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

NOAA, National Marine Fisheries Service

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Executive Summary

U.S. fisheries harvest tuna and tuna-like species in the North Pacific from coastal waters of North America to the archipelagoes of Hawaii, Guam and the Commonwealth of the Northern Mariana Islands (CNMI) in the central and western Pacific Ocean. The small-scale gill net, harpoon, pole-and-line, and tropical troll and handline fisheries operate primarily in coastal waters, whereas the large-scale purse seine, distant-water troll, and longline fisheries that account for most of the catch operate both within U.S. Exclusive Economic Zones and on the high seas. The increase in the total USA catches in 2007 was primarily a result of increased numbers of active purse seine vessels, up by 11 to 23 in 2007, with the industry responding to improved skipjack tuna (*Katsuwonus pelamis*) prices, catching 8,889 t in 2007 despite higher fuel costs. Longline landings also increased in 2007 after decreasing in 2006, due to a partial closure of the fishery sector targeting swordfish (*Xiphius gladius*) to limit the bycatch of sea turtles. Bigeye tuna (*Thunnus obesus*) landings by longliners reached an all time record high of 6665 t in 2007, while active vessels increased by two to 130, in 2007. The thousands of trollers and handliners operating in the tropical Pacific Islands represent by far the largest number of vessels but contribute a small fraction of the catch. Trollers fishing for albacore (*Thunnus alalunga*) numbered 625 in 2007, up by 24 from 2006 but caught a little less than in 2006.

The National Oceanic and Atmospheric Administration (NOAA) Fisheries conducted research on Pacific tuna and associated species at its Southwest and Pacific Islands Fisheries Science Centers and in collaboration with scientists from other organizations. Fisheries monitoring and economics work included the continuing survey of billfish anglers, indicating improved catch rates in recent years. Improvements were made to the integration of fisheries statistics from fishermen's reports with data from fish sales, and monitoring of the retail fish market in Honolulu was initiated that will address consumer choices with regard to carbon monoxide treatment of raw tuna products. Stock assessment research was conducted almost entirely in collaboration with member scientists of the ISC and other international Regional Fisheries Management Organizations.

NOAA Fisheries biological and oceanographic research on tunas, billfishes, and sharks addressed fish movements, habitat choices, post capture survival, feeding habits, and age and growth. Salient results include a model analyses of bigeye tuna habitat depth from archival tag studies that predicts the high CPUE found in the fourth quarter in the Hawaii-based longline fishery, and a finding that jumbo squid (*Dosidicus gigas*) are an increasingly important component of the mako shark (*Isurus oxyrinchus*) diet off California. Research on bycatch and fishing technology included work on dolphin habitat as well as their prey, commensals, competitors, and predators. Other dolphin work indicates that the purse seine fishery is negatively affecting the behavior of dolphins. Research on sea turtles focused on developing an advisory for avoiding sea turtle habitat in the North Pacific Subtropical Frontal Zone, and testing

of circle hooks. A promising technique using electronegative metal attachments to fishing gear as shark repellants for fishing gear was also studied.

I. Introduction

Various U.S. fisheries harvest tuna and tuna-like species in the North Pacific Ocean. Large-scale purse seine, albacore (*Thunnus alalunga*) troll, and longline fisheries operate both in coastal waters and on the high seas. Small-scale gill net, harpoon, handline and pole-and-line fisheries as well as commercial and recreational troll and hook and line fisheries usually operate in coastal waters. Overall, the range of U.S. fisheries in the North Pacific Ocean is extensive, from coastal waters of North America to Guam and the Commonwealth of the Northern Mariana Islands (CNMI) in the western Pacific Ocean 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 Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries or federal agency) and by partner fisheries agencies in the states of California, Oregon, Washington, Hawaii, and territories of American Samoa, Guam, and the CNMI. On the federal side, monitoring is conducted 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. NOAA Fisheries 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 Ocean, 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 among 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).

This report provides information on the number of active vessels by fleet and their catches of tunas and billfishes in the North Pacific Ocean based on the data available through 2007. Data for 2007, however, are considered preliminary and are subject to change. Although the report is focused on tunas and billfishes, many of the fisheries described catch other pelagic fish important to the fishing fleets and local economies; catch data for these species are not included.

NOAA Fisheries also conducts scientific research programs in support of marine resource conservation and management both domestically and internationally. These studies include stock

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

assessments, biological and oceanographic studies, socio-economic analysis, and more. This report includes summaries of recent and ongoing scientific work by NOAA Fisheries of relevance to the ISC.

II. Fisheries

A. 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 Ocean (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,WCPO fishery only). 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 110 in 1985 to 12 in 2006 (Table 1). Twenty-three vessels fished in 2007. 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 five years, fishing in both areas has been about equally distributed between free-swimming schools and schools associated with floating objects.

U.S. purse seine catches of tunas north of the equator are shown in Table 2. Catches in the North Pacific Ocean, over the past five years (most of the catch is south of the equator), are primarily skipjack tuna (*Katsuwonus pelamis*) (65%) with lesser quantities of yellowfin tuna (*Thunnus albacares*) (25%) and bigeye tuna (*Thunnus obesus*)(10%). Skipjack tuna catches peaked in 1988 at 78,250 t (metric tons) then decreased to 4,002 t in 2002. In 2007, 8,899 t of skipjack tuna were caught by U.S. purse seiners. Yellowfin tuna catches generally decreased from a high of 123,044 t in 1987 to 1,111 t in 2006. In 2007, 1,536 t of yellowfin tuna were caught by U.S. purse seiners.

U.S. purse seine vessels fishing in the WCPO have been monitored by NOAA Fisheries 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 NOAA Fisheries personnel as vessels land their catches in American Samoa (coverage approximately 1-2% of landings) (Figure 2). Species composition samples are also taken and used to separate yellowfin tuna from bigeye tuna in the reported landings. The Forum Fisheries Agency (Treaty Manager) places observers on approximately 20% of the vessel trips.

The IATTC monitors U.S. purse seine vessels fishing in the ETP. 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.

B. 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 regimes freely until 2000 when domestic regulations placed restrictions on moving between the two domestic management regimes The Hawaii-based component of the U.S. longline fishery comprises a majority of the vessels, fishing effort, and catch. Regulatory restrictions, due to interactions with endangered sea turtles, curtailed Hawaii-based longline swordfish-directed effort in 2000 and 2001 followed by a prohibition altogether in 2002 and 2003, after which the Hawaii-based longline fishery targeted tunas exclusively. The Hawaii-based fishery for swordfish (shallow-set longline) was reopened in April 2004 under a new set of regulations to reduce sea turtle interactions. 2005 was the first complete year in which the Hawaii-based longline fishery was allowed to target swordfish. In the following year, the shallow-set longline fishery reached the annual interaction limit of 17 loggerhead sea turtles (*Caretta caretta)* and the fishery was closed 20 March 2006. The vessels that targeted swordfish converted to deep-set longline and targeted tunas for the remainder of the year. The Hawaii-based shallow-set longline fishery stayed below the annual sea turtle interaction limit and remained open throughout the entire year in 2007.

The California-based longline fishery consisted primarily of vessels that also participated in the Hawaii-based fishery. The number of vessels in the California-based fishery was relatively low and was composed mainly of vessels that targeted swordfish. The California-based longline fishery for swordfish was closed in 2004 and resulted in relocation of most of those vessels back to Hawaii. There was only one vessel that fished exclusively in the California longline fishery in 2005 to 2007.

The longline fishery extends from outside the U.S. West Coast 200 mile Exclusive Economic Zone (EEZ) to 175°W longitude and from the equator to 35°N latitude in 2007 (Figure 3). The number of vessels participating in the longline fishery decreased from 141 in 1991 to a low of 114 vessels in 1996 before rebounding to 140 in 1999 (Table 1). Since then, the number of vessels has generally decreased to 130 in 2007. In Hawaii and California, swordfish are generally landed as trunks (headed, tailed, and gutted). Tunas and large marlins are landed, gilled and gutted while other bony fishes are usually landed whole. Sharks are landed headed and gutted. The landed catch is weighed at the fish auction (Figure 4, 5)

Catch levels and catch-species composition in the U.S. longline fishery has changed considerably over the past years in response to fishery and regulatory changes. The majority of the catch is now of tunas and billfishes and rose to over 10,000 t in 1993, 1999 and 2000 (Table 2). Bigeye tuna dominates the tuna catch with landings over 4,000 t in the past four years. The 2007 bigeye tuna catch was 6,665 t. Swordfish has been the dominant component of the billfish catch from 1990 and reached a peak of 5,936 t in 1993 before decreasing to 1,185 t in 2004. The 2007 swordfish catch was 1,750 t.

The Hawaii-based longline fishery is monitored by NOAA Fisheries and the State of Hawaii’s Division of Aquatic Resources (DAR). Longline fishers are required to complete federal longline logbooks for each fishing operation. The logbook data include information on effort, area fished, catch, and other details of operation. Logbook coverage for the Hawaii-based longline fishery is estimated at 100%. DAR also requires fish dealers to submit landings data, and coverage for the longline fishery is very close to 100%. Observers contracted by NOAA Fisheries are placed on longline vessels to monitor protected species interactions, vessel operations, and catches. The mandatory observers are required aboard Hawaii-based longline vessels at a rate of coverage of no less than 20% for deep-set (tuna-target) vessels and 100% for shallow-set (swordfish-target) vessels.

The California-based longline fishery is monitored by NOAA Fisheries and the California Department of Fish and Game (CDFG). Longline landings are collected from 100% of the fleet by the CDFG Landing Ticket system. Logbooks, developed by the fishing industry (similar to the federal logbooks used in Hawaii), were submitted voluntarily to NOAA Fisheries until 1994. From 1995 to 1999, CDFG collected logbooks from 100% of the fleet, and NOAA Fisheries has continued this collection since 1999. Landed swordfish were measured for cleithrum length by CDFG port samplers until 1999. NOAA Fisheries currently places observers on California-based longline vessels. The observers collect data on protected species interactions, fish catch and measure the sizes of a sample of fish caught (retained and discarded).

C. Distant-water Troll

The U.S. distant-water troll fishery for albacore in the North Pacific Ocean started in the early 1900s. The fishery operates in waters between the U.S. west coast and 160°E longitude (Figure 6). 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 172 in 1991 to a high of 1172 in 1997 (Table 1). In 2006, 601 vessels participated in the fishery and 625 vessels fished in 2007.

The troll fishery catches mainly albacore with minor incidental catches of skipjack, yellowfin and bluefin tunas (*Thunnus orientalis*), eastern Pacific bonito (*Sarda chiliensis lineolata*), yellowtail (*Seriola lalandi),* and mahi mahi (*Coryphaena hippurus*). Since 1985, the albacore catch has ranged between 1,845 t in 1991 and 16,938 t in 1996 (Table 2). In 2006, 12,524 t were caught and in 2007, 11,436 t were caught. Sampled albacore caught in 2007 ranged in fork length between 43 and 97 cm and averaged 70 cm (Figure 7).

U.S. troll vessels voluntarily submitted logbook records to NOAA Fisheries until 1995 when those vessels fishing on the high-seas were required to submit logbooks. Starting in 2005, all vessels must submit logbooks under a Highly Migratory Species Fishery Management Plan (HMSFMP). The logbook coverage rate in 2007 was approximately 62% of the landings. Landings are monitored by NOAA Fisheries and various state fisheries agencies through landing receipts and coverage is 100% of the fleet. Landings are also sampled for fork length by state agency port samplers along the U.S. west coast and by NOAA Fisheries personnel in American Samoa. Coverage rate in 2007 is approximately 2% of the landings.

