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U.S. Fisheries and Research on Tuna and Tuna-Like Species in the North Pacific Ocean[1]

Southwest Fisheries Science Center
NOAA, National Marine Fisheries Service
La Jolla, California U.S.A.

and

Pacific Islands Fisheries Science Center
NOAA, National Marine Fisheries Service
Honolulu, Hawaii U.S.A.

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Introduction

Various U.S. fisheries harvest tuna and tuna-like species in the North Pacific. Large-scale purse seine, albacore troll, and longline fisheries operate both in coastal waters and on the high seas. Small-scale gill net, harpoon, and pole-and-line fisheries and commercial and recreational troll and handline fisheries usually operate in coastal waters. Overall, the range of U.S. fisheries in the Pacific is extensive, from coastal waters of North America to Guam and the Northern Mariana Islands in the western Pacific and from the equatorial region to the upper reaches of the North Pacific Transition Zone.

In U.S. Pacific fisheries for tunas and billfishes, fishery monitoring responsibilities are shared by the National Marine Fisheries Service (NMFS) and by partner fisheries agencies in the states of California, Oregon, Washington, Hawaii, and territories of American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands. On the federal side, monitoring is conducted by the by the Southwest Regional Office (SWRO) and the Southwest Fisheries Science Center (SWFSC) in California and the Pacific Islands Regional Office (PIRO) and the Pacific Islands Fisheries Science Center (PIFSC) in Hawaii. NMFS fishery monitoring activities include collection of landings and sales records at markets and ports of landing, federally-mandated logbook statistics on fishing effort and catch, observer data, and biological sampling data. In California, Washington, and Oregon, landings receipts are collected by state agencies and placed in the Pacific Fisheries Information Network (PacFIN) system. State agencies are also mandated to collect logbook data and have also collected size composition data. In the central and western Pacific, monitoring by partner agencies also involves market sampling and surveys of fishing activity and catch and is coordinated by the Western Pacific Fishery Information Network (WPacFIN), a federally funded program managed by the PIFSC[1]. The management of data on U.S. Pacific fisheries for tuna and tuna-like species is coordinated between the SWFSC, SWRO, PIFSC, and PIRO. Data catalogs, metadata, data summaries, reports, and related information are being assembled as part of a Web-based portal hosted at the SWFSC (still under construction).

[1] http://www/pifsc.noaa.gov/wpacfin/

This report provides information on the number of active vessels by fleet and their catches of tunas and billfishes in the North Pacific based on the data available through 2004, which are considered complete. Data for 2005 are incomplete and are still being assembled. However, in some cases provisional estimates are given for 2005. Although the report is focused on tunas and billfishes, many of the fisheries described catch other pelagic fishes important to the fishing fleets and local economies; catch data for these species are not included.

NMFS also conducts scientific research programs in support of marine resource conservation and management both domestically and internationally. These studies include stock assessments, biological and oceanographic studies, socio-economic analysis, and more. This report includes summaries of recent and ongoing scientific work at the PIFSC and SWFSC of relevance to the ISC.

Fisheries

Purse Seine

The U.S. purse seine fishery consists of two separate components, one that operates in the western - central Pacific Ocean (WCPO), and another that operates in the eastern tropical Pacific (ETP). The ETP purse seine fishery started in the mid 1900s and dominated the catch until 1993 when vessels moved to the WCPO in response to dolphin conservation measures in the ETP. The WCPO fishery operates mainly in areas between 10° N and 10° S latitude and 130° E and 150° W longitude and the ETP fishery in areas between 20° N and 20° S latitude and between the Central American coastline and 150° W longitude (Figure 1). The number of U.S. vessels participating in the U.S. purse seine fishery and fishing north of the equator decreased from a high of 85 in 1990 to 24 in 2004 (Table 1). Before 1995 the fleet fished mainly on free-swimming schools of tunas in the WCPO and on schools associated with dolphins in the ETP. During the last 5 years, fishing in both areas has been about equally distributed between free-swimming schools and schools associated with floating objects.

U.S. catches of tunas north of the Equator are shown in Table 2. Catches in the North Pacific, over the past five years (most of the catch is south of the equator), are primarily skipjack tuna (65%) with lesser quantities of yellowfin tuna (25%) and bigeye tuna (10%). Skipjack tuna catches peaked in 1992 at 71,174 t (metric tons) then generally decreased to 3,837 t in 2004. Yellowfin tuna catches decreased from a high of 64,375 t in 1990 to a low of 1,750 t in 2000 and then increased to 3,427 t in 2004. Preliminary estimates of the catches of skipjack and yellowfin tuna in 2005 are 17,471 t and 6,051 t, respectively.

In 2004, average sizes skipjack tuna caught in the ETP (52 cm fork length, FL) were slightly larger than those caught in WCPO (48 cm FL, Figures 2 and 3). The average size of yellowfin tuna caught in the ETP was 62 cm FL and in the WCPO, 63 cm FL. The average size bigeye tuna caught in the ETP was 57 cm FL and in the WCPO, 50 cm FL.

U.S. purse seine vessels fishing in the WCPO have been monitored by NMFS under the South Pacific Regional Tuna Treaty since 1988. Logbook and landings data are submitted as a requirement of the Treaty (coverage 100%). Landings are measured for fork length by PIRO

personnel as vessels land their catches in American Samoa (coverage approximately 1-2% of landings). Species composition samples are also taken and used to separate yellowfin tuna from bigeye tuna in the reported landings. The Forum Fisheries Agency (which manages the Treaty) places observers on approximately 20% of the vessel trips.

The IATTC monitors U.S. purse seine vessels fishing in the EPO. Logbooks (coverage 100%) are submitted by vessel operators, and landings (coverage 100%) are obtained from each vessel or from canneries or fish buyers. Fish are measured for fork length by port samplers (coverage unknown but probably less than 2% of the fish landed). IATTC observers are placed on all large purse seine vessels.

Longline

The U.S. longline fishery targeting tuna and tuna-like species in the North Pacific Ocean is made up of two components, the Hawaii-based fishery and the California-based fishery. Vessels transited between the two areas freely until 2000 when domestic regulations placed restrictions on moving between the two domestic management areas. The Hawaii-based component of the U.S. longline fishery comprises a majority of the vessels, fishing effort, and catch.

The Hawaii-based longline fishery started in the early 1900's targeting tunas in the coastal waters of Hawaii. The fishery continued to target tunas until the late 1980's, and the fishing grounds expanded into oceanic waters off Hawaii. The fishery continued its expansion in the late 1980's and early 1990's as new participants arrived from the Gulf of Mexico and the U.S. Atlantic seacoast. During this time, the fleet began exports of high quality bigeye tuna to Japan and also increased targeting of swordfish. Regulatory restrictions, due to interactions with endangered sea turtles, curtailed swordfish-directed effort in 2000 and 2001. Swordfish targeting was prohibited altogether in 2002 and 2003, after which the fishery targeted tunas exclusively. The Hawaii-based fishery for swordfish was reopened in 2004. The first complete year which the Hawaii-based longline fishery was allowed to target swordfish was in 2005

The California-based longline fishery began in 1991 and consists of vessels that also participated in the Hawaii-based fishery until 2000. The California-based fishery remained relatively small until Hawaii-based longline vessels that targeted swordfish prior to the prohibition elected to stay in California to continue targeting swordfish. The California-based longline fishery for swordfish was closed in 2004 and resulted in relocation of most of those vessels back to Hawaii.

The longline fishery extends from the U.S. West Coast 200 mile EEZ to 170° W longitude and from the Equator to 40° N latitude (Figure 4). The number of vessels participating in the longline fishery decreased from 141 in 1991 to a low of 100 vessels in 2002 (Table 1). Since then, the number of vessels has increased to 125 in 2004 and 124 in 2005. In Hawaii and California, swordfish are generally landed as trunks (headed, tailed, and gutted). Tunas and other bony fishes are usually landed whole. Sharks are landed headed and gutted.

Catch levels and catch species composition in the longline fishery changed considerably over the past years in response to fishery and regulatory changes. The majority of the catch is of tunas and billfishes and rose to over 10,000 t in 1993, 1999 and 2000 (Table 2). Bigeye tuna dominates the tuna catch and reached a high of over 4,000 t in 2002 and 2004. The 2005 bigeye tuna catch was 3,901 t. Swordfish dominates the billfish catch and reached a peak of 4,857 t in 2000 before decreasing to 860 t in 2004. The 2005 swordfish catch was 1,362 t.

The Hawaii-based longline fishery is monitored by the PIFSC and the State of Hawaii's Division of Aquatic Resources (DAR). PIFSC biologists collect mandatory logbooks of fishing effort, catch, and other information from longline fishers, generally at the docks in Honolulu. Logbook coverage is 100%. DAR also requires fish dealers to submit landings data and coverage is very close to 100%. Observers contracted by NMFS's Pacific Islands Regional Office are placed on longline vessels to monitor protected species interactions, vessel operations, catches and fish sizes. The coverage rate of the observer data is mandated by law to be no less than 20% for vessels targeting tunas, and 100% on vessels targeting swordfish.

California-based longline fishery is monitored by the SWFSC and the California Department of Fish and Game (CDFG). Landings are collected from 100% of the fleet by the CDFG. Logbooks, developed by the fishing industry (similar to the federal logbooks used in Hawaii), were submitted voluntarily to NMFS until 1994. From 1995 to 1999, CDFG collected logbooks from 100% of the fleet, and SWFSC has continued this collection since 1999. Landed swordfish were measured for fork length by CDFG port samplers until 1997. NMFS's Southwest Regional Office currently places observers on California longline vessels. The observers also collect length measurements.

Distant-waterTroll

The U.S. distant-water troll fishery for albacore in the North Pacific Ocean started in the early 1900's. The fishery operates in waters between the U.S. west coast and 160° E longitude (Figure 5). Fishing usually starts in May or June and ends in October or November. The number of vessels participating in the fishery ranged from a low of 179 in 1991 to a high of 1,121 in 1997 (Table 1). In 2004, 734 vessels participated in the fishery and a preliminary estimate of 630 vessels fished in 2005.

