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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 Services

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In the North Pacific Ocean

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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 2008 was primarily a result of increased numbers of active purse seine vessels, up by 10 to 28 in 2008, with the industry responding to improved skipjack tuna (*Katsuwonus pelamis*) prices, catching 14,378 t in 2008 despite higher fuel costs. Longline landings increased again in 2008. 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*) decreased to 466 in 2008, down by 162 from 2007 but caught only a little less than in 2007.

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 conducts fishery monitoring and socio-cultural research on tunas, billfishes, and animals caught on bycatch in those fisheries. In 2008, the International billfish Angler Survey continued to provide billfish biology and angler effort information, WPacFIN improved its sampling protocol, and five socioculture studies were completed which characterize fishermen's perspectives on bycatch reduction.

NOAA Fisheries biological and oceanographic research on tunas, billfishes, and sharks addressed fish movements, habitat choices, post capture survival, feeding habits, abundance, maturity, and age and growth. Salient results include analyses of tuna foraging ecology from stomach contents which will help determine short-term impacts of environmental variation, and a finding that there is a direct relationship between broadbill swordfish eye to fork length and squid mantel length around the U.S.-Mexico border.

Research on sharks focusing on abundance surveys indicates that there is a declining trend in nominal CPUE for both shortfin mako and blue sharks in the Southern California Bight and that juvenile common thresher sharks occur predominantly in shallow, near-sharoe waters less than 90 m. Shark tagging studies continue, and provide an increasing body of migration data. A new survivorship study of thresher sharks caught in the recreational fishery preliminarily indicates that large tail-hooked threshers with longer fight times have increased rates of mortality. Research on bycatch and fishing technology included work on dolphin habitat as well as their prey, commensals, competitors, and predators. 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 as were the effects of operational differences in the longline fisheries on shark bycatch rates.

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. Some state agencies also collect logbook and 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. The management of data on U.S. Pacific fisheries for tuna and tuna-like species is coordinated among the SWFSC, SWRO, PIFSC, and PIRO.

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 2008. Data for 2008, however, are considered preliminary and are subject to change. Although the report is focused on tunas and billfishes, many of the fisheries described catch of 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 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 most catch came from there until 1993 when vessels moved to the WCPO in response to dolphin conservation measures in the ETP. Vessels also moved to the WCPO because fishing access was granted by the South Pacific Tuna Treaty. 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.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-eight vessels fished in 2008. Before 1995 the fleet fished mainly on free-swimming schools of tunas in the WCPO and on schools associated with dolphins in the ETP.

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*) (77%) and yellowfin tuna (*Thunnus albacares*) (20%). Skipjack tuna catches peaked in 1988 at 78,250 t (metric tons) then decreased to 4,002 t in 2002. In 2008, 14,378 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 1,112 t in 2006. In 2008, 3,694 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). Species composition samples are also taken and used to separate bigeye tuna from yellowfin 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 to NOAA Fisheries, 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 2008.

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 2008.

The longline fishery extended 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 2008 (Figure 1). 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 2008. 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.

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 and 2000 (Table 2). Bigeye tuna dominates the tuna catch with landings over 4,000 t in the past five years. The 2008 bigeye tuna catch was 5,779 t. Swordfish has been the dominant component of the billfish catch from 1990 and reached a peak of 5,909 t in 1993 before decreasing to 147 t in 2003. The 2008 swordfish catch was 1,944 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 2). 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 2007, 628 vessels participated in the fishery and 466 vessels fished in 2008.

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 from a low of 1,845 t in 1991 to a high of 16,938 t in 1996 (Table 2). In 2007, 11,887 t were caught and in 2008, 10,245 t were caught. Sampled albacore caught in 2008 averaged 69 cm (Figure 3).

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). 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.

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. 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. Preliminary pole-and-line catches of skipjack, yellowfin and albacore tunas were 292 t, 24 t, and 6 t, respectively, in 2008.

NOAA Fisheries collects West Coast pole-and-line logbook data. Logbook submissions since 2005 are mandatory under the HMS FMP. 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. Coastal 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 1961 vessels in 2008 (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.

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 1,443 t in 2008. Yellowfin tuna made up 44% of the troll and handline catch. The next largest components were skipjack tuna, bigeye tuna, and blue marlin (*Makaira mazara*). The Hawaii troll and handline fisheries accounted for 84% of the total U.S. troll and handline landings in 2008.

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.

F. 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. 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 51 in 2008 (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 473 t in 2007 (Table 2) and then down to 372 in 2008.

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 from less than 1% of the landings. NOAA Fisheries places observers on gill net vessels who also collect length data.