D. 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. 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 2002 to 10 in 2007 (Table 1). Skipjack tuna was usually the largest component of the catch. The highest skipjack tuna catch was 3.450 t in 1988 (Table 2). The highest yellowfin tuna catch for the pole-and-line fishery was 2,636 t, recorded in 1993. Pole-and-line catches of skipjack and yellowfin tunas were 272 t and 23 t, respectively, in 2007.

For the West Coast pole-and-line fishery, logbook data are collected by the IATTC and NOAA Fisheries. Logbook submissions since 2005 are mandatory under the HMSFMP. Fork-length data for yellowfin and skipjack tunas are collected by the IATTC. Albacore fork-length data are collected by NOAA Fisheries 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 Commercial Fish Catch reports submitted by fishers and Commercial Marine Dealer reports submitted by fish dealers.

E. Troll and Handline

Troll fisheries operate in Hawaii, Guam, and the CNMI. Handline fisheries also operate in Hawaii. These fisheries catch tuna and tuna-like fish in the North Pacific Ocean. 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 1,878 in 1988 to 2,502 in 1999 with 1907 vessels in 2007 (Table 1). 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. Weights of individual fish are obtained when fish are landed (Figure 8, 9).

The total catch from these troll and handline fisheries ranged from 1,163 t in 1992 to 2,199 t in 2001 (Table 1). Total troll and handline catch was 1,567 t in 2007. Yellowfin tuna made up 45% of the troll and handline catch. The next largest components were bigeye tuna, skipjack tuna and blue marlin (*Makaira mazara*). The Hawaii troll and handline fisheries accounted for 85% of the total U.S. troll and handline landings in 2007.

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 NOAA Fisheries, 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 Fish Catch reports and Commercial Marine Dealer reports. The CNMI monitors the troll fishery using their Commercial Purchase database.

E. Gill Net

The U.S. drift and set gill net fisheries operate in areas within the 200-mile EEZ of California and sometimes off Oregon (Figure 10). 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 220 in 1986 to 33 in 2004 and increased to 50 in 2007 (Table 1). Swordfish catches are the major portion of the catch and peaked in 1985 at 2.990 t. Since then, swordfish catches have fluctuated while decreasing to 182 t in 2004 before rebounding slightly to 474 t in 2007 (Table 2).

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 1999. Less than 1% of the landings were sampled. NOAA Fisheries places observers on gill net vessels and also collects length data.

F. Harpoon

The harpoon fishery operates in areas within the 200-mile EEZ of California between 32°N and 34°N latitude (Figure 11). The number of vessels participating in the fishery generally decreased from 113 in 1986 to 23 in 2001 (Table 1). Twenty-eight vessels fished in 2007. Swordfish is targeted and trends in catches generally decreased from 305 t in 1985 to 20 t in 1991 (Table 2). Fifty-nine metric tons were landed in 2007.

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 1999, covering less than 1% of swordfish landings.

IV. RESEARCH

A. Fishery Monitoring, Management, and Socio-Economic Research

International Billfish Angler Survey – NOAA Fisheries and billfish angling community have worked together since 1963 to study various aspects of billfish biology and obtain an index of angler success in the Pacific Ocean. In 2006, billfish anglers reported catching 5123 Pacific billfish during 6045 fishing days. The mean CPUE for all billfish in the Pacific was 0.85, which is just above the previous record of 0.82 set in 2003. With the 2006 data, there is a new high six-year average catch rate of 0.67 ± 0.17 billfish per angler day for the entire time series, which extends back to 1969. The lowest value (0.34) was reported for the late 1970s (1975-79). CPUE time series were extended for each of the main species caught, including Pacific blue marlin (*Makaira nigricans*, striped marlin (*Kajikia audax*), Pacific sailfish (*Istiophorus platypterus*), and black marlin (*Makaira indica*) in the main fishing areas (Tahiti, Hawaii, Baja California, Southern California, Mexico, Guatemala, Costa Rica, Panama, and Australia).

Central and western Pacific monitoring **–**The Western Pacific Fishery Information Network (WPacFIN) which manages data from most of the US central and western Pacific fisheries has completed basic procedures for integrating Hawaii fisheries catch data (numbers) and fishing trip information from fishermen's reports with fish weight and sales data from dealers sales reports, so that the weight and value of most catches can be linked. This provides average fish weight data by gear type, time period, and species that are used to estimate total catch weights for the Hawaii fisheries in this report. Other enhancements to this integration are under development, such as the linking the dealer data on longline-caught fish weights with some approximation of the geographic location, and addressing fishermen's species misidentifications based on species indicated by dealer and observer data. A project devoted to estimating corrected species compositions and catch histories of billfishes in the Hawaii-based longline fishery from 1994-2006 was completed and published, but is not yet operationally applied to routine data reporting (i.e. the data reported here).

A new retail monitoring system completed a year of data collection on fresh fish retail markets in Honolulu in 2007 to better understand the economic contribution of fisheries and the market impacts of regulations by exploring how price changes travel through the fish 'value chain' from the fisherman to the consumer. The database includes retail-level price data for bigeye and yellowfin (*Thunnus albacares*) tuna. A conjoint study was launched on *ahi poke* (a very popular raw tuna product mixed with seasoning). The objective is to investigate the attributes of *ahi poke* that contribute to consumers choices, and to assess how awareness of carbon monoxide (CO) treatment of the *ahi poke* affects consumer purchases. The *ahi poke* survey was completed in May 2008, and this study may help differentiate the demand for locally produced fresh tuna versus previously frozen and CO-treated tuna.

A new cost-earnings survey was initiated on the Hawaii small boat fishery that harvests mainly pelagic fish using trolling and handling gear. This research was designed to allow fishery managers to better understand the costs of fishing and the economic and social value it provides to local communities. Information collected include levels of investment, trip expenditures, scale of fishing effort, spatial effort allocation, gear usage, and access to markets, which will have implications for future management of the fishery.

B. Stock Assessment Research

NOAA Fisheries continues to support stock assessment modeling efforts in the Pacific Ocean as part of several international fora including the International Scientific Committee for Tuna and Tuna-Like Species (ISC) and the Western and Central Pacific Fisheries Commission (WCPFC) In particular, NOAA Fisheries analysts have been involved in model development for population analysis on albacore, Pacific bluefin tuna (*Thunnus orientalis*), bigeye tuna, striped marlin, swordfish, and blue shark (*Prionace glauca*). Stock assessment research generally involves collaborative development of population models, which provide stock status determinations and form the basis for management advice to regional fisheries management organizations (RFMOs). As this work is conducted as international collaborations and reported directly to the RFMOs, it is not further described here.

C. Biological and Oceanographic Research

Meta Analysis of Archival Tags - An analysis is underway on the performance of pop-off archival transmitting (PAT) tags deployed on a wide array of highly migratory species. Based on the fate of 1433 tags described in the literature plus data from 731 tags provided by collaborators in a performance assessment database, there is a 75% overall reporting rate. There are only two vendors of PSATs, and one vendor's tags were deployed about twice as much as the other's. A logistic and Cox Proportional Hazards analyses performed on the 731 tags in the database indicates both vendors' tags had virtually the same reporting rate, and indicates that deployment on slow-moving and deep-diving animals are key issues in reduced tag reporting. The slow-moving effect could be due to bio-fouling, and deep diving may cause tag failure due to repeated and extreme variation in pressure. Lower tag retention rates could be linked to higher infection rates, through tag anchor rejection, in areas of higher ocean productivity. Of 662 PSATs attached to sharks, billfish, tunas and turtles, 520 or 79% reported data, but only 87 or 17% stayed attached until their programmed pop-off date.

Tunas

North Pacific Albacore Archival Tagging **–** NOAA Fisheries and the American Fishermen's Research Foundation (AFRF) have worked together since 2001 to study migration patterns and general life history strategies of subadult (ages 2-5) North Pacific albacore using archival tags. Through December 2007, 504 archival tags were deployed, twenty of which were recovered. Most of these were at liberty for over a year and provided over 5,000 days of data and nearly nine million samples of water depth, water temperature, and body temperature from tagged fish. Tag returns indicate that the tagged fish: migrated from the southern tip of Baja California to Vancouver Island and from the coast of North America to the eastern coast of Japan; routinely dove to depths of 250 to 300 m during the day while remaining near the surface at night; spent most of their time in areas where surface water temperatures are 15°C to 19°C but dove into deeper waters with temperatures as low as 9°C; conserved internal heat with visceral temperatures averaging 3°C to 4°C above ambient water temperatures. Tagging efforts will continue in 2008.

Bigeye Tuna Archival Tagging - The spatiotemporal variability in bigeye tuna dive behavior in the central North Pacific Ocean was investigated based on data from 29 pop-up archival transmission (PAT) tags deployed on commercial size (122.2 +/- 7.8 cm F.L.) tuna in the central North Pacific Ocean from 4º - 32ºN During the day bigeye tuna generally spent time in the 0 – 50 m and 300 – 400 m depth ranges, with spatial and temporal variability in the deep mode. At night, bigeye tuna generally inhabited the 0 – 100 m depth range. Three daily dive types were defined based on the percentage of time spent in specific depth layers during the day. These three types were defined as shallow, intermediate and deep, and represented 24.4%, 18.8%, and 56.8% of the total number of days in the study, respectively. More shallow and intermediate dive type behavior was found in the first half of the year, as well as in the ranges from 14º – 16ºN and north of 28ºN. A greater amount of deep dive behavior was found in the regions south of 10ºN and between 18º–28ºN during the third and fourth quarters of the year. Dive type behavior also varied with oceanographic conditions, with more shallow and intermediate behavior found in colder surface waters. Intermediate and deep dive types were pooled to reflect the depths where bigeye may have potential interactions with fishing gear. A Generalized additive model showed that sea surface temperature had the most significant effect on the pooled intermediate and deep dive behavior, and predicted that the largest percentage of potential interaction would be in the fourth quarter from 18 – 20ºN, which corresponds to the time and place of the highest CPUE of bigeye tuna by the Hawaii-based longline fishery.

Billfishes

Recreational Billfish Tagging Program **–** NOAA Fisheries' Billfish Tagging Program has provided tagging supplies to recreational billfish anglers for 45 continuous years. Tag release and recapture data are used to determine movement and migration patterns, species distribution, and age and growth patterns of billfish. Since its inception, over 57,000 fish of 75 different species have been tagged and released. In 2006, 1,121 billfish and 15 other fish species were tagged and released by 807 anglers and 188 fishing captions.

Striped Marlin Age and Growth - The examination of striped marlin bony hardparts has been initiated to evaluate their use as growth mark indicators. Sampling was initially focused only on obtaining bony hardparts (otoliths, dorsal & anal fin rays, cleithrum, and vertebrate) from Hawaii marketing sampling, and has now expanded to include observers who sample onboard longline vessels and collect heads (otoliths) and whole gonads. Billfishes are gutted at sea, so gonads and gender identity were unavailable through the market sampling. The gonad samples will be used to determine length at 50% reproductive maturity for both sexes. Observers have also been able to collect ~20 unusually small (<110 cm EFL) whole juvenile specimens that are rarely available. Collaborations are currently being sought with researchers in Mexico and Australia who are actively conducting similar striped marlin studies in those regions.

Swordfish Age and Growth- NOAA Fisheries has collaborated with researchers from Australia on a review of regional differences in swordfish length at 50% female reproductive maturity and length-at-age curves. Results indicate the need for high quality histological sections of gonads (fixation at sea rather than stored frozen) in order to distinguish resting-mature from immature females when sampling does not coincide temporally and/or spatially with spawning activity. Interpretation of diffuse and/or multiple growth banding in fin ray sections will require more standard and objective criteria to differentiate apparent age and growth differences from those created by differing estimation protocols.

