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REPORT ON THE TUNA FISHERY, STOCKS, AND ECOSYSTEM IN THE EASTERN PACIFIC OCEAN IN 2018

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INTRODUCTION

This report provides summary information about the fishery for tunas in the eastern Pacific Ocean (EPO), summary assessments of the major stocks of tunas and billfishes that are exploited in the fishery, updated stock status indicators for silky sharks, and an evaluation of the pelagic ecosystem in the EPO, in 2018. It is based on data available to the IATTC staff in March 2019; therefore, some of the data tables for 2018 are incomplete, and all data for 2017 and 2018 should be considered preliminary.

All weights of catches and discards are in metric tons (t). In the tables, 0 means no effort, or a catch of less than 0.5 t; - means no data collected; * means data missing or not available. The following acronyms are used:

<u>Species:</u>			
ALB	Albacore tuna (<i>Thunnus alalunga</i>)	SFA	Indo-Pacific sailfish (<i>Istiophorus platypterus</i>)
BET	Bigeye tuna (<i>Thunnus obesus</i>)	SKJ	Skipjack tuna (<i>Katsuwonus pelamis</i>)
BIL	Unidentified istiophorid billfishes	SKX	Unidentified elasmobranchs
BKJ	Black skipjack (<i>Euthynnus lineatus</i>)	SSP	Shortbill spearfish (<i>Tetrapturus angustirostris</i>)
BLM	Black marlin (<i>Makaira indica</i>)	SWO	Swordfish (<i>Xiphias gladius</i>)
BUM	Blue marlin (<i>Makaira nigricans</i>)	TUN	Unidentified tunas
BZX	Bonito (<i>Sarda</i> spp.)	YFT	Yellowfin tuna (<i>Thunnus albacares</i>)
CGX	Carangids (Carangidae)	<u>Fishing gears:</u>	
DOX	Dorado (<i>Coryphaena</i> spp.)	FPN	Trap
MLS	Striped marlin (<i>Kajikia audax</i>)	GN	Gillnet
PBF	Pacific bluefin tuna (<i>Thunnus orientalis</i>)	HAR	Harpoon

LL	Longline
LP	Pole and line
LTL	Troll
LX	Hook and line
OTR	Other ¹
NK	Unknown
PS	Purse seine
RG	Recreational
TX	Trawl

Ocean areas:

EPO	Eastern Pacific Ocean
WCPO	Western and Central Pacific Ocean

Set types:

DEL	Dolphin
NOA	Unassociated school
OBJ	Floating object
	LOG: Flotsam
	FAD: Fish-aggregating device

Flags:

IATTC Members & Cooperating Non-Members

BLZ	Belize
BOL	Bolivia
CAN	Canada
CHL	Chile
CHN	China
COL	Colombia
CRI	Costa Rica
ECU	Ecuador
EUR	European Union
EU (CYP)	Cyprus
EU (ESP)	Spain
EU (PRT)	Portugal
FRA	France
GTM	Guatemala
HND	Honduras
IDN	Indonesia
JPN	Japan
KIR	Kiribati
KOR	Republic of Korea
LBR	Liberia
MEX	Mexico
NIC	Nicaragua
PAN	Panama

PER	Peru
SLV	El Salvador
TWN	Chinese Taipei
USA	United States of America
VEN	Venezuela
VUT	Vanuatu

Other flag codes

COK	Cook Islands
CYM	Cayman Islands
NZL	New Zealand
RUS	Russia
VCT	St. Vincent and the Grenadines
UNK	Unknown

Stock assessment:

<i>B</i>	Biomass
<i>C</i>	Catch
CPUE	Catch per unit of effort
<i>F</i>	Rate of fishing mortality
MSY	Maximum sustainable yield
<i>S</i>	Index of spawning biomass
SBR	Spawning biomass ratio
SSB	Spawning stock biomass
SSI	Stock status indicator

¹ Used to group known gear types

A. THE FISHERY FOR TUNAS AND BILLFISHES IN THE EASTERN PACIFIC OCEAN

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INTRODUCTION

This document summarizes the catches and effort of the fisheries for species covered by the IATTC’s Antigua Convention (“*tunas and tuna-like species and other species of fish taken by vessels fishing for tunas and tuna-like species*”) in the eastern Pacific Ocean (EPO) in 2018. The most important of these species are the scombrids (Family Scombridae), which include tunas, bonitos, seerfishes, and some mackerels. The principal species of tunas caught are the three tropical tuna species (yellowfin, skipjack, and bigeye), followed by the temperate tunas (albacore, and lesser catches of Pacific bluefin); other scombrids, such as bonitos and wahoo, are also caught.

There are important fisheries for dorado, sharks, and other species and groups that interact with the tuna fisheries in the EPO, and are thus within the IATTC’s remit. This document therefore also covers other species such as billfishes (swordfish, marlins, shortbill spearfish, and sailfish), carangids (yellowtail, rainbow runner, and jack mackerel), dorado, elasmobranchs (sharks, rays, and skates), and other fishes.

Access to the fishery is regulated by Resolution [C-02-03](#), which requires vessels to be on the IATTC [Regional Vessel Register](#) in order to fish for tunas in the EPO. Vessels are authorized to fish by their respective flag governments, and only duly authorized vessels are included in the Register. The Register lists, in addition to a vessel’s name and flag, its fishing gear, dimensions, carrying capacity, date of construction, ownership, home port, and other characteristics. However, this requirement has not been applied to the thousands of small artisanal vessels, called *pangas*, that are known to catch tunas, among other species, in coastal waters of the EPO, but data on their numbers, effort, and catches are incomplete or unavailable. A pilot program, focused on sharks, is underway in Central America to collect data on these fisheries, and a long-term sampling program is scheduled to commence in 2020.

The IATTC staff has collected and compiled data on the longline fisheries since 1952, on catches of yellowfin and skipjack since 1954, bluefin since 1973, and bigeye since 1975. The data in this report, which are as accurate and complete as possible, are derived from various sources, including vessel logbooks, on-board observer data, unloading records provided by canners and other processors, export and import records, reports from governments and other entities, and the IATTC species and size composition sampling program. The methods for sampling the catches of tunas are described in the [IATTC Annual Report for 2000](#) and in IATTC [Stock Assessment Reports 2](#) and [4](#).

1. CATCHES AND LANDINGS OF TUNAS, BILLFISHES, AND ASSOCIATED SPECIES

Almost all the catches in the EPO are made by the purse-seine and longline fleets; pole-and-line vessels, and various artisanal and recreational fisheries, account for a small percentage of the total catches. The IATTC staff compiles catch data for all these gears, including trolls, harpoons, and gillnets.

Detailed catch data are available for the purse-seine fishery, which takes over 90% of the total reported catches; the data for the other fisheries are incomplete. Purse-seine data for 2017 and 2018, and data for longlines and other gears for 2016-2018, are preliminary.

Purse-seine: Since 1993 all Class-6¹ purse-seine vessels carry observers, who collect detailed data on catches, both retained and discarded at sea. Estimates of the total amount of the catch that is landed (hereafter the “retained catch”) are based principally on data collected during vessel unloadings.

Longline and other: Longline vessels, particularly the larger ones, fish primarily for bigeye, yellowfin, albacore, and swordfish. Data on the retained catches of most of the larger longline vessels are obtained from the vessels’ flag governments; data for smaller longliners, artisanal vessels, and other vessels that fish for species covered by the Antigua Convention are incomplete or unavailable, but some are obtained from logbooks, or from governments or governmental reports. Data for the western and central Pacific Ocean (WCPO) were provided by the Ocean Fisheries Programme of the Secretariat of the Pacific Community (SPC).

This report summarizes data from all the above sources. The estimated total catches of tropical tunas (yellowfin, skipjack, and bigeye) in the entire Pacific Ocean from all sources mentioned above are shown in [Table A-1](#), and are discussed further in the sections below.

Estimates of the annual retained and discarded catches of tunas and other species taken by tuna-fishing vessels in the EPO during 1989-2018 are shown in [Tables A-2a-c](#). The catches of tropical tunas during 1989-2018, by flag, are shown in [Tables A-3a-e](#), and the purse-seine catches and landings of tunas during 2017-2018 are summarized by flag in [Tables A-4a-b](#).

2. CATCHES BY SPECIES

2.1. Yellowfin tuna

The total annual catches of yellowfin in the Pacific Ocean during 1989-2018 are shown in [Table A-1](#) and [Figure B-1](#). The 2018 EPO catch of 239 thousand t is less than the average for the previous 5-year period (244 thousand t). In the WCPO, the catches of yellowfin reached a record high of 676 thousand t in 2017.

The annual retained catches of yellowfin in the EPO, by gear, during 1989-2018 are shown in [Table A-2a](#). During 2003-2017 the annual retained purse-seine and pole-and-line catch averaged 233 thousand t (range: 167 to 384 thousand t). The preliminary estimate of the retained catch in 2018, 237 thousand t, is 13% greater than that of 2017, and 2% greater than the 2003-2017 average. On average, about 0.6% (range: 0.1 to 1.5%) of the total purse-seine catch of yellowfin was discarded at sea during 2003-2017 ([Table A-2a](#)).

During 1990-2003, annual longline catches in the EPO averaged about 23 thousand t (range: 12 to 35 thousand t), or about 8% of the total retained catches of yellowfin. They then declined sharply, to an annual average of 10 thousand t (range: 8 to 13 thousand t), or about 4% of the total retained catches, during 2005-2017. Catches by other fisheries (recreational, gillnet, troll, artisanal, *etc.*), whether incidental or targeted, are shown in [Table A-2a](#), under “Other gears” (OTR); during 2003-2017 they averaged about 2 thousand t.

2.2. Skipjack tuna

The total annual catches of skipjack in the Pacific Ocean during 1989-2018 are shown in [Table A-1](#). Most of the catch is taken in the WCPO. Prior to 1998, WCPO catches averaged about 900 thousand t; subsequently, they increased steadily, from 1.2 million t to an all-time high of 2 million t in 2014. In the EPO, the greatest catches occurred between 2003 and 2018, ranging from 153 to 343 thousand t, the record catch in 2016.

The annual retained catches of skipjack in the EPO, by gear, during 1989-2018 are shown in [Table A-2a](#).

¹ Class 6: carrying capacity greater than 363 metric tons (t)

During 2003-2017 the annual retained purse-seine and pole-and-line catch averaged 266 thousand t (range: 147 to 338 thousand t). The preliminary estimate of the retained catch in 2018, 287 thousand t, is 8% greater than the average for 2003-2017, but 15% less than the record catch of 2016.

Discards of skipjack at sea decreased each year during the period, from 8% in 2004 to a low of less than 1% in 2017, averaging about 3% of the total catch of the species ([Table A-2a](#)).