G. Harpoon

The harpoon fishery operates in areas within the 200-mile EEZ of California between 32°N and 34°N latitude. The number of vessels participating in the fishery generally decreased from 113 in 1986 to 23 in 2001 (Table 1). Thirty-one vessels fished in 2008. Swordfish is targeted and trends in catches generally decreased from 305 t in 1985 to 20 t in 1991 (Table 2).Forty-eight metric tons were landed in 2008.

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.

III. RESEARCH

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

International Billfish Angler Survey – NOAA Fisheries and the billfish angling community have worked together since 1963 to study various aspects of billfish biology and to obtain an index of angler effort and success in the Pacific Ocean. In 2007, billfish anglers reported catching 3786 Pacific billfish during 5575 fishing days. The mean CPUE for all billfish in the Pacific was 0.68, which is high compared to the annual CPUE reported over the last 20 years but well below the 0.82 CPUE reported in 2006.

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 integrated 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 weight and value of most catches can be linked. Other enhancements also

are under development, such as linking the weight of longline-caught fish from the Hawaii Marine Dealer with the Hawaii-based longline logbook data to approximate weight of catch by geographic location. This data link has also been used to help correct species misidentifications on a trip level by cross-referencing the longline logbook data, the Hawaii Marine Dealer data, and the observer data.

Hawaii Pelagic Longline Economics -- Significant strides have been made recently to assess the change of important economic indicators of the important Hawaii-based pelagic longline fisheries that target tuna and swordfish. Since the project was started in August 2004, data on fishing costs and other economic information have been collected for over 1,000 longline fishing trips. The data collected provide important economic indicators of the fisheries. For example, the data showed an increasing trend in cost of tuna trips (not including fixed cost and labor costs) over the past five years. Over the period 2004-2008, the average trip cost in the Hawaii longline fishery for tuna target trip increased by about 112%, from $12,300 per trip to $26,100 per trip. Fuel cost made up about 50% of the total trip cost. The cost of fuel doubled during the period of study, as did the cost of other non-labor items.

Hawaii Small Boat Economics -- Another economic survey was conducted to assess the fishing trip cost structure within the Hawaii small boat fishery, and shed light on the social and economic importance of small boat fishing. Intercept interviews were conducted at boat ramps across the state of Hawaii from April 2007 – April 2008, and researchers completed approximately 345 interviews. Results suggest that fuel is the primary cost fishers must incur on a fishing trip. For an average trolling trip in 2007, fuel accounted for 70% of total trip costs, and the increasing price of fuel may challenge the future economic viability of small boat fishing in Hawaii.

Hawaii Longline Industry Perspectives on Bycatch -- In 2008, NOAA Fisheries completed a study of Hawaii longline fishermen's perspectives on bycatch reduction. The research consisted of developing five case studies to complement more-comprehensive studies of sociocultural characteristics of the Hawaii longline industry. The case studies were chosen to deal with a range of bycatch reduction techniques, from gear-based strategies that are already in use and mandated by law (such as the use of circle hooks and fish bait for vessels targeting swordfish), to social sanctions within ethnic networks of the fleet. This research focused on fishermen's perceptions of and reactions to the strategies. The research is currently being developed into a NOAA Technical memorandum that is expected to be available in 2009. The five case studies were:

Case Study One: Fishing Vessel Operators' Experiences with Circle Hooks: Success for Fishermen and Fisheries Managers. This case study utilized open-ended interviews and focus groups to extract opinions of circle hooks regarding overall satisfaction with circle hooks and mackerel bait, perceived effects on catch rates of target species, turtle interactions, cost, efficiency and on-board safety.
Case Study Two: Adoption of the Seabird Avoidance Method of Side Setting on Board a Hawaii Longline Tuna Fishing Vessel. This case study explored the reasons why some

vessel operators converted and implemented side-setting techniques with relative ease, success, and satisfaction.
Case Study Three: Mechanisms of Communication and Transfer of Knowledge Within the Hawaii Longline Community: Implications for Bycatch Reduction Strategies. This case study explored the transfer of knowledge among Hawaii Longline fishing vessel operators.
Case Study Four: Hawaii Longline Swordfish Fishing Vessel Operators Use of Social Sanctions to Meet Regulatory Intent. This case study assessed the human dimensions involved in the decisions of Hawaii swordfish fishermen to self-regulate in response to regulations limiting the number of interactions with leatherback and loggerhead sea turtles.
Case Study Five: Re-defining Bycatch: One Hawaii Longline Vessel Operator's Ideas for Marketing Bycatch. This case study explored one particular fishing vessel operator's attempt to reduce bycatch of sharks and some other non-target species by modifying his operations and creating a market for bycatch species that otherwise would be discarded.