The troll fishery catches mainly albacore with incidental catches of skipjack, yellowfin and bluefin tunas, eastern Pacific bonito, yellowtail, and mahimahi. Since 1985, the albacore catch has ranged between 1,845 t in 1991 and 16,938 t in 1996 (Table 2). In 2004, 13,432 t were caught. The preliminary estimate of the 2005 catch is 8,411 t. Sampled albacore caught in 2004 ranged in fork length between 52 and 96 cm and averaged 68 cm (Figure 6).

U.S. troll vessels voluntarily submitted logbook records to the SWFSC until 1995 when those vessels fishing on the high-seas were required to submit logbooks. Starting in 2005, troll vessel logbook coverage is 100%. Logbook coverage rate in 2004 is approximately 40% of the landings. Landings are monitored by SWFSC and various state fisheries agencies through landing receipts and coverage is 100% of the fleet. Landings are also measured for fork length

by state agency port samplers along the U.S. west coast and by PIRO personnel in American Samoa. Coverage rate in 2004 is approximately 2% of the landings.

Pole-and-line

There are two components of the pole-and-line fishery, one that operates around the Hawaiian Islands and another that operates in waters along the U.S. west coast to areas off Central America and South America. The vessels usually target yellowfin tuna and skipjack tuna or albacore. The number of pole-and-line vessels operating north of the equator decreased from 13 in 1993 to 3 in 2004 (Table 1). Preliminary estimates of the number of vessels operating in 2005 are not available at this time. The highest yellowfin tuna catch north of the equator was 1,779 t, recorded in 1992. The highest skipjack tuna catch was 1,960 t in 1983 (Table 2). Pole-and-line catches of yellowfin and skipjack tunas were 18 t and 276 t respectively in 2004.

For the west coast pole-and-line fishery, logbook data are collected by the IATTC and SWFSC. Logbook coverage as of 2005 is 100%. Fork-length data for yellowfin and skipjack tunas are collected by the IATTC. Albacore fork-length data are collected by the SWFSC through a contract with state agencies of Oregon, Washington, and California. Coverage rates for length data are less than 1% of the landings. Landings data are collected by state agencies (coverage 100%).

Hawaii DAR monitors the Hawaii pole-and-line fishery using catch reports submitted by fishers and market reports submitted by fish dealers.

Troll and Handline

Troll fisheries operate in Guam and the Northern Mariana Islands and troll and handline fisheries operate in Hawaii. These fisheries catch tuna and tuna-like fish in the North Pacific. The vessels in these fisheries are relatively small (typically around 8 m in length) and make mainly day long trips fishing in coastal waters. The number of vessels ranged from 1,847 to 2,166 during 1990 to 2004. The operations range from recreational, subsistence, and part-time commercial to full-time commercial. Their catches generally are landed fresh and whole, although some catches are gilled and gutted.

The total catch from these troll and handline fisheries ranged from 1,163 t to 1,923 t during 1990-2004. Estimates of the 2005 catch are not available at this time. Yellowfin tuna made up about half of the troll and handline catch. The next largest components were blue marlin and skipjack tuna. Bigeye tuna and albacore represented small components of the catch. The Hawaii troll and handline fisheries typically account for almost 90% of the total U.S. troll and handline landings.

The Guam Division of Aquatic and Wildlife Resources (DAWR) monitors the troll fishery using a statistically designed creel survey. The Guam DAWR, with the assistance of PIFSC, extrapolates the creel survey data to produce total catch, fishing effort, and participation estimates. The Hawaii troll and handline fishery catch and effort summaries are compiled from

Hawaii DAR commercial catch reports and fish dealer reports. The Commonwealth of the Northern Mariana Islands monitors the troll fishery using their Commercial Purchase database.

Gill Net

The drift gill net fishery operates mainly in areas within the 200 mile EEZ of California and sometimes off Oregon (Figure 7). Tuna and tuna-like fishes are caught mainly by drift gill nets, with minor quantities caught incidentally in set gill nets. The number of vessels participating in the fishery decreased from 146 in 1990 to 33 in 2004 and 38 in 2005 (Table 1). Swordfish catches were 1,400 t in 1993 and have fluctuated while decreasing to 126 t in 2004 (Table 2). The preliminary 2005 swordfish catch estimate is 148 t.

Gill net fishery landings data (100% coverage) are collected by state agencies in California, Washington and Oregon (only minor amounts of tuna and tuna-like fishes are landed in Oregon or Washington). Logbook data for gill net fisheries are collected from 100% of the fleet by the CDFG. CDFG also collected length data for swordfish landings until 1997; less than 1% of the landings were sampled. NMFS places observers on gill net vessels and also collect length data.

Harpoon

The harpoon fishery operates in areas within the 200-mile EEZ of California between 32°N and 34°N latitude (Figure 8). The number of vessels participating in the fishery decreased from 49 in 1994 to 28 in 2004 and 25 in 2005 (Table 1). Swordfish is targeted and catches decreased from 169 t in 1993 to 47 t in 2004 (Table 1). The 2005 estimated swordfish catch is 50 t.

Landings and logbook data for the harpoon fishery are collected by the CDFG and coverage is 100% of the fleet. Length measurements were taken until 1997, covering less than 1% of swordfish landings.

Research

U.S. government research on tunas and tuna-like species of the North Pacific Ocean is shared between the SWFSC and PIFSC. Studies are largely carried out from laboratories in La Jolla, California for the SWFSC and in Honolulu, Hawaii for the PIFSC and in collaboration with scientists of other government or university laboratories, both in the U.S. and abroad. Both Centers have studies devoted to stock assessment, biological and oceanographic research, and fishery management issues, but each Center concentrates largely on different species and fisheries in order to minimize duplication. In this section, selected studies that are underway are described and recent results are provided.

Southwest Fisheries Science Center (SWFSC)

The Southwest Fisheries Science Center has a long history of research on stocks and fisheries for highly migratory species (HMS). During the past few years, the SWFSC has

focused increased resources on research of North Pacific HMS in order to address growing concerns about resource status and sustainability. Studies described in the following section are largely designed to address the growing concerns and are guided by NMFS strategic plan objectives of promoting resource stewardship and building sustainable fisheries.

Stock Assessment Studies − The SWFSC investment in stock assessment research is designed to deliver accurate information on stock status and for providing relevant advice for managers. During the past year, SWFSC scientists have been conducting assessment related research to support the goals of the ISC Albacore, Marlin, and Bluefin Working Groups.

Albacore

The SWFSC hosted the first meeting of the Albacore Working Group of the International Scientific Committee (ISC-AWG—formerly, the North Pacific Albacore Workshop) that was held in November/December 2005 in La Jolla, CA. Researchers from Japan, Taiwan, Canada, and the Inter-American Tropical Tuna Commission attended that meeting. The meeting addressed four broad areas of research: (1) improvement of stock assessments through critical review of input data and modeling platforms used in population analysis; (2) appropriate biological reference points for potential management of the stock; (3) research studies needed to improve knowledge of albacore biology; and (4) maintenance and improvement of the ISC-AWG data base catalog, which contains catch, length, and catch/effort information collected from the various international fleets that harvest the stock.

Scientists from the SWFSC presented papers that addressed various topics, including stock assessment modeling of the albacore population, issues surrounding the ISC-AWG's scientific information exchange and centralized data bases, ongoing development of fishery statistics applicable to the USA troll and longline fisheries, ongoing research regarding movement and distribution of juveniles based on archival tag deployments, and development of a Pacific Ocean-wide biological sampling program that would generate timely and accurate estimates of maturity. The SWFSC assessment team's efforts along all of these lines are continuing in preparation for the two ISC-AWG meetings scheduled later this year (July and November 2006).

Marlin

In 2005, marlin assessment research at the SWFSC focused on striped marlin in order to meet the ISC Marlin Working Group goal of completing a North Pacific striped marlin assessment in 2005. SWFSC scientists participated in two ISC Marlin Working Group meetings. Prior to and at the first meeting in September, 2005 the SWFSC team helped to prepare the data base of international landings, catch and effort and size frequency. At the meeting, the available data were reviewed, and potential modeling platforms were identified to be used for the assessments. The SWFSC took the lead in developing a fully integrated forward simulation model using Stock Synthesis 2. Results of the Working Group's assessment efforts will be presented at the 2006 ISC Plenary meeting.

Bluefin Tuna

In 2005, SWFSC scientists began assessment efforts on bluefin tuna. Prior to and during the ISC Bluefin Working Group meeting in early 2006, the SWFSC team worked closely with other members of the working group in developing an assessment database, deriving indices of abundance, and exploring alternative stock assessment models. In particular, SWFSC scientists took the lead in developing a fully integrated forward simulation model using Stock Synthesis 2. Much of this work is continuing in efforts to improve the bluefin stock assessment.

Biological and Oceanographic Research − The SWFSC conducts research on the biology of a tuna, billfishes and pelagic sharks. Projects range from behavior and movement of North Pacific albacore to food habits of sharks. A few of the projects are described below.

Albacore

- Since 1971, the SWFSC has had an ongoing partnership with the West-Coast based U.S. albacore fishing industry. Research is conducted in cooperation with the American Fishermen's Research Foundation (AFRF), a private foundation established by the Western Fishboat Owner's Association to promote research on albacore and related fish. Past projects have included exploratory fishing with simultaneous collection of oceanographic data, development of a standard logbook, research into the impact of high seas driftnetting, onboard and port sampling for size frequencies, and conventional tagging to study movements, growth, and longevity. Since 2001, SWFSC and AFRF have been conducting an archival tagging project to study migratory patterns, depth and temperature preferences of north Pacific albacore. The goal is to deploy 500 tags by the end of 2006. In 2005, 150 more tags were deployed, bringing the total to 427 tags deployed, and 5 more tags were recovered. The data demonstrate extensive movement and diurnal vertical excursions to beyond 200 m during daytime with fish remaining in the upper 50 m at night.