Progress has also been made in studies of young-of-year swordfish otoliths collected from the main Hawaiian Islands, the equatorial central Pacific Ocean, French Polynesia, coastal Japan, the subtropical convergence zone north of Hawaii, coastal Ecuador, and the western Indian Ocean. Sagittal otoliths were polished to expose the otolith core region and the series of daily growth increments formed during the larval stage (ca. first 60 increments). Otoliths were analyzed for the presence of 12 trace elements (plus calcium and strontium) using the laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) instrument at Oregon

State University. This data are currently being analyzed to determine whether otoliths contain trace elemental "fingerprints" unique to particular nursery regions.

Pelagic Sharks

NOAA Fisheries shark research program focuses on highly migratory pelagic sharks that occur along the U.S. West Coast, including the shortfin mako, blue shark (*Prionace glauca*), and three species of thresher shark: common thresher (*Alopias vulpinus),* bigeye thresher (*A. superciliosus),* and pelagic thresher (*A. pelagicus)*. Some of the recently completed or ongoing shark research activities are discussed below.

Abundance Surveys – To track trends in the abundance of juvenile and sub-adult blue and shortfin mako sharks and neonates of common thresher shark, fishery-independent surveys have been conducted in the Southern California Bight each summer since 1994 for mako and blue sharks and since 2003 for thresher sharks: for mako and for blue sharks; there is a declining trend in CPUE for both species since the survey began. While it is still too early to develop a pre-recruit thresher shark index, a number of interesting patterns are emerging across years. Depth-stratified sampling revealed that over half of the neonates were caught in shallow waters from 0 to 46 m and almost all individuals are caught shallower than 90 m. The distribution of thresher sharks is very patchy and areas of high abundance are not consistent across years. In all years, a large percentage of the catch has been neonates which were found in all areas surveyed.

Migration Studies – Since 1999, NOAA has used satellite technology to study the movements and behaviors of blue, shortfin mako and common thresher sharks and to link the data to physical and biological oceanography in the California Current. In recent years, tag deployments have been carried out in collaboration with the Tagging of Pacific Pelagics research program (www.topp.org), Mexican colleagues at CICESE (Centro de Investigación Científica y de Educación Superior de Ensenada) and Canadian colleagues at the DFO (Department of Fisheries and Oceans) Pacific Biological Station in Nanaimo, British Columbia. Since 1999, a total of 68 makos, 62 blue sharks, and 32 common threshers have been satellite tagged through these collaborative projects.

Feeding Ecology Studies – Since 1999, NOAA Fisheries has investigated the feeding ecology and identified diet differences of the blue, shortfin mako, common thresher, and bigeye thresher sharks. Stomach content data from recent years reveal that jumbo squid (*Dosidicus gigas*) are an increasingly important component of the mako shark diet. Of 228 stomachs examined since 2002, 49 contained jumbo squid remains.

The large number and diversity of taxa in the bigeye thresher diet suggest that the bigeye thresher is an opportunistic feeder that forages over a broad range of habitats to exploit locally abundant prey.

Age, Growth and Maturity Studies – In 2007, NOAA Fisheries initiated OTC validation studies on blue sharks and continued OTC validation studies on mako and thresher sharks.

Since the beginning of the program in 1997, 1,368 OTC-marked individuals have been released during juvenile shark surveys. As of January 2008, recaptured OTC-marked sharks included 68 mako, 19 common thresher, and two blue sharks; however, vertebrae were returned for only about half of the recaptures. Time at liberty ranged from seven to 1,938 days with net movements of individual sharks as high as 3,410 nmi.

Survival after Capture-and-Release Studies - NOAA Fisheries is conducting a study to determine the survivability of blue sharks caught and released alive by the California drift gillnet fishery. During the 2007-08 fishing season, seven sharks in various conditions at time of release were tagged with PAT tags. The tagged sharks were tracked and preliminary results indicate that survivability is high; all seven sharks survived for at least six weeks following tagging. A collaborative project was initiated by NOAA Fisheries and Pfleger Institute of Environmental Research in spring 2007 to determine the survivability of thresher sharks caught and released alive by recreational fishermen. Four thresher sharks hooked by the tail by anglers were fitted with PAT tags and released.

D. Bycatch and Fishing Technology Research

Sea turtles

TurtleWatch Advisory - Operational longline fishery characteristics, bycatch information, and loggerhead turtle satellite tracks were used in conjunction with remotely sensed sea surface temperature data to identify the environmental area where the majority of historical loggerhead turtle bycatch in the Hawaii longline fishery occurred during 1994 - 2006. A resulting "TurtleWatch" advisory product was developed to see if this information could help reduce inadvertent interactions between Hawaii-based longline fishing vessels and loggerhead turtles. The majority of shallow longline sets and associated loggerhead turtle bycatch were near the north Pacific subtropical frontal zone. The TurtleWatch advisory was released to fishers and managers starting in late 2006 recommending that shallow sets be deployed in waters warmer than the 18.5ºC isotherm, representing the warm edge of the zone. Fishery information from 2007 was later compared with data in the years 2005-2006 to assess the response of the fishery, which indicated increased effort to the north, in the area recommended for avoidance by the TurtleWatch product. However, turtle bycatch was reduced. The TurtleWatch advisory was subsequently refined to recommend avoidance of the temperature band from 17.5º – 18.5ºC (~63.5º – 65.5ºF) such that the area recommended for fishing could be either north or south of this band.

Gear Modification to Reduce Bycatch - NOAA Fisheries is contracting or otherwise assisting in longline fishing vessels trials to test the efficacy of sea turtle bycatch mitigation methods in Costa Rica, Brazil, Uruguay, Indonesia, and Italy to test effects of gear modifications (e.g., use of large circle hooks, appendage hooks, hook offsets) on the rates of hooking and entanglement of sea turtles in longline fisheries. The primary new result in 2008 was a finding of improved target species capture rates and reduced bycatch in Indonesian tuna fishery using circle hooks (size 16/0) compared to their traditional tuna hook. Otherwise, similar trends are being found as reported last year. Circle hooks (size 18/0) resulted in nearly equivalent rates of swordfish capture rates and reduced rates of capture of sea turtles and pelagic rays in Italy, Brazil, and Uruguay as compared to J hooks. The Italy results indicate that circle hook shape (not just its width) may be effective in reducing turtle bycatch rates, since the J hook and circle hooks tested had very similar minimum widths.

Circle hooks may sometimes result in increased rates of shark capture, as was found in the circle hook testing studies in Indonesia, Brazil and Uruguay. Research on the effects of shark shapes and light sticks on rates of sea turtle capture in a gillnet fishery in Baja California, Mexico is also underway.

Sharks

Workshop on Reducing Incidental Capture - Due to growing concern for increase capture of sharks in longline fisheries, a meeting was hosted at the New England Aquarium during April 2008 entitled the "Shark Deterrent and Incidental Capture Workshop". Researchers from academic institutions, NOAA science centers, NGO research institutions, as well as industry leaders participated.

Shark Repellants for Fisheries - The ability of electropositive metals (lanthanide series) to repel sharks from fishing gear is being tested off Oahu in Hawaii. Electropositive metals release electrons and generate large oxidation potentials when placed in seawater. It is thought that these large oxidation reactions perturb the electrosensory system in sharks and rays, causing the animals to exhibit aversion behaviors. Since commercially targeted pelagic teleosts do not have an electrosensory sense, this method of perturbing the electric field around baited hooks may selectively reduce the bycatch of sharks and other elasmobranchs. Feeding behavior experiments were conducted to determine whether the presence of these metals would deter sharks from biting fish bait. Experiments were conducted with Galapagos sharks (*Carcharhinus galapagensis*) and sandbar sharks (*Carcharhinus plumbeus*). Results indicate that sharks significantly reduced their biting of bait associated with electropositive metals. In addition, sharks exhibited significantly more aversion behaviors as they approached bait associated with these metals. Further studies on captive sandbar sharks, *Carcharinus plubeus,* in tanks indicated sharks would not get any closer than 40 cm to baits in the presence of the metal (metal approximately the same size as a 60g lead fishing weight used by Hawaii longline fishermen).

Barbless Hooks and Dehookers - Testing of the dehookers on sharks on research longline cruises has indicated removal of circle hooks from shark jaws with the dehookers can be quite difficult. The feasibility of barbless circle hooks to make it easier to dehook unwanted catch with less harm is being investigated. Preliminary research in the Hawaii shore fishery has indicated that barbless circle hooks catch as much as barbed hooks, but the situation could be different with more passive gear like longlines, where bait must soak unattended for much of the day and fish have an extended period in which to try to throw the hook. Preliminary results from very limited longline testing of barbless hooks on research cruises indicated a substantial increase in bait loss using barbless hooks. Subsequent testing used rubber retainers to prevent bait loss. Summary information from before and after the use of bait retainers showed no difference between barb and barbless hooks in the catch and catch rates of targeted species and sharks, although catches have so far been too few to provide much statistical power. The efficacy of the pigtail dehooker required by U.S. regulations for releasing sea turtles showed much higher success rate in dehooking and releasing live sharks on barbless hooks, compared to when used with sharks caught on barbed hooks. A dehooker was developed and tested, indicating >90 percent effectiveness in removing both barb and barbless circle hooks from sharks; however, the prototype appears to work best on smaller sharks.

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Table 1. Number of vessels fishing in the North Pacific Ocean in various U.S. fisheries. Data for 2005 and 2006 are preliminary

Year	Purse Seine	Longline	Distant-water troll	Pole-and-Line	Troll & Handline	Gill Net	Harpoon
1985	110	36	792	27	na	210	99
1986	85	39	419	19	na	220	113
1987	85	37	486	18	1,899	210	98
1988	87	50	531	17	1,878	192	83
1989	84	88	338	18	2,002	158	44
1990	85	138	368	12	2,042	146	49
1991	65	141	172	12	2,117	123	32
1992	62	124	602	11	2,160	113	48
1993	62	122	608	13	2,132	105	44
1994	62	127	721	11	2,210	112	49
1995	55	116	471	11	2,387	127	39
1996	40	114	676	9	2,411	100	30
1997	38	117	1,172	9	2,400	104	31
1998	37	122	841	9	2,370	87	26
1999	25	140	776	9	2,502	78	30
2000	27	130	645	7	2,229	77	26
2001	29	125	860	9	2,208	64	23
2002	27	123	644	13	2,045	45	29
2003	29	128	729	14	1,940	37	34
2004	19	126	695	11	1,994	33	28
2005	23	126	541	10	1,909	37	24
2006	12	128	601	11	1,917	45	24
2007	23	130	625	10	1,907	50	28