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 in the North Pacific Ocean (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

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 2008, 552 archival tags were deployed, 22 of which were recovered. Preliminary data from the recovered tags demonstrate a wide range of behaviors of juvenile albacore. Most fish were at liberty for over a year and have provided over 5,000 days of data. New analyses of tag returns indicate that: During summer and fall months near the U.S. West Coast off Oregon and Washington, the mean daytime swimming depth of juvenile albacore was roughly 20 m and greater than 85% of their time was spent in the top isothermal layer of the water column; during summer months off southern California and northern Baja California, Mexico, mean swimming depths were similar; however, albacore tended to spend more time diving through the

thermocline during the day. In contrast, off the west coast of Japan in May one fish spent only 20% of its time during the day in the upper isothermal layer with a mean daytime swimming depth of 150 m.

Striped Marlin Age and Growth -- An examination of striped marlin hardparts has been initiated to evaluate their use as growth mark indicators. The study focuses on hardparts (otoliths, dorsal & anal fin rays, cleithrum, and vertebrate) collected through Hawaii market sampling, and includes otoliths (from heads) and whole gonads collected at sea by observers onboard longline vessels. Evaluation of the various hardparts has determined that the 4th dorsal fin ray and sagittal otoliths are the hardparts bested suited for age determination. The observer collected gonad samples will be used to determine length at 50% reproductive maturity for both sexes. Observers are now collecting subsamples of gonads and preserving them at-sea in a non-toxic histological preservative. The performance of this preservative as a substitute for Formalin will be evaluated once these samples are prepared at a histology facility. Observers also continue to collect valuable small-sized (<110 cm eye-fork length) whole juvenile specimens; billfish of this size are rarely available. Collaborations are currently being sought with researchers in Mexico who are actively conducting similar striped marlin studies.

North Pacific Albacore Biological Data Sampling Program – Since 1961, a biological data collection program, or port sampling program, has been in place for collecting size data from albacore landings made by the U.S. and Canadian troll fleets at ports along the U.S. Pacific coast. State fishery personnel collect the biological data by following sampling and data processing instructions provided by the SWFSC, where the database is maintained. In recent years, with AFRF support, fishermen have collected biological data during selected fishing trips. These data are collected to augment data collected through the port sampling program. Following procedures established by SWFSC scientists, fishermen provided length data from eleven trips during the 2007 season. The sample information provided by the fishermen was found to be generally similar to that collected through the port sampling program.

Foraging Ecology of Tunas in the Southern California Bight – In an effort to collect biological data on the recreationally caught tuna and dorado that seasonally forage in the Southern California Bight (SCB), NOAA Fisheries and the Sportfishing Association of California initiated a biological sampling program in 2007 working with the commercial passenger fishing vessels. Species collected to date include albacore (*Thunnus alalunga*), bluefin (*T. orientalis*), yellowfin (*T. albacares*), skipjack (*Katsuwonus pelamis*), and dorado (*Coryphaena hippurus*). Biological samples are collected from each fish caught, including stomach contents and tissue samples. By identifying stomach contents and analyzing stable isotope ratios in tissues we can begin to understand both the daily and long-term feeding habits of tuna in the SCB. In 2007 for albacore (n = 116), fish were the dominant prey species by frequency of occurrence (89%), followed by cephalopods (18%) and crustaceans (16%). Preliminary results for 2008 show a shift in the composition of prey forage with cephalopods making up a higher percentage of the diet. This could be due to small changes in environmental factors favoring the recruitment of squid in 2008. Studies over multiple years will help determine the impacts of short-term

environmental variation on available forage and the implications for assessing habitat quality. This should help explain migration timing and patterns within the SCB and northern Baja California, Mexico.

Billfishes

Recreational Billfish Tagging Program – NOAA Fisheries' Billfish Tagging Program has provided tagging supplies to recreational billfish anglers for 46 continuous years. Tag release and recapture data are used to determine movement and migration patterns, species distribution, and age and growth patterns. Since its inception, over 57,700 fish of 75 different species have been tagged and released. In 2007, 841 billfish and five other fish species were tagged and released by 603 anglers and 142 fishing captains.

Broadbill Swordfish Stomach Content Analyses – Since 2007, NOAA Fisheries has been studying the feeding behavior of the broadbill swordfish in order to determine the trophic relationships. Sixty-four stomachs were collected by fishery observers over two fishing seasons from 2007 to 2008. All samples were collected within the U.S. EEZ between the U.S.-Mexico border and Point Conception. Swordfish sampled ranged in size from around 120 to 200 cm eye to fork length (EFL). Of the stomachs examined, 98% contained food representing at least 26 taxa. The most important prey overall was the jumbo squid (*Dosidicus gigas*), which was present in 82% of the stomachs and ranged in size from around 20 to 70 cm mantel length (ML). Preliminary data reveal that there is a direct relationship between swordfish EFL and squid ML with larger swordfish able to feed on larger jumbo squid. Other important prey included the boreopacific gonate squid (*Gonatopsis borealis*) and teleosts of the family Paralepididae (Barracudinas).