- The SWFSC is also collaborating with PIFSC scientists to better define albacore habitat in the north Pacific. Catches recorded in logbook data from the U.S. albacore troll fishery are being examined in relation to satellite derived images of oceanographic features on a fine scale resolution (sea surface temperature, chlorophyll and height).

Billfishes

- The SWFSC's Billfish Tagging Program began in 1963 and has provided tagging supplies to recreational billfish anglers for 43 continuous years. Tag release and recapture data are used to determine movement and migration patterns, species distribution, and age and growth patterns of billfish. This volunteer tagging program depends on the participation and cooperation of recreational anglers, sport fishing organizations, and commercial fishers. Since inception over 53,000 fish of 75 different species have been tagged and released. Emphasis continues to be on the skillful tagging of billfish and bluefin tuna only. The tagging of other sport fish is not encouraged by this program. Billfish Tagging Report cards received for 2004 indicate that a total of 1,047 billfish and 285 other fish were tagged and released by

761 anglers and 190 fishing captains. In all, 525 blue marlin, 149 striped marlin, 217 sailfish, 137 spearfish, 6 black marlin, and 9 unknown billfish were reported tagged and released in 2004.

- In 2002, National Marine Fisheries Service scientists from the SWFSC and SEFSC joined forces with the Presidential Challenge billfish tournament series conducted off the coasts of Central America and Mexico to establish the Adopt-A-Billfish satellite tagging program. The team deployed 41 satellite archival tags on sailfish in Mexico, Guatemala, Costa Rica and Panama. Results show that sailfish survive being caught and released when proper tagging protocols are followed. Three of the 41 tagged sailfish died, but only after being at liberty for 28, 63 and 70 days after being tagged. The data also showed significant movements across international boundaries from Mexico to Panama, highlighting the need for international management. Deployments ranged from 5 to 118 days and net movements ranged to 574 nmi. These sailfish spent up to 80% their time above 25 meters and rarely descended to depths greater than 100 meters. Over 75% of their time was in water 28° to 30° C. The program plans to expand sailfish satellite tagging operations into the mouth of the Sea of Cortez, Mexico in the summer of 2006.

- The SWFSC continued monitoring recreational billfish catch in the Pacific through the Billfish Angler Survey. Results for recreational fishing in 2004 were compiled in 2005 and published in the 2005 angler survey. In 2004, 761 billfish anglers reported catching 3,409 Pacific billfish during 4,988 fishing days. The mean CPUE for all billfish in the Pacific for 2004 was 0.66 which is lower than the record set in 2003 of 0.87, but above the latest five-year average of 0.62 (2000 - 2004). This was a new high five year average catch rate for the entire time series which extends back to 1969. CPUE times series were extended for each of the main species caught (Pacific blue marlin, striped marlin, Pacific sailfish, and black marlin) in the main fishing areas (Tahiti, Hawaii, Baja, southern California, central Mexico, Guatemala, Costa Rica, Panama, and Australia).

Pelagic Sharks

- A wide range of biological studies are conducted in conjunction with the abundance surveys for juvenile shortfin mako, blue and common thresher sharks. Some past and ongoing efforts include conventional tagging for movement information, biopsying for genetics studies, marking with oxytetracycline (OTC) for age and growth studies, blood sampling for condition factors caused by capture stress and/or injury, acoustic and satellite archival tagging for movement and physical habitat pattern descriptions, and a variety of physiological studies addressing cardiac function, swimming performance, and condition factors. During the 2005 surveys 121 blue, 90 shortfin mako and 14 common thresher sharks were caught. Eighty six sharks were tagged with conventional tags and OTC, and 84 DNA samples were collected. Satellite tags were deployed on 9 makos, 5 threshers, and 2 blue sharks.

- Since 1997, 502 makos have been injected with OTC, tagged, and released in the southern California Bight during scientific surveys. Thirty one of the OTC labeled

sharks have been recaptured, and vertebral samples were obtained from fourteen. Time at liberty ranged from 7 to 1594 days and the size of OTC-marked fish ranged from 81 to 189 cm FL at time of recapture. Preliminary analyses of the labeled vertebrae indicate the formation and deposition of two band pairs (opaque and semi-translucent) per year. In addition, growth during the time at liberty from these recovered fish, combined with recapture information from a larger scale conventional tagging effort, demonstrates average growth rates of 18 cm/year for juvenile makos (size range of roughly 90-160 cm FL at the time of tagging).

- SWFSC scientists are also studying the movement and habitat use patterns of common thresher sharks, which are an important target species of the west coast based drift gillnet fishery. A satellite-tagging project was started in 1999 in the Southern California Bight during the spring-summer occupancy. Satellite-linked telemetry was used on 19 individuals during the years 1999, 2004 and 2005. Results from 11 individuals represent the most detailed fishery-independent information about this species, previously known exclusively from catch data. Depth and temperature records demonstrate that common thresher sharks have a diurnal pattern of swimming behavior foraying into deeper depths of up to 200 m during the daytime, while staying closer to the surface at night. The data are being examined with respect to oceanographic features (bathymetry, surface temperature, water column profile, and surface chlorophyll) in order to quantify the essential habitat of these sharks.

- A food habits study of shortfin mako, blue and common thresher sharks is also underway. All three species are captured in the pelagic drift gillnet fishery operating off the California and Oregon coasts. In order to determine whether the 3 species feed on common prey in their overlapping habitats, stomach contents of sharks sampled from the pelagic drift gillnet fishery between 2002 and 2005 were examined. Of 115 mako shark stomachs examined, 81 contained prey representing 23 taxa. Jumbo squid (*Dosidicus gigas*) and Pacific saury (*Cololabis saira*) were the two most important prey items. Of 97 blue shark stomachs examined, 67 contained prey representing 24 taxa. Squid of the *Argonauta* spp. and *Gonatus* spp. were the most important prey items. Of 89 thresher shark stomachs examined, 55 contained prey representing 18 taxa. Pacific sardine (*Sardinops sagax*) and northern anchovy (*Engraulis mordax*) were the two most important prey items. Comparing the first 12 prey items ranked by GII for each species, results demonstrate that mako sharks fed on a combination of different taxa of teleosts and cephalopods, blue sharks fed primarily on different squid species, while threshers consumed mostly teleosts, especially coastal pelagic species, and very little squid. The analyses are ongoing to determine whether there were interannual differences in the main prey items consumed and to examine correlations between the diets and potential prey availability or prevailing oceanographic conditions.

Fishery Management Research − A limited but important number of studies at the SWFSC falls into this category of fishery management research. SWFSC researchers are applying different economic models to understand the economics of fishing and factors

contributing to overcapacity in tuna fisheries. Included in the studies is analysis of incentives for reducing sea turtles interaction in longline fisheries, such as in the North Pacific.

Pacific Islands Fisheries Science Center (PIFSC)

Scientists at the Pacific Islands Fisheries Science Center are actively engaged in research on tuna and tuna-like species and the fisheries that pursue them in the North Pacific. Studies are underway on stock assessment, biology, oceanography, economics, and methods to reduce the incidental catch and mortality of protected species in longline fisheries. The work is conducted by PIFSC staff and affiliated scientists employed by the NOAA-University of Hawaii Joint Institute for Marine and Atmospheric Research (JIMAR) and co-located at the PIFSC. Many of the studies are funded by JIMAR's Pelagic Fisheries Research Program (PFRP). Selected recent research activities within the PIFSC Research Divisions are summarized below.

PIFSC Fishery Monitoring and Economics Division

Fishery Monitoring and Analysis Program

Research describing statistical models of blue marlin, *Makaira nigricans*, catches -- characterized by greater predictive accuracy and comprehensibility with little loss of precision relative to previous work -- was presented at the Fourth International Billfish Symposium in November 2005. Related work completed correcting species misidentifications as reported in commercial logbooks for five species of billfishes taken as incidental catch by the Hawaii-based longline fleet from March 1994 through 2004. Completion of the corrections for this closely related guild of economically and ecologically important fishes represents a first major step toward the establishment of a research-quality database at the PIFSC.

Recent progress in analyses of catch data from fishery observers and in logbooks was reported at the PFRP Semiannual meeting in November 2005.

Human Dimensions Research Program

<u>Sociology of the Hawaii-based Longline Fleet</u>
This study was designed to compile a comprehensive social profile of the longline fishing industry of Hawaii and provide the information to decision-makers. The Hawaii-based longline fleet, which lands the vast majority of the Hawaii commercial catch of pelagic fish, has been heavily regulated with little analysis of the resulting social and cultural impacts. Researchers obtained information from 234 individuals, primarily longline vessel owners, captains, and crew, between March 2003 and October 2004. This sample represented about 50 percent of vessel owners and captains and about 65 percent of Filipino crew involved in the industry at that time. Information was obtained from one or more fishermen on over 70 percent of the active vessels.

Analyses and paper, entitled *Impacts of the Hawaii Swordfish Closure on the Vietnamese-American Longline Fishing Community,* has been completed. The paper describes the web of financial, psychological, household, and community effects resulting from the closure. Drafts of three other papers documenting the study have been completed: one on longline fishermen's perceptions of observers and the observer program; one on fishermen's perceptions of regulations and management; and one on socio-cultural characteristics and experiences of Filipino crew working on Hawaii-based longline vessels.