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 2006 and 2007 are preliminary. NEI = not included elsewhere. Dashes indicate missing data. 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	BUM	MLS	UNSPEC. BILLFISH	UNSPEC. TUNA	TOTAL
Purse Seine:													
1985	26	92,623	47,634	1,751	3,320	0	3,360	32	0	0	0	0	148,746
1986	47	102,736	52,817	264	4,851	5	171	87	0	0	0	132	161,109
1987	1	123,044	48,667	222	861	1	3,093	2	0	0	0	56	175,947
1988	17	88,302	78,250	1,120	923	34	3,416	4	0	0	0	9	172,075
1989	1	77,744	35,671	516	1,046	85	795	6	0	0	0	70	115,934
1990	71	63,722	53,213	674	1,380	260	3,687	0	0	0	0	39	123,046
1991	0	26,789	50,107	415	410	2	218	2	0	0	0	7	77,950
1992	0	29,668	74,234	3,709	1,928	2	770	13	0	0	0	0	110,324
1993	0	23,805	60,485	3,035	580	0	186	17	0	0	0	0	88,108
1994	0	10,516	30,183	2,472	906	30	75	0	0	0	0	8	44,191
1995	0	16,934	60,036	5,803	657	9	20	0	0	0	0	0	83,459
1996	11	6,653	20,646	6,884	4,639	39	202	0	0	0	0	0	39,075
1997	2	20,866	37,525	8,702	2,240	0	115	2	0	0	0	7	69,459
1998	33	20,831	25,258	3,645	1,771	34	418	1	0	0	0	0	51,991
1999	48	4,989	18,710	3,236	184	62	18	0	0	0	0	0	27,248
2000	4	1,670	5,508	454	693	0	32	0	0	0	0	0	8,361
2001	51	5,362	17,794	1,122	292	13	0	0	0	0	0	0	24,634
2002	4	6,612	4,002	580	50	37	0	1	0	0	0	0	11,286
2003	44	3,562	21,212	3,528	22	70	0	0	0	0	0	0	28,439
2004	1	3,810	6,860	1,437	0	78	0	0	0	0	0	0	12,186
2005	0	6,792	19,171	3,992	201	0	0	0	0	0	0	0	30,157
2006	0	1,111	5,164	1,492	0	0	0	0	0	0	0	0	7,766
2007	77	1,536	8,899	3,644	42	0	0	0	0	0	0	0	14,198
Pole and Line :													
1985	1,498	472	1,328	0	3	0	0	68	0	0	0	0	3,369
1986	432	554	1,367	0	1	0	0	9	0	0	0	1	2,364
1987	158	1,861	2,087	0	0	0	1	22	0	0	0	0	4,129
1988	598	1,140	3,450	5	5	0	26	40	0	0	0	0	5,264
1989	54	1,318	2,456	0	9	0	1	26	0	0	0	3	3,867
1990	115	154	553	0	61	0	0	21	0	0	0	2	906
1991	0	942	1,840	0	0	0	0	22	0	0	0	0	2,804
1992	0	1,928	1,744	0	2	0	0	33	0	0	0	2	3,709
1993	0	2,636	2,850	0	5	0	0	139	0	0	0	5	5,635
1994	0	1,844	2,422	0	1	0	187	19	0	0	0	18	4,491
1995	80	394	2,393	0	1	0	0	21	0	0	0	0	2,889
1996	24	696	1,331	0	0	0	0	9	0	0	0	1	2,061
1997	73	468	1,755	0	1	0	0	1	0	0	0	0	2,298
1998	79	2,206	1,067	0	4	0	6	5	0	0	0	0	3,367
1999	60	57	601	4	2	0	0	17	0	0	0	0	741
2000	69	13	320	1	12	0	0	25	0	0	0	0	441
2001	139	4	448	0	1	0	0	19	0	0	0	0	611
2002	381	2	420	0	2	0	0	0	0	0	0	2	807
2003	59	35	587	0	3	0	1	1	0	0	0	4	690
2004	126	19	279	0	0	0	1	37	0	0	1	0	463
2005	66	68	353	0	0	0	0	0	0	0	0	1	488
2006	23	4	294	0	0	0	0	0	0	0	0	3	324
2007	21	23	272	0	0	0	0	0	0	0	0	1	317

Table 2. Continued.

FISHERY/YEAR	ALB	YFT	SKJ	BET	PBF	BKJ	BEP	SWO	BUM	MLS	UNSPEC. BILLFISH	UNSPEC. TUNA	TOTAL
Distant-water Troll:													
1985	6,415	5	0	0	0	0	0	0	0	0	0	0	6,420
1986	4,708	1	0	0	0	0	0	0	0	0	0	0	4,709
1987	2,766	76	0	0	0	0	33	0	0	0	0	0	2,875
1988	4,212	7	0	0	0	0	0	2	0	0	0	0	4,221
1989	1,860	1	0	0	0	0	0	0	0	0	0	0	1,861
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	1	0	0	0	1	6,455
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	1	0	0	0	0	9,414
1996	16,938	606	393	0	2	0	0	1	0	0	0	0	17,940
1997	14,252	4	2	0	1	0	0	1	0	0	0	0	14,260
1998	14,410	1,246	2	0	128	0	10	6	0	0	0	0	15,802
1999	10,060	52	16	0	20	0	0	1	0	0	0	0	10,149
2000	9,645	3	4	0	1	0	0	8	0	0	0	1	9,662
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	13,346	1	0	0	0	0	0	0	0	0	0	0	13,347
2005	8,413	0	0	0	0	0	0	0	0	0	0	0	8,413
2006	12,524	0	0	0	0	0	0	0	0	0	0	0	12,524
2007	11,436	0	0	0	0	0	0	0	0	0	0	0	11,436
Longline:													
1985	0	0	0	0	0	0	0	2	0	0	0	0	2
1986	0	0	0	0	0	0	0	2	0	0	0	0	2
1987	150	261	1	815	0	0	0	24	51	272	45	0	1,619
1988	307	594	4	1,239	0	0	0	24	102	503	68	0	2,842
1989	248	986	10	1,442	0	0	0	281	356	612	132	0	4,067
1990	177	1,098	5	1,514	0	0	0	2,437	378	538	58	0	6,205
1991	312	733	30	1,555	2	0	0	4,535	297	663	69	0	8,196
1992	334	346	22	1,486	38	0	0	5,762	347	459	142	0	8,936
1993	438	633	36	2,124	42	0	0	5,936	339	471	100	0	10,120
1994	544	610	53	1,827	30	0	0	3,807	362	326	99	5	7,663
1995	882	984	101	2,099	29	0	1	2,981	570	543	182	0	8,372
1996	1,185	634	41	1,846	25	0	0	2,848	467	419	115	2	7,581
1997	1,653	1,143	106	2,526	26	0	0	3,393	487	352	143	2	9,830
1998	1,120	724	76	3,274	54	0	0	3,681	395	378	172	9	9,883
1999	1,542	477	99	2,820	54	0	0	4,329	357	364	242	10	10,294
2000	940	1,137	93	2,708	19	0	0	4,834	314	200	152	0	10,397
2001	1,295	1,029	211	2,418	6	0	0	1,969	399	352	136	0	7,815
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	1,958	363	538	248	0	8,266
2004	360	715	142	4,339	1	0	0	1,185	283	376	200	9	7,610
2005	296	712	91	5,359	1	0	0	1,622	337	511	215	0	9,144
2006	270	958	94	4,219	1	0	0	1,211	409	611	174	0	7,947
2007	250	846	92	6,665	0	0	0	1,750	264	274	160	0	10,301

Table 2. Continued.

FISHERY/YEAR	ALB	YFT	SKJ	BET	PBF	BKJ	BEP	SWO	BUM	MLS	UNSPEC. BILLFISH	UNSPEC. TUNA	TOTAL
Gill Net:													
1985	2	12	0	2	8	0	289	2,990	0	0	0	0	3,303
1986	3	14	0	3	16	0	58	2,069	0	0	0	4	2,167
1987	5	3	0	6	2	0	95	1,529	0	0	0	5	1,645
1988	15	7	0	5	4	0	33	1,376	0	0	0	2	1,442
1989	4	1	5	0	3	0	12	1,243	0	0	0	3	1,271
1990	29	1	1	1	11	0	35	1,131	0	0	0	2	1,211
1991	17	1	3	3	4	0	14	944	0	0	0	3	989
1992	0	4	1	1	9	0	7	1,356	0	0	0	6	1,384
1993	0	7	2	0	32	0	8	1,412	0	0	0	9	1,470
1994	38	0	0	0	28	0	1	792	0	0	0	2	861
1995	52	2	70	1	20	0	2	771	0	0	0	1	919
1996	83	2	2	0	43	0	2	761	0	0	0	0	893
1997	60	3	2	5	58	0	6	708	0	0	0	0	842
1998	80	2	3	4	40	0	4	931	0	0	0	2	1,066
1999	149	0	0	2	22	0	1	606	0	0	0	1	781
2000	55	1	0	2	30	0	1	649	0	0	0	0	738
2001	94	5	1	0	35	0	0	375	0	0	0	0	510
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	12	1	0	0	10	0	2	182	0	0	0	0	207
2005	20	2	0	0	5	0	0	220	0	0	0	0	247
2006	3	1	2	0	1	0	0	443	0	0	0	1	451
2007	4	0	0	0	2	0	0	474	0	0	0	0	480
Harpoon:													
1985	0	0	0	0	0	0	0	305	0	0	0	0	305
1986	0	0	0	0	0	0	0	291	0	0	0	0	291
1987	0	0	0	0	0	0	0	235	0	0	0	0	235
1988	0	0	0	0	0	0	0	198	0	0	0	0	198
1989	0	0	0	0	0	0	0	62	0	0	0	0	62
1990	0	0	0	0	0	0	0	64	0	0	0	0	64
1991	0	0	0	0	0	0	0	20	0	0	0	0	20
1992	0	0	0	0	0	0	0	75	0	0	0	0	75
1993	0	0	0	0	0	0	0	168	0	0	0	0	168
1994	0	0	0	0	0	0	0	157	0	0	0	0	157
1995	0	0	0	0	0	0	0	97	0	0	0	0	97
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	69	0	0	0	0	69
2005	0	0	0	0	0	0	0	77	0	0	0	0	77
2006	0	0	0	0	0	0	0	71	0	0	0	0	71
2007	0	0	0	0	0	0	0	59	0	0	0	0	59

Table 2. Continued.

FISHERY/YEAR	ALB	YFT	SKJ	BET	PBF	BKJ	BEP	SWO	BUM	MLS	UNSPEC. BILLFISH	UNSPEC. TUNA	TOTAL
Unclassified,other or recreational:													
1985	1,176	58	5	1	107	0	426	100	0	42	0	468	2,383
1986	196	227	0	6	52	0	28	105	0	19	0	6	639
1987	74	2,159	633	1	52	0	266	27	0	28	0	67	3,307
1988	74	936	372	1	48	0	335	58	0	30	0	2	1,856
1989	183	849	103	0	121	0	137	49	0	52	0	0	1,494
1990	28	508	147	0	85	0	227	38	0	23	0	1	1,057
1991	77	235	137	0	92	0	69	38	0	12	0	0	660
1992	74	1,119	1,014	0	123	0	78	46	0	25	0	2	2,481
1993	25	2,031	2,279	0	322	0	140	157	0	11	0	0	4,965
1994	319	3	0	0	89	0	12	20	0	17	0	0	460
1995	103	5	263	0	258	0	0	23	0	14	0	0	666
1996	88	0	0	4	40	0	0	10	0	20	0	0	162
1997	1,019	0	83	0	203	0	0	4	0	21	0	0	1,330
1998	1,210	43	0	0	467	0	0	12	0	23	0	1	1,756
1999	3,622	0	0	0	528	0	0	18	0	12	0	0	4,180
2000	1,801	1	0	0	342	0	0	33	0	10	0	0	2,186
2001	1,635	0	0	0	356	0	0	19	0	0	0	0	2,010
2002	2,357	27	1	0	654	0	0	3	1	0	0	1	3,044
2003	2,214	8	2	3	394	0	0	1	0	0	0	0	2,622
2004	1,506	27	2	132	49	0	0	37	5	0	0	0	1,758
2005	1,719	0	0	0	79	0	2	0	0	0	0	0	1,800
2006	296	349	12	0	96	0	0	1	0	0	0	0	755
2007	1,064	92	1	3	14	0	0	16	0	0	0	0	1,190
Hawaii, Guam, and CNMI Troll and Handline:													
1985	7	967	101	8	0	0	0	4	145	18	12	2	1,264
1986	5	1493	120	5	0	0	0	4	220	19	14	4	1,884
1987	6	1616	137	8	0	0	0	4	261	31	20	11	2,094
1988	9	941	172	17	0	0	0	6	266	54	20	11	1,496
1989	36	828	153	14	0	0	0	7	326	24	23	11	1,422
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	1019	181	24	0	0	0	9	293	29	33	4	1,923
2000	120	1080	415	207	0	0	0	0	235	14	20	15	2,106
2001	194	878	523	226	0	0	0	0	291	42	32	13	2,199
2002	235	632	355	586	0	0	0	0	225	29	13	6	2,081
2003	85	735	275	213	0	0	0	10	210	29	18	25	1,600
2004	157	746	261	381	0	0	0	7	188	35	30	45	1,850
2005	175	679	269	295	0	0	0	5	187	20	15	14	1,659
2006	95	504	296	303	0	0	0	4	160	21	14	12	1,409
2007	100	700	278	321	0	0	0	6	123	13	12	14	1,567