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 (*Isurus oxyrinchus)*, 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.

Juvenile Mako and Blue Sharks
Abundance Surveys – To track trends in abundance the SWFSC conducts annual fisheries independent surveys for juvenile and sub-adult blue and shortfin mako sharks and neonates of common thresher shark. In addition to the catch data, these cruises provide a valuable opportunity to conduct complimentary studies on age and growth, migrations, essential habitat and foraging ecology.

In 2008, the fifteenth juvenile shark survey since 1994 was conducted for blue and mako sharks. Working aboard the *F/V Ventura II*, a total of 6,007 hooks during 29 daytime sets inside seven focal areas within the Southern California Bight were fished. From the catch data, the index of relative abundance for juvenile sharks, defined as catch per 100 hook-hours, was calculated for the seven target survey areas. Survey catch totaled 40 shortfin mako, 233 blue sharks, one common thresher, five pelagic rays (*Pteroplatytrygon violacea*), and one bat ray (*Myliobatis californica*). The overall survey catch rate was 0.184 per 100 hook-hours for shortfin mako and 1.090 per 100 hook-hours for blue sharks. The nominal CPUE for blue sharks was somewhat higher than in 2007; however, there is a declining trend in nominal CPUE for both species over the time series of the survey.

For common thresher sharks, a pre-recruit index and nursery ground survey was initiated in 2003 and and has been conducted each year since. In 2008, 48 longline sets were made over an 18-day cruise, and 300 common threshers, two spiny dogfish, 28 soupfin sharks (*Galeorhinus galeus*), two leopard sharks (*Triakis semifasciata*), and five brown smoothhound (*Mustelus henlei*) were caught. An examination of catch locations reveals that juvenile common thresher sharks occur predominantly in shallow, near-shore waters of less than 90 m.

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 77 makos, 66 blue sharks, and 27 common threshers have been satellite tagged through these collaborative projects.

Satellite tag deployments using fin-mounted SPOT tags went particularly well in 2008. These tags communicate with the satellite when the shark's fin breaks the surface. Five of six SPOT tags deployed on blue and mako sharks in 2008 were still transmitting in early 2009 after more than 200 days. In addition, three satellite tags deployed in 2007 on mako sharks were also transmitting a year and a half after being deployed. These longer-term and multi-year records provide an incredible opportunity to examine seasonal movement patterns and regional fidelity. The longer tracks reveal that some mako sharks make an annual migration to the North Equatorial Current and interestingly, animals returned to the same general regions as in the previous year. The migrations are relatively directed with animals spending an average of four weeks south of 18°N before returning to the waters off Mexico and California.

Age, Growth and Maturity Studies – Age and growth of mako, common thresher, and blue sharks are being estimated from band formation in vertebrae. To validate aging methods, all three species caught during juvenile shark surveys have been injected with oxytetracycline (OTC). 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, 1959 OTC-marked individuals have been released during juvenile shark surveys. As of April 2009, recaptured OTC-marked sharks included 71 mako, 40 common thresher, and 31 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 2007-2008 fishing season, seven sharks in various conditions at time of release were tagged with pop-up satellite archival tags (PSAT). During the 2008-2009 season, three additional blue sharks were tagged. The tagged sharks were tracked and results indicate that survivability is high; nine of the 10 sharks survived for at least 30 days following tagging and the tenth shark survived for at least 17 days, after which it appears the tag was ingested by another animal. Final tagging efforts of smaller sharks and those of the poorest conditions will be conducted during the 2009-2010 season to conclude the study.

Thresher Sharks Released by the Recreational Fishery – 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 by recreational fishermen. Anglers often hook the tails of thresher sharks and pull the fish backwards to the boat. When the fight time is long, the fish may be exhausted by the time it is released. A total of 28 thresher sharks were caught and released during the 2008 season, 26 of which had been tail hooked. All individuals with fight times less than 85 minutes survived following release as determined by the PSAT records. Preliminary data suggest that large tail-hooked thresher sharks exposed to prolonged fight times have increased mortality rates when compared to smaller individuals which can be brought to the boat more quickly. Further tagging is planned for 2009 to increase the sample size and

experiment with alternative fishing techniques, including teasers with drop-back bait that should reduce tail hooking.

