FINAL

ISC/18/PLENARY/09

PLENARY 9

18th Meeting of the
International Scientific Committee for Tuna
and Tuna-Like Species in the North Pacific Ocean
Yeosu, Republic of Korea
July 11-16, 2018

National Report of USA (USA Fisheries and Research on Tuna and Tuna-Like Species in the North Pacific Ocean)

NOAA, National Marine Fisheries Service

July 2018

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U.S.A. Fisheries and Research on Tuna and Tuna-like Species in the North Pacific Ocean

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Executive Summary

Various U.S.A. fishing fleets harvest tuna and tuna-like species in the North Pacific Ocean (NPO) from coastal waters of North America to the archipelagoes of Hawaii, Guam and the Commonwealth of the Northern Mariana Islands (CNMI) and American Samoa in the central and western Pacific Ocean (WCPO). Small-scale gillnet, harpoon, tropical pole-and-line, troll, and handline fleets operate primarily in coastal waters, whereas large-scale purse seine, albacore troll, and longline fleets, which account for most of the tuna catches, operate both within U.S.A. Exclusive Economic Zones and on the high seas. Thousands of small-scale troll and handline vessels operate in waters around the tropical Pacific Islands; however, these fleets account for only a minor fraction of the total tuna catch.

The National Oceanic and Atmospheric Administration (NOAA) Fisheries continued to conduct research in 2017 on Pacific tunas and associated species at its Southwest and Pacific Islands Fisheries Science Centers and also in collaboration with scientists from other organizations. Fishery monitoring and socio-economic research was conducted on tunas, billfishes, and bycatch species in U.S.A. Pacific coastal and high-seas fisheries. As in previous years, fishery monitoring and angler effort information were compiled in 2017, and economic performance indicators in the Hawaii longline and small-boat fisheries were assessed.

Stock assessment research on tuna and tuna-like species was conducted primarily through collaboration with participating scientists of the International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean (ISC) and international Regional Fisheries Management Organizations (RFMOs).

NOAA Fisheries successfully completed biological and oceanographic research on tunas, billfishes, and sharks. Reported research includes: efforts to collect and analyze biological samples to support stock assessments, the development of modeling software, the utility of observer data support ecosystem-based fisheries management, models for calculating fishing mortality, advancement of an electronic logbook project, impacts of ocean acidification and climate change on populations, alternative modelling approaches for age-based movement, results of a petition to list Pacific bluefin tuna (*Thunnus orientalis*) (PBF), use of chemical tracers in migration analyses, use of EcoCast in avoiding non-target blue sharks, diet and feeding habits.

I. Introduction

Various U.S.A. fleets harvest tuna and tuna-like species in the North Pacific Ocean. Large-scale purse seine, albacore troll, and longline fisheries operate both in coastal waters and on the high seas. Small-scale coastal purse seine, gillnet, harpoon, troll, handline and recreational hook 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.A. 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) and American Samoa in the western Pacific Ocean and from the equatorial region to the upper reaches of the North Pacific Transition Zone.

In the U.S.A., the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries or federal agency) shares monitoring responsibilities for tunas and billfishes with partner fisheries agencies in the states of California, Oregon, Washington, Hawaii, and territories of American Samoa, Guam, and the CNMI. NOAA's West Coast Regional Office (WCRO) 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 conduct federal monitoring. NOAA Fisheries monitors the landings and sales records, 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 maintained in the Pacific Fisheries Information Network (PacFIN) system (http://pacfin.psmfc.org/). Some state agencies also collect logbook and size-composition data. In the WCPO, 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) system (http:// http://www.pifsc.noaa.gov/wpacfin/), a federally funded program managed by the PIFSC. The SWFSC, WCRO, PIFSC, and PIRO share management of data on U.S.A. Pacific fisheries for tuna and tuna-like species.

This report provides information on the number of active vessels by fleet and their catches of tunas and billfishes in the NPO based on the data available through 15 March 2018. Data for 2017 are considered preliminary and are subject to change. Although the report is focused on tunas and billfishes, many of the fisheries' catch includes catch of other pelagic fish important to the fishing fleets and local economies; catch data for these species are not included in this report but are included in the ISC data submissions.

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 highlights of recent and ongoing scientific work by NOAA Fisheries of relevance to the ISC.

II. Fisheries

A. Purse Seine

Currently, the U.S.A. purse-seine fishery consists of two separate fleets, one composed of large purse-seine vessels that operate in the WCPO, and a small coastal purse-seine fleet that operates in the eastern Pacific Ocean (EPO). Figure 1 shows the spatial distribution of the U.S.A. purse-seine fishery. Historically, the purse-seine fishery started in the EPO in the mid-1900s and most catch came from that ocean area until 1993 when vessels moved to the WCPO in response to dolphin conservation measures in the EPO. Vessels also moved to the WCPO because fishing access was granted by the South Pacific Tuna Treaty (SPTT) in 1987. The WCPO fleet operates mainly in areas between 10°N and 10°S latitude and 130°E and 150°W longitude, with the majority of the fishing effort south of the equator. The EPO fleet operates off the coast of Southern California and outside the exclusive economic zone (EEZ) of Mexico, off Baja California. The number of unique U.S.A. purse-seine vessels (WCPO and EPO) fishing north of the equator decreased from a high of 74 in 1988 to 11 in 2006 (Table 1) then increased to 46 in 2009. In 2017, there were 41 purse seine vessels fishing in the North Pacific. Prior to 1995 the fleet fished mainly on free-swimming schools of tunas in the WCPO and on schools associated with dolphins in the EPO. Since 1995, most catches have been made on fish aggregation devices and other floating objects in the WCPO. The California-based EPO purse-seine fishery targets mostly small coastal pelagics, such as sardine, mackerel and squid, and targets tunas opportunistically. Larger vessels from the WCPO occasionally fish in the EPO.

The Inter-American Tropical Tuna Commission (IATTC) monitors the purse-seine fleets fishing in the EPO. U.S.A. purse-seine vessels fishing in the WCPO have been monitored by NOAA Fisheries under the SPTT since 1988. Logbook and landings data are submitted as a requirement of the Treaty (coverage 100%). Landings are sampled for species and size composition as vessels land their catches in American Samoa by NOAA Fisheries personnel and by SPC samplers in other ports (coverage approximately 1-2% of landings). The Forum Fisheries Agency (SPTT Treaty Manager) places observers on 100% of the vessel trips. In the EPO, logbooks are submitted by vessel operators to NOAA Fisheries or the IATTC, and landings are obtained for each vessel trip from canneries or fish buyers. IATTC observers are placed on all large purse-seine vessels in the EPO.

B. Longline

The U.S.A. longline fishery targeting tunas and tuna-like species in the NPO is made up of the Hawaii-based fleet, the California-based fleet, and the American Samoa-permitted fleet in the NPO. Vessels operated freely in an overlapping area managed by two domestic management regimes until 2000 when domestic regulations placed restrictions on moving between the two domestic management regimes. The Hawaii-based component of the U.S.A. longline fishery currently comprises a majority of the vessels, fishing effort, and catch.

Regulatory restrictions, due to interactions with endangered sea turtles, curtailed Hawaii-based longline effort for swordfish (*Xiphias gladius*) in 2000 and 2001 followed by a prohibition altogether in 2002 and 2003, during 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. The year 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 on March 20, 2006. The majority of 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 also closed on November 18, 2011, as a result of reaching annual interaction limit of 16 leatherback turtles. In the Hawaii-based shallow-set longline fishery in 2012, the interaction limits for leatherback (*Dermochelys coriacea*) and loggerhead sea turtles were increased for the Hawaii shallow-set longline fishery to 26 and 34, respectively. Leatherback and loggerhead sea turtle interactions have been less than their respective limits since the levels were revised, though the fishery was closed in 2018 due to a court order.

The number of vessels in the California-based fishery has always been low compared to the Hawaii-based fishery, and composed mainly of vessels that target swordfish. Most vessels with landings to California also participated in the Hawaii-based fishery. The California-based shallow-set longline fishery for swordfish was closed in 2004, resulting in relocation of most of those vessels back to Hawaii. Only one California-based vessel fished between 2005 and 2017 using deep-set longline to target tunas. Additionally, seven Hawaii-permitted deep-set longline vessels and at least five shallow-set vessels reported landings in California in 2017.

In the North Pacific, the longline fishery extended from 125°W, just outside the U.S.A. West Coast EEZ to 175°W longitude and from 10°N to almost 40°N latitude in 2017 (Figures 2 and 3). The total number of vessels participating in the longline fishery increased from 36 in 1985 to a high of 141 vessels in 1991 (Table 1). Since then, the number of vessels has varied from 114 to 145 with approximately 145 vessels participating in 2017. In Hawaii and California, swordfish are generally landed dressed (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. In Hawaii, the landed catch biomass is the reported total fish weight by species recorded at the fish auction. Dressed weights are converted to whole weight for reporting of total catches using standard conversion factors.

