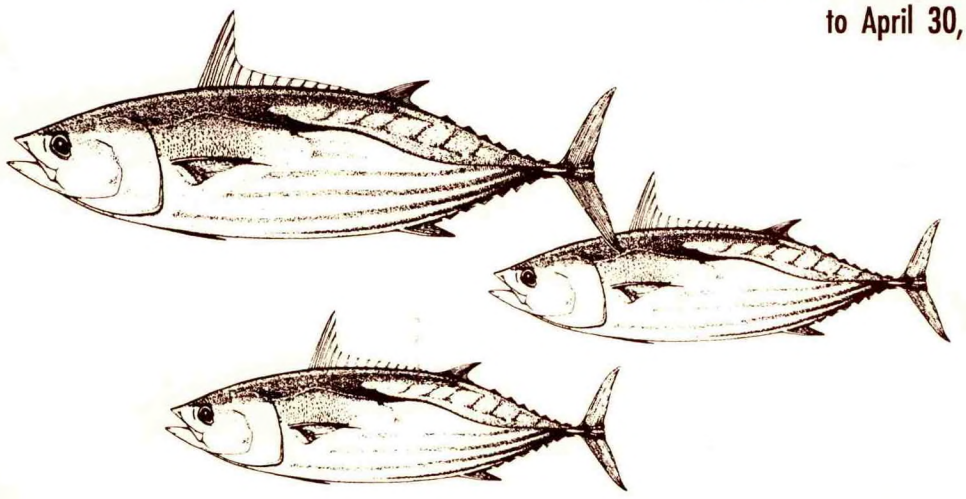
National Marine Fisheries Service
Southwest Fisheries Science Center
P.O. Box 271
La Jolla, CA 92038

Director's Report to the 45th Tuna Conference

On Tuna &
Tuna-Related Activities at the
Southwest Fisheries Science Center
for the Period May 1, 1993
to April 30, 1994



ADMINISTRATIVE REPORT LJ-94-05

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I. PREFACE

Tropical tunas, albacore, billfishes, and other large pelagic fishes have been an important focus of study at the Southwest Fisheries Science Center (SWFSC) for over 35 years. These large, powerful fishes, which range widely across international boundaries in their migrations, support major commercial and recreational fisheries in the United States, in the exclusive economic zones (EEZ) of other countries, and around the world in international waters. The SWFSC, which provides quality fishery analyses and management information, represents a substantial part of the U.S. commitment to supporting international and regional management of commercial and recreational fisheries for tuna, billfish, and other large pelagic species.

During the past year, the SWFSC continued to provide scientific information and advice for managing fisheries for tunas and other large pelagic fishes and fishery-associated marine mammals and endangered sea turtles. Since May 1993, much of the Center's fishery research has been focused on supporting the needs of the Western Pacific Regional Fisheries Management Council (WPRFMC), international working groups and committees, and NMFS' Southwest Region and Headquarters.

Tuna and billfish research conducted by the Center is designed to meet the information needs of fishery managers both in the long and short term and includes stock assessment and basic biological research to improve the scientific basis for effective 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.

Due to a recent Biological Opinion by the NMFS Office of Protected Species, measures were required in the Hawaii-based domestic longline fishery to minimize interaction with marine turtles. As a first step in this process, an observer program was implemented and research was proposed on the mortality factors relating to hooking in this fishery. The SWFSC's Honolulu Laboratory convened a workshop November 16-18, 1993, to plan research needed to estimate the mortality rates of marine turtles incidentally hooked or entangled in the fishery.

SWFSC researchers studying marine mammals associated with tuna fisheries were largely occupied with preparing information for new regulations and reauthorization of the Marine Mammal Protection Act (MMPA) in 1994 and in conducting the common dolphin survey and dolphin-safe research projects in California and Mexico waters and in producing stock assessments. Status of stocks reports for fishery-associated marine mammals were updated for the 1993 edition of the joint Alaska Fisheries Science Center/SWFSC report, "Status of Living Marine Resources off the Pacific Coast of the United States for 1993," which was released in January 1994.

Monitoring U.S. fisheries for large pelagics and archiving and analyzing fisheries data are other important activities at the Center. Honolulu Laboratory scientists monitor important commercial fisheries in and beyond the central and western Pacific U.S. EEZ for tuna, mahimahi, billfish, swordfish, and other large pelagics. The staff participates on the Western Pacific Council's Scientific and Statistical Committee and Pelagics Plan Monitoring Team, preparing annual status of stocks and fisheries reviews and assisting fishery managers in evaluating regulatory alternatives following the end of the moratorium on new entry into the Hawaii-based domestic longline fishery in 1994. With the help of the Western Fishboat Owners' Association, staff at the La Jolla Laboratory also continue to coordinate the albacore observer program to monitor the incidence of driftnet scarring of albacore caught by the U.S. troll fishery in the North Pacific.

In addition, the SWFSC staff handles extensive and complex fishery data bases from tuna fisheries around the world. At the La Jolla Laboratory, the staff processes tuna fishery observer data, Califor-

nia coastal gillnet observer data, tropical tuna fisheries data, North and South Pacific albacore data, and other data collected from field experiments, expeditions, and port sampling. The staff maintains the Atlantic tropical tuna fishery data base and develops and maintains data bases for Pacific Ocean and Indian Ocean fisheries for tunas and large pelagics. The staff also processes South Pacific Regional Tuna Treaty data, evaluates the sampling regime for their collection, and provides reports to the Forum Fisheries Agency as required by the treaty. Annual summaries and analyses for the U.S. Pacific albacore fishery are provided to the albacore fishing fleet, and tuna-dolphin observer data are provided for use in marine mammal stock assessments. The Center also monitors tropical tuna trade and fishery developments on a global scale to help interpret and evaluate fishery statistics used to analyze stock condition. Data obtained from various sources are summarized in the SWFSC's Tuna Newsletter.

The Center staff also remains active on international forums concerning tuna and other large pelagic fishes, such as the Western Pacific Yellowfin Tuna Research Group, MEXUS-Pacifico, International Commission for Conservation of Atlantic Tunas, and South Pacific Albacore Research group. On December 8-14, 1993, the Center hosted the 13th North Pacific Albacore Workshop at the La Jolla Laboratory, where attendees from Japan, Korea, Mexico, Taiwan, and the United States reviewed 30 working documents on North Pacific albacore and identified future research needs. Work also continues with the Inter-American Tropical Tuna Commission (IATTC) in processing incidental dolphin mortality data from the ETP purse seine fishery and collaborating on research relating to development of dolphin-safe fishing methods. The Center coordinates the Pacific International Billfish Angler Survey and Cooperative Marine Gamefish Tagging program and publishes the annual Billfish Newsletter, providing summaries of the results of these programs. The Center has continued to distribute tags to billfish anglers in Mexico, Hawaii, and elsewhere in the Pacific.

The following sections describe research at the SWFSC between May 1993 and April 1994 relating to tuna and other large pelagic fishes and to marine mammals that are affected by these fisheries. The work was conducted at the Center's La Jolla Laboratory in La Jolla, California, and at the Honolulu Laboratory in Honolulu, Hawaii. The various reports provide informal summaries of activities and events that have taken place since last year's Tuna Conference in May, emphasizing highlights of the previous year.

MICHAEL F. TILLMAN, PH.D.
Science and Research Director
Southwest Region

May 1994
La Jolla, California

II. ECONOMIC OVERVIEWS

Statistics of the U.S. Canned Tuna Industry Compiled for the First Three Quarters of 1993

Statistics for the U.S. canned tuna industry for the first three quarters of 1993 were tabulated by Pat Donley of the Southwest Regional Office and were summarized by Al Jackson of the Southwest Fisheries Science Center. The reports describing the statistics appear as articles in the August and November 1993, and February 1994, issues of the SWR/SWFSC Tuna Newsletter.

The total number of vessels in the U.S. tropical tuna purse seine fleet in the third quarter of 1993 was 10, which was unchanged from the previous year.

For the first quarter of 1993, receipts of domestic and imported raw tuna by U.S. canners were down 15 percent from the first quarter of 1992, at 94,300 short tons (st), converted to round weights. Second quarter totals showed a 2-percent increase, with 116,300 st received, and third quarter receipts showed a 1-percent decrease over the previous year's receipts, with 119,900 st. Species composition data for all three quarters showed skipjack tuna to be the largest component of the deliveries, comprising 57 percent of the total, followed by 22 percent albacore and 21 percent yellowfin tuna.

As in the first three quarters of 1992, tuna delivered to U.S. canneries for the first three quarters of 1993 originated principally in the western Pacific. Tuna imported by U.S. canneries increased from 43 percent of the total receipts in the first quarter to 55 percent of the total receipts in the second quarter of 1993, but in the third quarter imports declined to 39 percent of the total receipts.

Imports in the first quarter of 1993 were mainly from Taiwan, France, and Japan. Taiwan provided 28 percent of U.S. cannery imports. The top three supplying nations provided 64 percent of all imports. In the second quarter, Taiwan, France, and Japan contributed 57 percent of the imports. The same three countries provided 63 percent of the total U.S. cannery imports in the third quarter (in the same order). U.S. imports of canned tuna packed in water totaled 34,700 st for the third quarter of 1993, up 7 percent from 1992. For the first 9 months of 1993, imports of canned tuna stood at 88,500 st, down 34 percent from the previous year.

Contract prices for domestically caught yellowfin and skipjack tuna delivered to U.S. canners in the third quarter of 1993 were considerably higher than the third quarter prices of the previous year for all size categories of fish. Maximum prices (not adjusted for inflation) have increased in each of the past four quarters, reversing a downward trend that started in 1988. Between the first quarter of 1988 and the third quarter of 1992, prices fell approximately 40 percent.

To obtain a more detailed account of tuna statistics, write to Tuna Newsletter, Southwest Fisheries Science Center, P.O. Box 271, La Jolla, California 92038. *(A. Jackson, [619] 546-7048)*

III. PACIFIC OCEANIC FISHERIES

PACIFIC ALBACORE

13th North Pacific Albacore Workshop Held

The 13th North Pacific Albacore Workshop was conducted at the Southwest Fisheries Science Center in La Jolla, California, December 8-14, 1993. Participants from Japan, Korea, Mexico, Taiwan, and the United States reviewed 30 working documents, concluding that (1) the catch-per-unit (CPUE) indices for young albacore have declined by 50-70 percent since the mid-1970s while the CPUE for adult fish has been stable or slightly declining since 1972, and (2) biomass of the stock dropped below that needed to support a maximum sustainable yield (MSY) in 1974 and continued to decline until about 1990, reaching a level of about 40 percent of MSY biomass. With a suspension of the driftnet fishery and a significant reduction in fishing effort since 1990, stock biomass is anticipated to increase. If this reduced fishing continues and annual catches remain at the 30,000-metric ton (t) level (average of the last 5 years minus the driftnet catches), the biomass should continue to increase and reach the level needed to support MSY catches in 5 years. If catches, however, increase to an annual level of 50,000 t, the recovery time will be more than 10 years.

Participants identified further research needed to confirm their findings and developed a plan to verify the results and to understand the population recovery process.

Mathematical Statistician Al Coan presented a paper at the Workshop, "Available fisheries data from albacore fisheries in the North Pacific," in which he documented the available catch, catch and effort, and length-frequency data for albacore fisheries operating in the North Pacific.

Catch data by fishing gear were listed for the period 1952-1992 for Japan, Taiwan, Korea, the United States, and Canada. Catches for all fleets combined peaked in 1976 at 124,000 metric tons (t) and declined to a low of 36,000 t in 1991. The majority of the catch was made by Japan using pole-and-line, longline, gillnet, and purse seine fishing gears.

Catch-and-effort data were available for Taiwanese longline (1967-1991), Japanese longline (1952-1991), Japanese pole-and-line (1956-1991), Korean longline (1966-1970, 1975-1987), and U.S. pole-and-line and troll (1961-1992). The majority of the longline data were by month and 5° square, and the pole-and-line and troll data were by month and 1° square.

Albacore length-frequency data were available for Japan longline and pole-and-line (1956-1991) and U.S. pole-and-line and troll (1961-1992). The majority of the Japanese data were by quarter and 5° x 10° square, and the U.S. data were by month and 1° square.