D. Bycatch and Fishing Technology Research

Dolphins

ETP Dolphin Stock Assessments – During 2008, NOAA Fisheries continued to analyze abundance data for stock assessment research for both depleted and non-depleted dolphin stocks in the ETP. A NOAA Technical Memorandum was published with new estimates of ETP dolphin abundance based on cruises conducted in 2003 and 2006. Gerrodette et al. (2008) reported estimates of abundance for 10 dolphin stocks in the ETP for ten years between 1986 and 2006. Revised estimates of abundance for previous years were based on new data on observer school size estimation bias and the addition of unidentified spinner and unidentified common dolphins. The 2006 estimates of abundance for northeastern offshore spotted dolphins were somewhat higher, and for eastern spinner dolphins substantially higher, than estimates from 1998 to 2000.

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 ocean 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. Similar work has been conducted that involves tracking olive ridley turtles that had been caught in fishing gear, primarily to investigate post-release mortality, and secondarily to identify preferred habitat of olive ridley turtles in the Eastern Tropical Pacific using telemetry data.

Gear Modification to Reduce Bycatch - NOAA Fisheries is contracting or otherwise assisting in longline fishing vessel trials to test the efficacy of sea turtle bycatch mitigation methods in Costa Rica, Brazil, Uruguay, Indonesia, Spain, Cook Islands, Vietnam, and Italy. The trials will measure effects of gear modifications (e.g., use of large circle hooks, appendage hooks, hook offsets, rings) on the rates of hooking and entanglement of sea turtles in longline fisheries. Research from the previous few years indicate that relatively large circle hooks effectively reduce the bycatch of both loggerhead and leatherback sea turtles. These hooks have also shown to effectively capture acceptable rates of tuna species, yet have shown to result in slightly reduced catch rates of targeted swordfish. In addition, use of circle hooks has also been found to reduce the rates of capture of pelagic stingrays, which has been a motivating factor for especially Italian fishermen to convert to use of circle 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. Technical assistance was also provided to numerous programs, both governmental and non-governmental, as experimental longline tests expand worldwide. A recently completed relational database linked to NOAA's bycatch web site also provides public access. NOAA Fisheries also continues its investigations of the post-release mortality of sea turtles after their release from fishing gear. There are manuscripts in press regarding use of pop-up satellite archival tags (PSATs) to estimate olive ridley turtles' survivorship after release from longline fishing gear interactions in the Eastern Tropical Pacific and loggerhead turtles'survivorship in the North Pacific Ocean. Additionally, there is recent information from platform terminal transmitters (PTTs) placed on loggerhead sea turtles in the Mediterranean and S.W. Atlantic Ocean that were incidentally caught and released from longline fishing gear. Results indicate no differences in duration of transmissions as a function of turtles 'severity' of injury, specifically deep or shallow hookings, and that most sea turtles were tracked for the duration of the tags' battery life. It is anticipated that the results will be presented along with other studies from collaborating NOAA scientists to provide an empirical basis for NOAA's assumed mortality estimates.

Sharks

Experiments examining the effects of the metals on the catch rates of mako and blue sharks are being planned during the annual NOAA Fisheries pelagic shark surveys during summer 2009.

Longline Gear Effects on Shark Bycatch **--** To explore operational differences in the longline fishery that might reduce shark bycatch, the observer database is being used to compare bycatch rates under different operational factors (e.g., hook type, branch line material, bait type, the presence of light sticks, soak time, etc.). A preliminary analysis was completed that compared the catches of vessels using traditional tuna hooks to vessels voluntarily using size 14/0 to 16/0 circle hooks in the Hawaii-based tuna fleet. The study was inconclusive due to the small number of vessels using the circle hooks. Subsequently, 19 contracted vessels were used to test large (size 18/0) circle hooks versus tuna hooks in controlled comparisons. Preliminary analysis does not indicate these large circle hooks increase the catch rate of sharks, in contrast to findings of increased shark catch on circle hooks in studies comparing smaller circle hooks with J hooks in other fisheries.

Testing Deeper Sets -- An experiment with deeper-set longline gear conducted in 2006 has been analyzed and submitted for publication. The experiment altered current commercial tuna longline setting techniques by eliminating all shallow set hooks (less than 100 m depth) from tuna longline sets. The objective was to maximize target catch of deeper dwelling species such as bigeye tuna, and reduce incidental catch of many marketable but less desired species (e.g., billfish and sharks). The deep setting technique was easily integrated into daily fishing activities with only minor adjustments in methodology. The main drawback for the crew was increased time to deploy and retrieve the gear. Catch totals of bigeye tuna and sickle pomfret were greater on the deep set gear than on the controlled sets; but the bigeye results were not statistically significant. Catch

of several less valuable incidental fish (e.g., blue marlin, striped marlin, shortbill spearfish, dolphinfish, and wahoo) was significantly lower on the deep set gear than the controlled sets. Unfortunately, no significant results were found for sharks.