Catch levels and catch-species composition in the U.S.A. longline fishery have changed over the past years in response to fishery and regulatory changes. The majority of the longline catch now consists of tunas and billfishes and exceeded 10,000 t in 1993, 1999, 2000, 2008, 2011, and 2013-2017 (Table 2). Bigeye tuna (*Thunnus obesus*) dominates the tuna catch with landings over 4,000 t during the past sixteen years. The 2017 bigeye tuna catch was 7,984t. Swordfish has been the dominant component of the billfish catch since 1990 and reached a peak of 5,936 t in 1993 before decreasing to 1,185 t in 2004. The U.S.A. 2017 swordfish catch by longline was 1,617 t.

The Hawaii-based longline fishery is monitored by combined sampling efforts of the NOAA Fisheries and the State of Hawaii's Division of Aquatic Resources (DAR). Longline fishermen are required to complete and submit federal longline logbooks for each fishing operation. The logbook data include information on fishing effort, area fished, catch by species and amount, and other details of the fishing operations. Logbook coverage for the Hawaii-based longline fishery is at or near 100% coverage of vessel by trip. The Hawaii DAR also requires fish dealers to submit reports of landings data, and coverage for the longline fishery and the reporting rate for dealers are very close to 100%. DAR dealer data represent majority of the fish kept by the longline fishery with individual fish weighed to the nearest pound (Figures 4-6). Observers contracted by NOAA Fisheries are also placed on longline vessels to monitor protected species interactions, vessel operations, and multi-species catches. These observers are required by court decree to be 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. Information on the sizes of fish caught in the Hawaii-based longline fishery indicate, that in general, a higher proportion of smaller tuna and tuna-like fish species are captured in the shallow-set longline fishery compared to the deep-set fishery (Figures 4-6).

The California-based longline fishery is monitored by NOAA Fisheries and the California Department of Fish and Wildlife (CDFW). Data are collected for 100% of longline landings by the CDFW. Logbooks, developed by the fishing industry (similar to the federal logbooks used in Hawaii), were submitted voluntarily to NOAA Fisheries until 1994 when logbooks became mandatory. Landed swordfish were measured for cleithrum to fork length by CDFW port samplers until 1999. NOAA Fisheries has placed observers on all California-based longline trips since 2002. The observers collect data on fishing location, protected species interactions, fish catch, disposition of catch and bycatch, and size measurements of catch and bycatch (retained catch and discards).

C. Albacore troll and pole-and-line

The U.S.A. albacore troll and pole-and-line fishery in the NPO started in the early 1900s. The fishery currently operates in waters between the U.S.A. West Coast and 160°W longitude. Fishing usually starts in May or June and ends in October or November. In 2017, 494 participated in the fishery, down from 571 in 2016 (Table 1).

The troll and pole-and-line fishery catches almost exclusively albacore with minor incidental catches of skipjack (*Katsuwonus pelamis*), yellowfin (*Thunnus albacares*), and bluefin tunas, 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 16,962 t in 1996 (Table 2). In 2016 and 2017, 10,796 t and 7,216 t of albacore were caught, respectively.

U.S.A. troll and pole-and-line vessels operating within the U.S.A. EEZ voluntarily submitted logbook records to NOAA Fisheries from 1973 to 1995 when those vessels fishing on the high-seas were required to submit logbooks. In 2005, the Highly Migratory Species Fishery Management Plan required all U.S.A. troll and pole-and-line vessels to submit logbooks. NOAA Fisheries and various state fisheries agencies monitor the fleet's landings through sales receipts (fish tickets) and landings reported in logbooks.

Since 1961, a port sampling program has been in place for collecting size data from albacore landings along the U.S.A. Pacific coast. Generally sizes of albacore caught in the albacore troll and pole-and-line fishery range between 55 cm fork length (8.5 pounds) and 90 cm (32 pounds). Weight distribution of the catch for 2017 is shown in Figure 7. State fishery personnel collect the size data according to sampling instructions provided by NOAA Fisheries, who maintain the database. In recent years, cooperative fishermen have also collected size data on selected fishing trips to augment data collected through the port sampling program.

D. Tropical pole-and-line

The tropical pole-and-line fishery targets skipjack around the Hawaiian Islands. Hawaii DAR monitors the tropical pole-and-line fishery using Commercial Fish Catch reports submitted by fishers and Commercial Marine Dealer reports submitted by fish dealers. The number of vessels participating declined from a high of 27 in 1985 to a low of one in 2012. Skipjack tuna is usually the largest component of the catch by Hawaii pole-and-line vessels. The highest skipjack tuna catch for this fishery 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. To protect confidentiality, no catch data for the tropical pole-and-line fishery are reported.

E. Tropical Troll and Tropical Handline

Tropical troll fishing fleets for tuna and tuna-like species operate in Hawaii, Guam, and the CNMI. Tropical handline fishing fleets also operates in Hawaii. The vessels in these fisheries are relatively small coastal vessels (typically around 8 m in length) and primarily make one-day fishing trips in coastal waters. Historically, the number of U.S.A. troll and handline vessels combined ranged from 1,878 in 1988 to 2,502 in 1999, and there were 1,728 troll vessels and 487 handline vessels in 2017 (Table 1). The operations range from recreational, subsistence, and part-time commercial to full-time commercial. The small vessel catches generally are landed fresh and whole, although some catches are gilled and gutted.

Weights of individual fish were obtained from Hawaii DAR dealer data. The size distributions of tunas (skipjack and yellowfin) and marlins (striped marlin and blue marlin, Kajikia audax and Makaira nigricans) caught in the Hawaii fishery in 2017 are summarized in Figures 8 and 9.

The total retained catch from these tropical troll and handline fisheries combined ranged from 1,160 t in 1992 to 2,326 t in 2012 (Table 2). The majority of the catch was made up of yellowfin and skipjack tuna in 2017 followed by mahimahi and blue marlin.

The Guam Division of Aquatic and Wildlife Resources (DAWR) monitors the troll fishery using a statistically designed creel survey and commercial landings data. The Guam DAWR, with the assistance of NOAA Fisheries, extrapolated the creel survey data to produce estimates of total catch, fishing effort, and fishermen participation estimates by gear type. Similarly, the Hawaii tropical troll and handline fisheries catch and effort summaries are compiled from Hawaii DAR Commercial Fish Catch reports and Commercial Marine Dealer reports. The CNMI Division of Fish and Wildlife (DFW) monitors the tropical troll fishery in the CNMI region using creel surveys and commercial landings, and with the assistance of NOAA Fisheries, extrapolated the creel survey data to produce estimates of total catch, fishing effort, and fishermen participation estimates by gear type.

F. Drift Gillnet

The U.S.A. large mesh drift gillnet fishery targets swordfish and common thresher sharks in areas within the EEZ in California waters and historically off the coast of Oregon. Other pelagic sharks, and small amounts of tunas and other pelagic species are also caught in the large mesh drift gillnet fishery. The number of vessels participating in this fishery has steadily decreased from a high of 220 in 1986 to a low of 17 in 2012 and 2017 (Table 1). Swordfish dominate the catch and peaked in 1985 at 2,990 t. Since then, swordfish catches have fluctuated while decreasing to 62 t in 2010 (Table 2). The estimate of swordfish caught in the drift gillnet fishery for 2017 is 176 t, a decrease from 193 t caught in 2016.

Gillnet fishery landings data (100% coverage) are collected by state agencies in California and Oregon (no landings have occurred in Oregon since 2004). Logbook data for gillnet fisheries are required to be submitted to the CDFW for all trips. CDFW collected length data for swordfish landings between 1981 and 1999 from less than 1% of the landings. NOAA Fisheries observers on large mesh drift gillnet vessels have collected data on fishing location, protected species interactions, fish catch, disposition of catch and bycatch, and length since about 1990; observer coverage is about 20% of effort.

The U.S.A. fishing industry has been modifying a gear called "deep-set buoy gear" for use in the eastern Pacific Ocean as an alternative to gillnet fishing swordfish and as part of an effort to maximize economic benefits while minimizing non-target catch. Fishermen are testing deep-set buoy gear under an exempted fishing permit from NOAA Fisheries. The deep-set buoy system uses heavy weights to rapidly lower baited hooks to target swordfish between 1,000 and 1,500 feet. The buoy gear's strike detection system alerts fishermen when a fish is on the line and allows for its quick retrieval once hooked. It allows fishermen to avoid unmarketable or federally protected species that reside in shallower waters. Deep-set buoy fishing takes advantage of the fact that different marine species feed at different depths at certain times of the day. Sea turtles, whales, and many fish are most commonly found in warm surface waters known as the upper mixed layer. Other fish, such as swordfish, opah, and bigeye thresher sharks, pursue food resources in deeper waters. The results of the exempted fishing permits gear tests will help U.S.A. managers determine if the method can be scaled up to become a viable commercial fishery. A decision is expected in 2019.

G. Harpoon

The harpoon fishery targets swordfish and operates in areas within the EEZ in California waters between 32°N and 34°N latitude. The number of vessels participating in the fishery greatly decreased from 113 in 1986 to 10 in 2012. Twenty-one vessels participated in the fishery in 2017 (Table 1). Trends in swordfish catches have fluctuated from a high of 305 t in 1985 to 5 t in 2012, 2014, and 2015. Catch increased in 2016 and 2017 to 25 t and 24 t, respectively (Table 2).

Landings and logbook data for the harpoon fishery are collected by the CDFW with 100% coverage of the fleet. Length measurements were taken by CDFW between 1981 and 1999, covering less than 1% of swordfish landings.