Also at the Workshop, Fishery Biologists Norm Bartoo and Pierre Kleiber presented the results of a generalized additive model analysis of catch-and-effort data from the U.S. North Pacific troll fleet at the Workshop (see synopsis under Chapter V. OTHER TUNA-RELATED RESEARCH AT SWFSC).

Fishery Biologist Darlene Ramon presented a paper at the Workshop on the spawning seasonality of albacore, *Thunnus alalunga*, in the North Pacific. In the paper, she discussed the results of a study she made of albacore sampled aboard a U.S. troll vessel during the summer of 1990 in the North Pacific Transition Zone (NPTZ) and of another group of albacore caught near the Hawaiian Islands by U.S. longline vessels over the period 1991-1993.

Samples of three size groups of albacore from the NPTZ, collected on board the troll vessel *Pursuit*, were collected so that maturity and sex ratio could be determined. A total of 74 albacore gonads were collected during the 1990 fishing season, of which 63 were taken from females and 11 from males. The ovary samples from Hawaii were

collected during 1990-1993 from Honolulu fish markets by Biological Technician Don Hawn of Southwest Fisheries Science Center's Honolulu Lab. Samples were taken from 96 large female albacore.

Ramon determined maturity for the female albacore and measured oocyte diameters from the most advanced mode of oocytes within the ovary. The condition of albacore caught in the NPTZ was categorized as reproductively inactive, with the largest oocyte mode being 0.25 millimeters (mm). Hawaiian-caught albacore were large (90 centimeters) and ranged in development from inactive to mature. Hawaiian oocyte diameter increased significantly during April and maintained an advanced mode size of at least 0.5 mm through August. Because of the time between capture and sampling, histology was inconclusive on the presence of post-ovulatory follicles. Instead, residual oocytes were used as indicators of previous recent spawning. The residual oocytes were found in many ovaries collected during the summer but were absent in samples collected from September through March.

Results of Ramon's study indicate that, based on the criteria used to determine maturity, spawning activity near Hawaii occurs between April and August. *(N. Bartoo, [619] 546-7073)*

Albacore Fishery Data Summarized

Biological Technician Gary Rensink of La Jolla's Southwest Fisheries Science Center authored Administrative Report LJ-93-10, "Summary of the 1991-92 South Pacific albacore fishery data," and with Forrest Miller of the Inter-American Tropical Tuna Commission, he authored LJ-93-12, "Summary of the 1992 North Pacific albacore fisheries data." The following is a summary of these reports:

South Pacific Fisheries-- The 1991-92 U.S. South Pacific albacore fishery, centered mainly south of French Polynesia, started December 1991 and operated through April 1992. The number of U.S. jig vessels participating in the fishery was 35, a decrease from the 58 that participated during the 1990-91 fishing season. The total landings of albacore were 3,016 metric tons (t), a decrease from the 5,540 t that were landed in the 1990-91 fishing season. The average catch rate of 130 fish per day was also lower in 1991-92 than the 193 fish caught per day in 1990-91. The average size of albacore caught was 6.7 kilograms.

North Pacific Fisheries-- The 1992 U.S. North Pacific albacore fishery began in mid-May and continued into early November. As in past fishing seasons, the fishery started in the mid-Pacific off Midway Island early in the season and gradually moved eastward to the Oregon and Washington coastlines as the season progressed. Ocean frontal boundaries along the west coast were prevalent during the season, contributing to moderately good fishing between Vancouver Island and Cape Mendocino. Landings increased by 148 percent from 1991 landings to 4,572 t, the highest recorded since 1988. Average catch rate was 54 fish per day, an increase from 1991 (36 fish per day). Fish weight averaged 5.4 kilograms in 1992. *(G. Rensink, [619] 546-7079)*

Observers Document 1993 Albacore Troll Season with Catch and Gillnet Injury Data

During June-September 1993, for the fourth season, the Southwest Fisheries Science Center (SWFSC) at La Jolla placed biological technicians on U.S. albacore troll vessels to obtain catch and length-frequency data and to examine the catch for injuries (or marks) indicating previous encounters with foreign high-seas driftnets. Samples were taken from within the traditional U.S. albacore troll fishing grounds in the northeastern Pacific.

Highest numbers of albacore were taken west of 140° W longitude. A total of 10,738 albacore were examined for net marks and measured for both fork length and maximum girth during the 275 fishing days observed during the season. The 1993 length-frequency distribution indicates the presence of 2-, 3-, and 4-year-old albacore, more typical of the 1990 and 1991 data than the 1992. The strong 3-year-old age class of 1992 may have been influenced by El Niño conditions.

Of the catch observed, only 0.31 percent showed signs of previous interaction with drift-

nets, down from 3.1 percent in 1992 and a high of 12.4 percent in 1990. This is the first fishing season after the 1992 United Nations ban on all high-seas drift gillnet fishing in the North Pacific. Although effort data from the high-seas driftnet vessels are not available for the 1991 and 1992 seasons, both U.S. troll and high-seas driftnet fisheries were known to operate in overlapping areas of the North Pacific.

Technicians also collected 300 albacore heads during the cruises to use for ageing studies at both the Honolulu Lab and the Centro de Investigación Cientifica y de Educación Superior de Ensenada, Mexico. Preliminary results from both studies presented at the 1993 Albacore Workshop indicated matching results, thus confirming technical methodology. *(D. Holts, [619] 546-7186)*

Study Completed on Effects of Entanglement in High-seas Driftnets on North Pacific Albacore

Fishery Biologists Richard Brill and David Holts coauthored a publication, "Effects of entanglement and escape from high-seas driftnets on rates of natural mortality of North Pacific albacore, *Thunnus alalunga*," which was published in *Fishery Bulletin* (91[4]:798-803). Data for this publication were gathered before the United Nations moratorium was placed on the high-seas driftnet fishery in December 1992. The following is a summary of that publication:

Foreign driftnet fleets and U.S. trollers taking albacore target a common stock. Albacore that encounter driftnets, then escape and survive long enough to be recaptured by another fishery, can bear some external marks. U.S. trollers operating in the North Pacific have reported an increased frequency of net-marked fish with the expansion of the Taiwanese, Korean, and Japanese high-seas driftnet fleets. This study was undertaken to determine whether albacore that encounter driftnets, and subsequently escape alive, suffer higher than normal rates of natural mortality.

Differences in rates of natural mortality were measured by standard fitness, short- and long-term growth rates, and indications of bacterial infection and long-term stress. Indirect measures were employed because rates of natural mortality (or physiological changes) could not be directly observed in albacore encountering simulated driftnets in shoreside tanks.

No differences were found in any parameter that would indicate differences in natural mortality. Most fish recaptured by trollers were only minimally damaged or had healed scars, which may explain the lack of differences. There is most likely a spectrum of damage caused during encounters with driftnets. The number of albacore dying from falling out or escaping, but so badly injured that they are unable to resume feeding before becoming vulnerable to recapture by troll vessels, may well be significant but remains to be determined. *(R. Brill, [808] 943-1234)*

Albacore Ovary Preservation Effects Studied

In an examination of albacore ovaries comparing the effects of preservation by freezing versus preservation by using formalin, Fishery Biologist Darlene Ramon examined albacore ovary samples collected from various locations in the North and South Pacific as part of a larger study on reproductive maturity of albacore.

To assess the effect of formalin on ovary weights, samples were first weighed fresh, then placed in formalin for 1 to 3 months before being reweighed. A significant difference between the weight of fresh- and formalin-preserved samples was indicated (t=3.58, P<0.05, df=61). The same process of taking a fresh weight and reweighing the ovary was also done for samples that were frozen, which resulted in a significant difference between fresh samples and frozen samples (t=6.96, P<0.05, df=14).

The effect of preservation on oocyte diameter was also examined. Samples were available from the North Pacific jigboat fishery and from Hawaii. When obtained, one side of each ovary was frozen and the other side preserved in formalin. Samples were examined for differences resulting from preservation type. A significant level of difference was found to exist between the mean of the most advanced group of oocytes for the two sides (P<0.05). A control group for which both sides of

the ovary were preserved in formalin exhibited no significant differences ($P>0.05$). *(D. Ramon, [619] 546-7074)*

HAWAII FISHERIES

Western Pacific Pelagic Species Fishery Management Plan: Amendment 7 Submitted by WPRFMC

In April 1991, a moratorium on new entry into the rapidly growing Hawaii longline fishery was initiated. It was to last three years, at which point it would be replaced by a limited entry regime or the fishery would return to open access. Throughout the latter part of 1992 and all of 1993, the Western Pacific Regional Fishery Management Council (WPRFMC) struggled with issues pertaining to limited entry in the Hawaii-based domestic longline fishery. In 1993, this fishery was preliminarily estimated to have landed 26 million pounds ($53.3 million). Swordfish account for 50 percent of the landings.

During the 3-year period beginning in April 1991, two major changes occurred in the fishery. First, many of the longliners began targeting Pacific swordfish in areas primarily north and northeast of Hawaii and mostly outside of the U.S. Exclusive Economic Zone. This growth led to some significant questions concerning the status of the swordfish stocks, but the range of the fishery also began to extend into areas reachable by vessels operating out of the mainland United States (Alaska, Washington, Oregon, and California). Second, interaction between longliners and endangered sea turtles was noted. This led to a mandatory observer program which NMFS began implementing in January 1994. Reconciling these two issues, as well as the original allocation issues which confronted the WPRFMC in 1990 and 1991, was the purpose of Amendment 7 to the Pelagic Species Fishery Management Plan. The amendment, which was completed by the WPRFMC in January 1994 and forwarded to NMFS for review, proposes the following:

- Replacement of the moratorium with a limited entry program.
- Issuance of approximately 166 limited entry permits to almost all existing longliners (based on various size and landings criteria).
- Upgrading or replacement of vessels, except that the longest vessel in the limited entry fleet could not exceed the largest under the moratorium (expected to be 28.5 meters [93 feet] in overall length).
- Issuance of transferable permits, with or without sale of the vessel.
- Using framework process for adjusting overall fleet size as new information becomes available on the status of the fishery.
- Allowing NMFS to charge fees to cover the cost of administering the limited entry permits.

(C. Boggs, [808] 943-1222)

Presentation Made at Blue Marlin Workshop

Fishery Biologists Robert Skillman and Christofer Boggs and Industry Economist Samuel Pooley participated in a blue marlin workshop April 20-22, 1993, sponsored by the Western Pacific Regional Fishery Management Council (WPRFMC). Honolulu Lab participants reviewed available fishery statistics and assessments. Case studies from other regions were presented by R. Kearney of the Fishery Research Institute, Australia; O. Sosa-Nishizaki of Centro de Investigación Cientifica y de Educación Superior de Ensenada, Mexico; and S. Berkeley of Oregon State University. Views of the charter boat industry, recreational fishermen, and the longline fishery were presented by members of the Hawaii fishery community, followed by a structured discussion to identify problems and recommend courses of action to the WPRFMC. A report of the workshop was edited by WPRFMC's R. S. Shomura and is available from the WPRFMC.

The Honolulu Laboratory overview provided information on catch and catch rates of blue marlin fisheries in the Pacific and on stock assessment reports from the literature. Pacific-wide catches reached an all-time high in 1990, the most recent year for which catch statistics are available. The

increase was due to the expansion of Korean and Taiwanese longline fisheries after 1985. Stock assessments are out of date because of the unavailability of catch-per-unit effort (CPUE) data from foreign longline fisheries. One production model stock assessment, based on CPUE data through 1980, suggested that blue marlin were overexploited. Another assessment using more recent CPUE data through 1985 found little effect of fishing effort on catch, thus preventing a meaningful production model assessment.