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Table 1. Number of vessels fishing in the North Pacific Ocean in various U.S. fisheries. Data for 2007 and 2008 are preliminary [1]

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	1,960	37	34
2004	19	126	695	11	2,012	33	29
2005	23	126	541	10	1,917	37	24
2006	12	128	601	11	1,924	45	24
2007	18	130	628	59	1,888	49	28
2008	28	130	466	34	1,961	51	31

[1] Estimations of U.S. West Coast vessels targeting ISC species is currently under revision.

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 2007 and 2008 are preliminary. 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	1,112	5,075	1,492	0	0	0	0	0	0	0	0	7,678
2007	0	2,725	11,045	555	42	0	0	0	0	0	0	0	14,367
2008	0	3,694	14,378	512	0	0	0	0	0	0	0	0	18,584
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	72	3	320	1	12	0	0	24	0	0	0	0	432
2001	139	4	448	0	1	0	0	14	0	0	0	0	606
2002	382	2	420	0	2	0	0	0	0	0	0	2	808
2003	59	35	587	0	3	0	1	1	0	0	0	4	690
2004	127	18	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
2008	6	24	292	0	0	0	0	1	0	0	0	4	327

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	11,887	0	0	0	0	0	0	0	0	0	0	0	11,887
2008	10,254	0	0	0	0	0	0	0	0	0	0	0	10,254
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	4,999	1	0	0	1,622	337	511	216	0	8,785
2006	270	958	94	4,466	1	0	0	1,211	409	611	174	0	8,194
2007	250	844	93	5,798	0	0	0	1,735	262	276	160	0	9,418
2008	359	868	121	5,779	0	0	0	1,944	349	436	240	0	10,096

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	478	0	0	0	0	484
2008	1	0	0	0	0	0	0	372	0	0	0	0	373
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
2008	0	0	0	0	0	0	0	48	0	0	0	0	48

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	385	349	12	0	96	0	0	1	0	0	0	0	844
2007	1,224	0	0	0	14	0	0	12	0	0	0	0	1,250
2008	382	0	0	0	93	0	0	34	0	0	0	0	509
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	268	213	0	0	0	10	210	29	18	25	1,593
2004	157	746	251	381	0	0	0	7	188	35	23	45	1,833
2005	175	679	259	295	0	0	0	5	187	20	15	14	1,649
2006	95	504	291	303	0	0	0	4	160	21	14	12	1,404
2007	98	755	266	386	0	0	0	5	128	13	12	9	1,672
2008	29	645	359	201	0	0	0	6	174	14	14	10	1,452