Economics Program

The following are recent publications of the Economics Program:
1. "Rethinking Time/Area Closure for Turtle Take Reductions"
2. "Technology Changes and the Impact in Fishing Capacity in the Hawaii Longline Fleet"
3. "Economic Valuation of Fishing Tournaments in Hawaii"

PIFSC Fisheries Biology and Stock Assessment Division

Ecosystem Science and Management Planning Workshop

To assist regional managers and scientists with the development and implementation of ecosystem-based approach to fisheries management (EAF), the Council and NOAA hosted the Ecosystem Science and Management Planning Workshop in Honolulu, Hawaii from April 18 to 22, 2005. The goal of the workshop was to identify science requirements to support EAF and to develop a blueprint for implementing EAF in the Western Pacific Region. To promote discussion and foster development of the blueprint, the workshop steering committee developed a suite of tasks for consideration by workshop participants:

- Review state-of-the-art ecosystem models applied to marine resource management and their application in governance systems.
- Identify management requirements in the Western Pacific Region.
- Identify the best suite of quantitative ecosystem indicators and associated tradeoffs to support management requirements in the Western Pacific Region.
- In the short term, and within the confines of existing mandates (i.e., Magnuson-Stevens Act, National Marine Sanctuary Act, etc.), identify the most effective ecosystem-based approaches to marine resource management that can be implemented based on current data. Does the precautionary approach have a role?
- What new data or models are required to advance ecosystem-based approaches to marine resource management in the Western Pacific Region?

- What changes in policy or science administration are required to more effectively implement ecosystem-based approaches to marine resource management?

The workshop included plenary sessions, breakout sessions, and expert panels. Approximately 50 international and national scientists, managers, and economists participated. The plenary sessions addressed three topics: data sources, ecosystem models, and ecosystem indicators. The expert panelists and other participants made presentations on each topic area. The breakout sessions focused on the same three topic areas and provided recommendations with both a short- and long-term perspective for the development and implementation of EAF in the Western Pacific Region.

The discussions clarified several important issues. It was clear from presentations that considerable amounts of data exist to enable EAF in the Western Pacific Region, but because of shortfalls in available staff and funding, much of the data have yet to be analyzed. The quality of existing data cannot be assessed until the data are formally evaluated for consistency, precision, completeness, and variations in data collection practices. Models should be developed with management objectives and alternatives in mind, and model output should be couched in the context of risk. Models should be capable of exploring what-if scenarios; this capability is essential for evaluating adaptive management practices. A suite of ecosystem indicators was suggested covering a range technical and ecosystem management perspectives. The goal is to refine the list through testing and identify a list of Archipelago-specific indicators for the Western Pacific Region. There was much discussion on the social implications of adopting EAF. Accordingly, it was decided that a follow-up workshop on this topic would be convened in early 2006. The workshop report will be available in a few months.

<u>Technical Assistance Workshop on Sea Turtle Bycatch Reduction Experiments in Longline Fisheries</u>

Forty-three people from a dozen countries attended the first *Technical Assistance Workshop on Sea Turtle By Catch Reduction Experiments in Longline Fisheries* during April 11-14, 2005 in Honolulu. The objective of the workshop was to provide technical assistance to participants of the recent *FAO Technical Consultation on Sea Turtle Conservation and Fisheries* held last year, in Bangkok. Most participants in the FOA Technical Consultation want to conduct experiments with sea turtle bycatch reduction technology prior to making specific recommendations for bycatch mitigation measures in their fisheries. The workshop was intended to help participants design programs for developing and testing turtle bycatch reduction technology appropriate to longline fishing in their countries.

The Honolulu workshop was hosted by the Western Pacific Regional Fishery Management Council and sponsored by NOAA Pacific Islands Fisheries Science Center (PIFSC), Fish Biology and Stock Assessment Division (FBSAD). The meeting was attended by national delegations from Australia, Indonesia, Malaysia, Mexico, Philippines, and the United States, representatives of non-governmental organizations,

and researchers from Italy, New Caledonia, Papua New Guinea, Spain, Solomon Islands, and Vietnam. The workshop reviewed all research on turtle bycatch reduction in longline fisheries being conducted around the world. The United States has been the leader in these efforts, with significant research contributions also coming from the Azores (Portugal), Costa Rica, Ecuador, Japan, and Mexico.

The primary research findings have been that replacing J hooks and tuna hooks with circle hooks reduces the severity of injury to captured turtles, and that using larger circle hooks (i.e. wider than about 4.9 cm) or baiting with fish instead of squid, can substantially reduce sea turtle bycatch. The workshop reviewed the style of longline fishing operations and the amount of turtles caught in fisheries of the participating nations. It also reviewed the opportunities, and associated costs, of conducting bycatch reduction experiments and providing scientific observer coverage.

The Pacific Islands Regional Office provided a comprehensive presentation on turtle de-hooking, handling and release procedures; supported a presentation on efforts to enhance the capacity of the Western Pacific observer programs to address sea turtle issues; and provided participants from other nations with de-hookers, longline bycatch informational CDs and copies of the Hawaii longline observer manual. The Australia delegation also distributed information on turtle de-hooking and handling practices in their fishery. FBSAD provided samples of circle hooks to all participants.

Workshop participants described future projects and needs for financial support or technical assistance that might be provided by NOAA. The World Wildlife Fund (WWF) provided review material on the expanding number of programs in Latin America. WWF representatives from the Philippines, Solomon Islands, Indonesia, and Vietnam described the situation in those countries. The project descriptions are under review by FBSAD, and some will be funded this year. Researchers from the Philippines have already initiated a new study with their research vessels using gear provided by FBSAD, including 16/0 circle hooks for comparison with the tuna hooks used in their commercial fishery. The fisheries with the most turtle bycatch, and therefore the greatest opportunity to record statistically significant bycatch reductions, were those in Spain and Italy. Projects in those countries will have a high priority for support this year. Mexico and Australia are funding their own projects and collaborating with FBSAD on experimental designs. Related discussions will also take place at the Third International Fisheries Forum (IFF3) now scheduled for July 25-28th in Japan.

Table 1. Number of vessels fishing in the North Pacific in various U.S. fisheries. Data for 2004 and 2005 are preliminary. Data not available at this time, na.

Year	Purse Seine	Longline	Distant-water Troll	Pole-and-Line	Troll and Handline	Gill Net	Harpoon
1990	85	138	371	12	na	146	49
1991	65	141	179	12	na	123	32
1992	62	123	603	11	1,977	113	48
1993	62	122	518	13	1,987	105	44
1994	62	125	686	11	1,948	112	49
1995	55	110	464	11	2,020	127	39
1996	43	103	640	9	2,166	100	30
1997	42	105	1,121	9	2,149	104	31
1998	43	114	755	9	2,135	87	26
1999	28	119	705	9	2,127	78	30
2000	30	125	649	7	1,993	77	26
2001	32	101	870	9	1,937	64	23
2002	26	100	641	13	1,916	45	29
2003	30	129	834	7	1,938	37	34
2004	24	125	734	3	1,847	33	28
2005	24	124	630	na	na	38	25

Table 2. U.S. catches (metric tons) of tunas and tuna-like species (FAO codes) by fishery in the North Pacific Ocean, north of the equator. Data for 2004 and 2005 are preliminary. Data not available at this time, na. Species codes: ALB = albacore, YFT = yellowfin tuna, SKJ = skipjack tuna, BET = bigeye tuna, PBF = Pacific bluefin tuna, BKJ = black skipjack, BEP = bonito, SWO = swordfish, BUM = blue marlin, MLS = striped marlin.

FISHERY/YEAR	ALB	YFT	SKJ	BET	PBF	BKJ	BEP	SWO	BLZ	MLS	UNSPEC. BILLFISH	UNSPEC. TUNA	TOTAL
Purse Seine:													
1990	14	64,375	51,396	721	1,289	262	2,060	0	0	0	0	39	120,155
1991	0	27,764	46,991	909	306	20	146	0	0	0	0	7	76,143
1992	0	33,317	71,174	2,836	1,226	1	146	0	0	0	0	0	108,700
1993	0	29,886	62,092	4,319	300	21	100	0	0	0	0	0	96,718
1994	0	10,791	28,641	2,461	497	59	0	0	0	0	0	8	42,457
1995	0	17,170	60,083	2,874	564	36	13	0	0	0	0	0	80,741
1996	0	7,692	17,567	4,171	1,688	45	129	0	0	0	0	0	31,291
1997	3	22,260	32,441	5,823	1,012	0	0	0	0	0	0	7	61,546
1998	6	24,508	26,556	4,190	482	0	193	0	0	0	0	0	55,936
1999	0	5,028	17,028	2,946	18	78	0	0	0	0	0	0	25,098
2000	2	1,750	4,981	866	98	0	125	0	0	0	0	0	7,822
2001	4	4,841	15,919	1,497	31	70	0	0	0	0	0	0	22,363
2002	3	5,542	4,228	1,149	0	188	0	0	0	0	0	0	11,110
2003	3	3,256	18,875	2,553	22	162	0	0	0	0	0	0	24,870
2004	1	3,427	3,837	1,348	0	55	0	0	0	0	0	0	8,668
2005	0	6,051	17,471	3,187	0	0	0	0	0	0	0	0	26,709
Longline:													
1990	177	1,098	5	1,514	0	0	0	2,455	378	538	58	0	6,223
1991	312	733	30	1,555	2	0	0	4,547	297	663	69	0	8,208
1992	334	346	22	1,486	38	0	0	5,795	347	459	142	0	8,969
1993	438	633	36	2,124	42	0	0	6,074	339	471	100	0	10,258
1994	544	610	53	1,827	30	0	0	3,916	362	326	99	5	7,772
1995	882	984	101	2,099	29	0	1	2,992	570	543	182	0	8,383
1996	1,185	634	41	1,846	25	0	0	2,849	467	419	115	2	7,582
1997	1,653	1,143	106	2,526	26	0	0	3,545	487	352	143	2	9,982
1998	1,120	724	76	3,274	54	0	0	3,685	395	378	172	9	9,887
1999	1,542	477	99	2,820	54	0	0	4,433	357	364	242	10	10,398
2000	940	1,137	93	2,708	19	0	0	4,857	314	200	152	0	10,420
2001	1,295	1,029	211	2,418	6	0	0	1,983	399	352	136	0	7,829
2002	525	572	127	4,396	2	0	0	1,524	264	226	160	0	7,796
2003	524	809	207	3,618	1	0	0	1,959	363	538	248	0	8,267
2004	360	700	133	4,323	1	0	0	860	281	384	207	9	7,258
2005	277	750	93	3,901	1	0	0	1,362	250	377	211	0	7,222

Table 2. Continued.