Catches of skipjack in the EPO by longlines and other gears are negligible ([Table A-2a](#)).

2.3. Bigeye tuna

The total annual catches of bigeye in the Pacific Ocean during 1989-2018 are shown in [Table A-1](#). Overall, the catches in both the EPO and WCPO have increased, but with considerable fluctuations. In the WCPO they averaged more than 77 thousand t during the late 1970s, decreased during the early 1980s, and then increased steadily to 113 thousand t in 1996; they jumped to 158 thousand t in 1997, and reached a high of 180 thousand t in 2004, since when they have fluctuated between 132 and 156 thousand t. In the EPO, the average catch for the period was 104 thousand t, with a low of 73 thousand t in 1989 and a high of 149 thousand t in 2000.

The annual retained catches of bigeye in the EPO by purse-seine and pole-and-line vessels during 1989-2018 are shown in [Table A-2a](#). The introduction of fish-aggregating devices (FADs), placed in the water by fishers to attract tunas, in 1993 led to a sudden and dramatic increase in the purse-seine catches. Prior to 1993, the annual retained purse-seine catch of bigeye in the EPO was about 5 thousand t ([Table A-2a](#)); by 1994 it was 35 thousand t, and in 1996 was over 60 thousand t. During 1997-2017 it has fluctuated between 44 and 95 thousand t; the preliminary estimate for 2018 is 65 thousand t.

During 2000-2017 the percentage of the purse-seine catch of bigeye discarded at sea has steadily decreased, from 5% in 2000 to less than 1% in 2014, averaging about 1.8%.

Before the expansion of the FAD fishery, longliners caught almost all the bigeye in the EPO, averaging 86 thousand t annually during 1985-1992. Since then this has dropped to 36%, with a low of 25% in 2008 (average: 37 thousand t; range: 26 to 60 thousand t) ([Table A-2a](#)). The preliminary estimate of the longline catch in the EPO in 2018 is 21 thousand t ([Table A-2a](#)).

Small amounts of bigeye are caught in the EPO by other gears ([Table A-2a](#)).

2.4. Pacific bluefin tuna

The catches of Pacific bluefin in the EPO during 1989-2018, by gear, are shown in [Table A-2a](#). Until 2017, purse-seine vessels accounted for almost all of the annual average EPO retained catch of 5.0 thousand t (range: 2.8 to 9.9 thousand t); the preliminary estimate for 2018 is 2.9 thousand t ([Table A-2a](#)).

The catches of Pacific bluefin in the entire Pacific Ocean, by flag and gear, as reported by the vessels' flag governments to the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC), are shown in [Table A-5a](#).

Catches of Pacific bluefin by recreational gear in the EPO are reported in numbers of individual fish caught, whereas all other gears report catches in weight; they are therefore converted to tons for inclusion in the EPO catch totals. The original catch data for 1989-2018, in numbers of fish, are presented in [Table A-5b](#).

2.5. Albacore tuna

Data provided by the relevant CPCs on catches of albacore in the EPO, by gear and area (north and south of the equator), are shown in [Table A-6](#), and for the entire EPO in [Table A-2a](#). A portion of the albacore catch is taken by troll vessels, included under "Other gears" (OTR) in [Table A-2a](#).

2.6. Other tunas and tuna-like species

While yellowfin, skipjack, and bigeye tunas comprise the great majority of the retained purse-seine catches in the EPO, other tunas and tuna-like species, such as black skipjack, bonito, wahoo, and frigate and bullet tunas, contribute to the overall harvest. The estimated annual retained and discarded catches of these species during 1989-2018 are shown in Table A-2a. The catches reported in the “unidentified tunas” (TUN) category in [Table A-2a](#) contain some catches reported by species (frigate or bullet tunas) along with the unidentified tunas. The total retained catch of these other species by the purse-seine fishery in 2018 was 5.3 thousand t, less than the 2003-2017 average of 8.0 thousand t (range: 500 to 19 thousand t).

Black skipjack are also caught by other gears in the EPO, mostly by coastal artisanal fisheries. Bonitos are also caught by artisanal fisheries, and have been reported as catch by longline vessels in some years.

2.7. Billfishes

Catch data for billfishes (swordfish, blue marlin, black marlin, striped marlin, shortbill spearfish, and sailfish) are shown in [Table A-2b](#).

Swordfish are caught in the EPO with large-scale and artisanal longlines, gillnets, harpoons, and occasionally with recreational gear. During 1999-2008 the longline catch averaged 12.2 thousand t, but during 2014-2017 this almost doubled, to over 23 thousand t, possibly due to increased abundance of swordfish, increased effort directed toward the species, increased reporting, or a combination of all of these.

Other billfishes are caught with large-scale industrial and artisanal longlines and recreational gear. The average annual longline catches of blue marlin and striped marlin during 2003-2017 were about 3.6 thousand and 2.2 thousand t, respectively. Smaller amounts of other billfishes, such as black marlin and Indo-Pacific sailfish, are also taken by longline.

Little reliable information is available on the recreational catches of billfishes but, due to the common practice of catch-and-release, the retained catches are believed to be substantially less than the commercial catches for all species.

Prior to 2011, all billfishes caught in the purse-seine fishery were classified as “discarded dead”. However, the growing rate of retention of such bycatch species made it important to reflect this in the data, and since 2011 retained catch and discards are reported separately in [Table A-2b](#). During 2003-2017, purse seiners accounted for about 1% of the total catch of billfishes in the EPO.

2.8. Other species

Data on the purse-seine catches and discards of carangids (yellowtail, rainbow runner, jack mackerel), dorado, elasmobranchs (sharks, rays, and skates), and other fishes caught in the EPO are shown in [Table A-2c](#). Since 2011, bycatches in the purse-seine fishery are reported in Table A-2c as either retained or discarded.

Dorado are unloaded mainly in ports in Central and South America. The reported catches of dorado have declined, from a high of 71 thousand t in 2009 to 15 thousand t in 2016.

3. DISTRIBUTIONS OF THE CATCHES OF TROPICAL TUNAS

3.1. Purse-seine catches

The average annual distributions of purse-seine catches, by set type, of tropical tunas (yellowfin, skipjack, and bigeye) in the EPO during 2013-2017 are shown in [Figures A-1a](#), [A-2a](#), and [A-3a](#), respectively, and preliminary estimates for 2018 are shown in [Figures A-1b](#), [A-2b](#), and [A-3b](#).

Yellowfin: The majority of catches in 2018 were taken in sets associated with dolphins along the coast

of the Americas, principally south of Baja California, Mexico, and north and east from the Galapagos Islands to the coast. Larger-than-normal catches of yellowfin were taken in dolphin sets between 5°N and 15°N from 125°W to 145°W; lesser amounts were taken in unassociated sets along the coast of South America and around the Galapagos Islands, and in floating-object sets throughout the EPO south of 10°N ([Figure A-1b](#)).

Skipjack catches in 2018 declined in all areas from previous years, except for the area around the Galapagos Islands, which showed a large increase. Most of the catch was taken in floating-object sets throughout the EPO, except near the coast of Peru, where most of the catch came from unassociated sets ([Figure A-2b](#)).

Bigeye are not often caught north of about 7°N in the EPO. As in previous years, almost all of the 2018 catches were taken in sets on FADs. The catch was fairly evenly distributed across the EPO between 10°N and 10°S ([Figure A-3b](#)).

3.2. Longline catches

Since 2009, the IATTC has received catch and effort data from Belize, China, France (French Polynesia), Japan, the Republic of Korea, Spain, Chinese Taipei, the United States, and Vanuatu. Albacore, bigeye and yellowfin tunas make up the majority of the catches by most of these vessels. The distributions of the catches of bigeye and yellowfin in the Pacific Ocean by Chinese, Japanese, Korean, and Chinese Taipei longline vessels during 2013-2017 are shown in [Figure A-4](#).

4. SIZE COMPOSITIONS OF THE CATCHES OF TUNAS

4.1. Purse-seine, pole-and-line, and recreational fisheries

Length-frequency samples are the basic source of data used for estimating the size and age compositions of the various species of fish in the landings. This information is necessary to obtain age-structured estimates of the populations for various purposes, primarily the integrated modeling that the staff uses to assess the status of the stocks (see [Stock Assessment Reports](#)). Length-frequency samples are obtained from the catches of purse-seine vessels in the EPO by IATTC personnel at ports of landing in Ecuador, Mexico, Panama, and Venezuela.

The size-composition data presented in this report are for fish caught during 2013-2018. Two sets of length-frequency histograms are presented for each tropical tuna species; the first shows the data for 2018 by stratum (gear type, set type, and area), and the second the combined data for each year of the 2013-2018 period.

Yellowfin: nine purse-seine fisheries (four associated with floating objects (OBJ), three associated with dolphins (DEL), and two unassociated (NOA)) and one pole-and-line (LP) fishery, which includes all 13 sampling areas) are defined ([Figure A-5](#)). Of the 835 wells sampled during 2018, 685 contained yellowfin. The estimated size compositions of the fish caught are shown in [Figure A-6a](#). Most of the yellowfin catch was taken in sets associated with dolphins in the DEL-N and DEL-I fisheries during quarters 1-3. The largest yellowfin (>120 cm) were caught in the DEL-N fishery, with smaller yellowfin (<80 cm) in the DEL-I fishery, both in quarter 2. The smallest yellowfin (<60 cm) were caught in the OBJ fisheries throughout 2018.

The estimated size compositions of the yellowfin caught by all fisheries combined during 2013-2018 are shown in [Figure A-6b](#). The average weight of yellowfin in 2018, 7.7 kg, was greater than in the previous two years, but lower than the 2013-2015 averages, which ranged from 9.0 to 10.0 kg. The overall size distribution was consistent with the previous two years.

Skipjack: seven purse-seine fisheries (four OBJ, two NOA, one DEL) and one LP fishery are defined

([Figure A-5](#)); the last two include all 13 sampling areas. Of the 835 wells sampled, 565 contained skipjack. The estimated size compositions of the fish caught during 2018 are shown in [Figure A-7a](#). Most of the 2018 skipjack catch was taken in the four OBJ fisheries and in the NOA-S fishery throughout the year. The largest skipjack (>60 cm) were caught in the four OBJ fisheries in quarters 2-4; the smallest (<40 cm) were caught primarily in the OBJ-N and OBJ-S fisheries, also in quarters 2-4.

The estimated size compositions of the skipjack caught by all fisheries combined during 2013-2018 are shown in [Figure A-7b](#). The average weight of skipjack in 2018 (1.9 kg) was among the lowest for the 6-year period (1.8-2.5 kg).