H. Sport

Sport (recreational) catch and effort data are available from commercial passenger fishing vessels (CPFVs) and catch data are available from private vessels that target tunas and other pelagic fish. Logbook data for CPFVs are obtained from fisheries agencies in California while CPFV logbook data from vessels fishing out of Oregon and Washington are submitted to SWFSC. Estimates of landings for CPFV and private vessels are obtained through surveys and maintained in the Recreational Fisheries Information Network (RecFIN) database (http://www.recfin.org/) for California, Oregon, and Washington. Total sport catches of tunas, sharks and billfish are estimated from data obtained from RecFIN and augmented by state and federal logbook data sets where needed. The majority of the highly migratory species (HMS) catch is albacore, yellowfin and Pacific bluefin tuna. The albacore catch by sport vessels was 372 t in 2017 compared to 675 t in 2016.

Sport catches of Pacific bluefin tuna are estimated differently from other species. From 1993 through 2012 the IATTC collected size samples from bluefin landed by CPFVs. In 2013 no sampling occurred and in 2014 the SWFSC began collecting length samples from bluefin landed by CPFVs. A description of the size sampling and the procedure for estimating annual sport catches of Pacific bluefin are provided in working paper ISC/15/PBFWG-1/03. Catches vary and have ranged from a high of 809 t in 2013 to a low of 6 t in 1988. The 2017 catch was 369 t compared to 286 t in 2016. The spatial distribution of reported logbook fishing effort by the 2016 U.S.A. harpoon, gillnet, and west coast sport fisheries in the North Pacific Ocean are depicted in Figure 10. The size distribution of the Pacific bluefin tuna caught by the U.S.A. West Coast sportfishing industry is depicted in Figure 11.

III. Research

Just Another Bayesian Biomass Assessment

NOAA Fisheries developed new, open-source modelling software entitled ‘Just Another Bayesian Biomass Assessment’ (JABBA) (Winker et al., 2018). JABBA can be used for biomass dynamic stock assessment applications, and has emerged from the development of a Bayesian State-Space Surplus Production Model framework, already applied in stock assessments of sharks, tuna, and billfishes around the world. JABBA presents a unifying, flexible framework for biomass dynamic modelling, runs quickly, and generates reproducible stock status estimates and diagnostic tools. Specific emphasis has been placed on flexibility for specifying alternative scenarios, achieving high stability and improved convergence rates. Default JABBA features include: 1) an integrated state-space tool for averaging and automatically fitting multiple catch per unit effort (CPUE) time series; 2) data-weighting through estimation of additional observation variance for individual or grouped CPUE; 3) selection of Fox, Schaefer, or Pella-Tomlinson production functions; 4) options to fix or estimate process and observation variance components; 5) model diagnostic tools; 6) future projections for alternative catch regimes; and 7) a suite of inbuilt graphics illustrating model fit diagnostics and stock status results. As a case study, JABBA is applied to the 2017 assessment input data for South Atlantic swordfish (*Xiphias gladius*). The authors envision that JABBA will become a widely used, open-source stock assessment tool, readily improved and modified by the global scientific community.

Ecological data and ecosystem-based fisheries management

Data required from fisheries monitoring programs substantially expand as management authorities transition to implement elements of ecosystem-based fisheries management (EBFM). EBFM extends conventional approaches of managing single fishery effects on individual stocks of target species by taking into account the effects, within a defined ecosystem, of local to regional fisheries on biodiversity, from genotypes to ecological communities. This includes accounting for fishery effects on evolutionary processes, associated and dependent species, habitats, trophic food web processes, and functionally linked systems. This NOAA study (Gilman et al. 2017) demonstrates how data routinely collected in most observer programs and how minor and inexpensive expansions of observer data fields and collection protocols supply ecological data underpinning EBFM. Observer data enable monitoring bycatch, including catch and mortality of endangered, threatened and protected species, and assessing the performance of bycatch management measures. They provide a subset of inputs for ecological risk assessments, including productivity–susceptibility analyses and multispecies and ecosystem models. Observer data are used to monitor fishery effects on habitat and to identify and protect benthic vulnerable marine ecosystems. They enable estimating collateral sources of fishing mortality. Data from observer programs facilitate monitoring ecosystem pressure and state indicators. The examples demonstrate how even rudimentary fisheries management systems can meet the ecological data requirements of elements of EBFM.

Calculating population-level fishing mortality for single- versus multi-area models

Spatial considerations in stock assessment models can be used to account for differences in fish population dynamics and fleet distributions, which, if otherwise unaccounted for, could result in model misspecification leading to bias in model results. Calculating an overall fishing mortality rate (F) across spatial components is not straightforward but is often required for harvest management. Langseth and Schueller (2017) examined effects of spatial assumptions on model results under different approaches for calculating F. The authors show that (i) F can differ by as much as 50% depending on the spatial structure of the model; (ii) for multi-area models, F changes with size of area for all but one approach; and (iii) results are sensitive to model assumptions about catchability between areas and the spatial distribution of effort and abundance. Findings suggest caution be taken when interpreting results between models with different spatial structures. When comparing single- with multi-area models, the authors recommend adding F across areas when catchability is the same between areas and either effort or abundance is proportional to area. Otherwise no single approach can be expected to be superior in all cases. The authors suggest simulation be used to evaluate the best approach to meet particular management objectives (Langseth and Schueller 2017).

Ocean futures under ocean acidification

Olsen et al. (2018) leverages the global advances in ecosystem modeling to explore common opportunities and challenges for ecosystem-based management, including changes in ocean acidification, spatial management, and fishing pressure across eight Atlantis (atlantis.cmar.csiro.au) end-to-end ecosystem models. These models represent marine ecosystems from the tropics to the arctic, varying in size, ecology, and management regimes, using a three-dimensional, spatially-explicit structure parametrized for each system. Results suggest stronger impacts from ocean acidification and marine protected areas than from altering fishing pressure, both in terms of guild-level (i.e., aggregations of similar species or groups) biomass and in terms of indicators of ecological and fishery structure. Effects of ocean acidification were typically negative (reducing biomass), while marine protected areas led to both “winners” and “losers” at the level of particular species (or functional groups). Changing fishing pressure (doubling or halving) had smaller effects on the species guilds or ecosystem indicators than either ocean acidification or marine protected areas. Compensatory effects within guilds led to weaker average effects at the guild level than the species or group level. The impacts and tradeoffs implied by these future scenarios are highly relevant as ocean governance shifts focus from single-sector objectives (e.g., sustainable levels of individual fished stocks) to taking into account competing industrial sectors' objectives (e.g., simultaneous spatial management of energy, shipping, and fishing) while at the same time grappling with compounded impacts of global climate change (e.g., ocean acidification and warming).

Climate change impacts on fisheries and aquaculture of the United States - Pacific Islands
In the United States, commercial and recreational fisheries contribute $214 billion USD in sales to the nation's economy and support over 1.8 million jobs. Climate variability and change are impacting the living marine resources that support these fisheries. Spanning over 70 degrees of latitude and several oceans and seas, the Exclusive Economic Zone of the United States and its Territories experiences different types and magnitudes of climate-related change. Some regions are warming at a rate much higher than predicted, while others are experiencing ocean acidification as severe as, or exceeding the general projections for 100 years from now. Climate-driven regime shifts have altered the species composition of the fisheries in some areas while other regions have not yet detected significant changes. NOAA Fisheries highlights the current understanding of how climate change and variability has impacted, and will impact, fisheries and aquaculture across 6 regions of the United States Exclusive Economic Zone (Woodworth-Jefcoats 2017). With over 160 million people in the United States living within coastal communities, and fisheries and aquaculture contributing significantly to the social and economic well-being of the nation, a strong scientific understanding of how ocean ecosystems are changing, the mechanisms of these changes, and how to anticipate and account for future change is paramount to good stewardship of our living marine resources for current and future generations.

North Pacific Albacore Electronic Logbook Project
In 2005, a computer program was developed to allow albacore troll fishermen to enter their logbook data into a computer program rather than completing the traditional paper forms. The advantages of recording the data through a computer program include implementing validation rules at the point of entry thus limiting data entry errors, saving time and money on data entry costs, and making the data available in a timelier manner. Since 2006, the program has been used by 5-10 fishermen annually. The program has received positive feedback on its functionalities and ease of use. During the 2016 season, logs for 31 trips were submitted electronically. In 2015, NOAA Fisheries began developing a new, alternative electronic logbook in PDF format to upgrade the existing version and increase the use of electronic logbooks. Distribution of the new electronic logbook will begin in 2018.

Evaluation of alternative modelling approaches to account for spatial effects due to age-

based movement
Spatial patterns due to age-specific movement have been a source of un-modelled process error. Modeling movement in spatially-explicit stock assessments is feasible, but hampered by a paucity of data from appropriate tagging studies. Lee et al. (2017) used simulation methods to evaluate alternative model structures that either explicitly or implicitly account for the process of age-based movement in a population dynamics model. They simulated synthetic population using a two-area stochastic population dynamics operating model. Two different states of nature governing the movement process were explored. The model that includes the correct spatial dynamic is the only one that results in unbiased and precise estimates of derived and management quantities. In a single area assessment model, using the fleets as area (FAA) approach and estimating both length-based and time-varying, age-based selectivity to implicitly account for the contact selection and annual availability may be the second best option. A FAA approach, assuming each fleet represents a combination of gear and area and adds additional observation error, performed nearly as well. Future research could evaluate which stock assessment method is robust to uncertainty in movement and is more appropriate for achieving intended management objectives.