FISHERY/YEAR	ALB	YFT	SKJ	BET	PBF	BKJ	BEP	SWO	BLZ	MLS	UNSPEC. BILLFISH	UNSPEC. TUNA	TOTAL
Distant-water Troll:													
1990	2,603	0	0	0	0	0	55	0	0	0	0	0	2,658
1991	1,845	0	0	0	0	0	0	0	0	0	0	0	1,845
1992	4,572	0	0	0	0	0	0	0	0	0	0	0	4,572
1993	6,254	137	62	0	0	0	0	0	0	0	0	1	6,454
1994	10,978	769	352	0	0	0	0	0	0	0	0	0	12,099
1995	8,045	211	1,157	0	0	0	0	0	0	0	0	0	9,413
1996	16,938	606	393	0	2	0	0	0	0	0	0	0	17,939
1997	14,252	4	2	0	1	0	0	0	0	0	0	0	14,259
1998	14,410	1,246	2	0	172	0	10	0	0	0	0	0	15,840
1999	10,060	52	16	0	20	0	0	0	0	0	0	0	10,148
2000	9,645	3	4	0	1	0	0	0	0	0	0	1	9,654
2001	11,210	1	1	0	6	0	0	0	0	0	0	0	11,218
2002	10,387	0	0	0	1	0	0	2	0	0	0	0	10,390
2003	14,102	0	2	0	0	0	0	0	0	0	0	0	14,104
2004	13,432	1	0	0	0	0	0	0	0	0	0	0	13,433
2005	9,122	0	0	0	0	0	0	0	0	0	0	0	9,122
Pole-and-Line:													
1990	115	172	551	1	61	0	16	0	0	0	0	2	918
1991	0	945	1,572	2	0	0	16	0	0	0	0	0	2,536
1992	0	1,779	1,257	4	1	0	13	0	0	0	0	2	3,057
1993	0	1,514	1,960	20	4	0	1	0	0	0	0	5	3,504
1994	0	862	1,299	6	1	0	155	0	0	0	0	18	2,342
1995	80	254	1,219	0	0	0	0	0	0	0	0	0	1,554
1996	24	1	835	0	0	0	0	0	0	0	0	1	861
1997	73	141	1,162	0	1	0	1	0	0	0	0	0	1,378
1998	79	166	394	1	3	0	4	0	0	0	0	0	647
1999	60	57	601	4	2	0	0	0	0	0	0	0	725
2000	69	13	320	1	12	0	0	0	0	0	0	0	416
2001	139	4	447	0	1	0	0	0	0	0	0	0	591
2002	381	2	305	0	2	0	0	0	0	0	0	2	692
2003	59	25	436	0	2	0	1	1	0	0	0	0	524
2004	125	18	276	0	0	0	1	37	0	0	0	0	457
2005	na	na	na	na	na	na	na	na	na	na	na	na	0

Table 2. Continued.

FISHERY/YEAR	ALB	YFT	SKJ	BET	PBF	BKJ	BEP	SWO	BLZ	MLS	UNSPEC. BILLFISH	UNSPEC. TUNA	TOTAL
Troll and Handline:													
1990	15	891	138	25	0	0	0	5	295	27	17	11	1,424
1991	72	802	237	25	0	0	0	6	346	41	25	9	1,563
1992	54	602	167	13	0	0	0	1	260	39	17	10	1,163
1993	71	861	157	3	0	0	0	4	311	69	20	6	1,502
1994	90	870	138	7	0	0	0	4	298	35	22	8	1,472
1995	177	978	152	20	0	0	0	6	315	52	29	7	1,736
1996	188	934	224	7	0	0	0	5	409	55	18	5	1,845
1997	133	770	196	26	0	0	0	7	378	39	17	4	1,570
1998	88	766	143	9	0	0	0	7	242	26	19	6	1,306
1999	331	1,019	181	24	0	0	0	9	293	29	33	4	1,923
2000	120	1,044	88	207	0	0	0	0	191	14	20	4	1,688
2001	194	835	111	226	0	0	0	0	275	42	32	4	1,719
2002	235	605	98	586	0	0	0	0	201	29	12	3	1,769
2003	85	689	101	237	0	0	0	0	175	28	15	4	1,334
2004	186	695	94	521	0	0	0	0	171	56	31	3	1,757
2005	na	na	na	na	na	na	na	na	na	na	na	na	0
Gill Net:													
1990	29	1	1	1	9	0	35	1,028	0	0	0	2	1,106
1991	17	1	3	3	3	0	14	836	0	0	0	3	880
1992	0	4	1	1	8	0	7	1,332	0	0	0	6	1,359
1993	0	7	2	0	32	0	8	1,400	0	0	0	9	1,458
1994	38	0	0	0	28	0	1	799	0	0	0	2	868
1995	52	2	70	1	19	0	2	755	0	0	0	1	902
1996	83	2	2	0	43	0	2	752	0	0	0	0	884
1997	60	3	2	5	57	0	6	707	0	0	0	0	840
1998	80	2	3	4	40	0	4	924	0	0	0	2	1,059
1999	149	0	0	2	19	0	1	606	0	0	0	1	778
2000	55	1	0	2	29	0	1	646	0	0	0	0	734
2001	94	5	1	0	34	0	0	375	0	0	0	0	509
2002	30	1	0	0	7	0	1	302	0	0	0	0	341
2003	16	0	9	6	14	0	1	216	0	0	0	0	262
2004	9	1	0	0	10	0	2	126	0	0	0	0	148
2005	19	2	0	0	5	0	0	148	0	0	0	0	174

Table 2. Continued.

FISHERY/YEAR	ALB	YFT	SKJ	BET	PBF	BKJ	BEP	SWO	BLZ	MLS	UNSPEC. BILLFISH	UNSPEC. TUNA	TOTAL
Harpoon:													
1990	0	0	0	0	0	0	0	50	0	0	0	0	50
1991	0	0	0	0	0	0	0	16	0	0	0	0	16
1992	0	0	0	0	0	0	0	74	0	0	0	0	74
1993	0	0	0	0	0	0	0	169	0	0	0	0	169
1994	0	0	0	0	0	0	0	153	0	0	0	0	153
1995	0	0	0	0	0	0	0	96	0	0	0	0	96
1996	0	0	0	0	0	0	0	81	0	0	0	0	81
1997	0	0	0	0	0	0	0	84	0	0	0	0	84
1998	0	0	0	0	0	0	0	48	0	0	0	0	48
1999	0	0	0	0	0	0	0	81	0	0	0	0	81
2000	0	0	0	0	0	0	0	90	0	0	0	0	90
2001	0	0	0	0	0	0	0	52	0	0	0	0	52
2002	0	0	0	0	0	0	0	90	0	0	0	0	90
2003	0	0	0	0	0	0	0	107	0	0	0	0	107
2004	0	0	0	0	0	0	0	47	0	0	0	0	47
2005	0	0	0	0	0	0	0	50	0	0	0	0	50
Other:													
1990	28	508	147	0	134	0	227	137	0	0	0	1	1,182
1991	77	235	137	0	62	0	69	137	0	0	0	0	717
1992	74	1,119	1,014	0	174	0	78	44	0	0	0	2	2,505
1993	25	2,031	2,279	0	139	0	140	36	0	0	0	0	4,650
1994	319	3	0	0	125	0	12	8	0	0	0	0	467
1995	102	5	263	0	166	0	0	31	0	0	0	0	567
1996	88	0	0	4	30	0	0	10	0	0	0	0	132
1997	1,019	0	83	0	90	0	0	3	0	0	0	0	1,195
1998	1,209	43	0	0	214	0	0	13	0	0	0	1	1,480
1999	3,622	0	0	0	399	0	0	2	0	0	0	0	4,023
2000	1,801	1	0	0	220	0	0	9	0	0	0	0	2,030
2001	1,636	0	0	0	226	0	0	5	0	0	0	0	1,867
2002	2,358	27	1	0	348	0	0	3	1	0	0	1	2,740
2003	2,214	8	2	3	229	0	0	0	0	0	0	0	2456
2004	1,506	27	2	132	34	0	0	27	5	0	0	0	1733
2005	2	0	0	0	0	0	2	0	0	0	0	0	4