Bigeye: six purse-seine fisheries (four OBJ, one NOA, one DEL) and one LP fishery are defined ([Figure A-5](#)); the last three include all 13 sampling areas. Of the 835 wells sampled, 197 contained bigeye. The estimated size compositions of the fish caught during 2018 are shown in [Figure A-8a](#). Most of the 2018 catch of bigeye was taken in the OBJ-N and OBJ-S fisheries throughout the year, with lesser amounts caught in the OBJ-E fishery in quarters 1-2.

The estimated size compositions of bigeye caught by all fisheries combined during 2013-2018 are shown in [Figure A-8b](#). The average weight of bigeye in 2018 (4.8 kg) was consistent with the previous three years (4.7-5.0 kg), but lower than the 2013-2014 average of 5.6 kg.

Pacific bluefin are caught by purse-seine and recreational gear off California and Baja California from about 23°N to 35°N. In recent years catches have been made between 28°N and 32°N from late March through May, when the annual catch limit is reached, and the fishery is closed for the rest of the year. Mexico's National Fisheries Institute (INAPESCA) provided length-composition data for purse-seine catches during 2013-2017, most of which are transported live to grow-out pens near the coast of Mexico. The average weight of bluefin caught during 2017 (55.4 kg), calculated from these length data, was much higher than the 2013-2016 averages (range: 25.6-33.5 kg). The estimated size compositions are shown in [Figure A-9](#).

4.2. Longline fishery

The size compositions of yellowfin and bigeye caught by the Japanese longline fleet (commercial and training vessels) in the EPO during 2013-2017 are shown in [Figures A-10](#) and [A-11](#). The average annual weight during that period ranged from 49.4 to 61.0 kg for yellowfin, and from 60.7 kg to 63.5 kg for bigeye.

4.3. Catches of tunas, by flag and gear

The annual retained catches of tunas in the EPO during 1989-2018 by flag and gear, are shown in [Tables A-3a-e](#). The purse-seine catches of tunas in 2017 and 2018, by flag and species, are summarized in [Table A-4a](#). Of the nearly 596 thousand t of tunas caught in 2018, 46% were caught by Ecuadorian vessels, and 21% by Mexican vessels. Other countries with significant catches included Panama (12%), Colombia (6%), Venezuela (4%), United States (3%) and Nicaragua (3%). The purse-seine landings of tunas in 2017 and 2018, by species, and country of landing, are summarized in [Table A-4b](#). Of the more

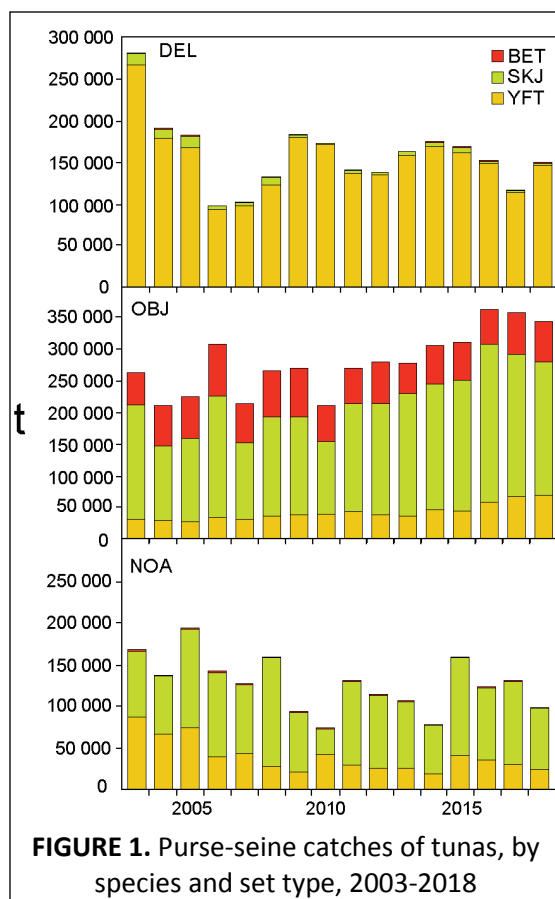


FIGURE 1. Purse-seine catches of tunas, by species and set type, 2003-2018

than 593 thousand t of tunas landed in the EPO in 2018, 61% were landed in Ecuadorian ports, and 21% in Mexican ports. Other countries with landings of tunas in the EPO included Colombia (5%) and Peru (4%).

5. FISHING EFFORT

5.1. Purse seine

Estimates of the numbers of purse-seine sets of each type (associated with dolphins (DEL), associated with floating objects (OBJ), and unassociated (NOA)) in the EPO during 2003-2018, and the retained catches from those sets, are shown in [Table A-7](#) and [Figure 1](#).² The estimates for small³ vessels were calculated from logbook data in the IATTC statistical data base, and those for Class-6 vessels from the observer data bases of the IATTC, Colombia, Ecuador, the European Union, Mexico, Nicaragua, Panama, the United States, and Venezuela.

Since the introduction of fish-aggregating devices (FADs) in the mid-1990s, they have become predominant in the floating-object fishery, and now account for an estimated 97% of all floating-object sets by Class-6 vessels ([Table A-8](#)).

5.2. Longline

The reported nominal fishing effort (in thousands of hooks) by longline vessels in the EPO, and their catches of the predominant tuna species, are shown in [Table A-9](#).

6. THE FLEETS

6.1. Purse-seine

The IATTC [Regional Vessel Register](#) contains detailed records of all purse-seine vessels that are authorized to fish for tunas in the EPO. However, only vessels that fished for yellowfin, skipjack, bigeye, and/or Pacific bluefin tuna in the EPO in 2018 are included in the following description of the purse-seine fleet.

The IATTC uses well volume, in cubic meters (m³), to measure the carrying capacity of purse-seine vessels. Reliable well volume data are available for almost all purse-seine vessels; the well volume of vessels lacking such data is calculated by applying a conversion factor to their capacity in tons ([Table A-10](#); [Figure 2](#)).

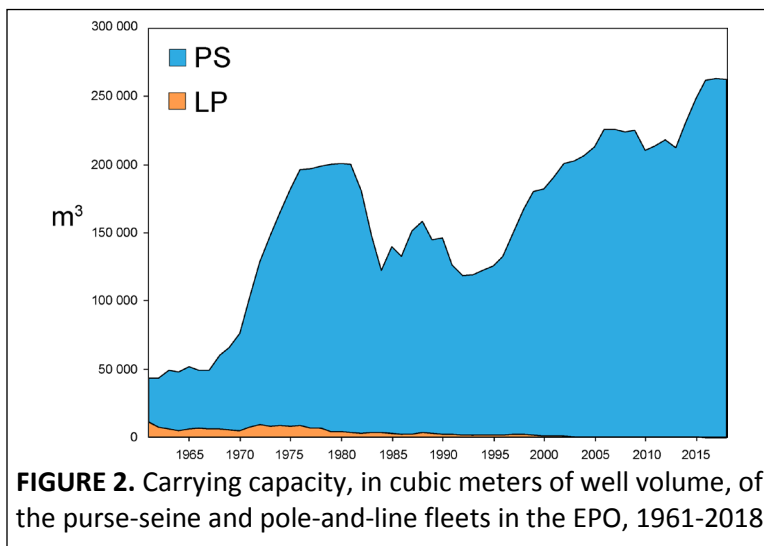


FIGURE 2. Carrying capacity, in cubic meters of well volume, of the purse-seine and pole-and-line fleets in the EPO, 1961-2018

² The catch data for 2003-2018 incorporate previously unavailable data, and are thus different from the corresponding data presented in previous publications.

³ ≤363 t carrying capacity

The 2017 and preliminary 2018 data for numbers and total well volumes of purse-seine vessels that fished for tunas in the EPO are shown in [Tables A-11a](#) and [A-11b](#). During 2018, the fleet was dominated by Ecuadorian and Mexican vessels, with about 35% and 24%, respectively, of the total well volume; they were followed by the United States (10%), Panama (8%), Venezuela (8%), Colombia (6%), Nicaragua (3%), El Salvador (2%), Peru (2%) and the European Union (Spain) (2%).⁴

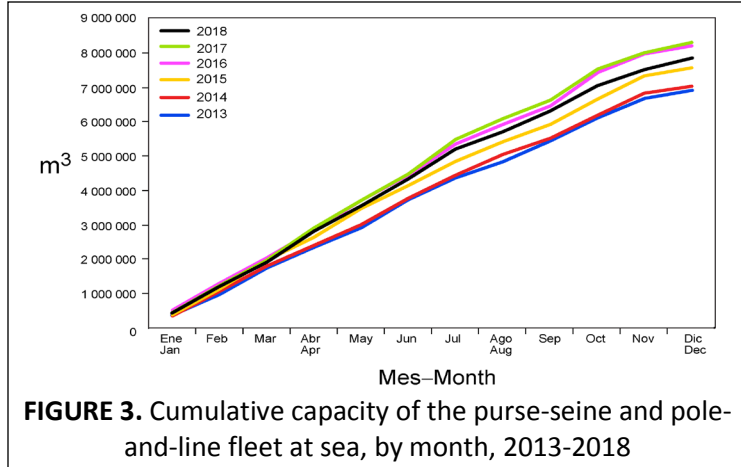


FIGURE 3. Cumulative capacity of the purse-seine and pole-and-line fleet at sea, by month, 2013-2018

The cumulative capacity at sea during 2018 is compared to those of the previous five years in [Figure 3](#).

The monthly average, minimum, and maximum total well volumes at sea (VAS), in thousands of cubic meters, of purse-seine and pole-and-line vessels that fished for tunas in the EPO during 2008-2017, and the 2018 values, are shown in [Table A-12](#). The monthly values are averages of the VAS estimated at weekly intervals by the IATTC staff. The average VAS values for 2008-2017 and 2018 were slightly over 140 thousand m³ (61% of total capacity) and about 152 thousand m³ (58% of total capacity), respectively.

6.2. Other fleets of the EPO

Information on other types of vessels that are authorized to fish in the EPO is available in the IATTC's [Regional Vessel Register](#). In some cases, particularly for large longline vessels, the Register contains information for vessels authorized to fish not only in the EPO, but also in other oceans, and which may not have fished in the EPO during 2018, or ever.

⁴ The sum of the percentages may not add up to 100% due to rounding.