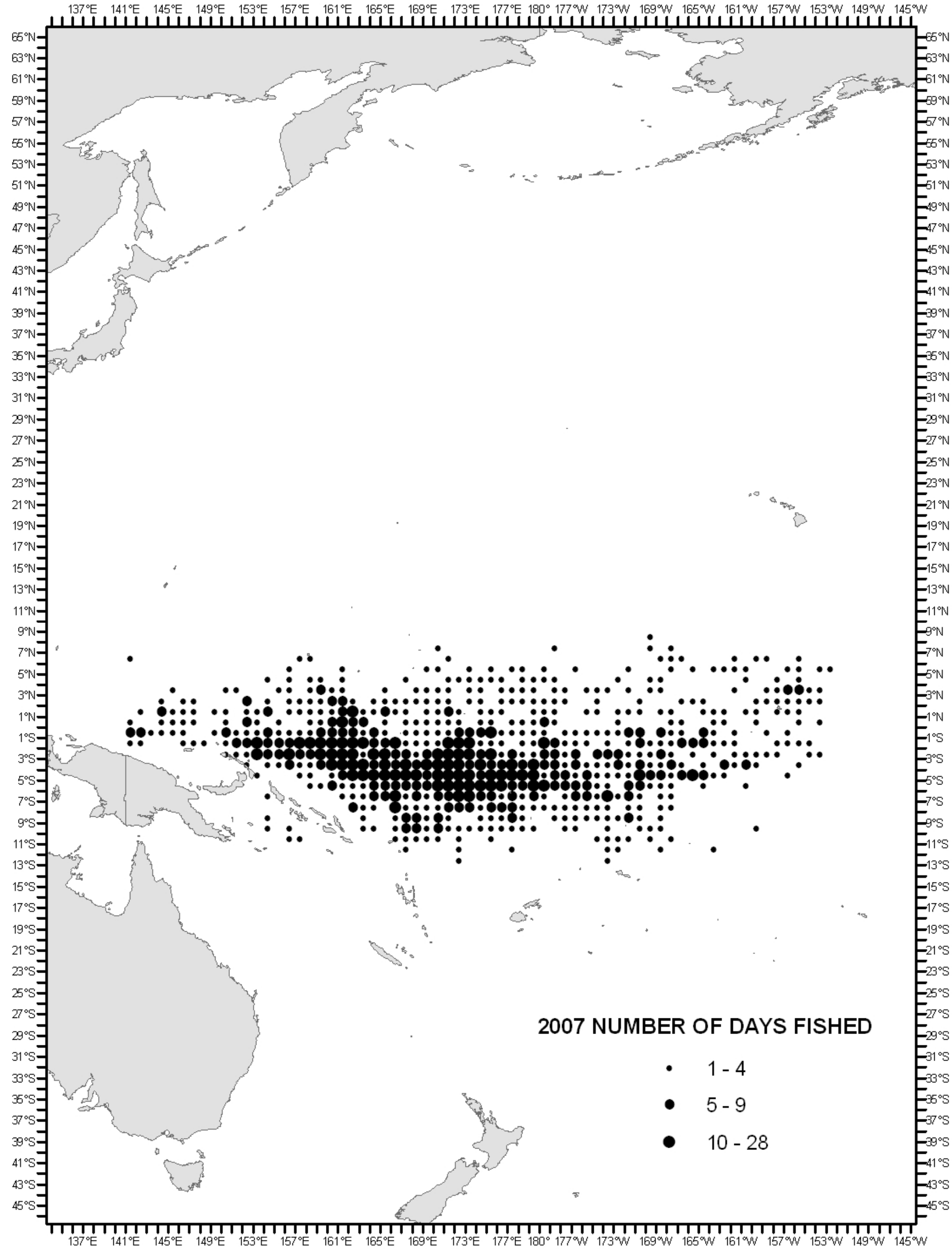


Figure 1. Distribution of nominal fishing effort (days fished) for the 2007 U.S. western-central Pacific purse seine fishery.

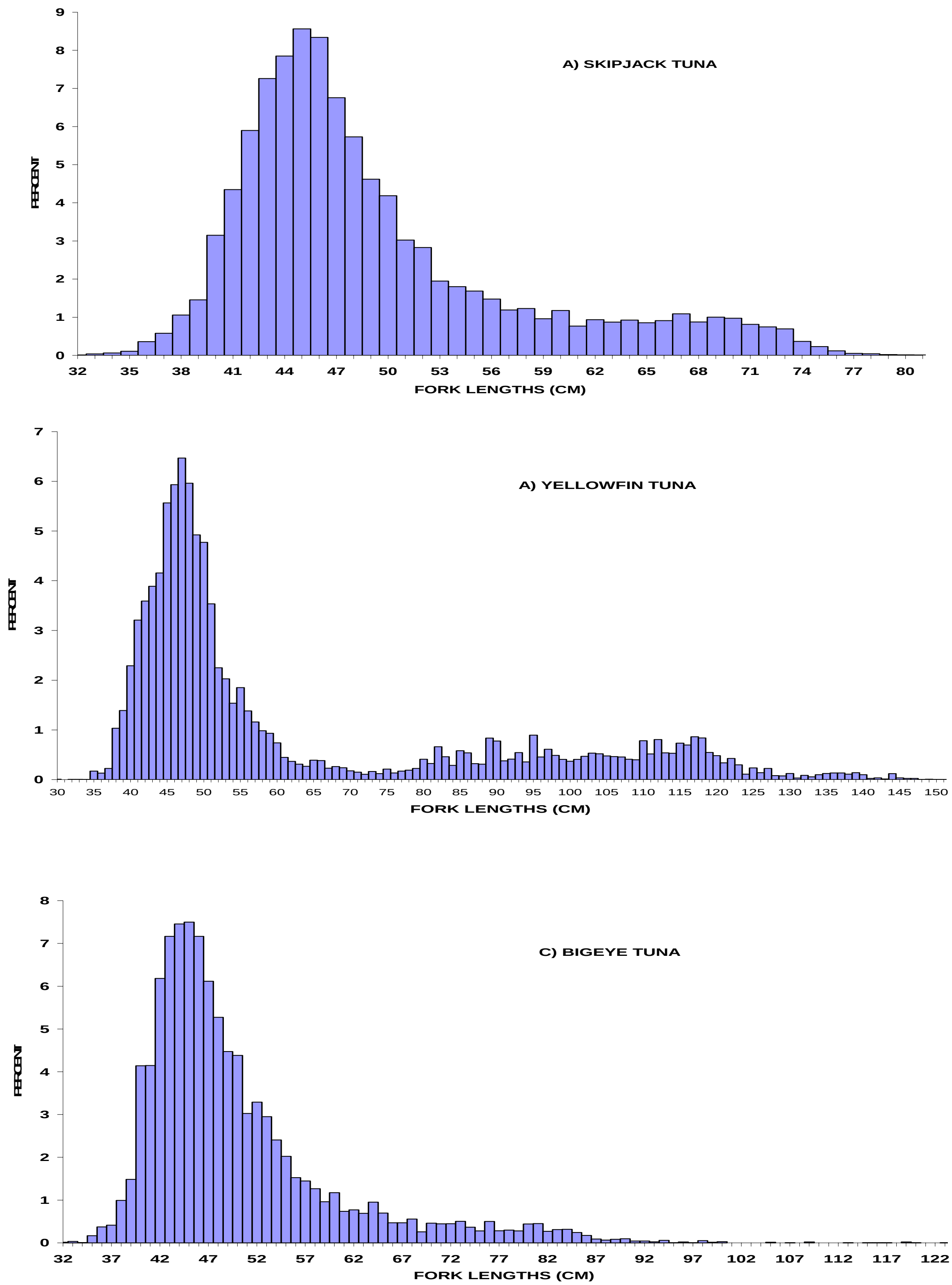


Figure 2. Size distribution of (A) skipjack tuna (*Katsuwonus pelamis*), (B) yellowfin tuna (*Thunnus albacares*) and (C) bigeye tuna (*Thunnus obesus*) caught by U.S. purse seiners in the western-central Pacific Ocean in 2007.