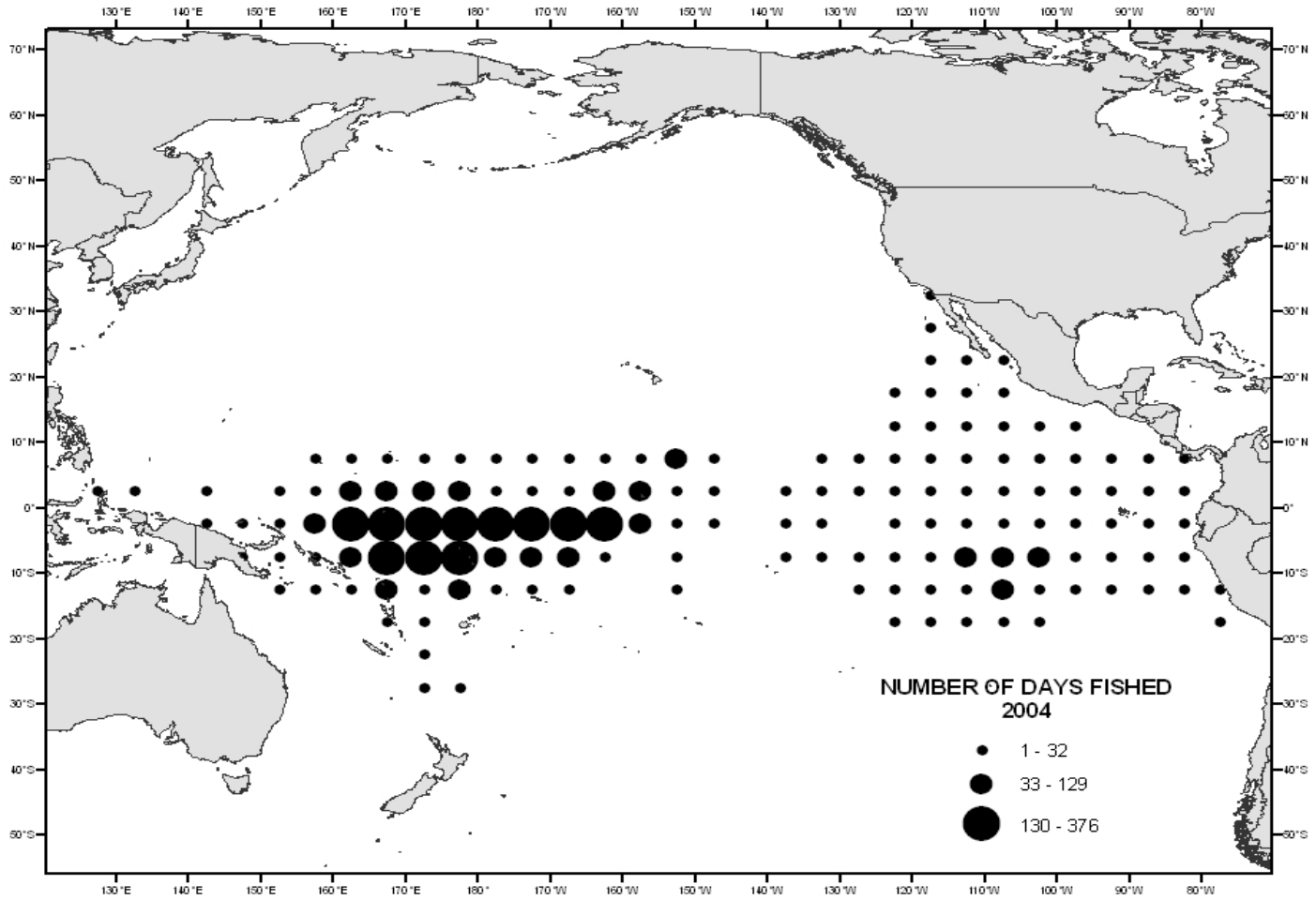

Figure 1. Distribution of nominal fishing effort (days fished) for the 2004 U.S. Pacific Ocean purse seine fishery.

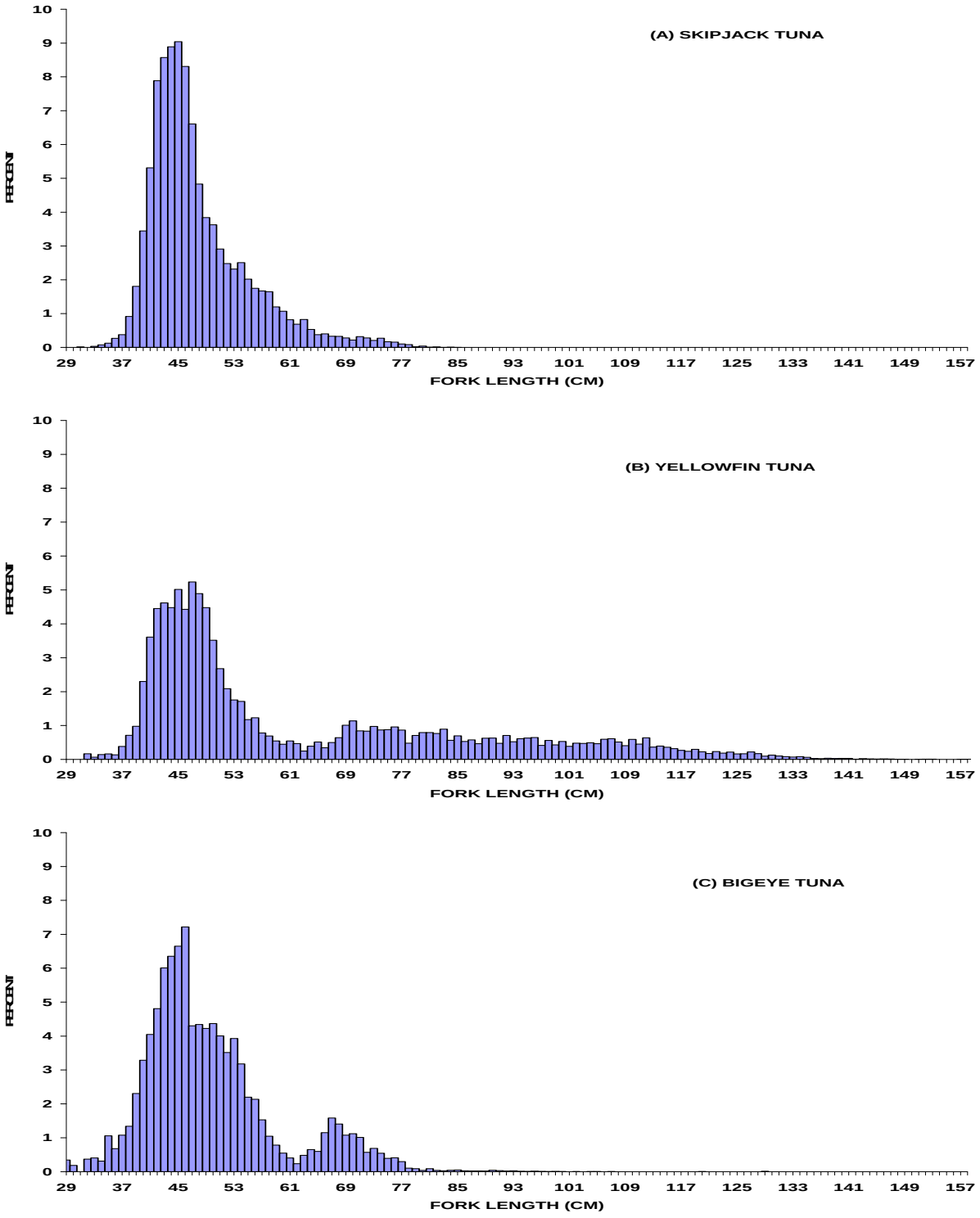

Figure 2. Size distribution of (A) skipjack tuna, (B) yellowfin tuna and (C) bigeye tuna caught by U.S. purse seiners fishing in the central-western Pacific Ocean in 2004.

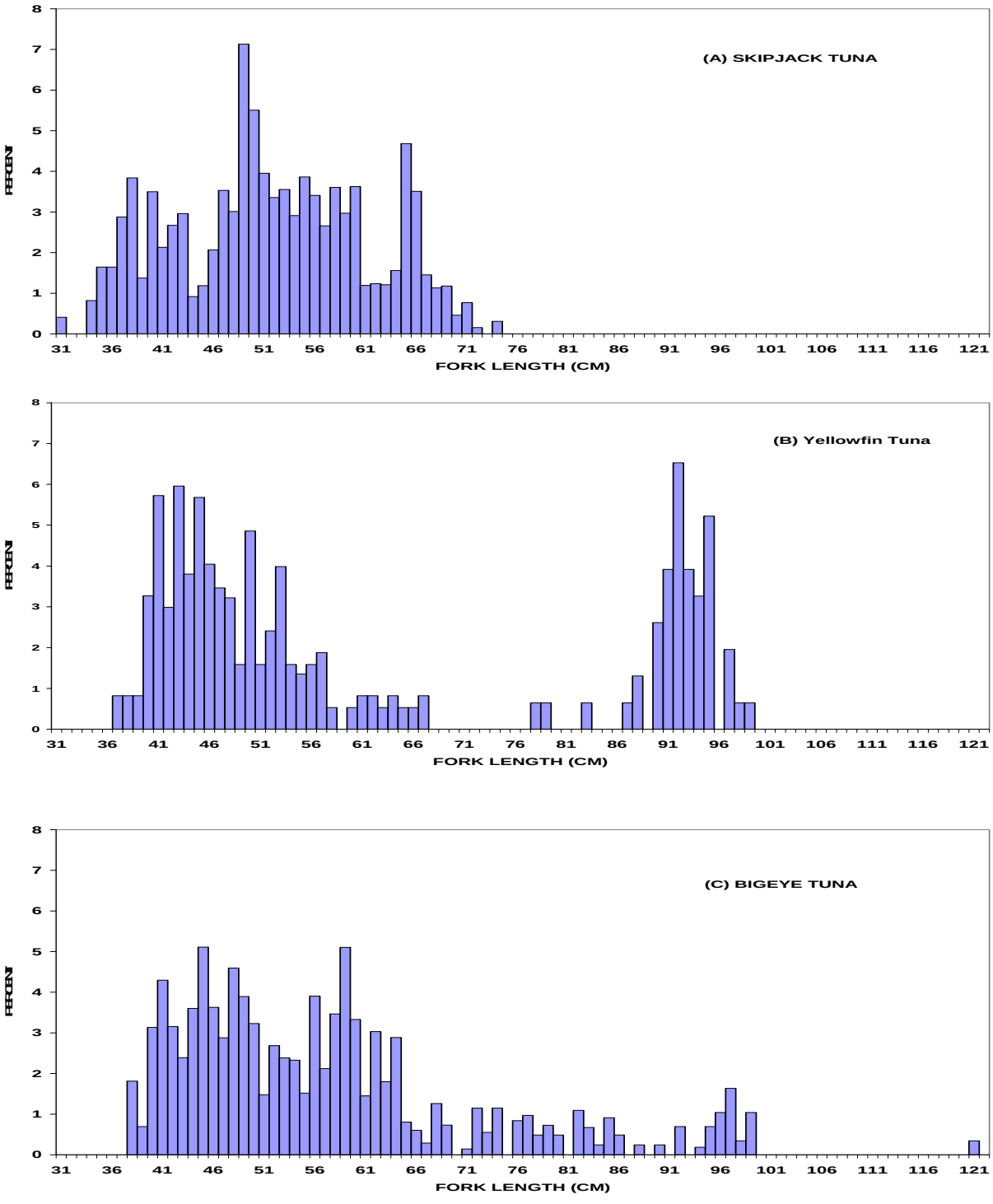

Figure 3. Size distribution of (A) skipjack tuna, (B) yellowfin tuna and (C) bigeye tuna caught by U.S. purse seine fishery in the eastern tropical Pacific Ocean in 2004.