Hawaii fisheries account for less than 4 percent of the Pacific-wide harvest of blue marlin. Domestic longline landings decreased during the 1960s as foreign longline landings in the Hawaii area increased. However, the first major increase in Hawaii landings occurred in the late 1970s due to the expansion of domestic commercial troll fishing. A second major increase in landings occurred with the revitalization of the domestic longline fishery in the late 1980s, and Hawaii catches have been relatively stable since 1988. Despite these increases, commercial troll CPUE has not shown a downward trend in recent decades. A major decline in blue marlin CPUE in the Hawaii longline fishery from the 1950s through the early 1970s corresponded with a Pacific-wide trend unrelated to domestic fishery expansion. Since 1970, total Hawaii catch has increased in rough proportion to estimated equivalent Hawaii fishing effort. Total equivalent Hawaii effort was estimated as catch divided by troll CPUE. Troll fishermen at the blue marlin workshop commented that catch rates have been maintained by improvements in fishing technology and they voiced their strong opinion that local blue marlin abundance has actually declined. *(R. Skillman, [808] 943-1257; C. Boggs, [808] 943-1222)*

Hawaii Longline Fishery Annual Reports Completed

Fishery Biologist Robert A. Dollar completed the Hawaii longline fishery annual report, Honolulu Administrative Report H-93-12, which was distributed to the Western Pacific Regional Fishery Management Council and to participants in the fishery. The report is also available to the general public.

The 1992 Hawaii longline fishery showed a continuing trend toward targeting swordfish (broadbill). Overall, however, the rapid growth in the late 1980s and 1990-91 was halted by the late-1991 moratorium on new entry into the fishery. The moratorium expires in April 1994 and is expected to be replaced by an effort limitation program.

Total longline landings in 1992 were approximately 25.1 million pounds (using average weights applied to logbook number of fish), compared to 26.8 million pounds in 1991. Swordfish landings increased to 10.9 million pounds, up from 9.9 million in 1991. These data are based on the logbook records of federally permitted longline fishing vessels. Additional market information, as well as more detailed information on size composition, will be included in a forthcoming general report on Hawaii's pelagic fishery.

Swordfish was the largest component of the landings (71,000 fish), followed by mahimahi (53,900 fish), and bigeye tuna (42,750 fish). Blue shark represented approximately 26 percent of the catch (61,500 fish), but few were landed. However, a market is developing for shark fins. Sharks which were finned but otherwise "released" may not have been recorded as "kept" in the logbooks. More on this topic will be covered in next year's annual report on the pelagic fishery as a whole. Major problems exist in the identification of blue and striped marlin (striped marlin are frequently misidentified as blue marlin). In the annual pelagic fishery report, shoreside sampling data are used to correct these figures. Sharks may also be mislogged as "kept" when they are killed and released while other sharks may not be logged as "kept" when finned.

Of 166 federally permitted longline vessels registered in Hawaii, 123 were active in 1992. Inactive vessels included vessels in the lobster and bottomfish fisheries, vessels which sank or had moved out of Hawaii, and 19 vessels that simply did not fish in 1992. In 1991, there were 140 active longline vessels in Hawaii.

There were 1,261 longline trips in 1992, compared to 1,665 trips in 1991. Approximately 22 percent of the trips specifically targeted swordfish

while approximately 35 percent of the trips targeted tuna. The remainder (42 percent) represented mixed or unknown targeting. Fishing effort (number of hooks set) was predominately outside the U.S. Exclusive Economic Zone (EEZ), 52 percent. Remaining fishing effort was within the 200-mile EEZ around the main Hawaiian Islands (40 percent); within the Northwestern Hawaiian Islands (6 percent); and in U.S. possessions, such as Johnston Atoll (2 percent). Catch-per-unit effort (CPUE), the number caught per 1,000 hooks set, for all areas was about the same in 1992 as in 1991. Swordfish CPUE was 6.36 per 1,000 hooks while bigeye tuna was 3.74 per 1,000 hooks.

Interactions with protected species are also recorded in the logbooks. The Hawaii fishery reported 180 interactions, of which 55.5 percent were with seabirds and 35.5 percent were with marine turtles. These interactions include those in which animals were released alive (either unharmed or injured), as well as those in which the animals were already dead when released. One dolphin and 71 seabirds were already dead when released in 1992. Over 80 percent of the interactions occurred outside the U.S. EEZ. *(S. Pooley, [808] 943-1216)*

Pilot Observer Program Guidelines Developed for Hawaii Longline Fishery

The report "Statistical guidelines for a pilot observer program to estimate turtle takes in the Hawaii longline fishery" was prepared by Fishery Biologist Gerard DiNardo, currently with the Joint Institute for Marine and Atmospheric Research (JIMAR). DiNardo's intent in the report was to provide statistical guidelines for development of an observer sampling program for the Hawaii longline fishery. Development and implementation of the sampling program is a requirement of a recent internal Biological Opinion rendered under the Section 7 Consultation conducted by NMFS in response to concerns regarding the incidental taking of listed sea turtles by this fishery.

The sampling design that was outlined in the guidelines was developed using 1991 and 1992 Hawaii longline logbook and 1990-92 observer data from vessels that exclusively targeted swordfish, tuna, or some mix of both. For all months, tuna fishing trips were generally proximal to the Hawaiian Islands, with mixed tuna and swordfish trips north of the tuna effort and swordfish effort north of the mixed effort. During the 1991 fishing season, 28 percent of the longline vessels fished exclusively for tuna, 11 percent fished exclusively for swordfish, and 24 percent always fished for a mixed catch. The remaining vessels (37 percent) switched between targets from trip to trip with no obvious pattern. During the 1992 fishing season, 30 percent of the longline vessels fished exclusively for tuna, 19 percent fished exclusively for swordfish, 31 percent always fished for a mixed catch, and 20 percent switched between targets. The identification of exclusive groups of vessels within the longline fishery is basic to developing strata and sampling frames.

A total of 11 trips (109 sets) were monitored by scientific observers in the longline fishery between 1990 and 1992. Cooperating vessels were opportunistically sampled. All vessels monitored fished exclusively for swordfish. A total of 7 turtle interactions were observed on 3 of the 11 monitored trips.

Information from the Hawaii longline logbook system has not been fully verified by scientific observer reports, so the reported take of protected species was most likely downwardly biased because of nonreporting. Because the available observer data set was small (11 trips) and limited to vessels fishing exclusively for swordfish, the data were not considered to be representative of turtle interactions in the Hawaii longline fishery.

Consequently, additional baseline turtle interactions data will be required. To collect such data, a stratified pilot sampling design was proposed as part of the guidelines for the pilot observer program. Data from the logbooks were used to identify appropriate strata and sampling frames while observer data were used to estimate sample size requirements.

As sources of variability in turtle take rates were not known, stratification was based on characteristics of the fishery. In the survey design, all potential vessel trips were classified into a unique

stratum defined by two stratification variables, time and trip type.

For the pilot program, an array of sample size choices was presented to cover a range of tolerance and confidence levels for estimation of total turtle take, assuming both normal and negative binomial take rate distributions. It was assumed that approximately 10 longline sets comprise a trip. A sampling frame for the pilot survey was developed and appropriate sample selection procedures were advanced. Procedures for optimizing future sampling were also described. *(G. DiNardo, [808] 943-1259)*

Workshop Held on Marine Turtle Hooking Mortality

A workshop on marine turtle hooking mortality, sponsored by the Honolulu Laboratory and NMFS Headquarters, was held November 16-18, 1993, in Honolulu. Turtle experts from across the United States, Australia, and Japan participated in this workshop, which was designed to develop a coordinated research plan for estimating the mortality and physiological impact on marine turtles hooked or entangled in longline fishing gear. The first day of the workshop was dedicated to technical presentations on longline fishing, the Endangered Species Act, and turtle physiology and fishery interactions. The second day was a facilitated strategic planning session in which specific research objectives and activities were identified. On the third day, a number of related issues, including mitigation and observer protocol, were discussed, and detailed research outlines were prepared. The results of the workshop were presented to NMFS Headquarters.

Those attending the workshop included Alan Bolten and Elliott Jacobson, University of Florida, Gainesville, Florida; Scott Eckert and Pamela Yochem, Hubbs-Sea World Research Institute, San Diego, California; Kiyoshi Katsuyama, Japan Fishing Agency, Tokyo, Japan; Itaru Uchida, Port of Nagoya Public Aquarium, Minatoku Hagoya City, Japan; Jeffrey Miller, Department of Environment and Heritage, Queensland, Australia; Bernard Thoulag, Micronesian Maritime Authority, Pohnpei, Micronesia; Charles Caillouet, NMFS, Galveston, Texas; Phil Williams, NMFS, Silver Spring, Maryland; Larry Ogren, Southeast Fisheries Science Center (retired); Frederick White, Scripps Institution of Oceanography (retired); and Christofer Boggs and Jerry Wetherall of the Honolulu Laboratory. *(G. Balazs, [808] 943-1240; S. Pooley, [808] 943-1241)*

Hawaii Pelagic Fishing Vessel Economics Project Under Way

Michael Travis, principal research assistant, and Rita Curtis and Marcia Hamilton, research associates, have recently begun research to determine the economic characteristics and optimal number (and spatial distribution) of Hawaii-based domestic longline fishing vessels, to identify the determinants of longline fishing vessel operations (spatial, temporal, and species) relative to interaction with other domestic fishing fleets, and to identify the economic characteristics of commercial troll-handline and charter boat operations.

Objectives specific to first-year funding include (1) determining the basic cost-earnings and fishing operation relationships of longline, pelagic handline, and commercial troll fishing and charter boat vessels in Hawaii, (2) developing a model of the impact of fish price and factor input prices on the supply of fishing effort in these fisheries, and (3) developing a model of dynamic factors of at-sea longline fishing behavior.

The research should provide fishery management information based on the economic characteristics of the Hawaii longline and troll-handline (and charter boat) fisheries. The primary client for the research is the Western Pacific Regional Fishery Management Council, a Federal organization authorized under the Magnuson Fishery Conservation and Management Act of 1976 that regulates fishing within the U.S. 200-mile Exclusive Economic Zone surrounding Hawaii as well as American Samoa, Guam, and the Northern Mariana Islands.

The project is part of the Pelagic Fisheries Research Program, which is funded through the University of Hawaii's School of Ocean and Earth Science and Technology (SOEST) and its Joint Institute for Marine and Atmospheric Research. The program is the outgrowth of a collaborative

process including the Council, SOEST, and NMFS. The Hawaii Pelagic Fishing Vessel Economics project is expected to last 3 years, depending on funding availability for the second and third years. Industry Economist Sam Pooley is the principal investigator at the Honolulu Laboratory. *(S. Pooley, [808] 943-1216)*

Social Science Investigators Meet

Investigators from the University of Hawaii's Pelagic Fisheries Research Program met at the Honolulu Laboratory on November 5, 1993, to discuss issues of large pelagic fishery project coordination.

During the meeting, Industry Economist Sam Pooley calculated revised estimates of 1992 commercial landings for Hawaii. Combining State of Hawaii commercial catch reports with NMFS logbook and shoreside monitoring information, total commercial landings in 1992 were 30.4 million pounds ($62 million). Longline landings accounted for 21.2 million pounds ($44.6 million) of this total; the small-scale troll handline pelagics fishery was the second largest fishery (4.4 million pounds, $7.2 million). Landings in 1991 were approximately 29 million pounds ($61 million). The 1992 information will be included in next year's *Fisheries of the United States. (S. Pooley, [808] 943-1216)*

DRIFTNET IMPACT WORK

Fish and Cephalopod Catch in North Pacific High-seas Driftnet Fisheries Estimated for 1990 and 1991

From the late 1970s, large-scale high-seas driftnet fisheries had been the dominant fisheries in the North Pacific Transition Zone. Neon flying squid and two faunal groups, tunas and billfishes, were traditionally targeted by the driftnet fisheries. The squid driftnet fishery was comprised of vessels from Japan, Taiwan, and the Republic of Korea that targeted neon flying squid. The large-net driftnet fishery was comprised of other vessels from Japan and Taiwan that targeted tunas and billfish.

The rapid expansion of large-scale driftnet fishing during the early 1980s led to increasing concern over the incidental killing of nontargeted species (including marine mammals, sea birds, turtles, and salmonids) by the driftnet fisheries, and its potential impact on the ecosystem resulted in the adoption of stricter time-area regulations and development of international monitoring programs. In 1989, a cooperative pilot scientific observer program was established between Japan, Canada, and the United States. Later, bilateral observer programs were launched by the United States and the Republic of Korea and the United States and Taiwan. The goals of the scientific observer programs were to monitor driftnet fishing operations and obtain data on the rates of incidental take of various species of fish, marine mammals, turtles, and birds in an effort to estimate total mortalities and assess impacts on the affected populations. Increased public concern over the potential impact of these fisheries resulted in a global United Nations ban on large-scale driftnet fishing effective December 31, 1992.