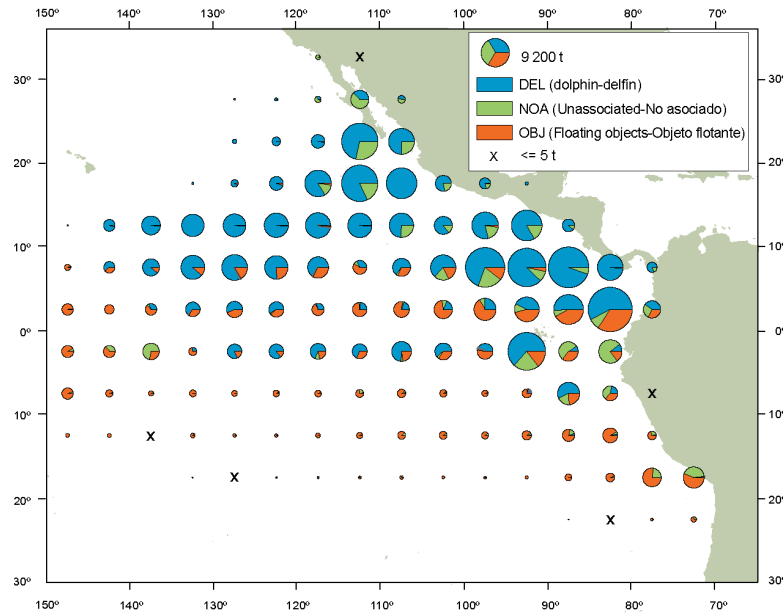


FIGURE A-1a. Average annual distributions of the purse-seine catches of yellowfin, by set type, 2013-2017. The sizes of the circles are proportional to the amounts of yellowfin caught in those 5° by 5° areas.
FIGURA A-1a. Distribución media anual de las capturas cerqueras de aleta amarilla, por tipo de lance, 2013-2017. El tamaño de cada círculo es proporcional a la cantidad de aleta amarilla capturado en la cuadrícula de 5° x 5° correspondiente.

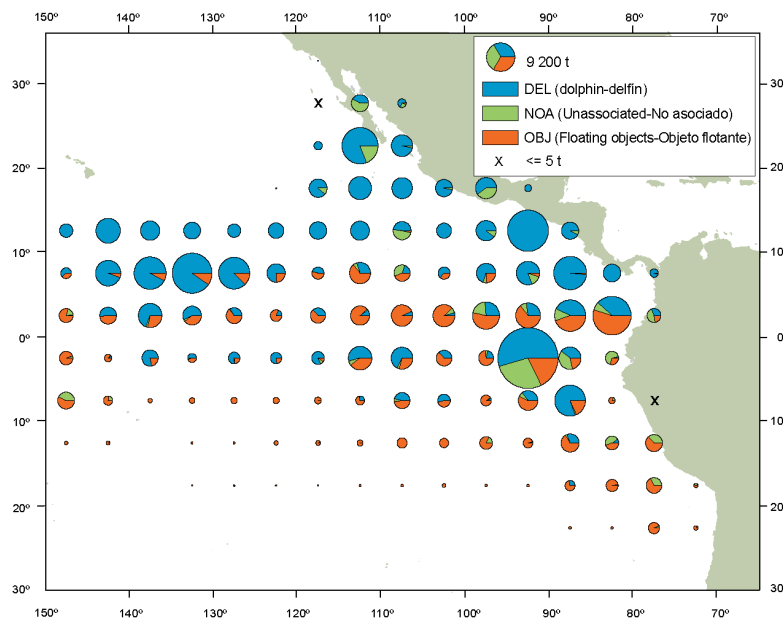


FIGURE A-1b. Annual distributions of the purse-seine catches of yellowfin, by set type, 2018. The sizes of the circles are proportional to the amounts of yellowfin caught in those 5° by 5° areas.
FIGURA A-1b. Distribución anual de las capturas cerqueras de aleta amarilla, por tipo de lance, 2018. El tamaño de cada círculo es proporcional a la cantidad de aleta amarilla capturado en la cuadrícula de 5° x 5° correspondiente.

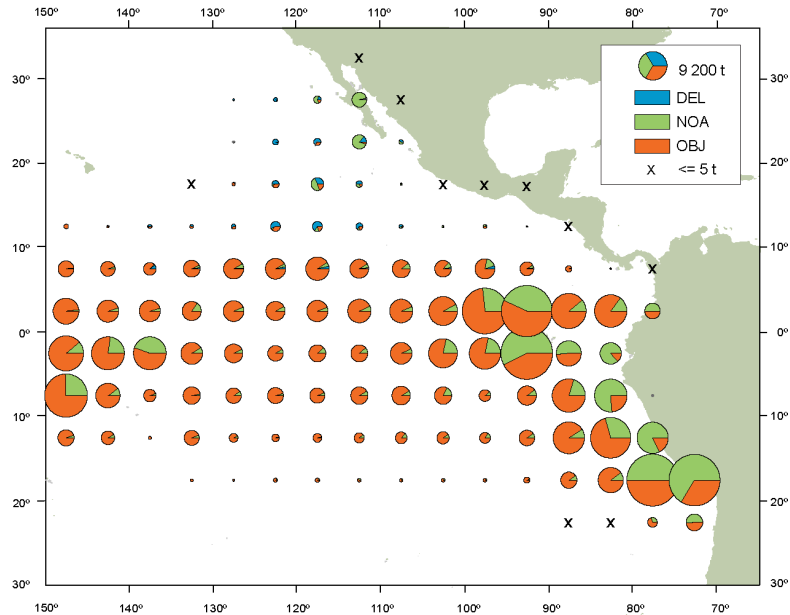


FIGURE A-2a. Average annual distributions of the purse-seine catches of skipjack, by set type, 2013-2017. The sizes of the circles are proportional to the amounts of skipjack caught in those 5° by 5° areas.
FIGURA A-2a. Distribución media anual de las capturas cerqueras de barrilete, por tipo de lance, 2013-2017. El tamaño de cada círculo es proporcional a la cantidad de barrilete capturado en la cuadrícula de 5° x 5° correspondiente.

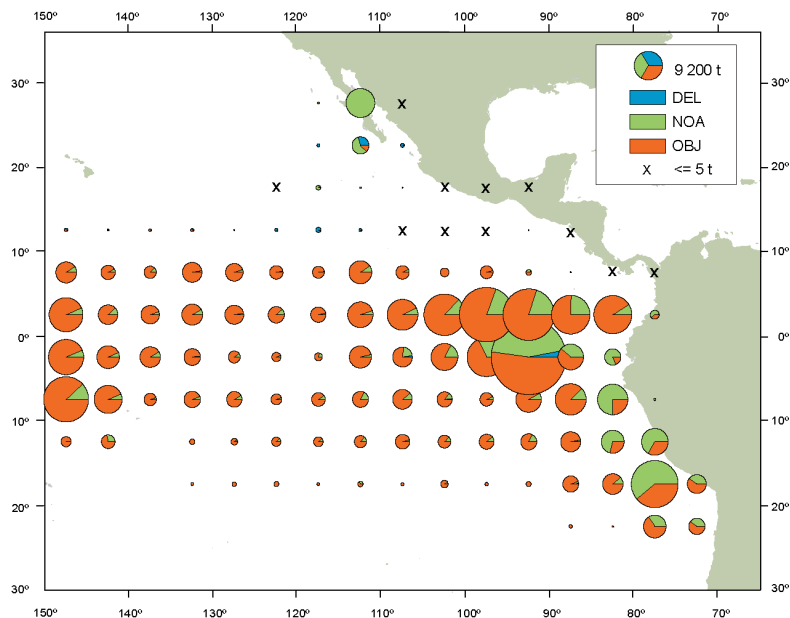


FIGURE A-2b. Annual distributions of the purse-seine catches of skipjack, by set type, 2018. The sizes of the circles are proportional to the amounts of skipjack caught in those 5° by 5° areas.
FIGURA A-2b. Distribución anual de las capturas cerqueras de barrilete, por tipo de lance, 2018. El tamaño de cada círculo es proporcional a la cantidad de barrilete capturado en la cuadrícula de 5° x 5° correspondiente.

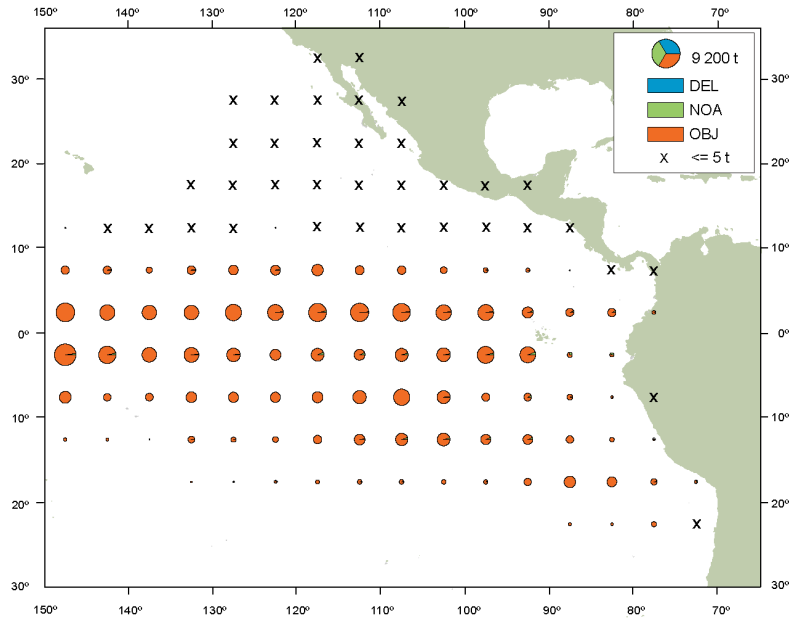


FIGURE A-3a. Average annual distributions of the purse-seine catches of bigeye, by set type, 2013-2017. The sizes of the circles are proportional to the amounts of bigeye caught in those 5° by 5° areas.
FIGURA A-3a. Distribución media anual de las capturas cerqueras de patudo, por tipo de lance, 2013-2017. El tamaño de cada círculo es proporcional a la cantidad de patudo capturado en la cuadrícula de 5° x 5° correspondiente.

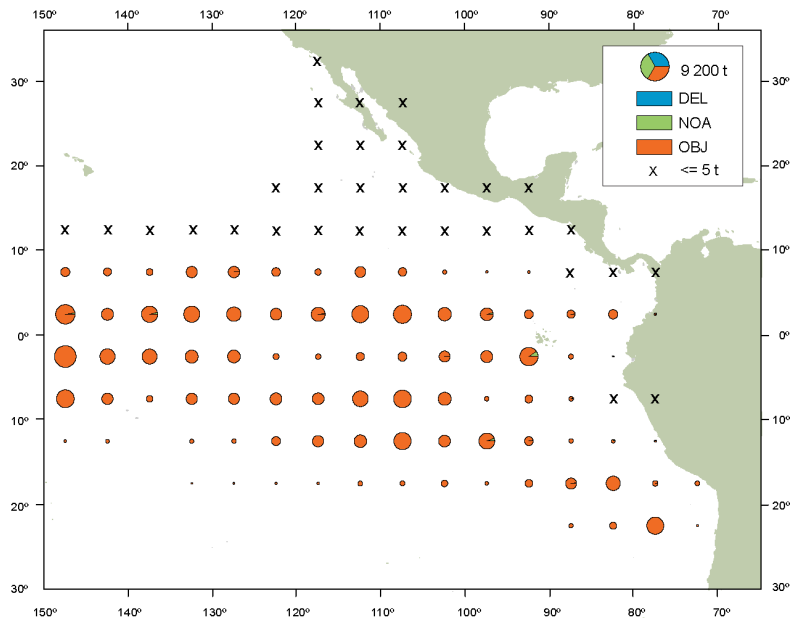


FIGURE A-3b. Annual distributions of the purse-seine catches of bigeye, by set type, 2018. The sizes of the circles are proportional to the amounts of bigeye caught in those 5° by 5° areas.
FIGURA A-3b. Distribución anual de las capturas cerqueras de patudo, por tipo de lance, 2018. El tamaño de cada círculo es proporcional a la cantidad de patudo capturado en la cuadrícula de 5° x 5° correspondiente.