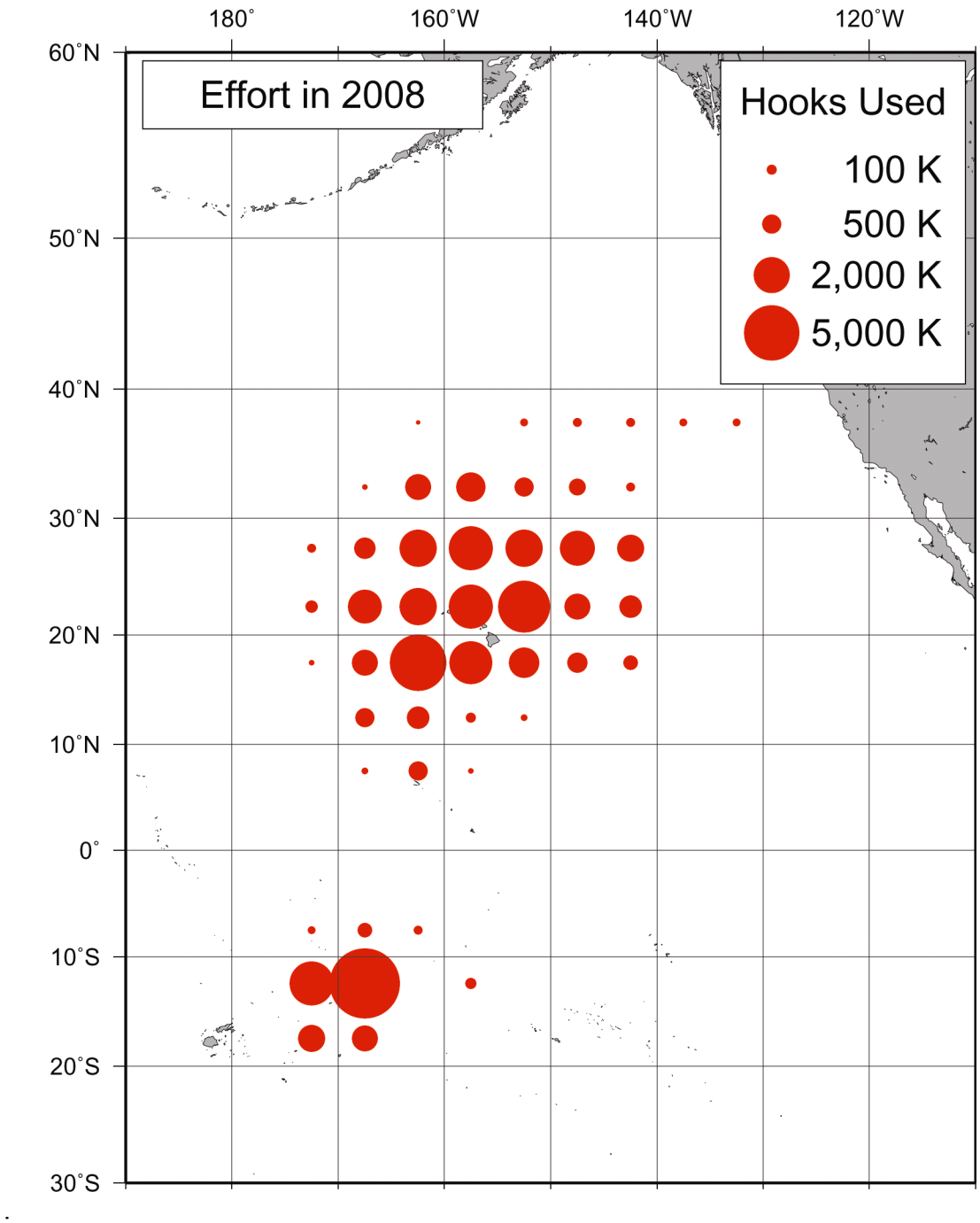

Figure 1. Spatial distribution of reported logbook fishing effort by the U.S. longline fleet, in 1,000s of hooks (K), in 2008 (provisional data). Area of circles is proportional to effort. Effort in some areas is not shown in order to preserve data confidentiality.