Total catches (numbers and biomass) of squids and pelagic fishes in the North Pacific high-seas drift gillnet fisheries have been estimated for the 1990 and 1991 fishing seasons. These estimates are based on data collected by multinational scientific observers and total fleet effort reported by the fishing nations. Catch was examined relative to the type of fishery (squid or large-mesh), the flag of the vessels involved (Japan, Korea, or Taiwan), and physical and operational factors affecting catchability.

An initial step toward estimating total catches required the assessment of "dropouts" during net retrieval. A dropout is defined as an animal that emerges from the water entangled in the net but becomes disentangled and falls out of the net before it reaches the deck, either on its own or by the crew's deliberate shaking of the net. A General Linear Model was used to explore factors that may be correlated with net retrieval dropouts, and the reported number of fish decked were "scaled-up" using mean dropout rates. Total catches by species and month were estimated using a ratio estimator. Species-specific metrics of exploited biomass were estimated by apportioning total catches into length categories based on length-fre-

quency data collected by observers, then converting catch-by-length to catch-by-weight using existing or derived length-weight relationships. Precision of the estimates of total catch was evaluated by bootstrap resampling.

In 1990, observers monitored 5,333 fishing operations in the North Pacific high-seas, and in 1991, they monitored 4,079. Observers reported 8 cephalopod and 76 fish species caught in these fishing seasons, representing five faunal groups--squids, sharks, tunas, billfishes, and other pelagic fishes.

For most species, dropout rates were similar between years. However, differences in dropout rates between fisheries were apparent. Dropout rates were generally lower in the large-mesh fisheries than in the squid fishery for all fish species.

Although the magnitude and composition of catches differed between fisheries and years, highest combined total catches were generally associated with intended target(s): neon flying squid by the squid driftnet fleets and albacore tuna, skipjack tuna, and striped marlin by the large-mesh driftnet fleets. While the catches by the Japanese squid fleet were dominated by neon flying squid, nontargeted pelagic species of low economic value (LEV) accounted for approximately 40 percent of the total numbers of cephalopods and fishes caught on an annual basis. LEV species are defined as those species included in the two faunal groups "other pelagic fishes" and "sharks." Paramount among LEV species caught by the Japanese squid fleet were Pacific pomfret, pelagic armorhead, blue shark, and yellowtail, with catch estimates of approximately 35.1, 3.2, 0.9, and 0.1 million animals in 1990 and 17.5, 0.9, 0.9, and 0.2 million animals in 1991, respectively. Relatively large numbers of LEV species including Pacific pomfret, blue shark, and yellowtail were also caught by the Korean and Taiwanese squid driftnet fleets. In 1990, approximately 9.0, 0.7, and 0.07 million and 0.6, 0.1, and 0.005 million Pacific pomfret, blue shark, and yellowtail were caught by the Korean and Taiwanese squid fleets, respectively. In 1991, approximately 1.4, 0.6, and 0.4 million and 0.3, 0.1, and 0.008 million Pacific pomfret, blue shark, and yellowtail were caught by the Korean and Taiwanese squid fleets, respectively.

The catches by the Taiwanese large-mesh fleet were predominately albacore tuna (5.2 million in 1990, 0.7 million in 1991) and skipjack tuna (0.4 million in 1990, 0.3 million in 1991), but species of LEV were also taken, Pacific pomfret in particular (1.3 million in 1990, 0.08 million in 1991). The catches by the Japanese large-mesh fleet were predominately species of LEV, Pacific pomfret (1.5 million) and mahimahi (0.3 million) being most prevalent. Relatively large numbers of albacore tuna (0.2 million) and skipjack tuna (1.4 million) were also caught as well as neon flying squid (0.6 million).

Highest estimates of total biomass removed occurred in the squid driftnet fisheries. From 1990 to 1991, approximately 461,000 metric tons (t) of squid and fish were caught by the squid driftnet fleets compared with 59,000 t by the large-mesh fleets. Highest biomass removed in the squid fishery was associated with the Japanese fleet (approximately 231,000 t) followed by the Korean (approximately 142,000 t) and Taiwanese (approximately 88,000 t) fleets. In the large-mesh fishery, highest biomass removed was associated with the Taiwanese fleet (approximately 45,000 t).

Within fleets, highest biomass removal estimates were associated with target species, followed by species of LEV. Paramount among LEV species were Pacific pomfret and blue shark. Interannual variability in biomass removal estimates was observed, particularly for target species and species of LEV.

The average weight and length of key species were generally larger in the large-mesh fisheries than in the squid fisheries. Within the squid driftnet fishery, no apparent trend in average weight and length of key species was observed between fleets. However, in the large-mesh fishery, the Japanese fleet generally caught larger fish compared with the Taiwanese fleet. *(G. DiNardo, [808] 943-1259)*

United Nations Driftnet Moratorium Economic Impact Report Completed

In September 1993, Daniel D. Huppert and Todd Mittleman of the University of Washington completed NOAA Technical Memorandum num-

ber 194, "Economic effects of the United Nations moratorium on high-seas driftnet fishing," which was the result of a research grant supported by the NMFS Southwest Fisheries Science Center.

In the memorandum, they concentrated on the likely disposition of the Asian driftnet fleet (which includes Japan, South Korea, and Taiwan) following the imposition of the moratorium in 1992. Table 1 indicates the projected disposition based on field work in Japan, South Korea, and Taiwan in late 1992. The basic alternative dispositions were to scrap it or shift it into alternative fisheries. The authors found that government compensation programs were important in scrapping vessels, with a much higher percentage of vessels being scrapped in Japan because of a well-financed compensation program. Restrictions and opportunities in alternative fisheries also differed among the countries, as did the relative costs and capabilities of the vessels. Alternate fisheries include the squid jigging, tuna longline and pole-and-line, trawl and bottom longline, and saury dipnet fisheries.

The authors found that the overall economic impact of the high-seas driftnet moratorium on the three countries was not easily summarized nor were the potential impacts on other countries through conversion into other fisheries or through reductions in landings of squid and albacore. However, they estimated that 8,000 of the 16,000 people employed by the driftnet fishing industry lost their jobs because of the moratorium and that the total value of lost seafood landings is $414 million. The purpose of the driftnet moratorium was to support the populations of high-seas marine mammals, birds, and turtles. *(S. Pooley, [808] 943-1216)*

SOUTH PACIFIC AND WESTERN PACIFIC TUNA FISHERIES

U.S. Purse Seine Fishery Reviewed for Tropical Tunas in the Western Pacific

At the annual meeting of the South Pacific Regional Tuna Treaty in Nadi, Fiji, March 7-9, 1994, Mathematical Statistician Al Coan presented a working paper titled "Review of the U.S. purse seine fishery for tropical tunas in the western Pacific Ocean, 1993," in which he reviewed data collected from the fishery. An abstract of the paper is as follows:

During 1993, 42 U.S. purse seiners fished for tropical tunas in the western Pacific. Preliminary data on landings from the fleet indicate a decrease of approximately 8 percent from landings in 1992. The fleet concentrated more of its fishing effort than in previous years in areas southeast of the Federated States of Micronesia and Kiribati where it experienced longer trip lengths, lower catch rates, and fewer sets per trip. The estimated ex-vessel value of the 1993 landings, however, increased 9 percent as canneries paid higher prices for fish, and the fleet found slightly larger sizes of fish which brought higher prices.

Sampling coverage of the U.S. fleet in 1993 remained very high. Logbook and landings coverage was at 100 percent and length-frequency coverage was well above those needed to estimate the major modal groups in the catch of both yellowfin and skipjack tunas. There were no landings in Tinian, Commonwealth of the Northern Marianas, that could not be adequately sampled in Pago Pago, American Samoa. Therefore, sampling in

Disposition	Country		
	Japan	Korea	Taiwan
Number vessels in 1991	454	142	223
Number vessels planned for scrap	280	30	60
Number vessels estimated for scrap	98	-	-
Number vessels switching to squid jigging	26	90	55
Number vessels switching to tuna longline and pole-and-line	32	-	90
Number vessels switching to trawl and bottom longline	18	-	18
Number vessels switching to saury dipnet	-	22	-
Total number vessels switching to alternative fisheries	76	112	163

Table 1. Projected disposition of the Asian base driftnet fleet (from Huppert and Mittleman 1993).

Tinian was not necessary. However, NMFS is actively seeking to find a way to sample landings in Tinian in the future, should the need arise. *(A. Coan, [619] 546-7079)*

SPAR 5 Meetings Held

The fifth meeting of the South Pacific Albacore Research (SPAR) Group was held in Papeete, French Polynesia, during March 29-April 2, 1993. Staff of the Southwest Fisheries Science Center (SWFSC) submitted three working documents for the meeting: (1) "Summary of the 1990-91 U.S. South Pacific albacore fisheries data" by G. Rensink, (2) "Report of SWFSC research activities for South Pacific albacore during 1991-92 and plans for 1993" by SWFSC staff, and (3) "Reproductive patterns of South Pacific albacore, *Thunnus alalunga*, as indicated by gonosomatic index and meiotic activity" by SWFSC Fishery Biologist Darlene Ramon and by the late Kevin Bailey of the South Pacific Commission. These documents along with others submitted by scientists from American Samoa, Australia, Cook Islands, Fiji, French Polynesia, Japan, New Caledonia, New Zealand, Solomon Islands, Taiwan, Tonga, and the South Pacific Commission formed the basis for an evaluation of fisheries results and condition of the stock by the Group.

Fisheries statistics reviewed at the meeting indicated that in 1992, the surface fishery caught an estimated 7,300 t of albacore from the South Pacific. This catch was well below the peak taken in 1989 (31,000 t) and the lowest catch for this fishery since 1987. Statistics for the 1992 longline fishery were not available; however, statistics for 1991, which indicated a total catch of 21,700 t, and anecdotal information on the 1992 fishery indicated that the 1992 catch was either the same as in 1991 or lower.

The Group reviewed the performance of the fisheries, trends in catch rates, and biological information to determine the condition of the stock. It concluded that since the moratorium on driftnet fishing went into effect in 1990-91, catches of South Pacific albacore have remained near or below their historical average. There is no evidence from the available stock abundance indicators that current levels of fishing are adversely affecting the stock. However, because the time series of abundance indicators is short and provides imprecise information on trends for recent years, the Group advised that rapid expansion in the catch not be encouraged at this time. *(G. Sakagawa, [619] 546-7177)*

Third Meeting of the WPYRG Held in June 1993 in Pohnpei, Federated States of Micronesia

The Western Pacific Yellowfin Tuna Research Group (WPYRG) was formed in 1990 in response to growing concerns over the expanding fisheries and catch of yellowfin tuna in the western Pacific. The Group consists of scientists and fishery officers who are interested in collaborative research on western Pacific yellowfin tuna for management advice. They are principally from South Pacific Island nations, distant-water fishing nations, the South Pacific Commission (SPC), and the Forum Fisheries Agency (FFA).

The strategic plan for the Group includes achieving three objectives by 1994 through collaborative research among participants: (1) determining the safe level of yield and exploitation for the stock, (2) determining the level of interaction among the different fisheries, and (3) determining the factors contributing to local depletion.

The Group held its third meeting in Pohnpei, Federated States of Micronesia, from June 21 through 23, 1993, under the chairmanship of Gary Sakagawa of the Southwest Fisheries Science Center. Scientists and fishery officers from 16 Pacific countries as well as from the Food and Agriculture Organization, the FFA, and the SPC participated.

The Group reviewed the latest information on the western Pacific yellowfin tuna fisheries. The information indicated that the total catch increased from 310,000 metric tons (t) for 1991 to a possible record of 349,000 t (estimated) for 1992. For 1993, preliminary information indicated poor fishing for many of the fleets during the first semester. The Group concluded that the total catch for the year may be less than for 1992.