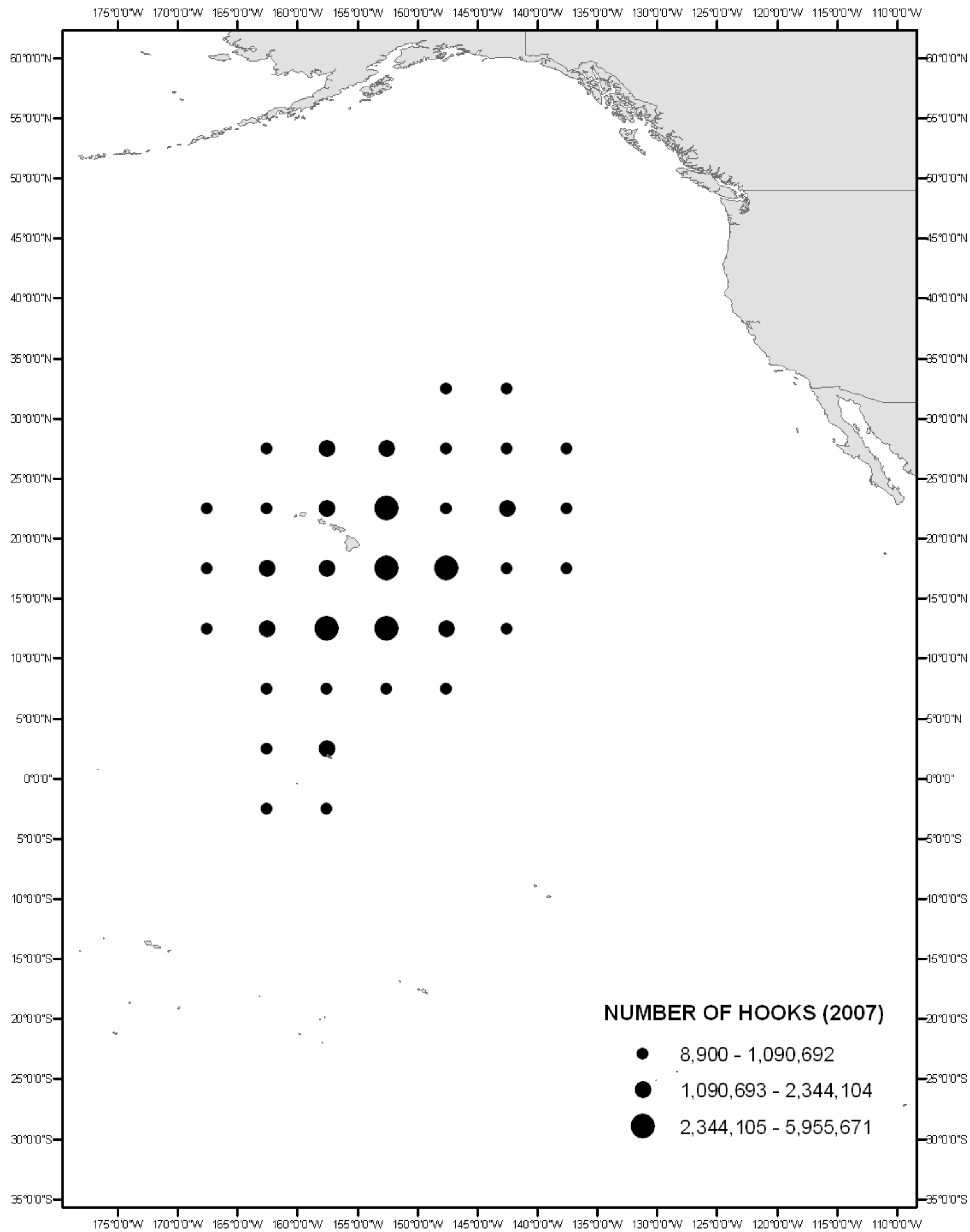


Figure 3. Distribution of fishing effort (number of hooks) for the U.S. longline fishery in the North Pacific Ocean, 2007.

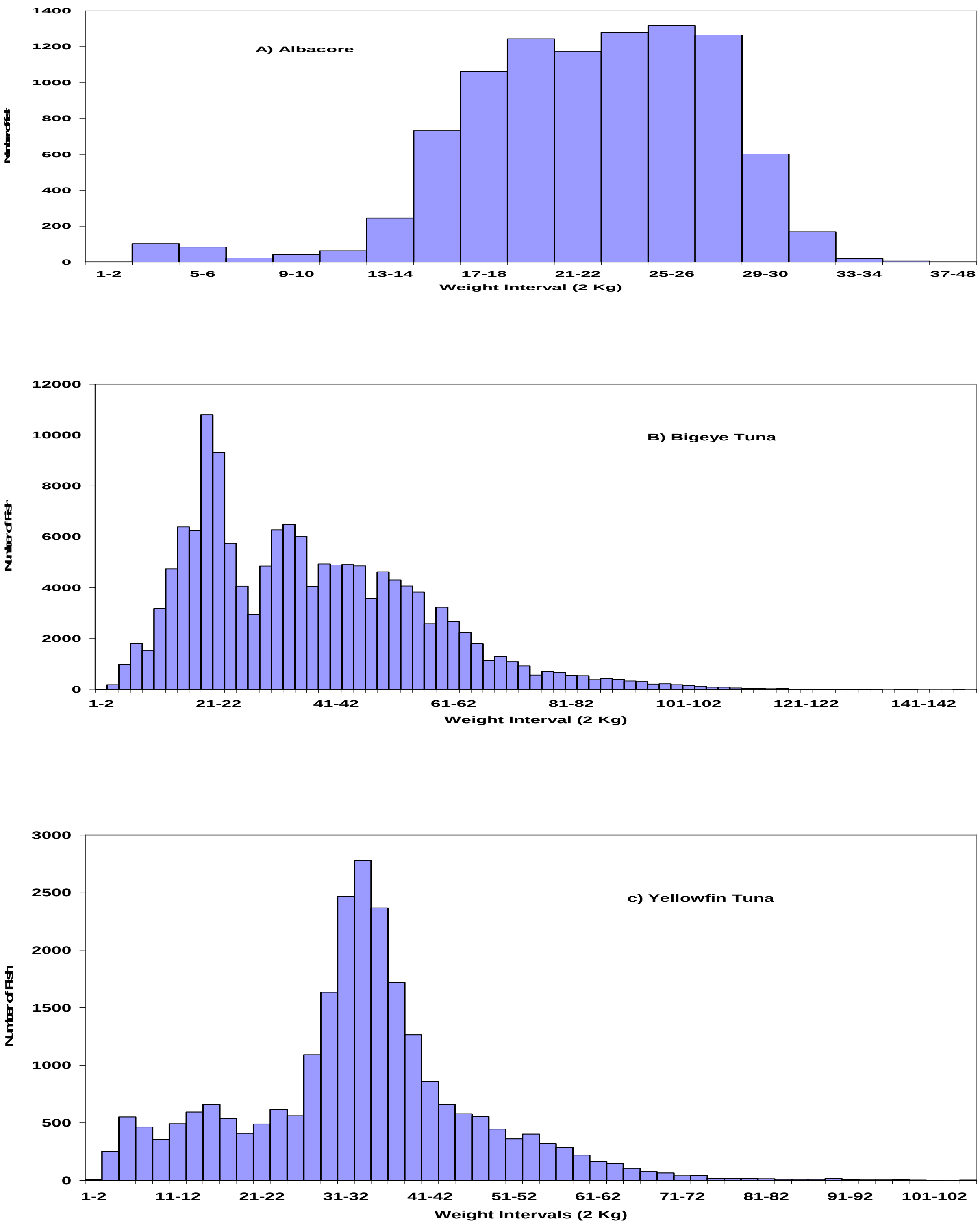


Figure 4. Size distribution of (A) albacore (*Thunnus alalunga*), (B) bigeye tuna (*Thunnus obesus*), and (C) yellowfin tuna (*Thunnus albacares*) caught by the Hawaii-based longline fishery in the north Pacific Ocean, 2007

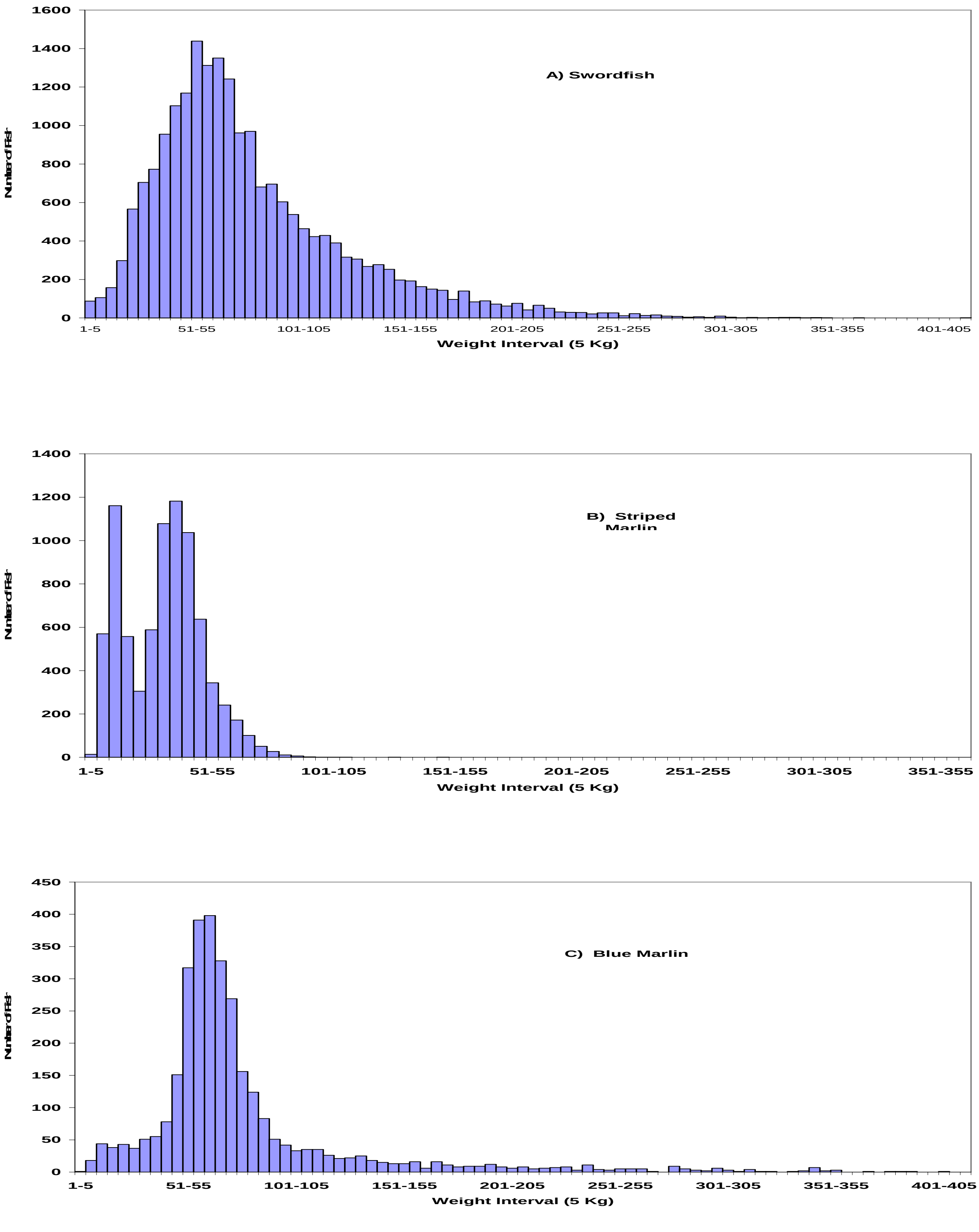


Figure 5. Size distribution of (A) swordfish (*Xiphias gladius*), (B) striped marlin (*Tetrapturus audax*) , and (C) blue marlin (*Makaira mazara*) catch by the Hawaii-based longline fishery in the north Pacific Ocean, 2007.