Petition to List Pacific Bluefin Tuna as Endangered or Threatened Under the U.S.A. Endangered Species Act
In 2016 NOAA Fisheries received a petition from the Center for Biological Diversity (CBD) and 13 co-petitioners requesting that Pacific bluefin tuna, *Thunnus orientalis* (PBF), be listed as endangered or threatened under the Endangered Species Act (ESA) throughout all or a significant portion of its range. After review of the petition, NOAA Fisheries published a positive 90-day finding in the Federal Register (81 FR 70074) on October 11, 2016, concluding that the petitioned actions may be warranted and announcing that a formal status review would be conducted as required by the ESA. A Status Review Team was tasked to conduct this review. On August 8, 2017, NOAA Fisheries published a 12 month finding on this petition and determined that, based on the best scientific and commercial data available, including the status review report, and after taking into account efforts being made to protect the species, listing of the Pacific bluefin tuna was not warranted. NOAA Fisheries concluded that PBF is not an endangered species throughout all or a significant portion of its range, nor likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. Information on the petition and final determination, including the status review report, may be found at
http://www.westcoast.fisheries.noaa.gov/fisheries/migratory_species/pbt_esa_status_review.html

Collection and Analysis of Biological Samples to Support Stock Assessments
Given the uncertainty surrounding current growth models, stock structure, and ecosystem interactions of several tuna and tuna-like species in the North Pacific, NOAA Fisheries has been working with a range of partners to collect biological samples of otoliths, muscle, DNA fin biopsies, gonads, and stomachs from a number of species along the U.S.A. West Coast. In 2007, NOAA Fisheries and the Sportfishing Association of California initiated a sampling program to collect data on tuna and other HMS. Initially the program was focused on the Southern California Bight (SCB). Since that time the program has been expanded to include a broader geographic range and increased number of species. In 2009 scientists began working

with commercial fishermen in the Northeast Pacific to collect samples from albacore off Oregon and Washington. In 2010, additional efforts were made to include central California (Monterey Bay and San Francisco) where albacore are sometimes encountered from August through November. Finally, in 2017, the program was again expanded to include opah and bigeye tuna caught by high-seas longliners landing their catch in California. Sample collection is ongoing and supports the ISC's proposed North Pacific-wide sampling program to address the uncertainties regarding biological information, notably growth models, maturity schedules, and stock structure of several tuna and tuna-like species. Samples of albacore, Pacific bluefin, yellowfin, skipjack (*Katsuwonus pelamis*), California yellowtail (*Seriola lalandi*), opah (*Lampris guttatus*), and dorado (*Coryphaena hippurus*) have been collected during NOAA research surveys and through cooperative programs with commercial passenger fishing vessels, seafood processors, the commercial fisheries operations, and recreational anglers.

Using Chemical Tracers (Stable Isotopes and Cesium-134) to Characterize Migratory Patterns of Pacific Bluefin Tuna

Understanding movement patterns of migratory marine animals is critical for effective management, but often challenging due to the cryptic habitat of pelagic migrators and the difficulty of assessing past movements. Chemical tracers can partially circumvent these challenges by reconstructing recent migration patterns. The radionucleotides released into the ocean off Japan after the 2011 tsunami provided a unique chemical tracer for animals occupying these waters, including Pacific bluefin tuna. A collaborative study with the State University of New York (SUNY) and Harvard University combined a Fukushima-derived radiotracer (^{134}Cs) with bulk tissue and amino acid stable isotope analyses of Pacific bluefin to distinguish recent migrants from residents of the EPO, and to time the migrations of juvenile bluefin as they cross the Pacific Ocean (Madigan et al. 2017b). The presence of ^{134}Cs, while detectable only until 2013, provided the opportunity to validate estimates using stable isotopes alone. Using additional samples, a more robust study was completed in 2016 (Madigan et al. 2017a). The results from this work show that the proportion of recent migrants to residents decreased in older year classes. All fish smaller than 70 cm FL were recent migrants, confirming that fish caught locally are from the western Pacific. Looking across age classes, the number of recent migrants decreased from ~ 80% for 1-2 year olds to ~30% for 2-3 year olds and ~2% for 3-4 year olds. The peak arrival time from the western Pacific is April and May. This information provides important insight into the dynamics of movements across the Pacific. By linking relative arrivals to climate variability on both sides of the Pacific, we should gain insights into the forcing mechanisms behind the high degree of variability in trans-Pacific migrations (Madigan et al. 2017a).

EcoCast

Both electronic tagging data and catch data for blue sharks in the California Current have been incorporated into EcoCast, to help fishers avoid blue sharks during drift gillnet fishing activities. EcoCast is a real-time data tool to help fishers and managers allocate fishing effort to optimize the harvest of target fish while minimizing bycatch of protected species. Motivations to reduce blue sharks landings include reducing bycatch as blue sharks have no marketable value and are discarded at sea. In addition, catching blue sharks increases haul back time, reduces efficiency and can damage gear. Given that the overall viability of a fishery depends on target species catch, EcoCast combines habitat preferences for both target (swordfish) and non-target species which includes sea lions and leatherback sea turtles in addition to blue sharks. The resulting product is updated daily based on environmental conditions and can be used by fishers to identify locations where target catch is maximized and bycatch is minimized. Current efforts are focused on beta testing EcoCast with fishers.

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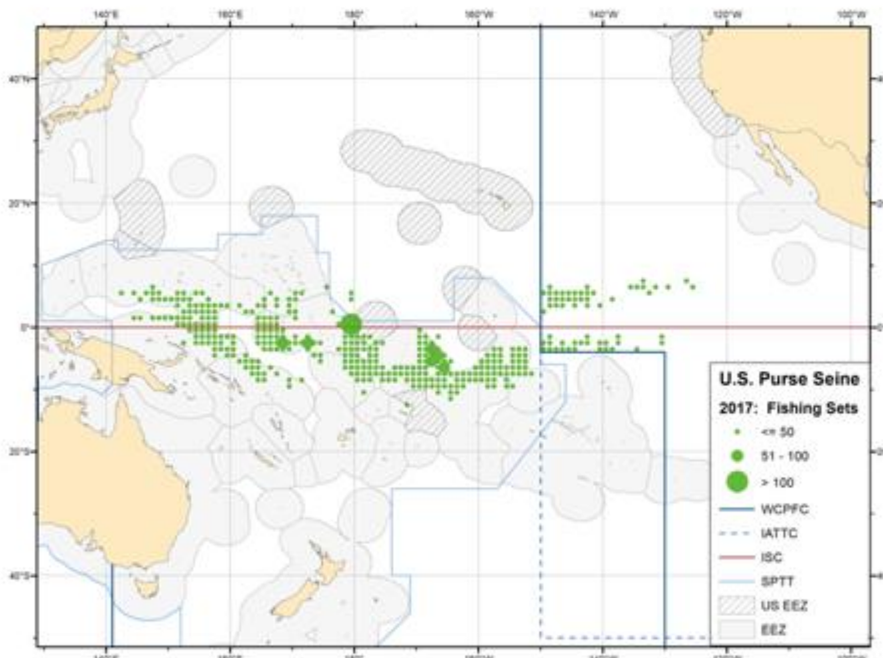


Figure 1. Spatial distribution of reported logbook fishing effort by the 2017 U.S. Pacific purse seine fishery in fishing sets. The size of circles is proportional to the amount of effort. Effort in some areas is not shown in order to preserve data confidentiality.