The Group also reviewed advances in development of a common data base, biological information, and investigations into stock abundance. Highlights of the reviews were that current catches are not excessive and the yellowfin tuna stock is capable of safely withstanding further fishing pressure. Catch-per-unit effort indices for monitoring trends in stock biomass were also determined to be unreliable and appropriately used only to monitor fishery performance.

Mathematical Statistician Al Coan presented a working paper at the 1993 WPYRG meeting on yellowfin tuna catches from the central and western Pacific. The paper was coauthored by Computer Programmer Doug Prescott.

Three types of U.S. fisheries that catch yellowfin tuna currently operate in the central and western Pacific: (1) the distant-water purse seine fishery, (2) the Hawaii-based commercial fisheries, and (3) the artisanal fisheries.

The distant-water purse seine fishery operates with purse seiners having 1,000 to 1,800 metric tons (t) carrying capacity in a large area of the southwestern Pacific. It targets yellowfin and skipjack tunas. The number of vessels participating in the fishery peaked in 1983 at 63, decreased to 32 in 1988, and increased to 46 in 1992. Yellowfin tuna landings peaked in 1987 at 66,400 t and, after a significant decrease the next year to 25,200 t, reached highs of 57,100 t in 1990 and 50,300 t in 1992. Statistics for the first half of 1993 show a decrease in both catch rate and average size of fish from statistics for the same period in 1992. Total yellowfin tuna landings are therefore anticipated to be 25 to 30 percent lower for 1993, or approximately 35,000 t. The number of vessels fishing in 1993 is expected to be approximately 44, the same as in 1992.

Hawaii-based commercial fisheries and artisanal fisheries use primarily handline, troll, and longline gears and operate mainly within the Exclusive Economic Zones of Hawaii, Guam, American Samoa, and the Commonwealth of the Northern Marianas. They target a variety of tunas, tuna-like fishes, and billfishes. The majority of the yellowfin tuna landings from these fisheries are from troll and handline gears operating in waters off Hawaii. Yellowfin tuna landings for Hawaii-based fisheries reached a high of 2,200 t in 1986. Since then, landings have decreased to 1,200 t in 1992. Yellowfin tuna landings for artisanal fisheries that operate off Guam, American Samoa, and the Northern Marianas are typically below 90 t a year.

Statistics to date for 1993 indicate that yellowfin tuna landings for 1993 will be approximately 1,400 t for Hawaii-based fisheries and about 70 t for the artisanal fisheries.

The year 1994 will mark the end of the term of the strategic plan; consequently, the fourth meeting will be largely devoted to highlighting achievements in meeting the objectives of the plan and discussing the future of the Group. *(G. Sakagawa, [619] 546-7177 and A. L. Coan, Jr., [619] 546-7079)*

PACIFIC BILLFISH PROGRAMS

Study Completed on the Horizontal and Vertical Movements of Striped Marlin

A study on the horizontal and vertical movements of striped marlin near the Hawaiian Islands has recently been published in *Marine Biology*. The paper was coauthored by Fishery Biologists Richard W. Brill and Randolph K. C. Chang, Honolulu Laboratory; David B. Holts, La Jolla Laboratory; Scott Sullivan, NOAA Corps; Heidi Dewar, Scripps Institution of Oceanography; and Francis G. Carey, Woods Hole Oceanographic Institute.

In the study, striped marlin movements were determined by ultrasonic telemetry with simultaneous measurement of oceanic currents. Fish movements were monitored using ultrasonic depth-sensitive transmitters, depth-temperature profiles were made using a bathythermograph system, and oceanic current patterns were measured using an acoustic Doppler-current profiler. Striped marlin near Hawaii, like Indo-Pacific blue marlin, spend over 85 percent of their time in the mixed layer (above 90 m). The maximum depth in which striped marlin are found appears to be limited by water temperatures 8°C colder than the mixed

layer, rather than by an absolute lower temperature. Also, the horizontal displacements of some striped marlin can be strongly influenced by currents. *(R. Brill, [808] 943-1234)*

Results of 1992 Angler Survey and 1993 Tagging Reported in 1994 Billfish Newsletter

The 1994 Billfish Newsletter was distributed in April 1994. The newsletter, with an emphasis on billfish angling results in the Pacific and Indian Oceans, is an annual publication produced by the Southwest Fisheries Science Center. Data used in the newsletter were taken from the 1992 Pacific Billfish Angler Survey, which follows the trends in fishing in terms of catch rates for the recreational fishery, and from the 1993 Cooperative Billfish Tagging Program reports. A summary of the information in the Newsletter is as follows:

Anglers responding to the international Billfish Angler Survey for 1992 reported catching 3,751 billfish throughout the Pacific and Indian Oceans. The total number of days reported fishing for billfish in the Pacific, Indo-Pacific, and Indian Oceans increased 6.4 percent to 8,712 days. The catch rate was 0.43 billfish caught per fishing day or 2.3 days/billfish. This is down about 25 percent from the 1991 catch rate of 0.57 but very similar to the 1990 catch rate of 0.42 billfish/day. Highest catch rates for striped marlin were at the southern tip of Baja California, Mexico. Best catch rates for blue marlin were in Hawaii and Tahiti, while black marlin were highest in Australia and New Guinea. The greatest success in fishing for sailfish was in the Indian Ocean (Seychelles) and off Costa Rica and Guatemala in the Pacific.

Billfish tagging reports received indicated a total of 1,153 billfish were tagged and released in 1993; a 35-percent increase over 1992. Recreational billfish anglers tagged 952 billfish while commercial swordfish/tuna longliners operating out of Hawaii tagged 187 billfish (mostly small swordfish). Fourteen billfish were tagged and released from NMFS research ships.

Fourteen billfish tags were returned in 1993. One was from a blue marlin, nine were from striped marlin, one was from a swordfish, and one each was from a yellowfin tuna, a bigeye tuna, and a blue shark. The blue marlin was at liberty only 6 days and had traveled just a short distance. Of the striped marlin tagged in southern California waters, one traveled in excess of 2,000 miles, from near Santa Barbara Island, California, to just northeast of the Island of Maui in 214 days. Another striped marlin tagged near Avalon, Santa Catalina Island, traveled 865 miles south to the East Cape area of Baja California in 144 days. Other striped marlin recoveries in and around the Hawaiian Islands indicate significant inter-island movement. The swordfish tagged in the North Pacific was at liberty a full year but only had a net movement of 321 miles.

Response to the Billfish Angler Survey and participation in the Billfish Tagging Program are voluntary and tagging supplies are available at no cost to billfish anglers from the SWFSC. The 1993 Angler Survey will be included with the mailing of this year's Billfish Newsletter. *(D. Holts, [619] 546-7186)*

International Pacific Swordfish Symposium Planned

An International Pacific Swordfish Symposium, hosted by Centro de Investigación Cientifica y Educación Superior de Ensenada (CICESE) with assistance from the Southwest Fisheries Science Center, is being planned for December 10-13, 1994, at CICESE in Ensenada, Mexico. The symposium will focus on recent developments in Pacific swordfish fisheries, markets, and biological research. Papers, which will be accepted through June 1994, will be peer reviewed and published following presentation at the symposium. This symposium is the first meeting in the Pacific dedicated exclusively to swordfish. *(N. Bartoo, [619] 546-7073)*

IV. EASTERN TROPICAL PACIFIC TUNA-DOLPHIN RESEARCH

Tuna Discards Studied from Log, Schoolfish, and Dolphin Set by U.S. Tuna Purse Seiners in the ETP, 1989-1992

A recent study conducted at the Southwest Fisheries Science Center focused on the extent of tuna bycatch discarded from the U.S. tuna purse seine fishery in the ETP, primarily with respect to set type modified by geographic area. The study described the general characteristics of the available data in terms of patterns in effort and resulting tuna bycatch discard, and it included development of a formula to estimate average tuna bycatch discarded per set, given set type and geographic area. This formula was used to estimate the total U.S. tuna discard in the ETP fishery during the study period. The formula was then applied to estimate total tuna discard by the international fleet (of which the U.S. fleet was only a small part) during the study period and to estimate expected tuna discard if the international effort had been redistributed from sets made primarily on dolphins to sets made primarily on school or log fish.

Although more detailed data reports would have been desirable, currently available data for the U.S. purse seine fleet include only per-set estimates of total tons of tuna discarded. Data on size classes and species composition of this discarded tonnage were not available, nor were data available on discards of species other than tuna. This study also could not include data about discard from the considerable number of non-U.S. purse seiners fishing in the ETP, or from U.S. seiners fishing outside the ETP, because the data were not available to NMFS.

Observed tons of tuna discard per set (all tuna species combined) from U.S. tuna purse seine vessels fishing in the ETP during 1989-1992 were two orders of magnitude higher for sets made on floating objects (log sets) than for sets made on dolphins (dolphin sets) and one order of magnitude higher than for sets made on pure schools of tuna (schoolfish sets). Estimated average discard was 7.0-15.0 tons per set on logs, 1.0-1.2 tons per set on schoolfish, and 0.06 tons per set on dolphins, depending on geographic area.

Extrapolating estimated average tuna discarded per set to the total effort by the U.S. fleet during the observation period produced total tuna discard estimates of 15,558 tons due to log sets, 1,546 tons due to schoolfish sets, and 266 tons due to dolphin sets. Redistributing effort by U.S. seiners from setting primarily on dolphins to setting primarily on schoolfish or log sets during the observation period could have increased total tuna discard by an estimated 357 percent (from 17,370 to 61,973 tons). Such redistribution of effort by U.S. boats is occurring in response to pressures to eliminate dolphin mortality by eliminating fishing on dolphins.

The U.S. fleet during the observation period was a small and decreasing fraction of the total international fleet. On average, U.S. vessels comprised only about one-eighth of the international fleet fishing during the study period (15 of the 120 vessels fishing the ETP were U.S. registered). Assuming that non-U.S. vessels spent the same amount of time fishing as U.S. vessels, then tuna discard for the international fleet can be estimated very roughly by multiplying the estimated U.S. bycatch by a factor of eight. This produces an estimated total tuna discard of 138,960 tons. Had all effort been directed toward logfish, total discard of tuna might have been as high as 495,784 tons.

These estimates of tuna discard extend through 4 calendar years but actually include only about 36 months (3 years) of data. Dividing the estimates of total discard by 3 produces a rough annual estimate of 5,790 tons of tuna discarded from the U.S. fleet and 46,320 tons from the international fleet. In comparison, total catch of yellowfin and skipjack tuna by the U.S. fleet during the single year 1991 was 36,800 tons; total catch by the international fleet was 330,343 tons. Thus, esti-

mated tuna discard represented about 14 percent of the tuna caught by the U.S. fleet and 12 percent of the tuna caught by the international fleet. Although this appears to represent a relatively small fraction of the total catch, its cumulative effect on the tuna populations could be substantial since this bycatch is composed primarily of pre-reproductive fish. *(E. Edwards, [619] 546-7099)*

Dolphin Mortality in U.S. Tuna Fishery Continues to Decline

The estimated number of dolphins killed in the U.S. eastern tropical Pacific tuna purse seine fishery in 1992 was 438, down 56 percent from the estimated 1991 kill of 1,004 animals, according to data collected by on-board observers from NMFS. The 1992 dolphin kill was well below the annual quota of 20,500 and was the lowest on record for the U.S. fleet. This quota was reduced to 800 dolphins for the period of January 1, 1993, to February 28, 1994, by passage of the International Dolphin Conservation Act of 1992 by the U.S. Congress.

The major reasons for the marked decrease in dolphin kill in 1992 were the continued reduction in the size of the U.S. fleet and an increase in the fishing effort on nondolphin-associated tuna by the remaining U.S. vessels; both are largely the result of the U.S. tuna canners' decision in April 1990 to purchase only "dolphin-safe" tuna.

In 1991 there were 13 U.S. purse seiners active in the eastern tropical Pacific, of which 9 made sets on dolphin-associated schools. In 1992 the active fleet declined to seven vessels, of which only five made sets on dolphin-associated schools. In both years, 1991 and 1992, the observer coverage rate was virtually 100 percent. Forty fishing trips and 430 dolphin-associated sets were observed in 1991. In 1992, 40 trips and 650 dolphin-associated sets were observed. The dolphin kill-per-set rate in 1992 was 0.7, down 70 percent from the 1991 rate of 2.3 dolphins per set. This was the lowest annual rate ever achieved by the U.S. fleet.