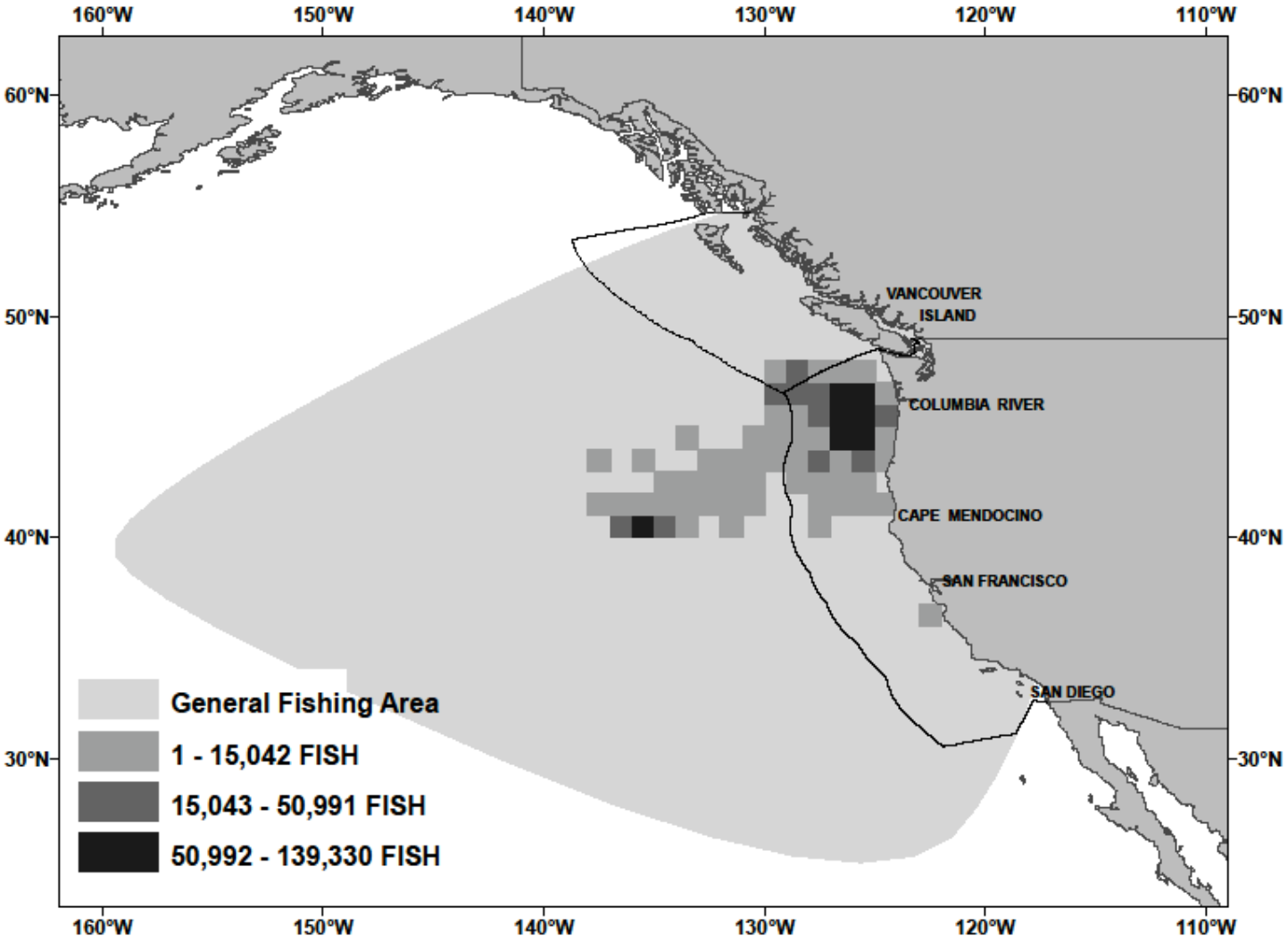

Figure 2. Distribution of fishing effort in numbers of fish caught for the U.S. albacore troll fishery, 2008.

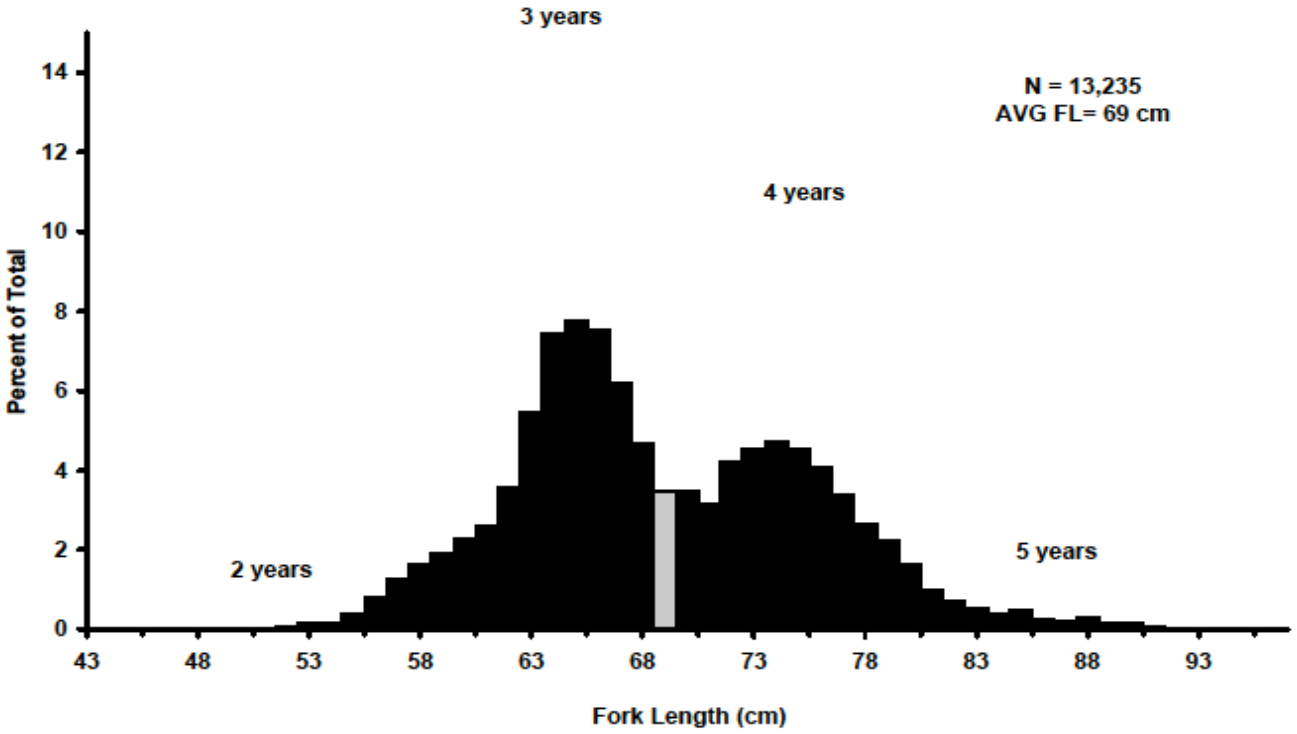

Figure 3. Size distribution of albacore caught by the U.S. albacore (*Thunnus alalunga*) troll fishery in 2008.