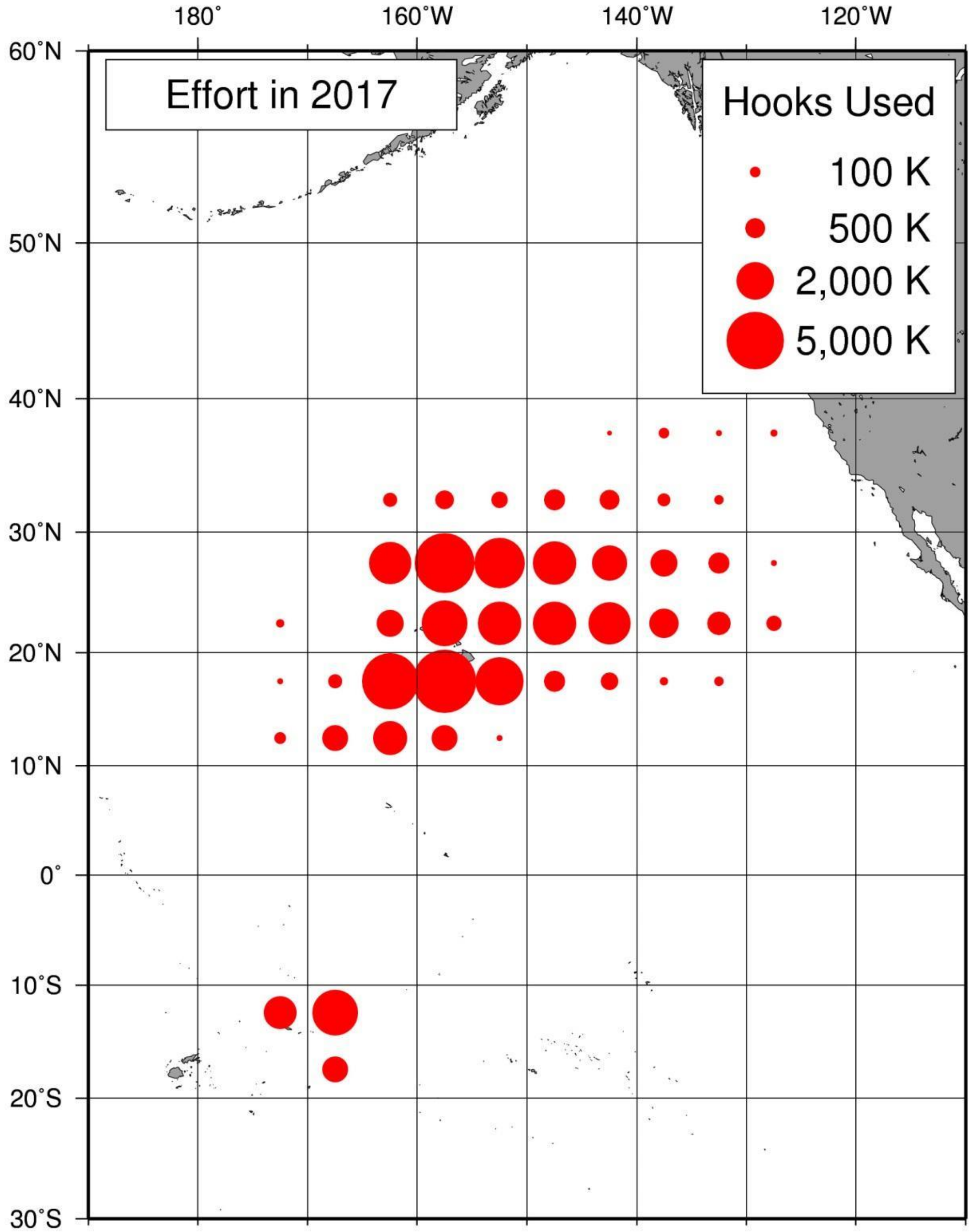


Figure 2. Spatial distribution of reported logbook fishing effort by the 2017 U.S.A. longline fishery in the Pacific Ocean, in 1,000s of hooks. The size of circles is proportional to the amount of effort. Effort in some areas is not shown in order to preserve data confidentiality.

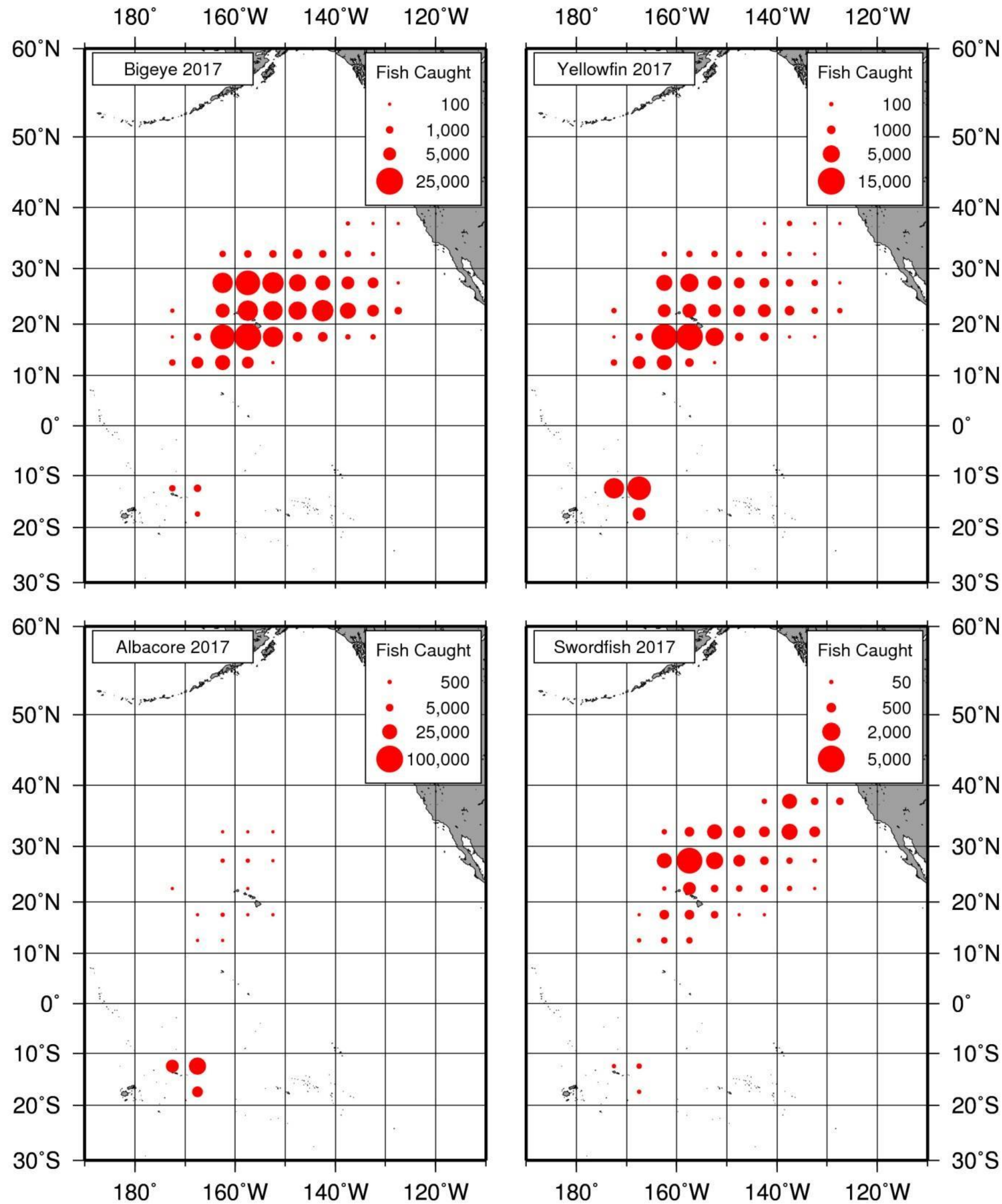


Figure 3. Spatial distribution of reported logbook fishing catch by the U.S.A. longline fishery in the Pacific Ocean, in numbers of fish, in 2017 for bigeye (*Thunnus obesus*), albacore (*T. alalunga*), yellowfin (*T. albacares*) and swordfish (*Xiphias gladius*). The size of circles is proportional to the amount of catch. Catch in some areas is not shown in order to preserve data confidentiality.