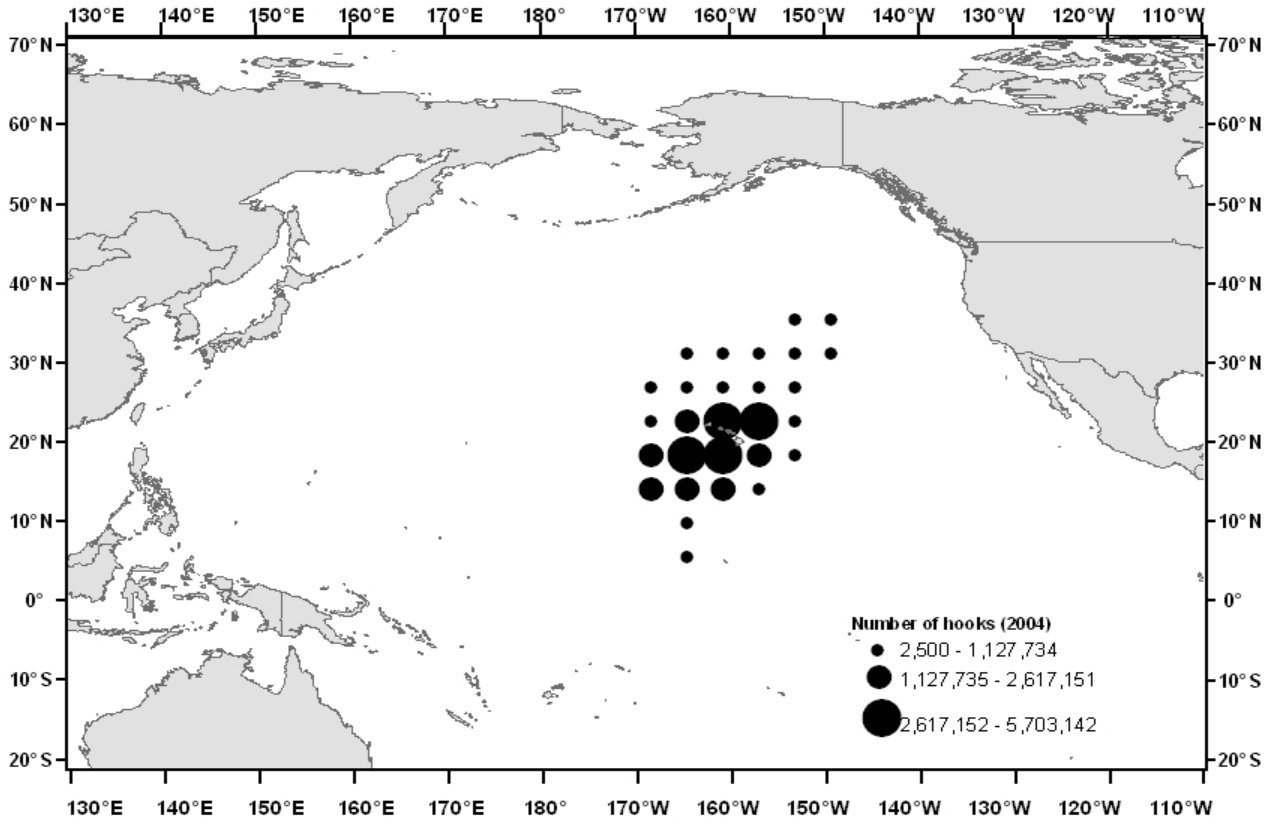

Figure 4. Distribution of nominal fishing effort (number of hooks) for the 2004 U.S. North Pacific longline fishery.

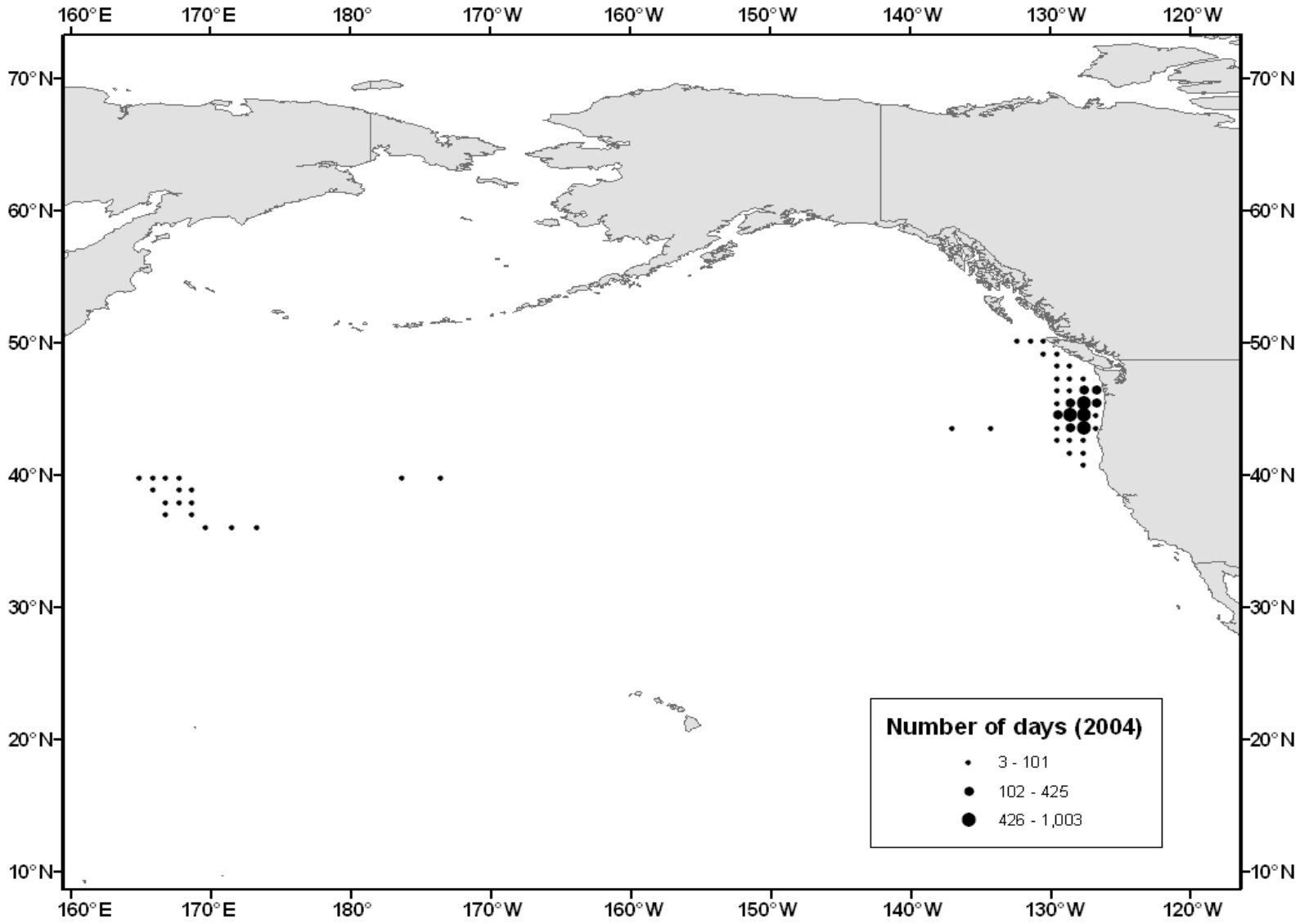

Figure 5. Distribution of nominal fishing effort (days fished) for the 2004 U.S. North Pacific troll fishery.