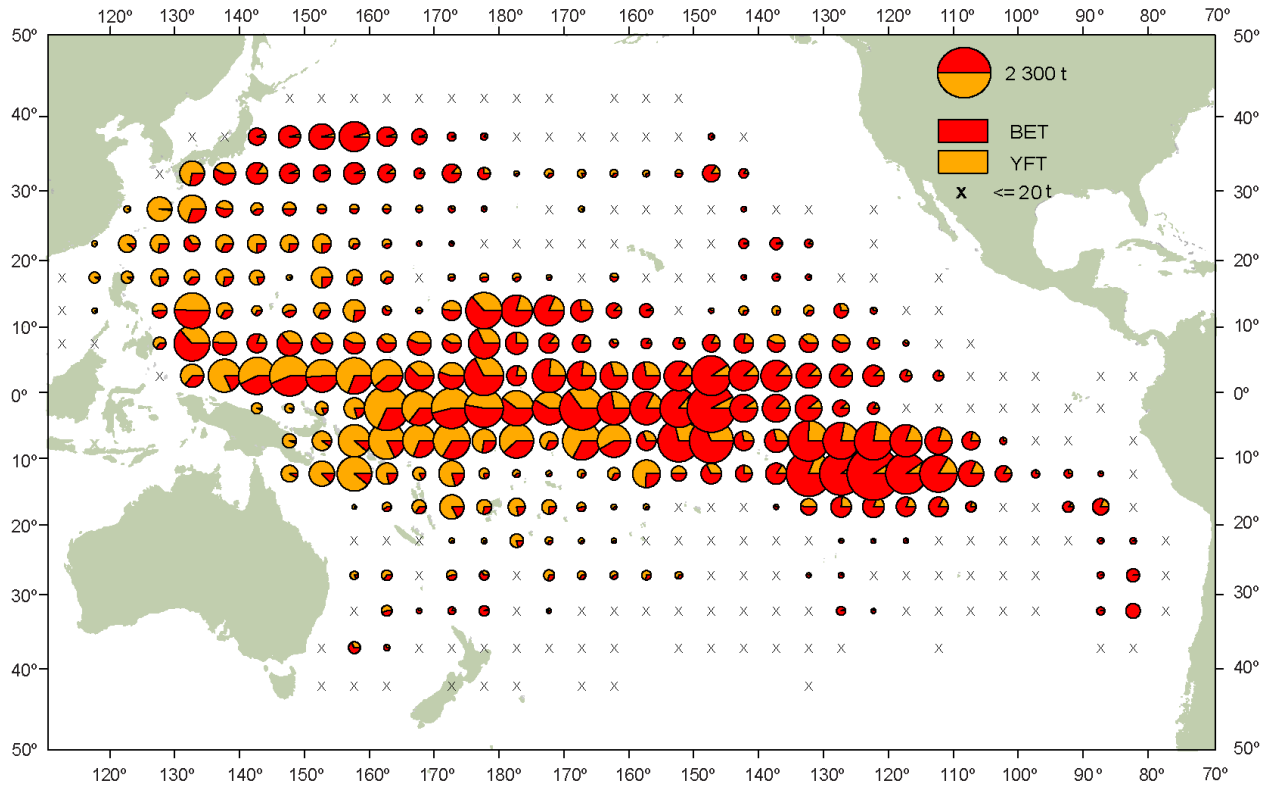


FIGURE A-4. Distributions of the average annual catches of bigeye and yellowfin tunas in the Pacific Ocean, in metric tons, by Chinese, Japanese, Korean, and Chinese Taipei longline vessels, 2013-2017. The sizes of the circles are proportional to the amounts of bigeye and yellowfin caught in those 5° by 5° areas.

FIGURA A-4. Distribución de las capturas anuales medias de atunes patudo y aleta amarilla en el Océano Pacífico, en toneladas métricas, por buques palangreros de China, Corea, Japón, y Taipei Chino, 2013-2017. El tamaño de cada círculo es proporcional a la cantidad de patudo y aleta amarilla capturado en la cuadrícula de 5° x 5° correspondiente.

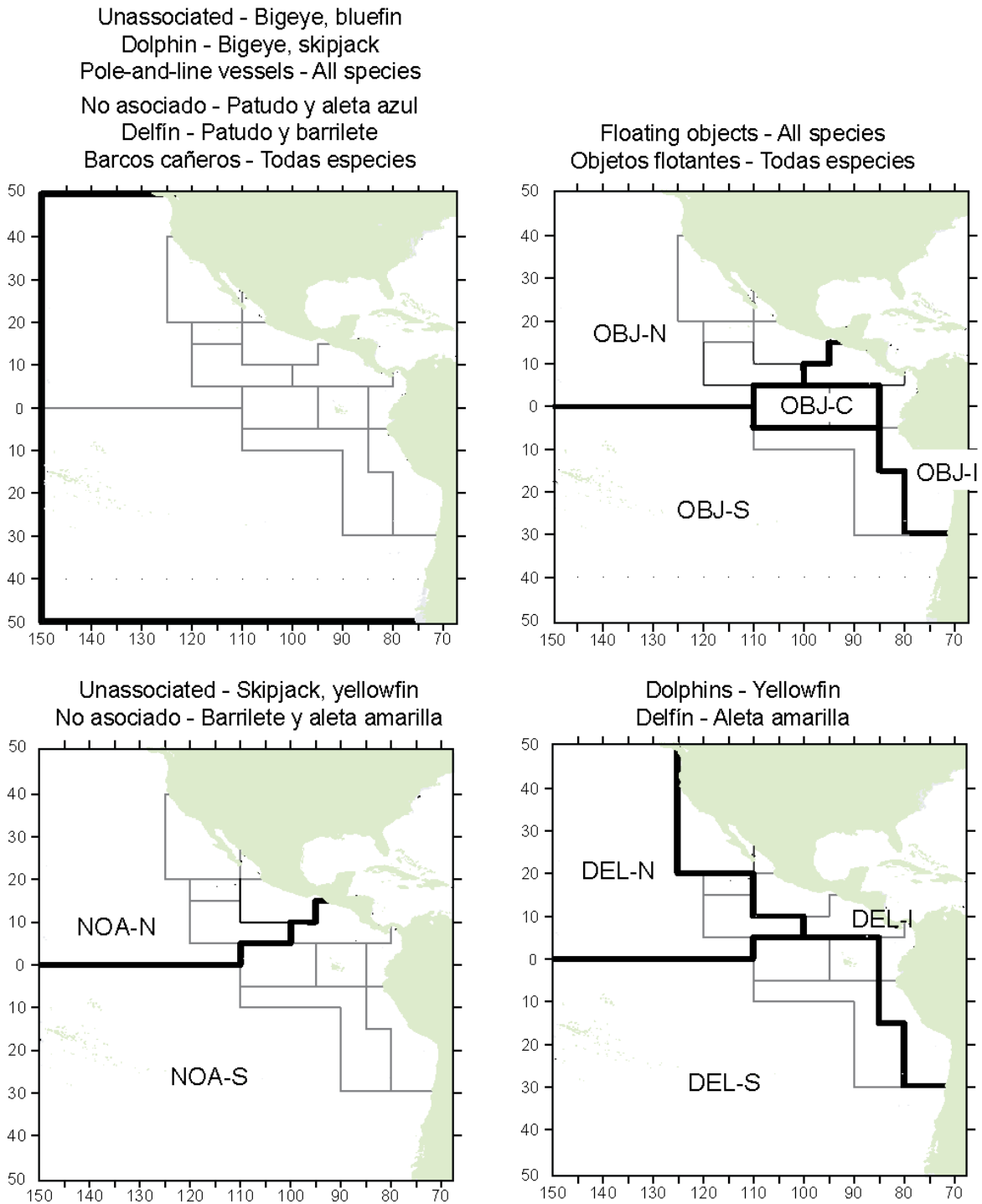


FIGURE A-5. The fisheries defined by the IATTC staff for analyses of yellowfin, skipjack, and bigeye in the EPO. The thin lines indicate the boundaries of the 13 length-frequency sampling areas, and the bold lines the boundaries of the fisheries.

FIGURA A-5. Las pesquerías definidas por el personal de la CIAT para los análisis de los atunes aleta amarilla, barrilete, y patudo en el OPO. Las líneas delgadas indican los límites de las 13 zonas de muestreo de frecuencia de tallas, y las líneas gruesas los límites de las pesquerías.