Based on preliminary data from observed trips completed during the first 8 months of 1993, the dolphin kill and kill-per-set rates remain at historical lows: 75 dolphins killed in 99 sets for a kill-per-set rate of 0.8. Of the eight U.S. purse seiners that are active in the eastern tropical Pacific and permitted to set on dolphins, only three actually made dolphin-associated sets during this period. *(A. Jackson, [619] 546-7048)*

Dolphin-Safe Cruise Completed

On December 5, 1993, the Dolphin-Safe research project in the eastern tropical Pacific was completed. The NOAA research vessel *McArthur* and the Mexican commercial tuna purse seine *Convemar* embarked upon a cooperative research effort directed toward developing a better understanding of the tuna-dolphin associations characteristic of this area. The primary goal of the research program was to collect information that will aid in developing methods of catching large yellowfin tuna in the eastern tropical Pacific Ocean without endangering the dolphins that often occur in association with these fish. Project objectives included the capture, tagging, and simultaneous tracking of spotted dolphins and yellowfin tuna. This was a cooperative study conducted by the Inter-American Tropical Tuna Commission (IATTC), NMFS, the University of Hawaii, the Tuna-Dolphin Program (Programa Nacional para el Aprovechamiento del Atún y Protección de los Delfines, or PNAAPD) of Mexico and the National Institute of Fisheries (Instituto Nacional de Pesca, or INP) of Mexico.

To study the relationship between yellowfin tuna and spotted dolphin, IATTC Chief Scientist Michael Scott proposed simultaneously radio tracking dolphins and sonic tracking yellowfin tuna from the same aggregation. Both tuna and dolphin tags were equipped with pressure-sensing devices which would transmit (tuna) or store (dolphin) dive data and permit analyses of their vertical distribution. The value of the data collected by this approach is twofold. First, understanding tuna and dolphin movements and interactions in conjunction with food habit studies which are under way at NMFS and IATTC should help to establish the dynamics and duration of the tuna-dolphin bond and the degree to which it is food based. Second, from a management perspective, it may be possible to determine if the bond weakens at

particular times, which may make the tuna catchable using dolphin-safe fishing methods.

The 1,200-gross ton, Mexican-flagged tuna purse seine vessel *Convemar* was contracted for 30 days of fishing. The primary function of the *Convemar* was to support the simultaneous tuna-dolphin tracking study by locating, capturing, tagging, and releasing spotted dolphins and yellowfin tuna for subsequent tracking by *McArthur* and its tracking launches.

Eighteen sets were made on dolphins during the 30-day Dolphin-Safe research cruise. Five spotted dolphins were captured and tagged with radio transmitter packages; all five were successfully tracked. The radio transmitter packages attached to four of the tagged dolphins were integrated with time-depth-recorder (TDR) units. The TDRs measured and stored the depth of tagged dolphins every 10 seconds and the ambient sea temperature every minute. One of the tagged dolphins was outfitted with a standard radio transmitter package. In order to download data from the TDRs, it was necessary to recapture tagged dolphins and remove the radio tags from the dorsal fins. Three of the four TDR packages were recovered from recaptured dolphins. One of the TDR-tagged dolphins evaded sets on three occasions before it was recaptured on the final set of the trip. This animal will furnish researchers with data on diurnal dive patterns as well as chase behavior. The dive data downloaded from the TDRs ranged from 18 hours to over 4 days in duration.

A total of six yellowfin tuna were tagged during the research cruise. Three of the tagged tunas were tracked successfully. Two of the tagged tunas were released simultaneously with the dolphin school during backdown procedure and one tagged tuna was released after the backdown procedure by releasing the end of the net. Each of the yellowfin tuna that was tracked was outfitted with 60-KHz sonic transmitters that broadcasted direction and dive data in real time to the tuna tracking team's tracking equipment. The three tuna tracks were 49, 1, and 8 hours in duration. *(W. Armstrong, [619] 546-5616)*

Population Status Estimated for Northeastern Offshore Spotted and Eastern Spinner Dolphins

Since 1959, dolphins have been killed in the tuna purse seine fishery in the eastern tropical Pacific, with the majority being either from the northeastern stock of spotted dolphin, or from the eastern stock of spinner dolphin. In a recent paper, National Research Council Fellow Paul Wade used data from five NMFS research vessel surveys completed from 1986-90 to calculate the current abundance of each stock. The calculations resulted in current estimates of 730,900 for the northeastern spotted and 631,800 for the eastern spinner. The population status of both stocks was assessed in 1993 by back calculating initial population size in 1959 from these current estimates of abundance. The eastern spinner dolphin was estimated to be at 44 percent of its level in 1959 while the northeastern spotted dolphin was found to be at 22 percent of its level that year.

Both stocks are currently significantly below the maximum net productivity level, indicating that they are both depleted as defined by the MMPA. To improve upon the back-calculation technique, in 1993 Wade later developed a new method using Bayesian statistics to simultaneously estimate the rate of increase of a dolphin population and its initial population size by fitting a population model to available time-series-of-abundance data. This analysis resulted in an estimated rate of increase of 2.2 percent annually for the eastern spinner dolphin, with the current population level estimated to be at 23 percent of its initial population size in 1959. For the northeastern offshore spotted dolphin, the annual rate of increase was 3.8 percent, which was 27 percent of its 1959 population size. The eastern spinner and northeastern offshore spotted dolphins were formally listed as depleted by NMFS in 1993. *(P. Wade, [619] 546-7097)*

PODS93 Survey Completed

In November 1993, the NOAA research vessels *McArthur* and *David Starr Jordan* completed a 3-month survey of the area inhabited by the northern stock of the common dolphin. This year's

survey, referred to as PODS93 (Population of *Delphinus* Stocks 1993), was a cooperative study between Southwest Fisheries Science Center (SWFSC) and SEPESCA (the Mexican Secretaria de Pesca) and CICIMAR (Mexico's Centro Interdisciplinario de Ciencias Marinas - La Paz). The primary objective of this year's project was to survey the ocean area inhabited by the short and long-beaked forms of the northern stock of common dolphin and make estimates of their absolute abundance. These data are used to assess the impact of dolphins killed incidental to fishing operations in California waters and international yellowfin tuna commercial fishing operations in the eastern tropical Pacific (ETP). Other objectives included collecting physical, biological, and oceanographic data regarding the habitat of marine mammals to better understand their distribution.

Information provided by the 1993 survey will be useful in determining the status of the two forms of the northern stock of common dolphin relative to their optimum sustainable population level. These absolute abundance estimates are important because information obtained from tuna vessel observer data indicate that over the last 10 years, there has been a significant decline in the relative abundance of northern common dolphins in the ETP. Summaries of the various aspects of the survey follow:

Marine Mammal Survey Overview-- The survey area extended along the west coast of North America from Cabo Corrientes, Mexico, to the California-Oregon border, covering approximately 606,700 square miles and extending about 300 nautical miles offshore.

On each vessel, surveys were conducted by maintaining a visual watch during daylight hours using 25-power binoculars mounted to the ship's flying bridge, with a maximum ship-to-horizon sighting distance of approximately 6 nautical miles. Generally, all schools encountered within 3 nautical miles were approached to confirm identification and obtain school size estimates. An event-driven data acquisition system (CRUISE2) was employed to record all environmental parameters and sighting information.

Each observer made an independent estimate of school size and species composition for each sighting. Marine mammal observers aboard *David Starr Jordan* recorded a total of 1,072 sightings, of which 780 were "on effort." Observers aboard *McArthur* recorded a total of 632 sightings, of which 506 were "on effort." The "on effort" sightings will be used to calculate final abundance estimates. Collected data will be analyzed using line-transect methods to produce abundance estimates for common dolphins and other species. These results will be submitted to the Scientific Committee of the International Whaling Commission during their annual meeting in May.

Southwest Fisheries Science Center (SWFSC) scientists also collected data that will aid in defining marine mammal stock boundaries. To complement the aerial photogrammetry (see below), shipboard photographs were taken to document dolphin body morphology and color patterns, which for example, are known to vary between onshore and offshore animals. Eighteen different species of cetaceans were photographed.

These photographic methods provide a detailed, noninvasive examination of vital population parameters such as survival rates, reproductive rates, calving intervals, and age at first reproduction. Photo identification has proven to be a versatile and powerful technique for addressing a wide variety of management-related issues such as movement, stock identity, and abundance. This year's effort, in conjunction with the ship and aerial surveys, and the genetic inquiries (see below), will allow the SWFSC an unprecedented assessment of cetaceans off the coast of Mexico and California. For more detail, see SWFSC Technical Memorandum 185. *(T. Gerrodette, [619] 546-7131)*

Marine Mammal Photogrammetry Activities-- Helicopter operations were conducted from *David Starr Jordan* to obtain dolphin school photographs for calibration of observer sightings, cetacean length-frequency analysis, and assessment of pinniped island colonies. Estimates of cetacean school size made by observers aboard both vessels will be calibrated against counts from aerial photographs. This reveals, and allows correction for, tendencies to over- or underestimate school size,

thus providing more accurate estimates of dolphin population size. During the 1993 survey, 203 dolphin schools were photographed, and of these, 47 were suitable for school size calibration. Because photographs are taken vertically and with such high resolution, lengths of dolphins and whales can be accurately determined. Measurements from the aerial photographs will be used to identify possible differences in average body size among common dolphin stocks. *(W. Perryman, [619] 546-7014)*

Biopsy Tissue Samples Collected for Genetic Analysis-- SWFSC scientists also collected skin biopsy samples to aid in defining the structure and boundaries of cetacean stocks. Samples were taken from dolphins that approached the vessel to ride the bow wave. A scientist stationed at the bow of the vessel used a crossbow, firing a bolt with a small, hollow tip and then retrieving the line to obtain a tiny piece of tissue from the back of each animal. In general, the procedure did not cause the animals to halt their bow ride. During the PODS93 survey, 41 tissue samples were collected from 5 different species by scientists on board *David Starr Jordan*, and 29 tissue samples were collected from 8 different species by scientists on board *McArthur*.

The tissues will be analyzed for genetic differences using a standard, well-established DNA procedure. Briefly, the procedure first involves extraction of the total cell component of DNA (nuclear and extra-nuclear) from the tissue. The DNA segment desired for analysis (approximately 500 base pairs) is isolated and amplified to high concentrations using the polymerase chain reaction (PCR), a rather extraordinary procedure considering that the ratio of desired DNA to the rest of the DNA is less than 1 in 10,000. The amplified segment is analyzed to determine the sequence of nucleotide bases (abbreviated A, C, G, or T) that constitutes the genetic signature of the particular animal. The animals' sequences are then analyzed using computer programs that determine the degree of relatedness between individuals. Besides revealing existence of reproductively isolated populations (stocks) and evolutionary lineages, recently developed methodologies allow estimation of gene flow between lineages and average dispersal distances per generation. *(A. Dizon, [619] 546-7089)*

Dolphin-Safe Program's FAD Projects Reviewed, 1991-1994

The Inter-American Tropical Tuna Commission (IATTC) and NMFS since 1991 have been cooperating on joint research projects to explore mechanisms of attracting mature tuna to FADs (fish aggregating devices) in sufficient quantities that fishing activity on tuna in association with dolphins can be decreased. Although the precise mechanisms involved in the attraction of fish to floating objects are unknown, this behavior occurs with sufficient regularity to justify research efforts that explore the use of FADs to enhance dolphin-safe fishing efforts in the eastern tropical Pacific ocean (ETP). This report briefly summarizes the research to date.

PAST ACTIVITIES: 1990-1992

Sea kites were provided in 1990 to captains of several purse seine vessels who volunteered to construct and deploy subsurface arrays for their drifting FADs. Sea kites are pyramidal structures, measuring 6 feet on a side, and are constructed with a fiberglass pole frame and yellow "rip-stop" nylon. A number of kites were attached at regular intervals to a weighted monofilament mainline suspended in the water from the surface buoy. Seven FADs with NMFS' sea kite arrays were deployed, and they remained in the water from 2 hours to 19 days. Observations of accumulations of forage fish, barnacles, and crabs were reported, but no tuna were observed and no sets were made on these FADs.