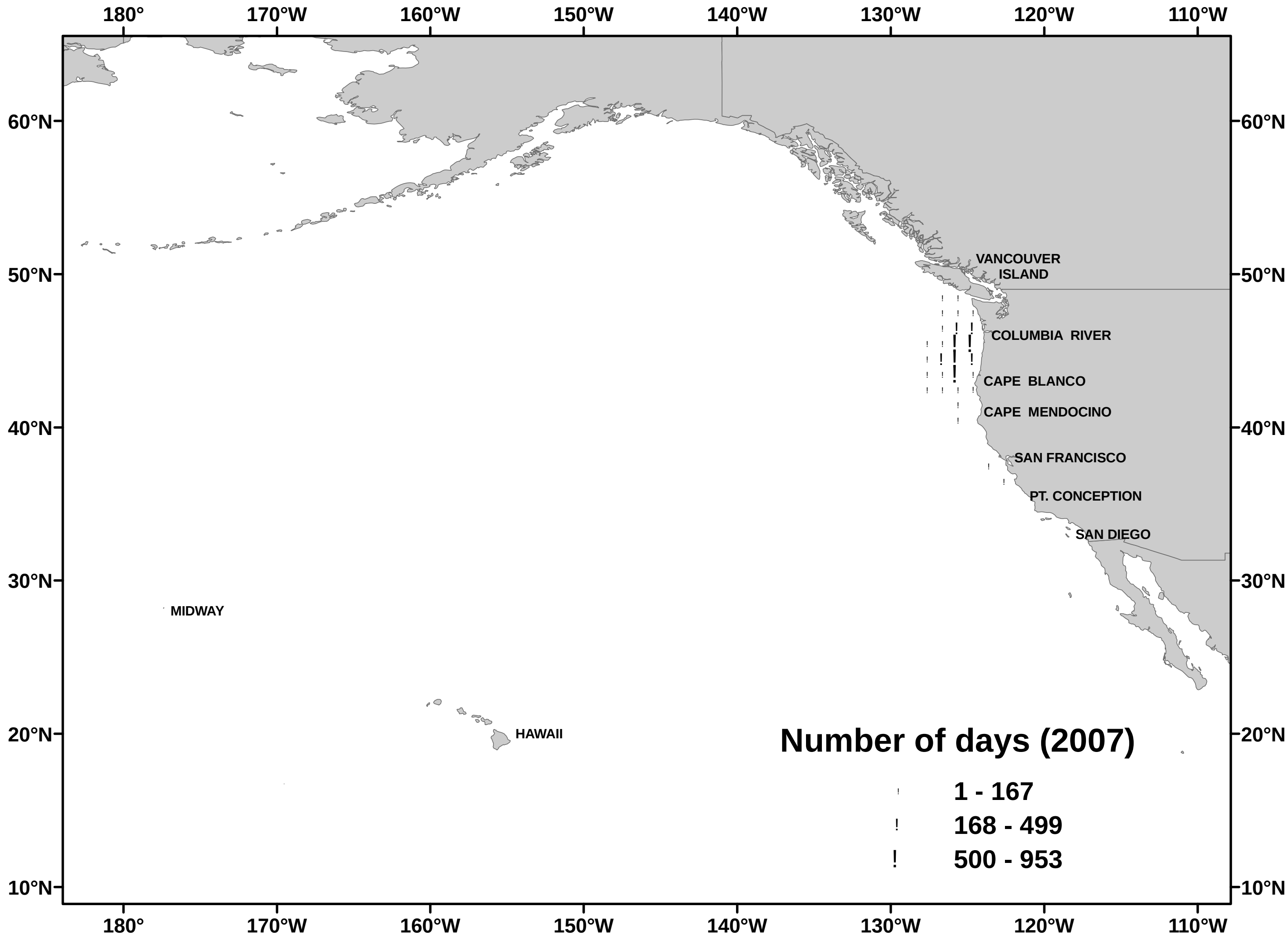


Figure 6. Distribution of fishing effort (days fished) for the U.S. albacore troll fishery, 2007.

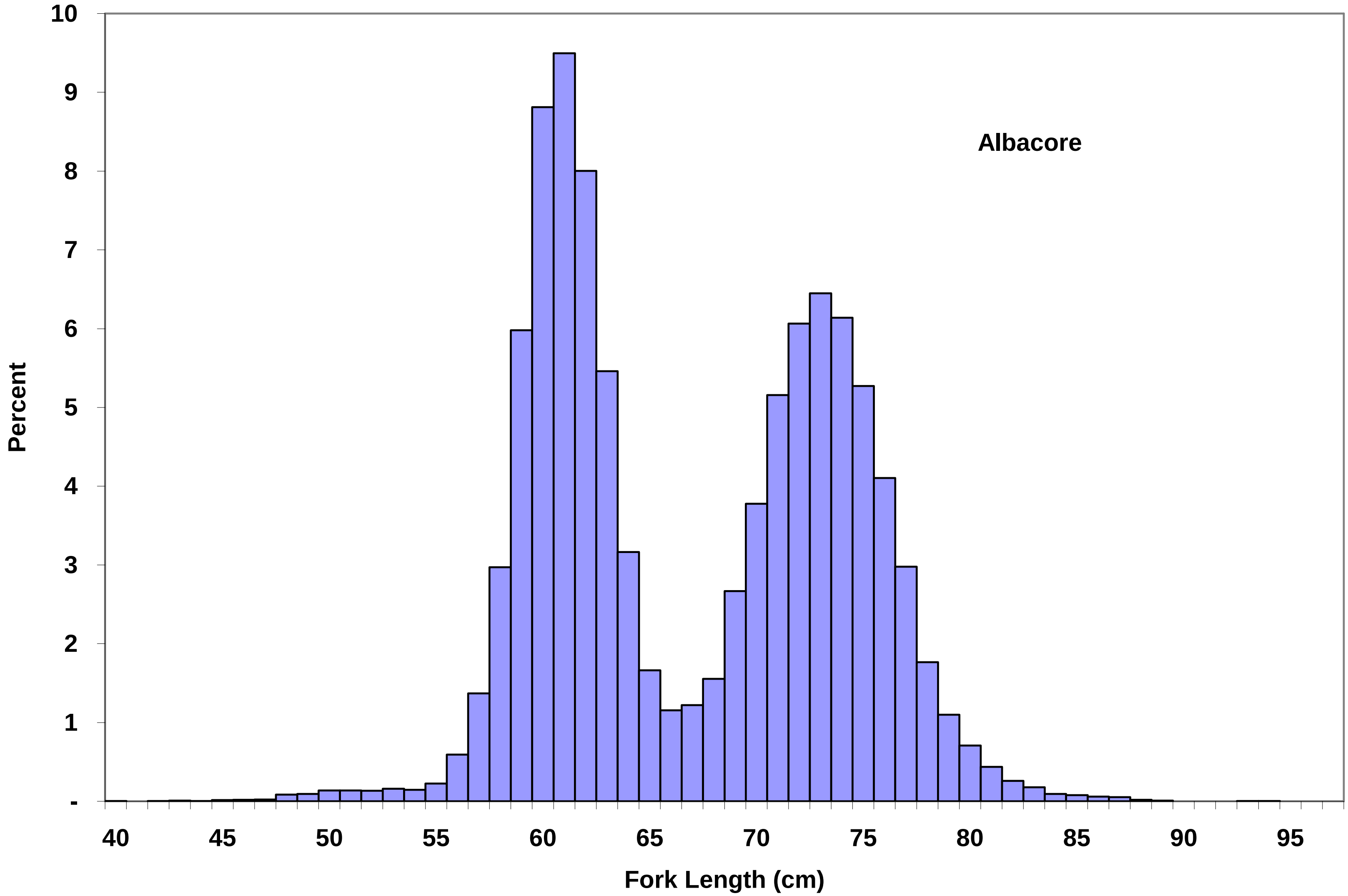


Figure 7. Size distribution of albacore caught by the U.S. albacore (*Thunnus alalunga*) troll fishery in 2007.

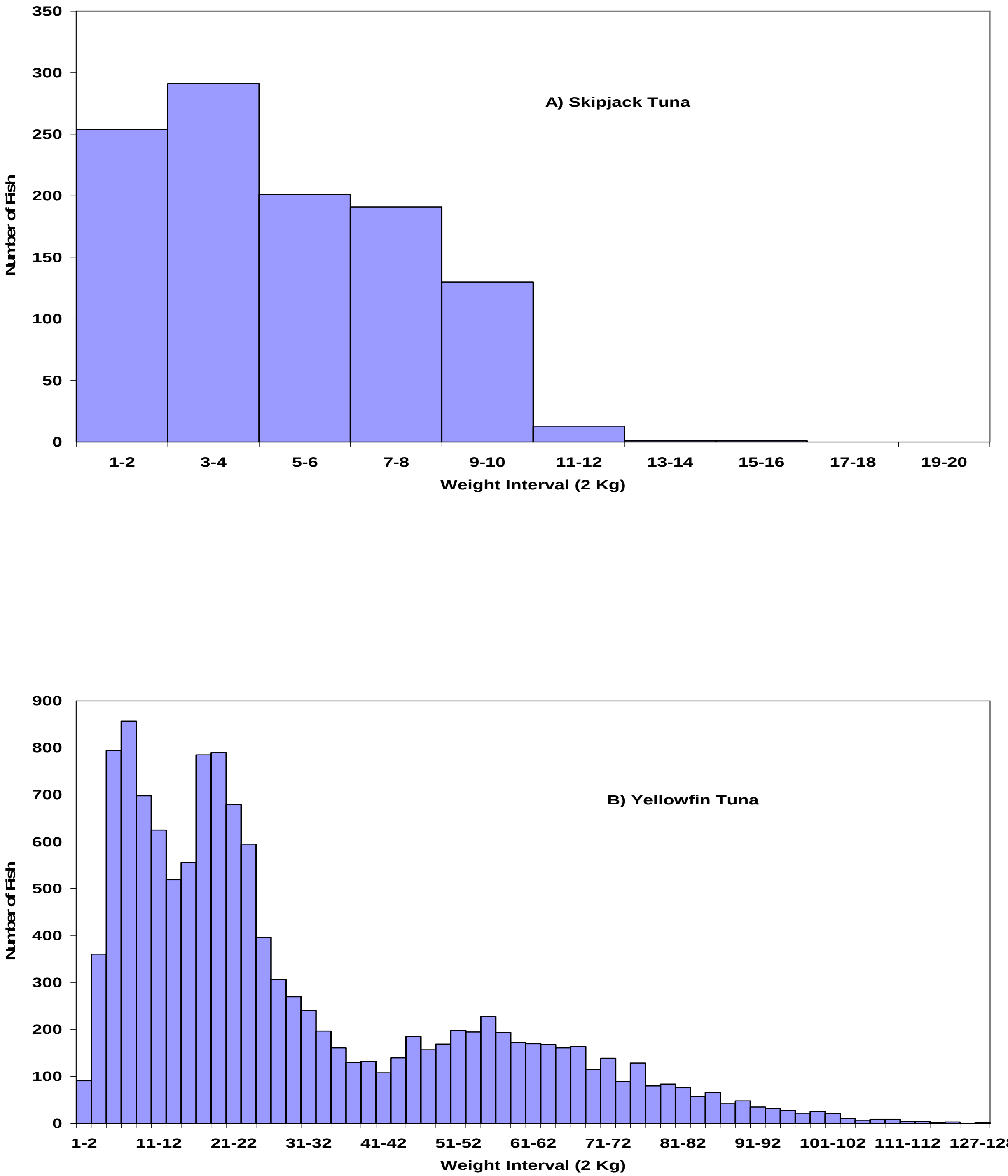
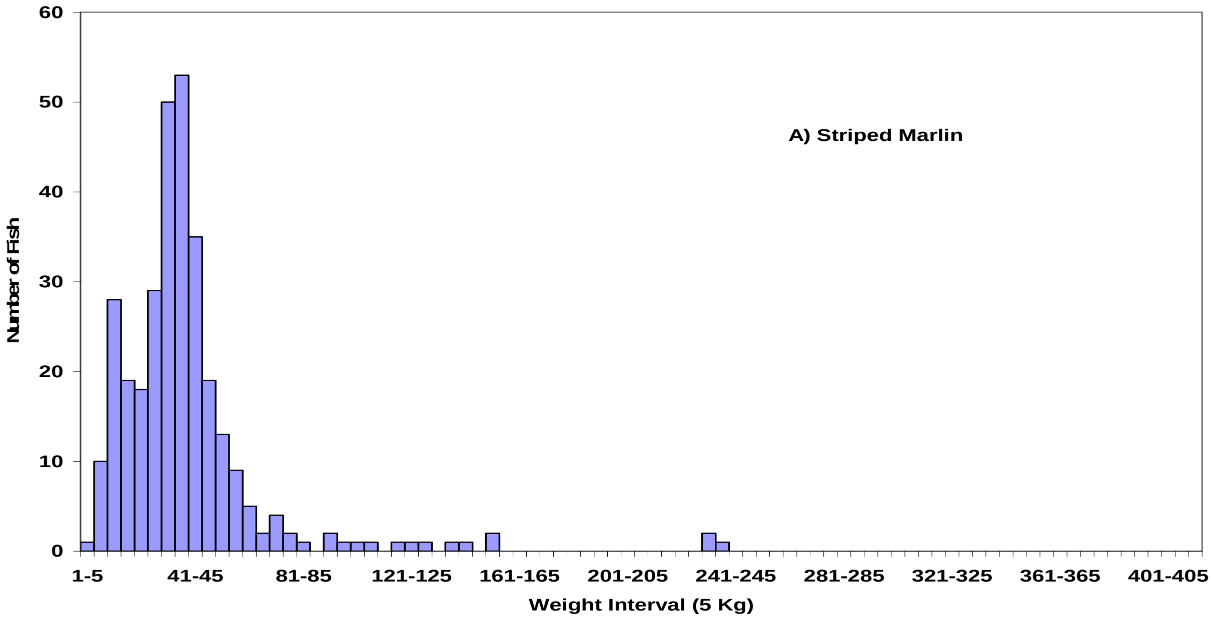


Figure 8. Size distribution of (A) skipjack tuna (*Katsuwonus pelamis*) and (B) yellowfin tuna (*Thunnus albacares*) caught by the Hawaii troll and handline fishery, 2007.