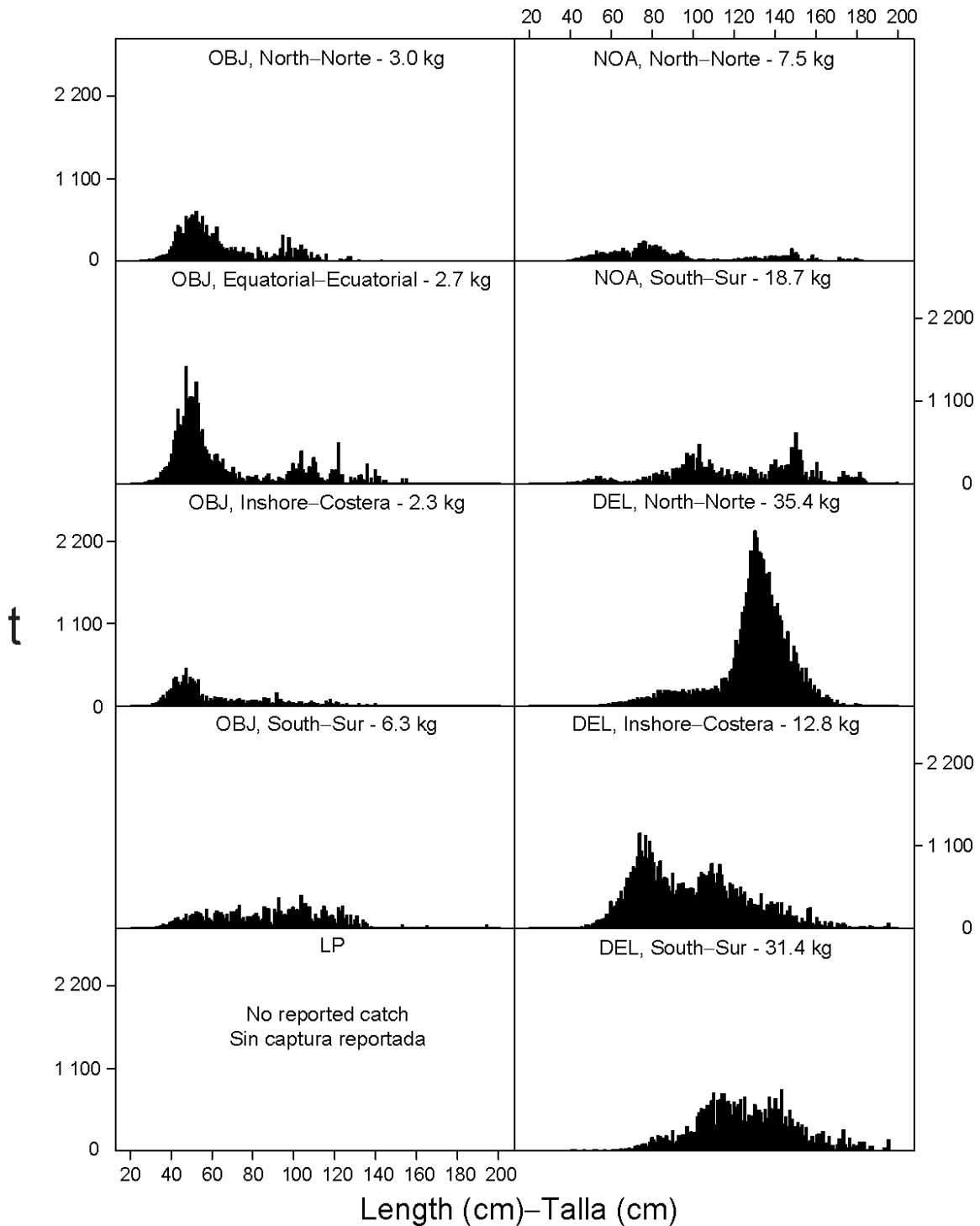


FIGURE A-6a. Estimated size compositions of the yellowfin caught in the EPO during 2018 for each fishery designated in Figure A-5. The value at the top of each panel is the average weight of the fish in the samples.
FIGURA A-6a. Composición por tallas estimada del aleta amarilla capturado en el OPO durante 2018 en cada pesquería ilustrada en la Figura A-5. El valor en cada recuadro representa el peso promedio del pescado en las muestras.

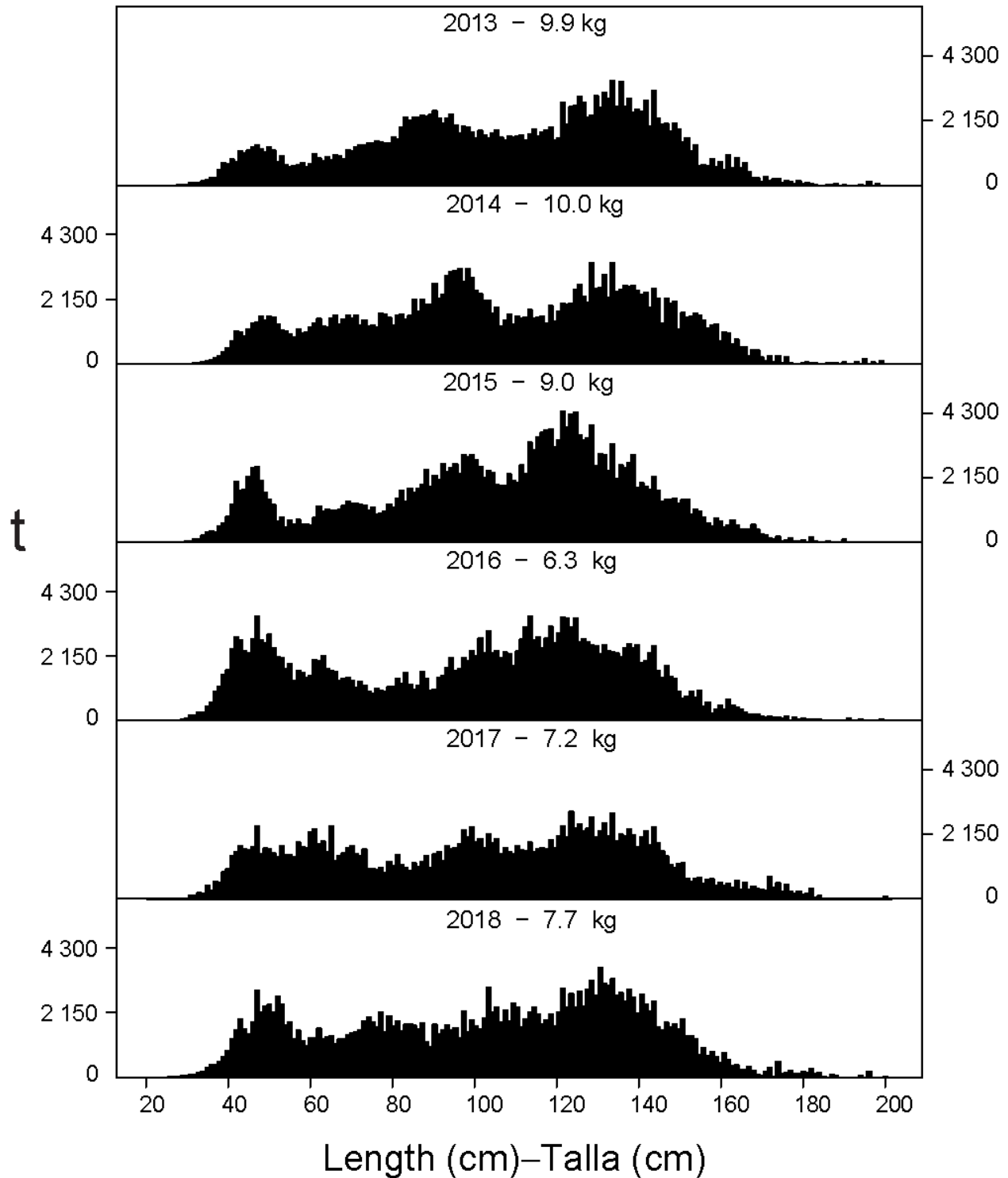


FIGURE A-6b. Estimated size compositions of the yellowfin caught by purse-seine and pole-and-line vessels in the EPO during 2013-2018. The value at the top of each panel is the average weight of the fish in the samples.

FIGURA A-6b. Composición por tallas estimada del aleta amarilla capturado por buques cerqueros y cañeros en el OPO durante 2013-2018. El valor en cada recuadro representa el peso promedio del pescado en las muestras.

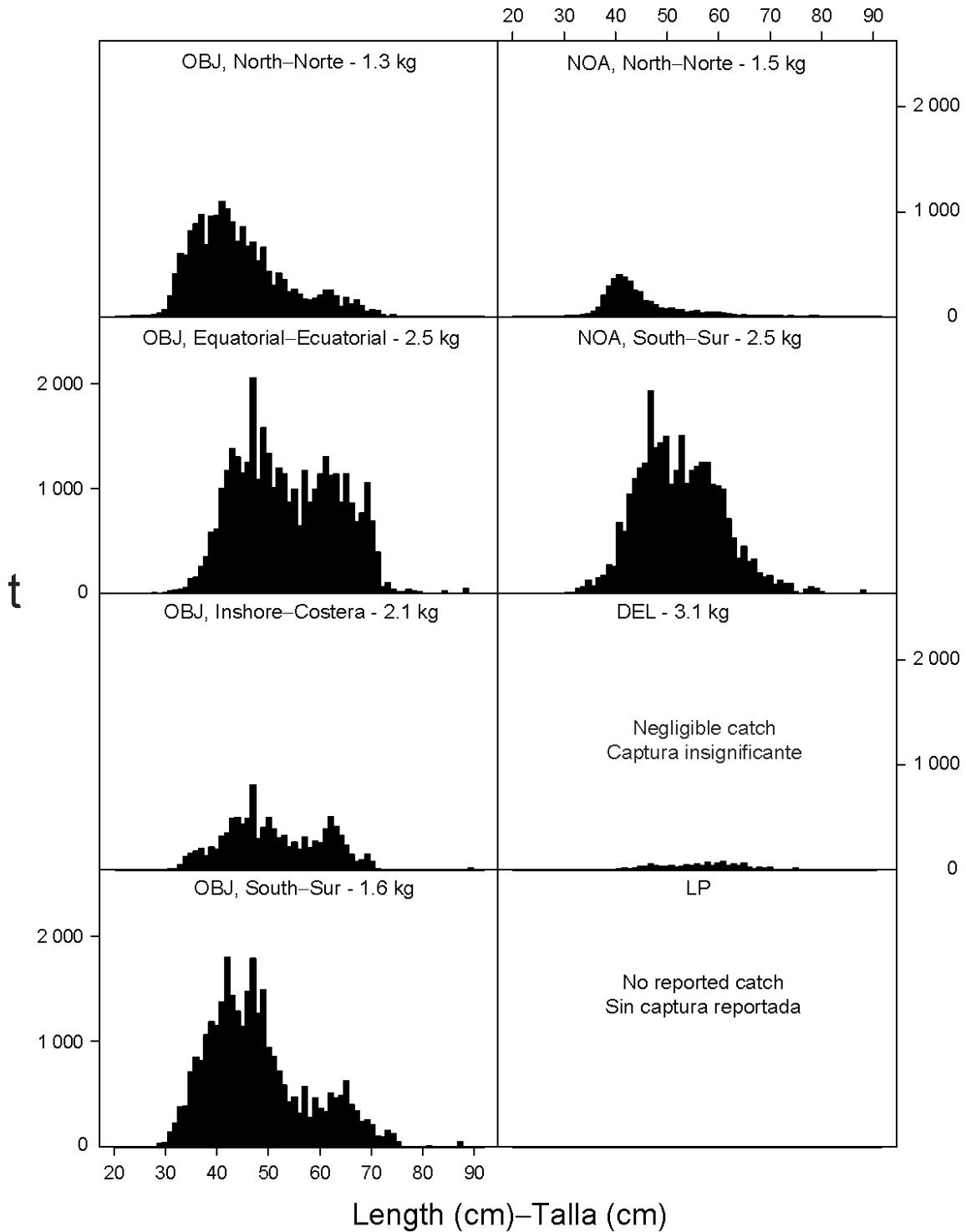


FIGURE A-7a. Estimated size compositions of the skipjack caught in the EPO during 2018 for each fishery designated in Figure A-5. The value at the top of each panel is the average weight of the fish in the samples.
FIGURA A-7a. Composición por tallas estimada del barrilete capturado en el OPO durante 2018 en cada pesquería ilustrada en la Figura A-5. El valor en cada recuadro representa el peso promedio del pescado en las muestras.