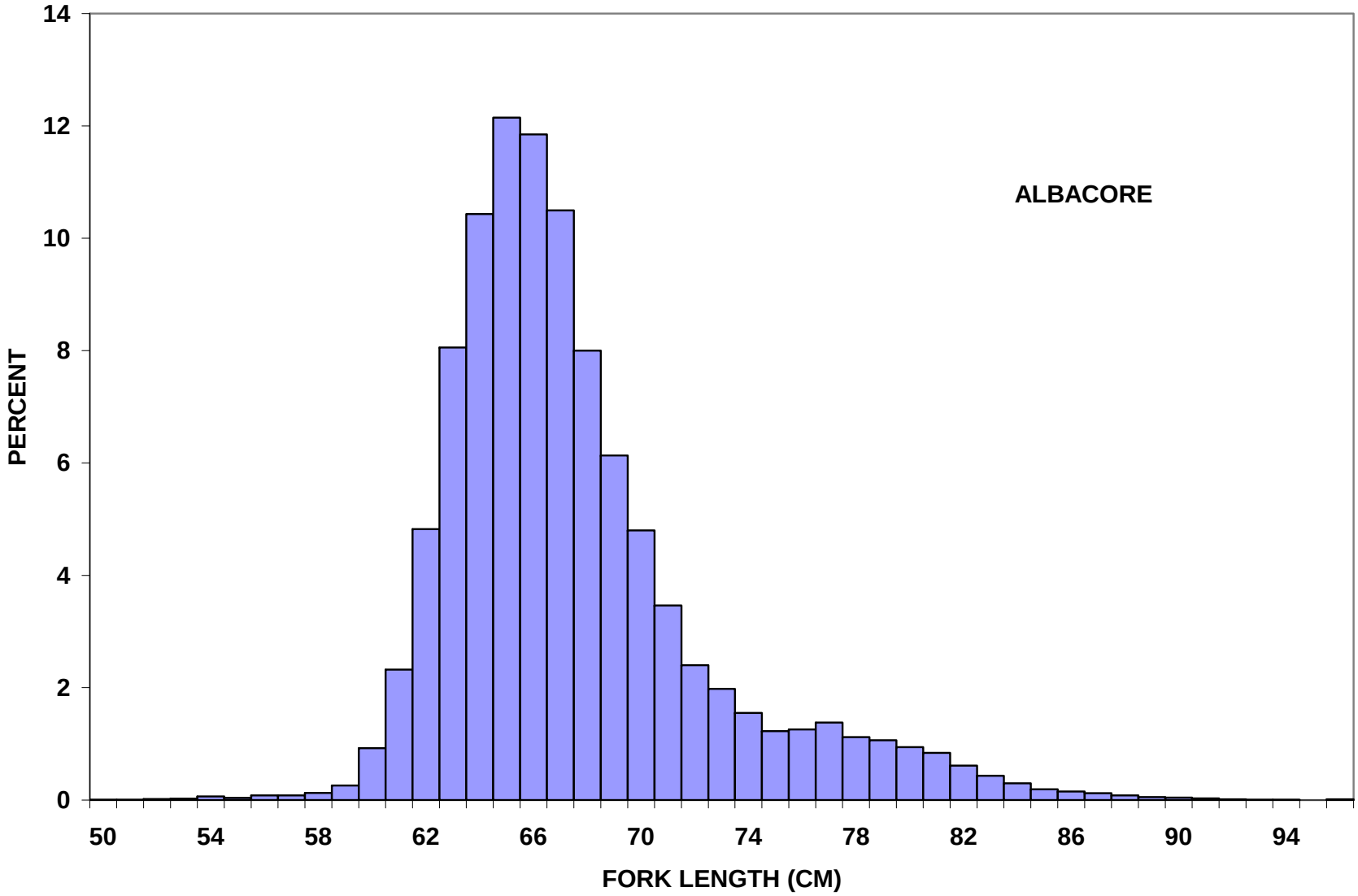

Figure 6. Size distribution of albacore caught by the U.S. North Pacific albacore troll fishery in 2004.

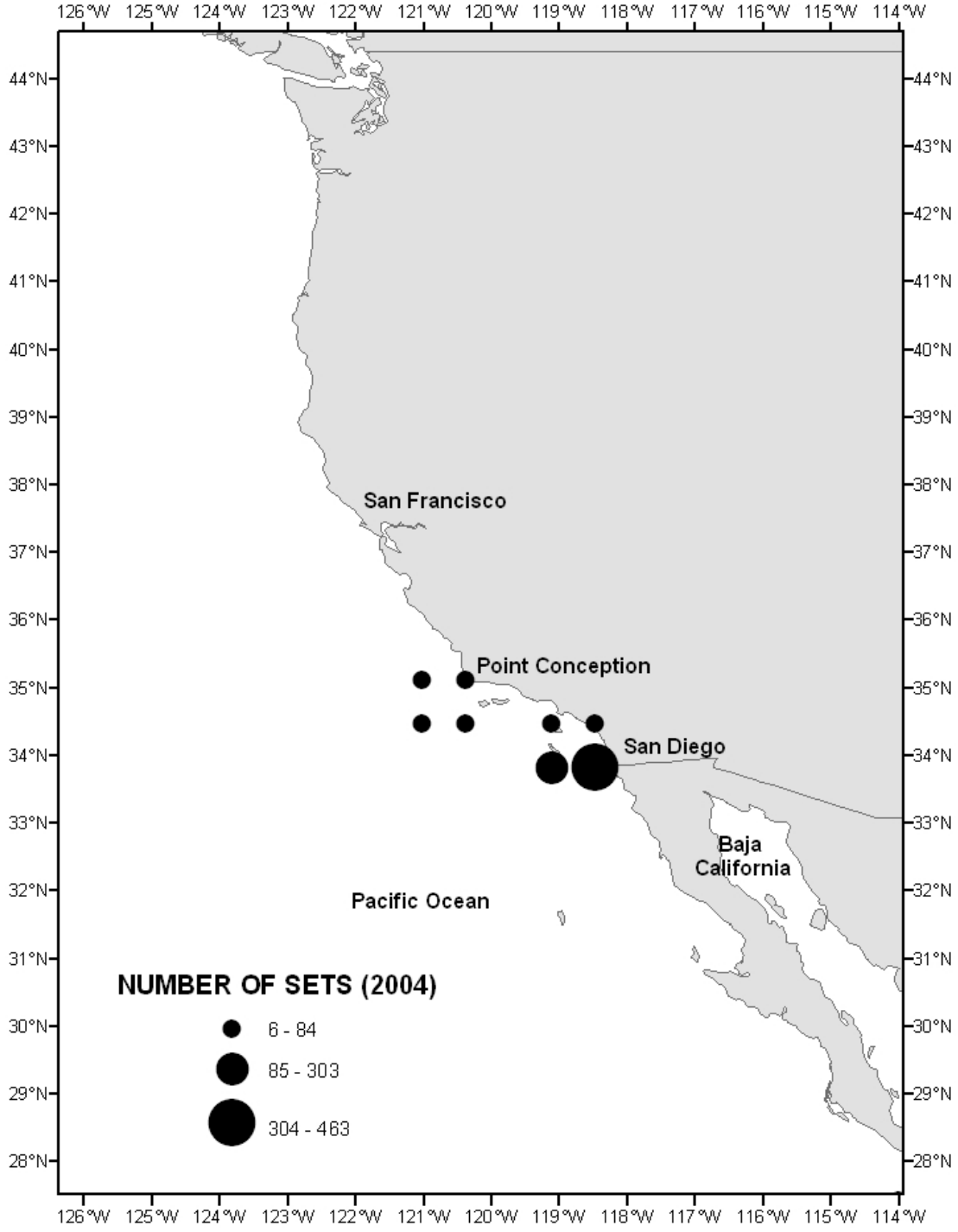

Figure 7. Distribution of nominal fishing effort (number of sets) for the 2004 U.S. North Pacific drift gill net fishery.

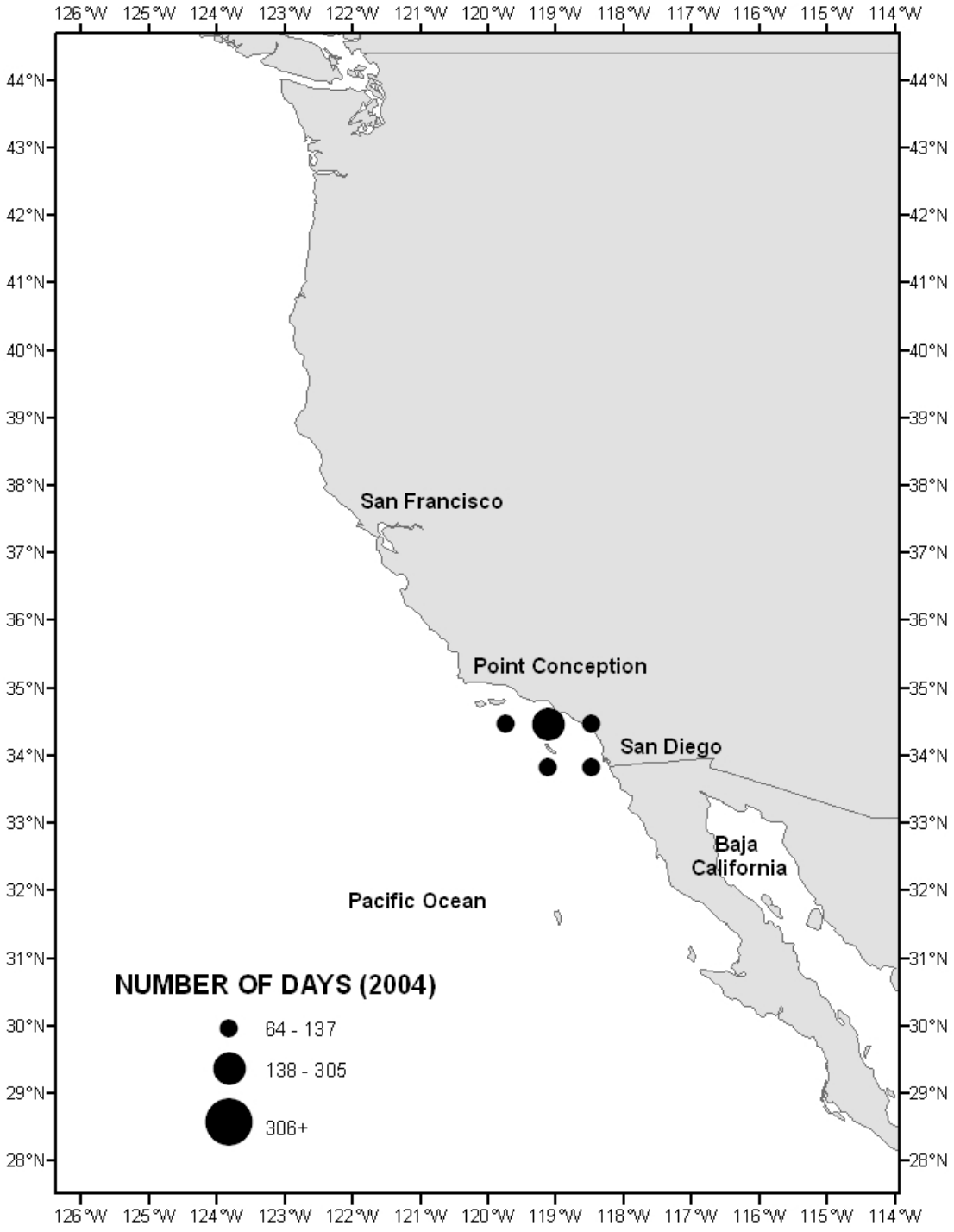

Figure 8. Distribution of nominal fishing effort (days fished) for the 2004 U.S. North Pacific harpoon fishery.