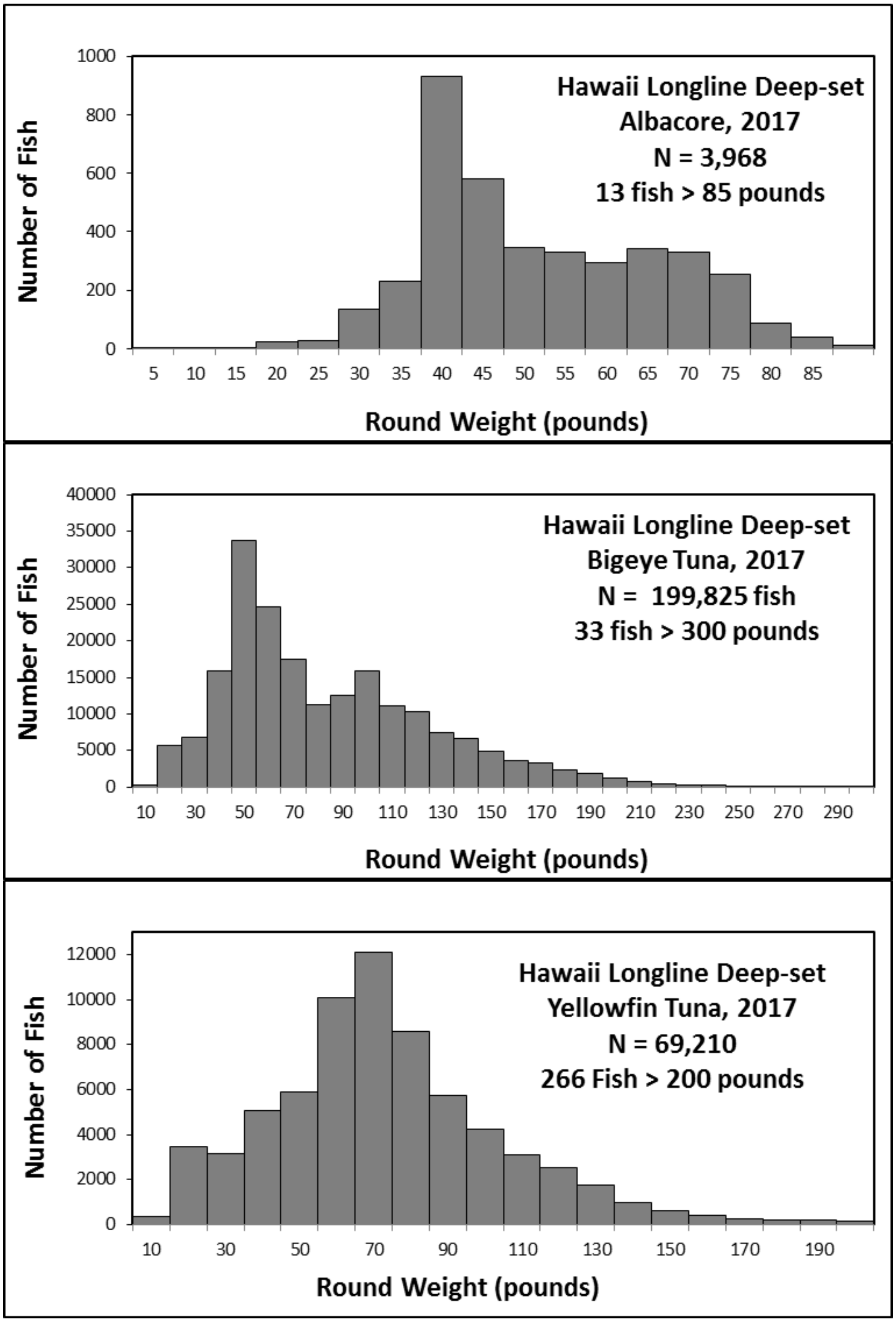


Figure 4. Size distribution of (top) albacore (*Thunnus alalunga*), (middle) bigeye tuna (*Thunnus obesus*), and (bottom) yellowfin tuna (*Thunnus albacares*) caught by the Hawaii-based deep-set longline fishery in the North Pacific Ocean, 2017.

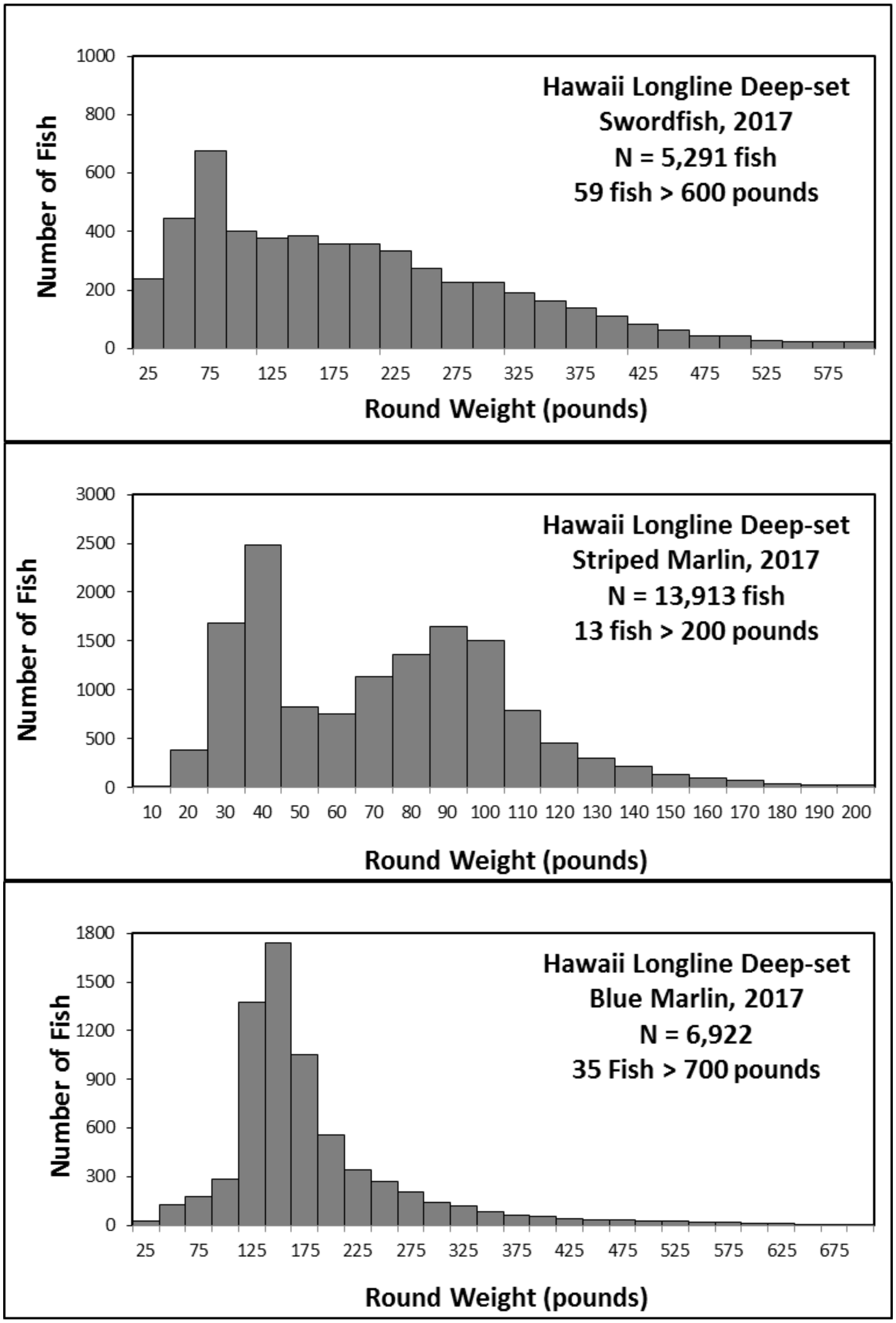


Figure 5. Size distribution of (top) swordfish (*Xiphias gladius*), (middle) striped marlin (*Kajikia audax*), and (bottom) blue marlin (*Makaira nigricans*) caught by the Hawaii-based deep-set longline fishery in the North Pacific Ocean, 2017.

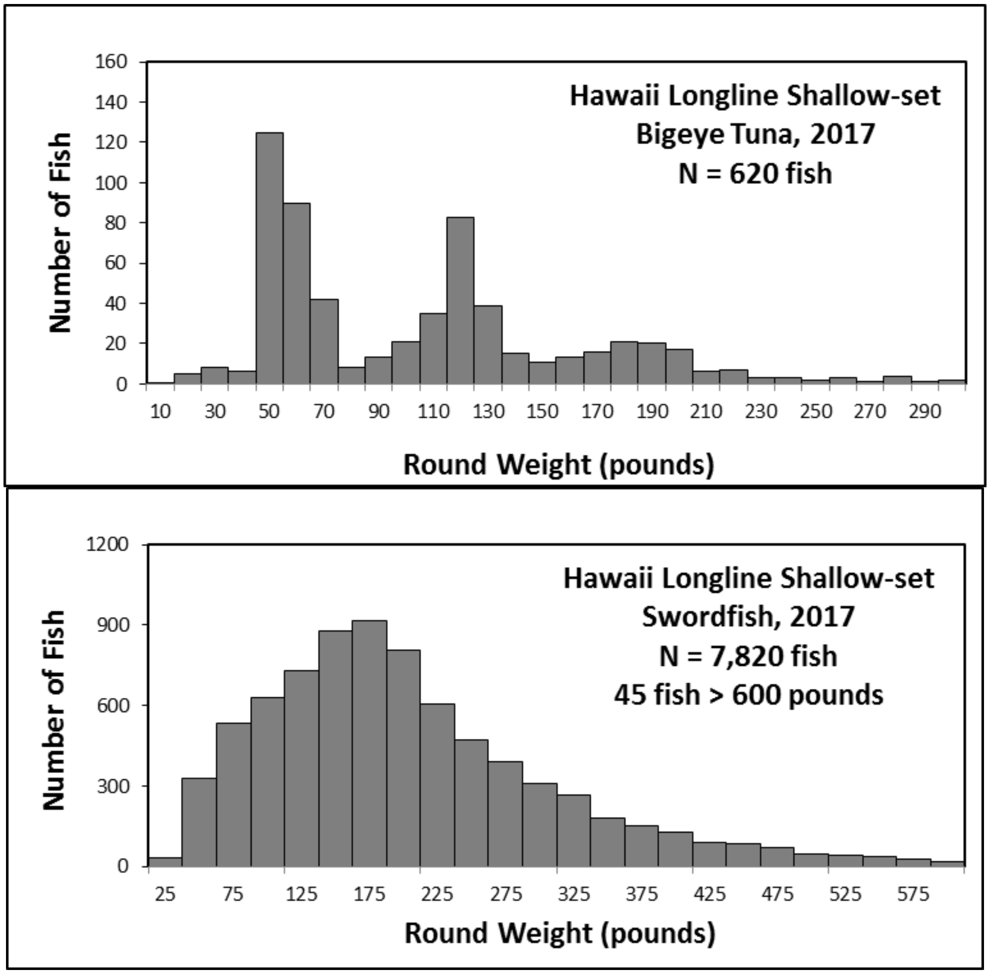


Figure 6. Size distribution of (top) bigeye tuna (*Thunnus obesus*), and (bottom) swordfish (*Xiphias gladius*) caught by the Hawaii-based shallow-set longline fishery in the North Pacific Ocean, 2017.