In January of 1991, two identical, satellite-trackable FADs were deployed by two purse seine vessels. These FADs were deployed to test the durability of the surface buoys and electronic components, and the practicality of tracking FADs by satellite to provide more-or-less continuous position information to fishing vessels. Positions and estimations of drift transmitted to vessels searching for the FADs were fairly accurate and sightings of the FADs by NMFS observers indicated that the surface buoys were in good condition.

Positions of low profile, wave- and wind-resistant drifting oceanographic buoys (drifting FADs) were provided by Don Hansen of Atlantic Oceanic and Meteorologic Laboratory, Miami, Florida, to Southwest Fisheries Science Center (SWFSC) at La Jolla, California, via OMNET twice each week from March 21, 1991, through October 5, 1992. These data were transmitted to interested purse seine skippers and owners on a weekly basis. Three sets were made on drifting buoys and significant quantities of tuna were caught. The ability of anchored oceanographic buoys to attract fish has been noted by personal observations of NMFS observers and purse seine fishermen, but these buoys are not actively promoted as FADs by the Dolphin-Safe program as fishing near or around these structures could damage them.

In late July 1991 NMFS, Bumblebee Seafoods Inc., and the IATTC deployed 30 FADs constructed of 10 different designs and equipped with various tracking and locating devices. The design of the surface buoys ranged from surface units only to surface units with arrays descending to 100 meters in depth. FADs were deployed in 10 groups, each group consisting of three identical FADs. One FAD in each group was equipped with a satellite transmitter that transmitted positions through the ARGOS satellite system. The other two were equipped with selective-calling (SELCALL), medium-wave radio buoys which operate only when activated by a vessel's signal generator. The satellite transmitters provided positions that were accurate to within a kilometer or less and position data could be accessed daily through Service ARGOS satellite system. SELCALL radio buoys can be interrogated by vessels at distances up to 200 kilometers.

These FADs were deployed 1,000 miles offshore of Mexico in an area from 9° to 11° N and between 121° and 124° W. This area and the region to the west where the FADs were expected to drift are the traditional fishing grounds for large yellowfin tuna caught in association with dolphins. IATTC's historical data also indicated that adjacent areas, although not especially rich in natural logs, had produced larger-than-average yellowfin for log sets.

All FADs were launched within a 24-hour period in roughly a 2° x 3° area. The deployment around the 10° N latitude appears to have overlapped the north equatorial countercurrent and the north equatorial current, as several of the FADs drifted in a northwesterly direction while others, positioned a short distance away, drifted to the southeast. Those drifting to the northwest eventually turned to the west. Those drifting to the southeast circled around to the northeast and then to the west as they encountered a westerly current near 12° N latitude. FADs were tracked for several months by NMFS and IATTC staff at the SWFSC in La Jolla, California, and daily positions were provided to vessel managers and IATTC field offices throughout Latin America.

The first failure of a satellite transmitter was recorded on November 6, 1991, 106 days after deployment, and was followed by the failure of a second satellite transmitter on November 8, 1991. The last positions obtained for the eight remaining satellite-equipped FADs were received from Service ARGOS Inc. on April 20, 1993, and indicated a continued westward movement well outside the fishing grounds. IATTC ceased providing weekly positions to their field offices on September 28, 1992, because all the remaining groups of FADs were well west of the fishing grounds. A Spar-type, SELCALL radio-equipped FAD was recovered by a fisherman from the Province of Southern Leyte in the Republic of the Philippines in May 1993. Technicians from the Fisheries Research Division of the Bureau of Fisheries and Aquatic Resources, Manila, Philippines, retrieved the device and contacted the IATTC.

CURRENT ACTIVITIES: 1993-1994

Dolphin-Safe Questionnaire-- Dolphin-Safe Research Program personnel created a questionnaire for tuna fishermen to solicit advice, stimulate suggestions, and offer critiques of existing and proposed methods to catch mature yellowfin tuna without encircling dolphins. The questionnaires will provide information about the types of support NMFS/IATTC could provide fishermen in terms of equipment, gear research projects, and data. Questionnaires were distributed at the IATTC Organizational Meeting of the Scientific Advisory

Board in San Diego during April 1993, and several have been mailed to owners and skippers in the U.S. fleet. Currently, two U.S. purse seine captains are participating in studies on anchored or drifting FADs.

Anchored FADs-- In December 1992, a U.S. tuna fleet skipper (Skipper-A) contacted the Dolphin-Safe Program and expressed interest in procuring materials to construct and deploy anchored FADs in waters 280-1000 meters deep offshore Costa Rica. The vessel owners provided materials to construct surface buoys and anchors, and NMFS supplied mooring line in November 1993. Skipper-A will construct at least five anchored FADs to be deployed in 1994. He will assemble anchored FADs using one or both of the following designs: (1) He will build multichambered metal surface buoys with a truck tire affixed to the bottom of each buoy. Several loops of steel cable will be threaded through the middle of the tire, and this cable will then be spliced and clamped to 100 meters of steel cable attached to a large swivel. Mooring line joined to the swivel will lead to the bottom and be connected to a large swivel coupled to the anchor's bridle. Anchors will be constructed of two 55-gallon drums filled with concrete. (2) The alternative design will incorporate all features of the previous model, plus a detachable buoy equipped with a generator and lights. Several hours before sunrise this buoy will be disconnected from the anchored surface buoy and towed away by a speedboat so that a set can be made away from the mooring. A logbook has been furnished to Skipper-A and NMFS will receive data on the design, construction, deployment, visits, sets, and catch on the anchored FADs.

Drifting FADs-- The Dolphin-Safe program purchased five Ryokuseisha[1] SELCALL radio buoys during June 1993 and loaned them to a second U.S. fleet skipper (Skipper-B) in exchange for information about construction, deployment, visits, and sets on drifting FADs assembled during his "dolphin-safe" fishing trips. Skipper-B constructs drifting FADs out of surplus materials found aboard the ship, including old net webbing, used corkline, balloon floats, scrap lumber, and wooden crates and pallets. He incorporates "seasoned" flotsam found at sea into the structure, which includes logs, driftwood, dead whales, and abandoned or discarded fishing gear such as longline floats, tangled gillnets, plywood, and floating line.

A general FAD design used frequently by Skipper-B utilizes two 4-meter-long two-by-fours tied together with net twine. Used corks are tied to the top of the boards. Net webbing, approximately 4 meters wide and 12 meters deep, is connected to the bottom of the two-by-fours. This design creates a curtain that can be rolled up for storage aboard the vessel, which simplifies deployment. A plastic, 55-gallon drum filled with discarded fish is connected to one end of the two-by-fours and a radio buoy is attached to this bait bucket with 20 meters of line. FADs are deployed as a group in areas where signs of tuna are detected. The radio buoys' signals can be activated from the seiner's helicopter, located, and the FADs checked for tuna.

Skipper-B is documenting the FADs he has used and is explaining how, where, and when they were constructed, deployed, and fished in a logbook provided to him by the Dolphin-Safe program. He has deployed 20 FADs during two separate fishing trips. On the first trip, five sets were made on FADs yielding a total of 27.5 tons of market-sized tuna (predominately bigeye tuna and a few tons of yellowfin and skipjack tuna). Fishing on FADs during this trip was not as successful as was hoped. During the second trip, an excess of 600 tons of market-sized bigeye, skipjack, and yellowfin was produced from eight sets. The first seven sets averaged 20-30 tons per set. At the time of the last set, 156 tons were needed to fill the ship's fish wells. This set proved to be exceptional. The skipper estimated that there were about 400 tons of tuna associated with this particular FAD and, in fact, he captured so much fish that it was necessary to cut the rings in order to release the excess 150-200 tons of live fish prior to brailing (hauling fish aboard using a dip net). These data illustrate the variability of FAD productivity over a relatively short period of time (3-4 months). He has volunteered to furnish detailed

[1]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

information on all the FADs deployed during his trips and not just the FADs attached to NMFS radio buoys. One of the key disappointments realized during previous NMFS/IATTC FAD research projects was the lack of visits to FADs by tuna purse seine vessels. Since Skipper-B is deploying FADs with NMFS radio buoys in conjunction with his own gear, program scientists believe he will visit the NMFS FADs on a regular basis.

The Dolphin-Safe program has proposed deployment of two anchored FADs in an area where large yellowfin tuna are known to occur to determine if pelagic, anchored FADs are capable of attracting large yellowfin, bigeye, and skipjack tuna in economically attractive quantities. The cost to construct and deploy such anchored FADs on the high seas would range from $1,000 to several thousand dollars per unit. The wide range in cost estimates is influencing the design and quality of materials used to construct various components of the anchored FADs, which await funding for construction and deployment. *(E. Edwards, [619] 546-7099)*

Consumption of Prey Studied for Eastern Tropical Pacific Spotted Dolphins and Yellowfin Tuna

Fishery Biologist Kelly Peltier and Wildlife Biologist Susan Chivers of the Population Identity Program, in collaboration with Lisa Roberts of Humboldt State University, have been analyzing the results from two independent studies and comparing the prey species consumed by spotted dolphin and yellowfin tuna from the eastern tropical Pacific.

Stomach contents were available for only one set, collected in 1985, in which both spotted dolphin and yellowfin tuna were sampled simultaneously. The remainder of the samples were collected from yellowfin tuna between 1970 and 1972, and from spotted dolphin sampled by observers on tuna purse seine vessels between 1989 and 1991. The cephalopod mandibles (beaks) and fish otoliths recovered from the stomachs of these two species were used to identify the fishes and cephalopods consumed. Beaks from 38 cephalopod taxa were found in the spotted dolphin stomachs (n=428) and 25 different taxa were found in the yellowfin tuna stomachs (n=760). The most frequently occurring cephalopod taxa differed in the spotted dolphin and the yellowfin tuna contents. For the spotted dolphin, the most frequently occurring cephalopods were squids of the family Ommastrephidae, whereas for the yellowfin tuna, they were the surface-dwelling argonauts, family Argonautidae.

Fishes have been identified from the samples, but as yet from only a subset of spotted dolphin stomachs. The most frequently occurring fishes identified to date have been members of the family Myctophidae.

Stratification of the yellowfin tuna by area and the spotted dolphin data by management unit (stock) indicate that the species composition of the prey changes seasonally and geographically.

Peltier and Chivers further stratified the data from the spotted dolphin sample to look for changes in stomach fullness with time-of-day as supporting evidence for the theory that spotted dolphins feed at night. There was a significant difference in stomach fullness between dawn and dusk; stomachs collected in the morning generally contained fresh prey items, and those collected in the late afternoon were empty of fresh prey remains. The most predominantly occurring squid found in the dolphin stomachs (Ommastrephidae) are known to occur primarily in the deep scattering layer that comes to the surface at night. Peltier and Chivers also tested the hypothesis put forward in the published literature that the proportion of squid in the diet of pregnant female spotted dolphins is significantly greater than for lactating females. Based on their analyses, the proportion of beaks recovered from the stomachs of lactating or pregnant females was significantly different, but it was the lactating females that show a greater proportion of squid consumed. *(S. Chivers, [619] 546-7093)*

V. OTHER TUNA-RELATED RESEARCH AT SWFSC

Tuna Movement Model Developed

Movement is a natural phenomenon of great importance in the lives of many fish species, but this phenomenon has been largely neglected in stock assessment models. Tuna are no exception. Much of Fishery Biologist Pierre Kleiber's research is devoted to making tuna movement models for the twofold purpose of measuring parameters of movement by fitting the models to data and incorporating movement information into tuna stock assessments.

One of the problems Kleiber has encountered in developing movement models of tuna is the high rate of movement in relation to the temporal and spatial scales that he is dealing with. To implement such models on a computer, it is necessary to divide time and space into descrete increments. In a recently developed model, he investigated an alternative algorithm for simulating movement in two spatial dimensions, using the variables of harvest and death rates of tagged tuna. The algorithm was part of a model that had been developed to study skipjack movement in relation to fish aggregating devices by analyzing tag return data from skipjack tagged and released in the Solomon Islands.