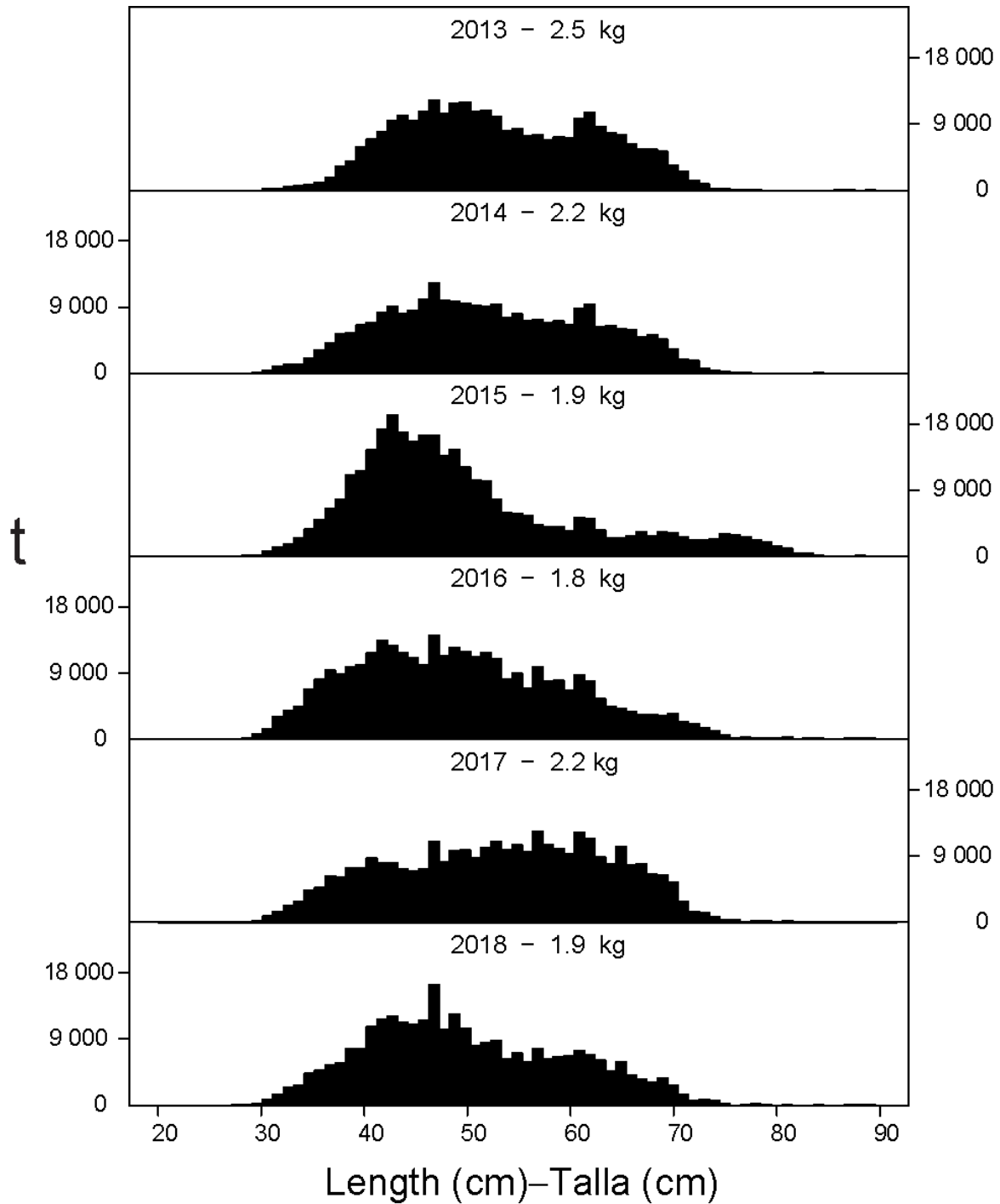


FIGURE A-7b. Estimated size compositions of the skipjack caught by purse-seine and pole-and-line vessels in the EPO during 2013-2018. The value at the top of each panel is the average weight of the fish in the samples.

FIGURA A-7b. Composición por tallas estimada del barrilete capturado por buques cerqueros y cañeros en el OPO durante 2013-2018. El valor en cada recuadro representa el peso promedio del pescado en las muestras.

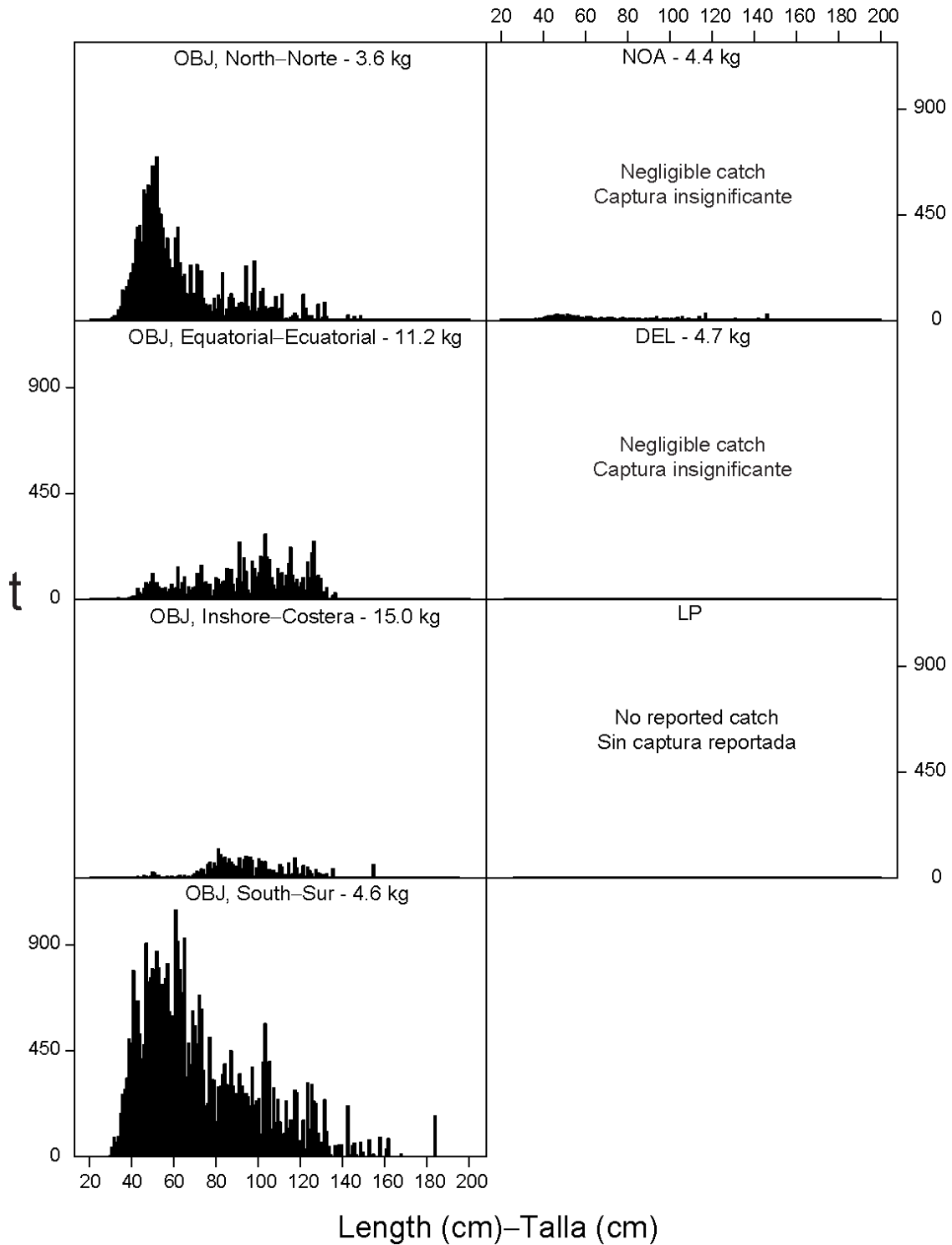


FIGURE A-8a. Estimated size compositions of the bigeye caught in the EPO during 2018 for each fishery designated in Figure A-5. The value at the top of each panel is the average weight.

FIGURA A-8a. Composición por tallas estimada del patudo capturado en el OPO durante 2018 en cada pesquería ilustrada en la Figura A-5. El valor en cada recuadro representa el peso promedio del pescado en las muestras.