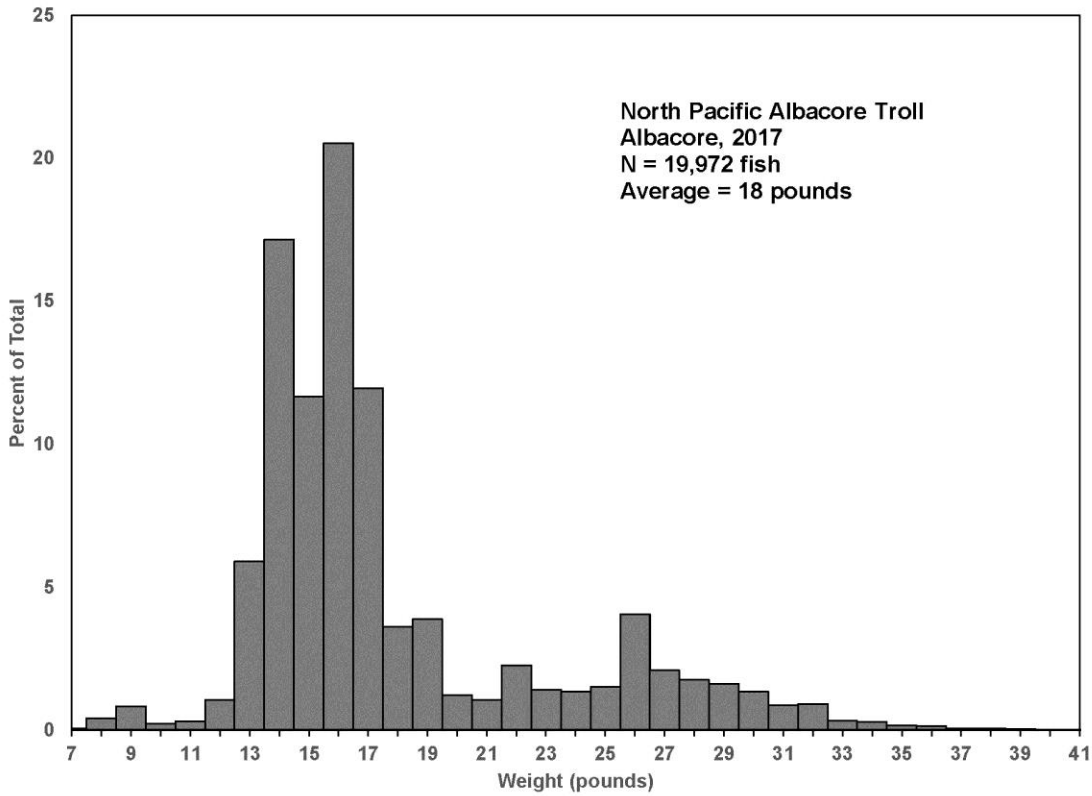


Figure 7. Size distribution of albacore catch by the U.S.A. North Pacific albacore (*Thunnus alalunga*) troll and pole-and-line fishery in 2017.

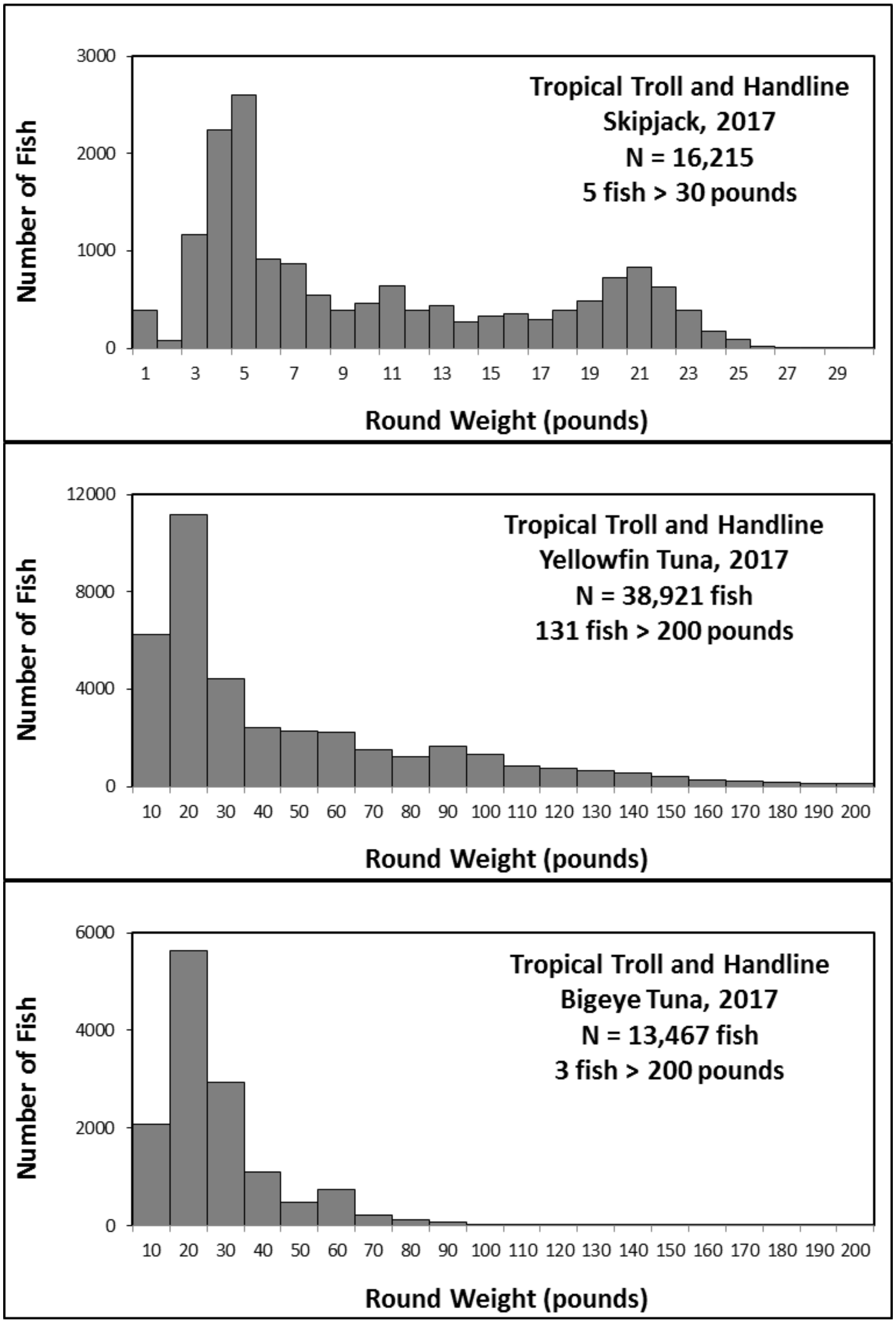
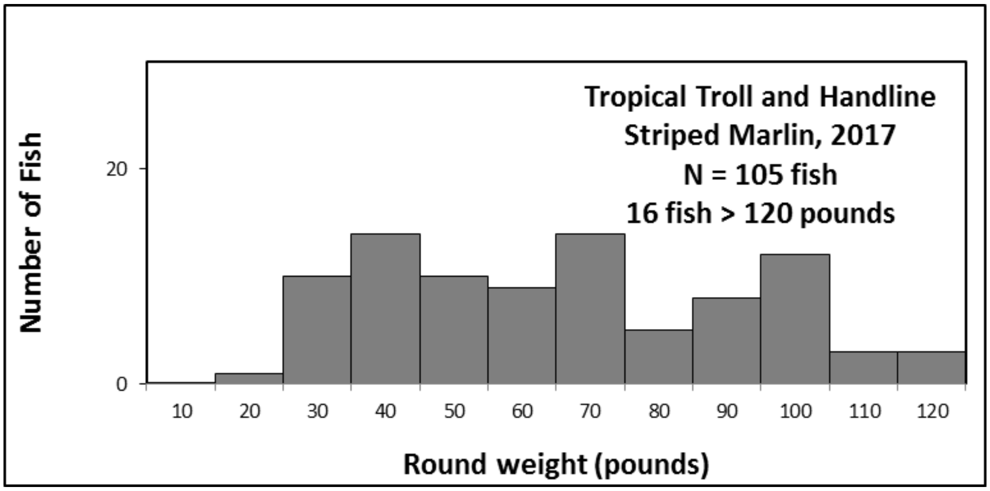


Figure 8. Size distribution of (top) skipjack tuna (*Katsuwonus pelamis*), (middle) yellowfin tuna (*Thunnus albacares*), and (bottom) bigeye tuna (*Thunnus obesus*) caught by the Hawaii troll and handline fisheries, 2017.



