological concern. In particular, the high F on young fish (ages-0-2) and older fish (ages-6+) is cause for concern with respect to maintaining sustainable fisheries in the future. For North Pacific albacore (from a presentation on behalf on the North Pacific Albacore Workshop (NPAWS)), because of good recruitment, biomass has generally trended upward over the last decade. However, recent fishing mortality rates (F) are at high level (roughly, $F_{20\%)}$ and both total biomass and spawning stock biomass are projected to decline even if good recruitment persists. Current F is in excess of many common biological reference points that are used as candidates for F_{msy} proxies for fish populations. For swordfish in recent years, the biomass level has been stable and well above 50% of the unexploited levels of stock biomass, implying that swordfish are not overexploited at current levels of fishing effort. The current interpretation is that the stock is neither overfished ($B_{current}/B_{msy}$) = 1.7) nor is overfishing occurring ($F_{current}/F_{msy}$ = 0.3). Noting that the WCPFC would come into force in June 2004 and the Inter-American Tropical Tuna Commission (IATTC) already exists in the eastern Pacific, a consensus was reached to continue the ISC as an independent scientific body focusing on pan-Pacific stocks of tuna and tuna-like species in the North Pacific with a role in providing scientific advice to the WCPFC and the IATTC. Two other significant events occurred during the plenary. The NPAWS was formally invited to join the ISC, and operational rules and procedures based on those used by the NPAWS were adopted.

ISC Swordfish Working Group (SWO-WG)

The SWO-WG met January 29 and 31, 2004. Country representatives attending included Canada, Chinese-Taipei, Japan, Mexico, and the United States. The IATTC was also represented at the meeting. Topics presented and discussed included a review of the fisheries by country; fishery statistics; research progress in age and growth, movement, stock structure, and feeding habits; current status of stocks; and future research projects. Current analysis of swordfish CPUE based on data from Japanese longline vessels shows a declining trend in the northwest sector of the North Pacific. It is unclear whether this observed regional trend is a result of fluctuations in abundance, environmental effects, or the preliminary nature of the analytical techniques employed. Participants recognized the need to further develop spatially explicit integrated models for stock assessment and the use of other models to clarify the observed CPUE trend. In support of stock assessment, future biological research will focus on population genetics and otolith elemental composition to clarify stock structure and natal origin, respectively. Regional differences in age and growth will continue to be studied to better evaluate the current pattern of higher growth rates observed in eastern Pacific swordfish compared to the western Pacific. Future collaborative biological research between PIFSC, Japan, and IATTC will involve the collection of YOY swordfish from across the North Pacific to expand the available muscle tissue samples for ongoing DNA-based stock structure studies. These YOY specimens will also provide otolith samples for a more definitive study to identify geographically distinct nursery grounds based on otolith trace element analysis. With this more comprehensive sampling of nursery grounds, it may soon be possible to identify the nursery ground origin of individual adult swordfish by analyzing the core and adjacent juvenile portion of the otolith using an elemental probe analysis technique such as laser ablation Inductively Coupled Plasma/Mass Spectrometry.

Standing Committee on Tuna and Billfish (SCTB)

PIFSC scientists participated in the 16th meeting of the Secretariat of the Pacific Community's Standing Committee on Tuna and Billfish in Australia, July 2003. The plenary session was proceeded by meetings of the following working groups: statistics, fishing technology, methods, yellowfin, bigeye, albacore, and billfish and bycatch. PIFSC scientists presented the following papers: "Observer coverage in the Hawaii-based longline fishery" to the statistics working group, "Comparison of deterministic and statistical habitat-based models to estimate effective longline effort and standardized CPUE for bigeye and yellowfin tuna" (in collaboration with IATTC) to the bigeye and yellowfin working groups, "Stock assessment of yellowfin tuna in the western and central Pacific Ocean" (in collaboration with a South Pacific Commission (SPC)/Ocean Fisheries Programme (OFP) scientist) to the yellowfin working group, "Stock assessment of bigeye tuna in the western and central Pacific Ocean" (in collaboration with SPC/OFP, IATTC, Japan, and Chinese Taipei scientists) to the bigeye working

group as well as a national fishery report to the plenary. For yellowfin tuna, the SCTB recommended there be no further increases in fishing mortality (particularly on juveniles) in the western and central Pacific. Also, if future evidence supports a shift to a lower productivity regime, a decrease in total catch would be anticipated to maintain the stock at sustainable levels. The SCTB concluded that the equatorial regions are likely to be fully exploited, while the temperate regions are likely to be underexploited. The Indonesian fishery has the greatest impact, particularly in its home areas, and the purse seine fishery also has high impact, particularly in the equatorial regions. For bigeye tuna, the SCTB recommended that there be no further increase in fishing mortality until the assessment results are further confirmed. While the assessment from the previous year indicated that the stock was not overfished nor was overfishing occurring, the 2003 assessment indicated that overfishing was occurring. While such a marked change in one year is unlikely, all the assessment models used were more pessimistic than last year's.

Western Central Pacific Fishery Convention (WCPFC)

PIFSC along with PIRO, the SWFSC, and headquarters staff have participated as members of the U.S. delegation, headed by the State Department, in meetings of the Preparatory Conference. The Prepatory Conference was established when the Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean was adopted on September 5, 2000. The purpose of the Preparatory Conference is to lay the groundwork for the formation of WCPFC when it comes into force. The role of PIFSC staff is to provide advice on scientific components of the WCPFC, particularly Working Group II (Science) and to a lesser extent Working Group III (Compliance). Working Group I deals with organization and budget. The fourth (Fiji, April 2003) and fifth (Cook Islands, October 2003) meetings of the Preparatory Conference have resulted in the adoption of the basic structure of the science and technical components, namely a science manager, a data manager, and an observer coordinator in the Secretariat, as well as some of the structure and relationships of contractors, working groups, member's fisheries offices associated with the Science Committee, which is established by the Convention. PIFSC staff have also participated in deliberations of a body, the Scientific Coordinating Group, established by the Preparatory Conference to provide interim advice on the status of stocks from available sources, for example the SCTB, IATTC, and ISC (Australia, August 2003).

Instituto de Fomento Pesquero (IFOP)

Since 1999, the PIFSC and the IFOP in Chile have collaborated on swordfish life history research. Current collaboration involves larval surveys to identify swordfish spawning areas within Chilean waters. Swordfish larvae would be used in an investigation of stock structure to determine the natal origins of the adult swordfish captured in the Chilean swordfish fishery. Chilean research

surveys have focused on waters adjacent to Easter Island as this is the only location where seasonal SST exceeds the lower limit of 24^{o}C associated with swordfish spawning. Larval specimens have been sent to the PIFSC for identification; thus far only istiophorid larvae have been collected. Another Chilean collection survey in December 2004 off Easter Island will attempt surface net tows to capture swordfish larvae.

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