Kleiber explained that the algorithm previously used in the model is satisfactory as long as the movement rate is moderate in relation to the temporal and spatial scales of the model but can be unstable (can generate negative fish) at higher movement rates. However, the alternative algorithm used by Kleiber holds the promise of improved stability (thus allowing higher movement rates) with the prospect of no significant sacrifice in computational speed. Stability and computation speed are both important when the model is embedded in an iterative parameter estimation scheme.

Kleiber reports that preliminary results are positive. The alternate algorithm is stable with order-of-magnitude higher movement rates than heretofore used in the model. Computation speed is somewhat slower than with the old algorithm, but some code optimization should increase the speed considerably. *(P. Kleiber, [619] 546-7076)*

Generalized Additive Model Analyzes Catch-and-effort Data

Fishery Biologists Norm Bartoo and Pierre Kleiber presented the results of a generalized additive model (GAM) analysis of catch-and-effort data from the U.S. North Pacific troll fleet at a biannual albacore workshop held at Southwest Fisheries Science Center in December 1993. The workshop was attended by albacore scientists from Japan, Korea, Taiwan, Canada, and the United States. Data used in the analysis span the years 1961 to the present.

GAM analyses are used to explore the statistical effects of arbitrary nonlinear transformations of independent variables on a dependent variable. For instance, catch-per-unit effort (CPUE) can depend on various factors in a lonlinear way. Wind may enhance CPUE up to a certain point, after which time the weather becomes too rough for fishing gear to operate. Thus, a nonlinear relationship between wind and CPUE is produced.

In their model, Bartoo and Kleiber searched for the optimum transformation for each independent variable. The dependent variable selected for the analysis was the log of the CPUE in spatio-temporal strata (1- or 2-degree squares and monthly time intervals) with 0.1 added to account for instances of zero catch. Various independent variables were evaluated, the main one being time, to generate a time series of CPUE with the effects of various other independent variables removed. Additional independent variables included latitude, distance from the North American west coast, and Southern Oscillation Index Index (SOII), which is related to El Niño events. The latter was dubbed an index of an index because it is the melding of two time

series, neither of which covers the whole span of years of the fishery data.

The subplots were the fitted nonlinear effects of the four independent variables. The vertical scales were the same so that the relative importance of the effects could be judged from the plots. Latitude appeared to have the strongest effect, which is confirmed by the chi-square measures of contributions of the various effects on the dependent variable. All effects were statistically significant ($P < .01$), but the magnitude of the SOII effect was substantially less than the others. The declining trend of CPUE with time is not a good sign if CPUE, with effects of variables other than time removed, is interpreted as an index of abundance, but Bartoo and Kleiber added that such an interpretation was not warranted at this time because results were preliminary. A better index of El Niño, covering the years of the fishery data, is needed to replace the SOII, and additional independent variates (such as upwelling index) need to be explored. Such changes could modify the trend in the effect of time seen in this analysis. *(N. Bartoo, [619] 546-7073; P. Kleiber, [619] 546-7076)*

Visiting Scientist Discusses Shark Research and Acoustic Tagging Methodology

A. Peter Klimley of the Bodega Marine Laboratory, University of California at Davis, visited the Honolulu Laboratory in March 1993 and presented two seminars on his shark research. Interest in sharks is high in Hawaii because of recent problems with tiger sharks, and Honolulu staff researchers are particularly interested in Klimley's work with archival tags for use in monitoring behavior of large Pelagic fishes.

Part of the shark research reported by Klimley involved concerned movement patterns in scalloped hammerhead sharks. He described a system of individually coded acoustic tags and moored receivers that automatically record the behavior of sharks around a seamount where hammerheads tend to aggregate at certain times of day. Arrivals and departures of many identified individuals were tracked to show coordinated behavior. The paths taken by sharks to and from the seamount were also tracked, and Klimley's analysis suggests that hammerhead sharks use contours of magnetic field topography for guidance.

Klimley has proposed using moored receivers and acoustic tags to record residence time, departure, and return of tuna to fish aggregating devices in Hawaii. Honolulu Laboratory personnel discussed development of archival tags with Klimley, who has received funding to further develop this technology. Current archival tags store information such as depth, temperature, and light intensity. Light intensity data are used to estimate local noon and day length to provide a sequence of low-resolution geographic position (a track line) when an animal ranges over a very broad area (hundreds of miles). Existing archival tag technology requires physical recovery of the tag to retrieve the data. Klimley hopes to adapt his acoustic tag and moored receiver system for use with an advanced archival tag that would acoustically download stored data whenever a tagged animal comes near a receiver. He also hopes to improve archival tag position estimation through incorporation of extinction coefficients (to quantify signal attenuation versus distance from source in the onboard microprocessing) and through use of magnetic sensors. *(C. Boggs, [808] 943-1222)*

VI. SWFSC PUBLICATIONS ON TUNA AND TUNA-RELATED SUBJECTS

Published

Balazs, G. H. 1993. Appendix A: Annotated list of shark attacks in the Hawaiian Islands, 1779-1993. *In* Borg, J., Tigers of the sea: Hawaii's deadly sharks, p. 63-83. Mutual Publishing, Honolulu, HI.

Bartoo, N., and D. Holts. 1993. Estimated drift gillnet selectivity for albacore, *Thunnus alalunga*. Fish. Bull., U.S. 91(2):371-378.

Bartoo, N., D. Holts, and C. Brown. 1993. Evidence of interactions between high-seas driftnet fisheries and the North American troll fishery for albacore. Bulletin 53 (II)—North Pacific Commission 53:367-380.

Boggs, C. H. 1992. Depth, capture time, and hooked longevity of longline-caught pelagic fish: timing bites of fish with chips. Fish. Bull., U.S. 90(4):642-658.

Brill, R. W., and D. B. Holts. 1993. Effects of entanglement and escape from high-seas driftnets on rates of natural mortality of North Pacific albacore, *Thunnus alalunga*. Fish. Bull., U.S. 91(4):798-803.

Cailliet, G. M., D. B. Holts, and D. Bedford. 1993. A review of the commercial fisheries for sharks on the west coast of the United States. *In* Pepperell, J., J. West, and P. Woon (eds.), Shark Conservation, p. 13-29. Proceedings of an International Workshop on the Conservation of Elasmobranchs held at Taronga Zoo, Sydney, Australia, February 24, 1991.

Carretta, J. V., and K. A. Forney. 1993. Report of the aerial surveys for marine mammals in California coastal waters utilizing a NOAA DeHavilland Twin Otter Aircraft March 9-April 7, 1991, February 8-April 6, 1992. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-185, 92 p.

DiNardo, G. T. 1993. Statistical guidelines for a pilot observer program to estimate turtle takes in the Hawaii longline fishery. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-190, 40 p.

Edwards, E. F. 1992. Energetics of associated tunas and dolphins in the eastern tropical Pacific Ocean: a basis for the bond. Fish. Bull., U.S. 90(4):678-690.

Hanan, D. A., D. B. Holts, and A. L. Coan, Jr. 1993. The California drift gill net fishery for sharks and swordfish, 1981-82 through 1990-91. Calif. Dept. Fish and Game, Fish Bull. 175, 95 p.

Holts, D., and D. W. Bedford. 1993. Horizontal and vertical movements of the shortfin mako shark, *Isurus oxyrinchus*, in the southern California Bight. Aust. J. Mar. Freshwater Res. 44:901-909.

Jackson, A. R. 1993. Summary of 1989 U.S. tuna-dolphin observer data. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-183, 31 p.

Jones, D. R., R. W. Brill, and P. G. Bushnell. 1993. Ventricular and arterial dynamics of anaesthetised and swimming tuna. J. exp. Biol. 182:97-112.

MacCall, A. D. 1993. Overview paper: Advice for stock rebuilding. *In* Rosenberg, A. (ed.), Defining overfishing—defining stock rebuilding. Report of the Second Annual National Stock Assessment Workshop, p. 47-59. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-F/SPO-8.

Skillman, R. A., C. H. Boggs, and S. G. Pooley. 1993. Fishery interaction between the tuna longline and other pelagic fisheries in Hawaii. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-189, 46 p.

Wetherall, J. A., G. H. Balazs, R. A. Tokunaga, and M. Y. Y. Yong. 1993. Bycatch of Marine Turtles in North Pacific high-seas driftnet fisheries and impacts on the stocks. Bulletin 53 (II)—North Pacific Commission 53:519-538.

Wetherall, J. A., and M. Y. Y. Yong. 1993. A comparison of driftnet fishery bycatch estimation methods based on empirical bootstrap distributions. Bulletin 53 (II)—North Pacific Commission 53:359-365.

Approved by Science and Research Director, SWR

Boehlert, G. W., and B. C. Mundy. 1993. Vertical and onshore-offshore distributional patterns of tuna larvae in relation to physical habitat features. For consideration for publication in Marine Ecology Progress Series.

Dewar, H., J. B. Graham, and R. W. Brill. Studies of tropical tuna swimming performance in a large water tunnel II: thermoregulation. For consideration for publication in Journal of Experimental Biology.

Perrin, W. F. Tuna/dolphin: areas and species, fishing history. For consideration for publication in proceedings of UC MEXUS volume "Current crises in marine mammal management, U.S.-Mexican perspectives."

Perryman, W. L., and M. S. Lynn. Examination of stock and school structure of striped dolphin, *Stenella coeruleoalba*, in the eastern Pacific from aerial photogrammetry. For consideration for publication in Fishery Bulletin, U.S.

Polovina, J. J., and B. B. Lau. Temporal and spatial distribution of catches of tiger sharks, *Galeocerdo cuvier*, in the pelagic longline fishery around the Hawaiian Islands. For consideration for publication in Marine Fisheries Review.

Uchiyama, J. H., R. A. Skillman, and J. D. Sampaga. Age, growth rates, and hatch dates of larval dolphins (Corphaenidae) from Hawaiian waters. For consideration for publication in Fishery Bulletin, U.S.

Administrative Reports

Armstrong, W. 1993. Field notes recorded by NMFS field party leader during dolphin-safe charter aboard the F/V *Nicole K* - November 4, 1992 - December 7, 1992. SWFSC Admin. Rep., La Jolla, LJ-93-16, 95 p.

Dollar, R. A. 1993. Annual report of the 1992 western Pacific longline fishery. SWFSC Admin. Rep., Honolulu, H-93-12, 25 p.

Rensink, G. M. 1993. Summary of the 1991-92 U.S. South Pacific albacore fishery data. SWFSC Admin. Rep., La Jolla, LJ-93-10, 20 p.

Rensink, G. M., and F. R. Miller. 1993. Summary of the 1992 North Pacific albacore fisheries data. SWFSC Admin. Rep., La Jolla, LJ-93-12, 29 p.

Squire, J. L., Jr., and A. F. Muhlia-Melo. 1993. Review of striped marlin, *Tetrapturus audax*; swordfish, *Xiphias gladius*; and sailfish, *Istiophorus platypterus*, fisheries and resource management by Mexico and the United States in the northeast Pacific Ocean. (English/Spanish) SWFSC Admin. Rep., La Jolla, LJ-93-06, 43 p.

Tillman, M. F. 1993. Director's Report to the 44th Tuna Conference on tuna and tuna-related activities at the Southwest Fisheries Science Center for the period May 1, 1992 to April 30, 1993. SWFSC Admin. Rep., La Jolla, LJ-93-05, 41 p.

Wade, P. 1993. Revised estimates of fisheries kill of dolphin stocks in the eastern tropical Pacific, 1959-1972. SWFSC Admin. Rep., La Jolla, LJ-93-17, 20 p.

———————. 1993. Population assessment of the northeastern stock of offshore spotted dolphin (*Stenella attenuata*). SWFSC Admin. Rep., La Jolla, LJ-93-18, 21 p.

Translations

Nakano, H., M. Makihara, and K. Shimazaki. 1985. Distribution and biological characteristics of the blue shark in the central North Pacific. Research Institute of North Pacific Fisheries, Faculty of Fisheries, Hokkaido University, Special Volume, No. 170. (Engl. transl. by W. G. Van Campen, 1993, 20 p., Transl. No. 149; available Honolulu Lab., Southwest Fish. Sci. Cent., Natl. Mar Fish. Serv., NOAA, 2570 Dole St., Honolulu, HI 96822-2396.)