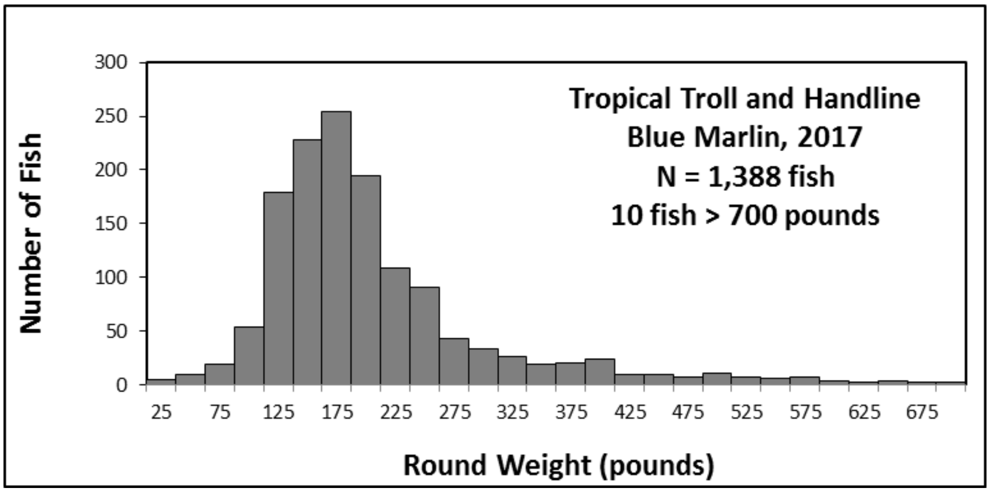


Figure 9. Size distribution of (top) striped marlin (*Kajikia audax*) and (bottom) blue marlin (*Makaira nigricans*) caught by the Hawaii troll and handline fisheries, 2017.

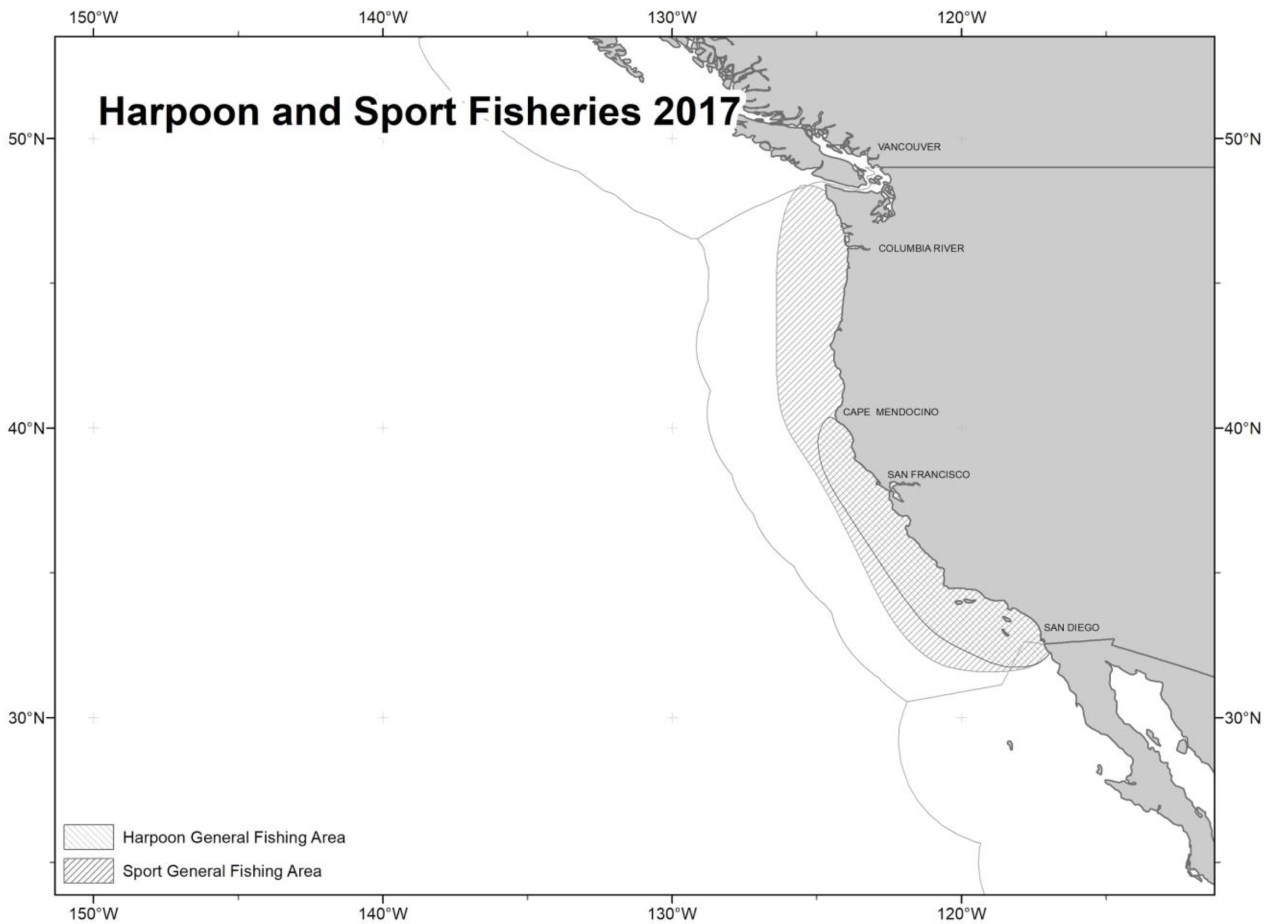


Figure 10. Spatial distribution of reported logbook fishing effort by the 2017 U.S.A. harpoon and west coast sport fisheries for HMS in the North Pacific Ocean.

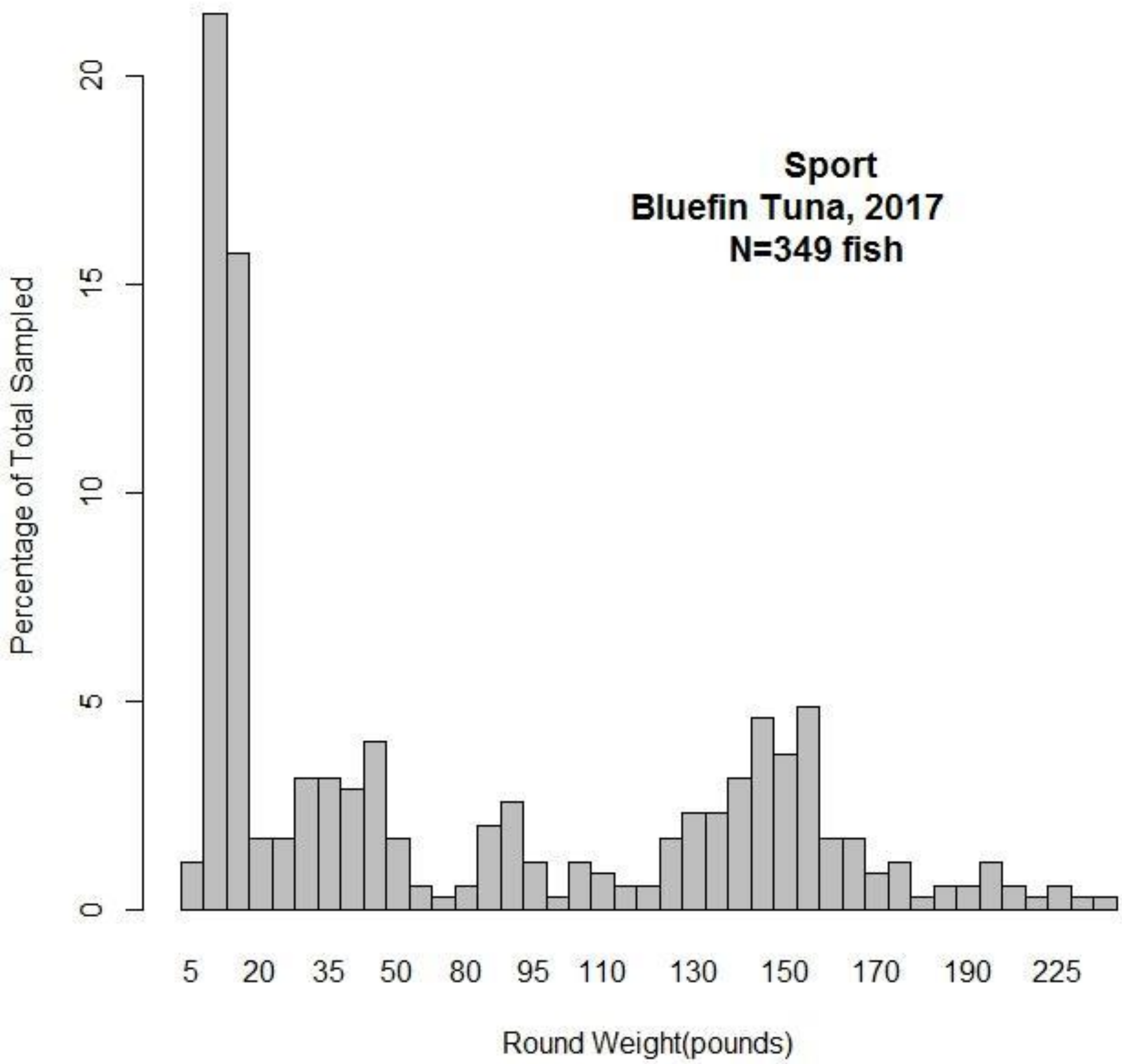


Figure 11. Size distribution of Pacific bluefin tuna (*Thunnus orientalis*) caught by the U.S.A. West Coast sportfishing industry, 2017.