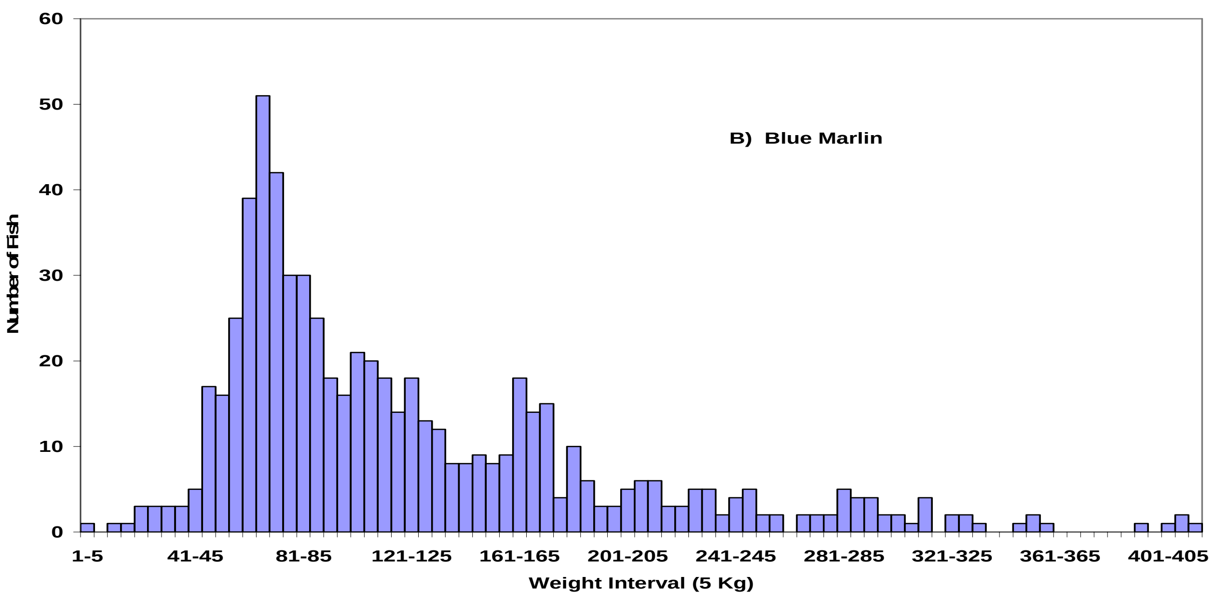


Figure 9. Size distribution of (A) striped marlin (*Tetrapturus audax*) and (B) blue marlin (*Makaira mazara)* caught by the Hawaii troll and handline fishery, 2007.

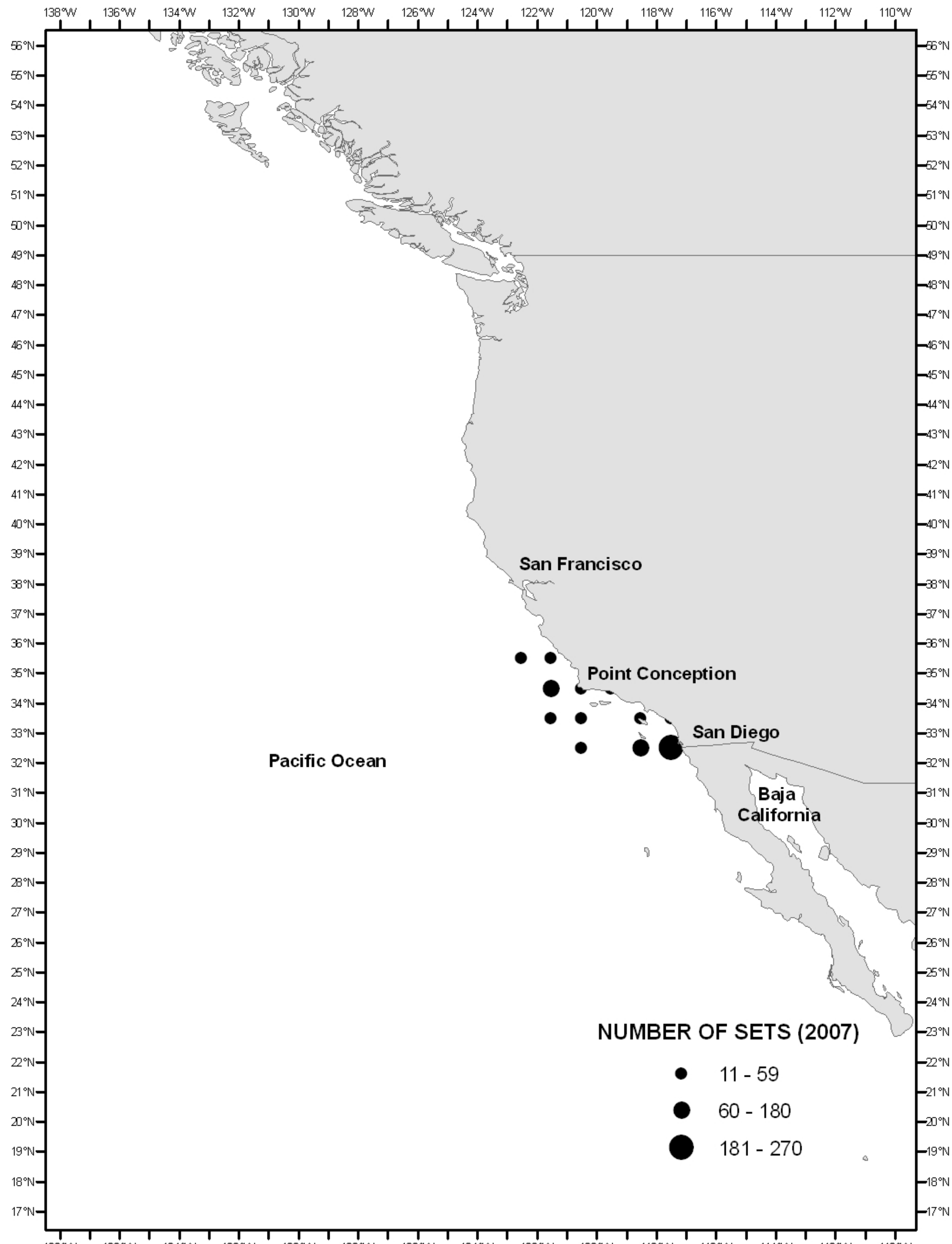


Figure 10. Distribution of fishing effort (number of sets) for the U.S. north Pacific drift gill net fishery, 2007.

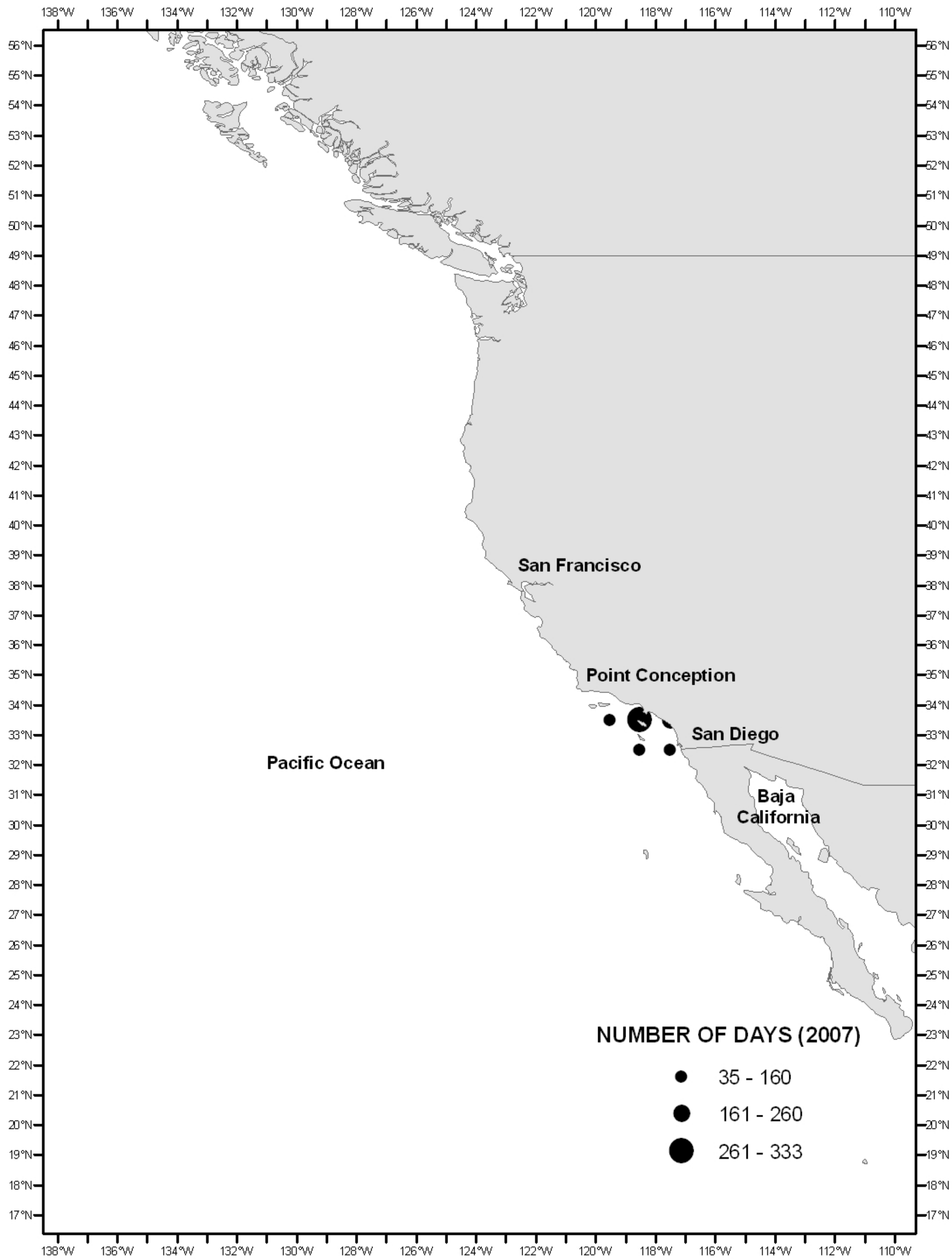


Figure 11. Distribution of fishing effort (days fished) for the U.S. north Pacific harpoon fishery, 2007.