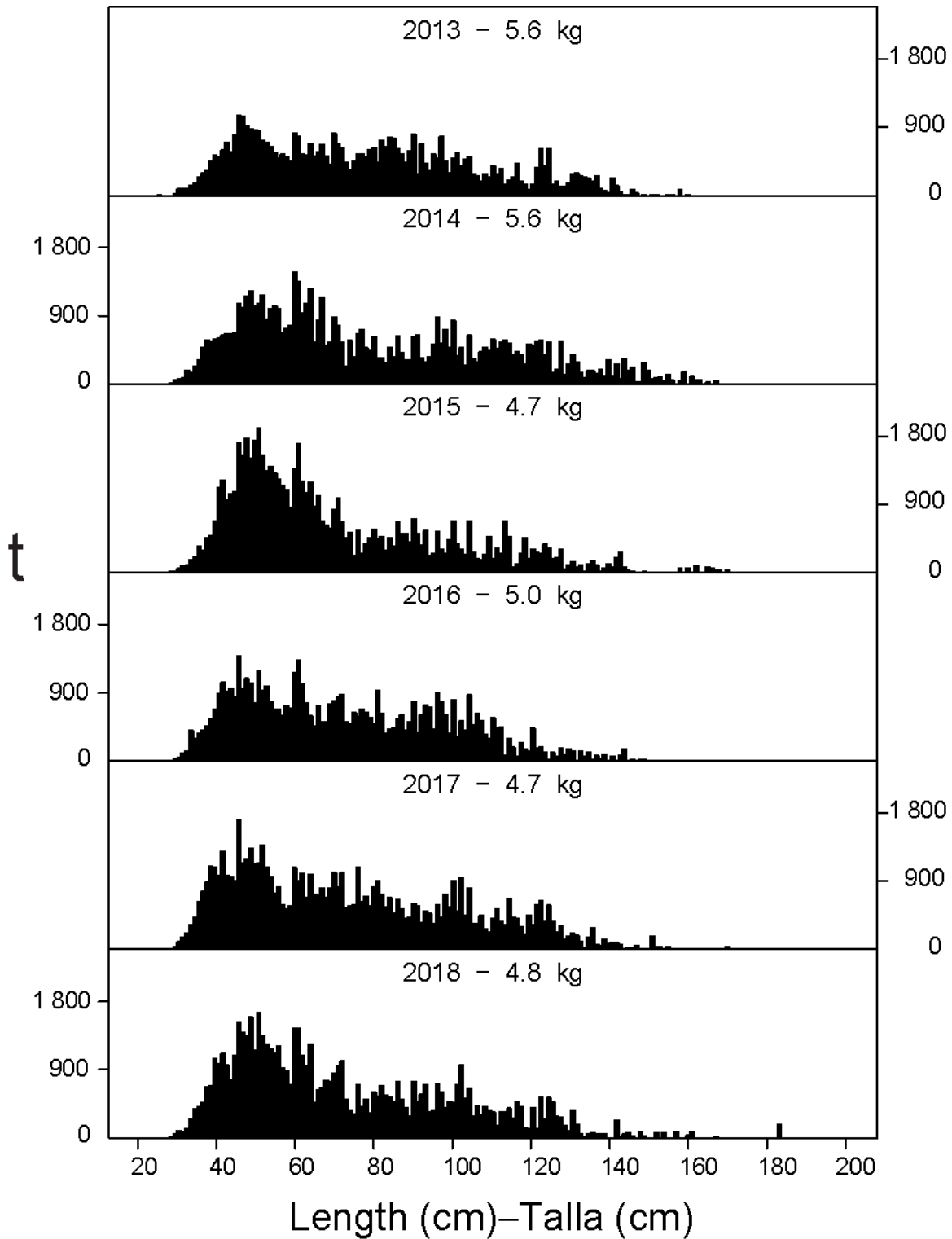


FIGURE A-8b. Estimated size compositions of the bigeye caught by purse-seine vessels in the EPO during 2013-2018. The value at the top of each panel is the average weight.

FIGURA A-8b. Composición por tallas estimada del patudo capturado por buques cerqueros en el OPO durante 2013-2018. El valor en cada recuadro representa el peso promedio del pescado en las muestras.

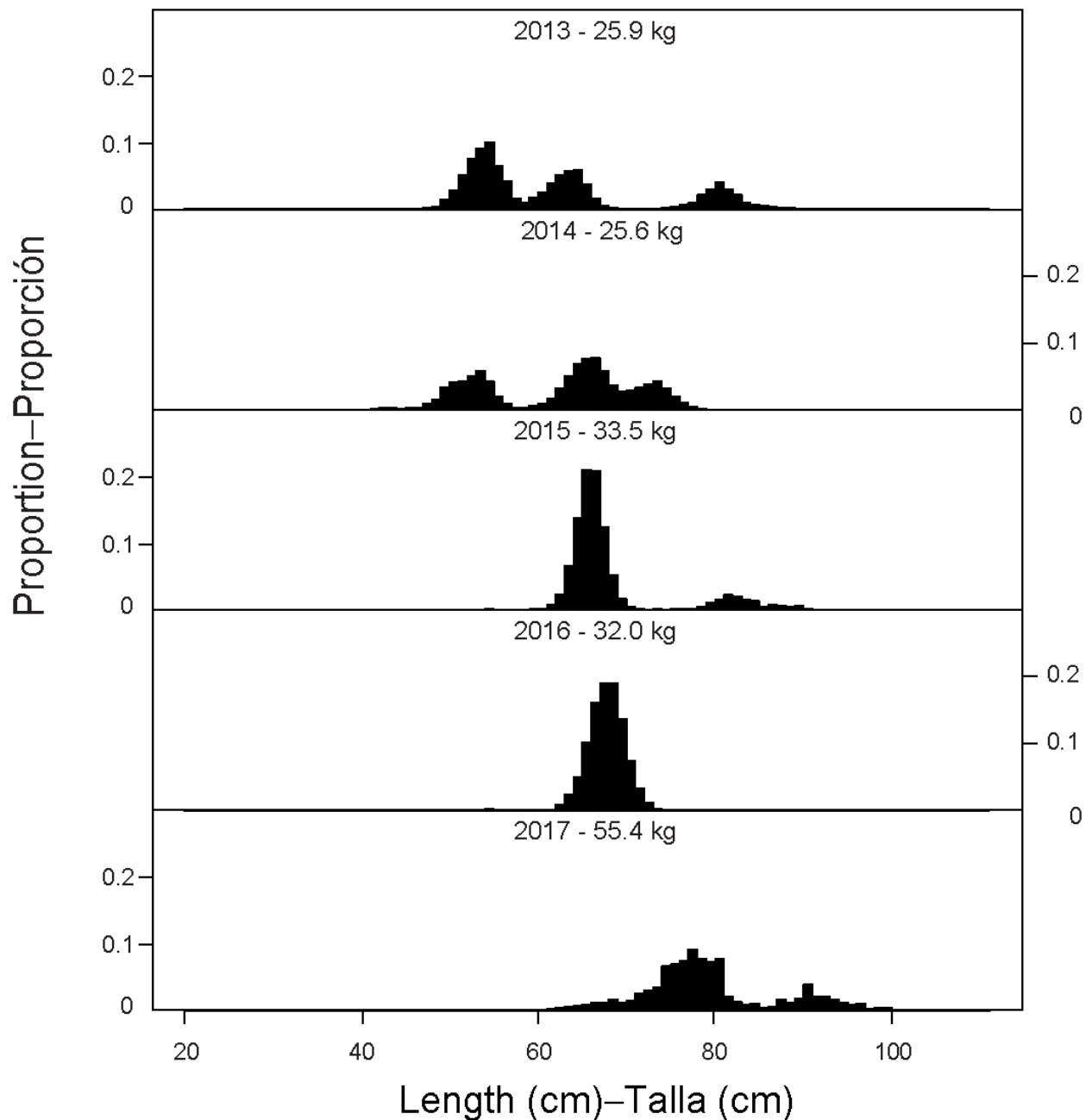


FIGURE A-9. Estimated size compositions of purse-seine catches of Pacific bluefin tuna, 2013-2017. The size distribution has been standardized as a proportion of the total number of measured tuna in each size range. The value at the top of each panel is the average weight. Source: INAPESCA, Mexico.

FIGURA A-9. Composiciones por talla estimadas de las capturas de atún aleta azul del Pacífico, 2013-2017. La distribución de las tallas ha sido estandarizada como proporción del número total de atunes medidos en cada gama de tallas. El valor en cada recuadro representa el peso promedio. Fuente: INAPESCA, México.

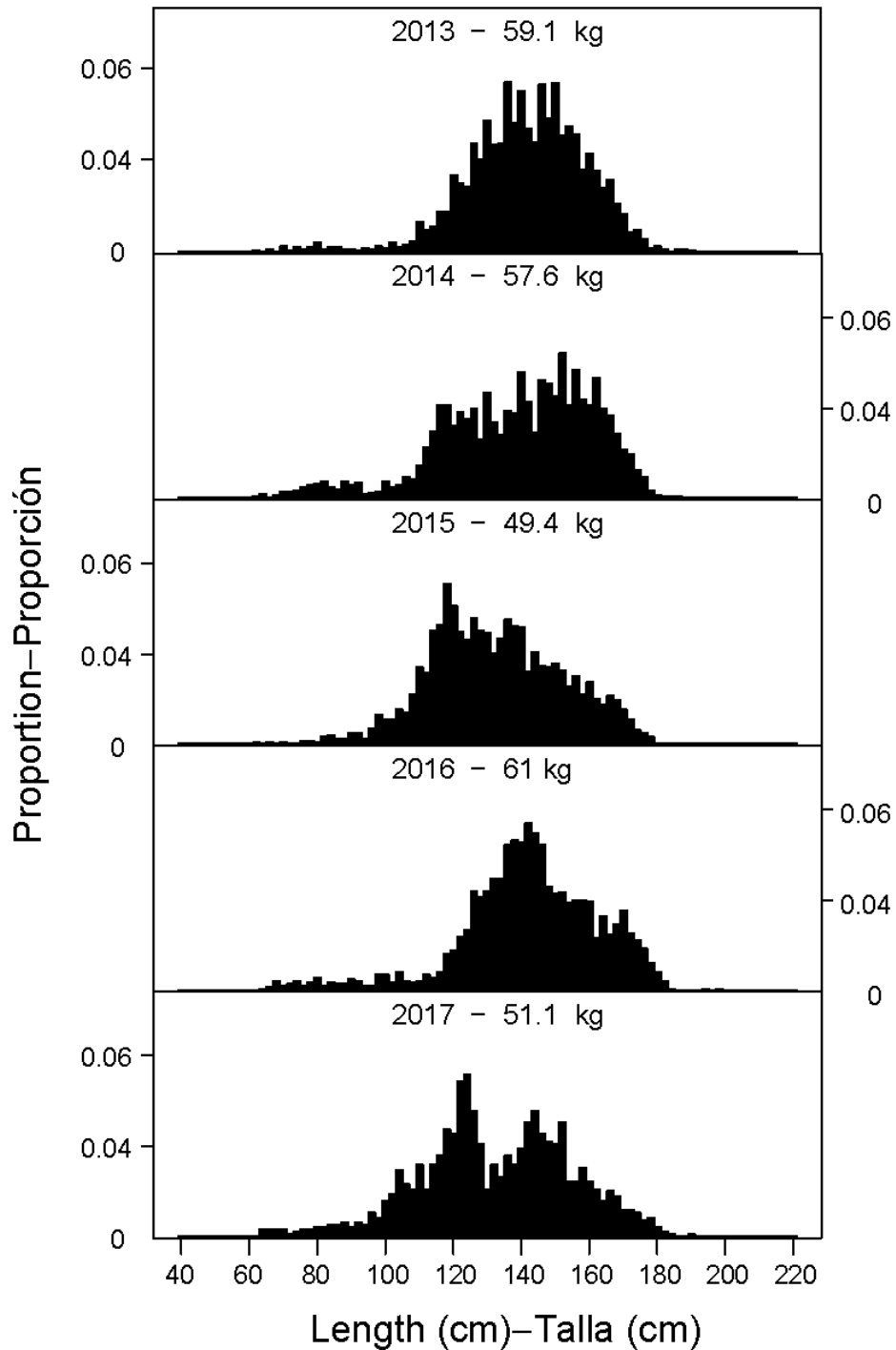


FIGURE A-10. Estimated size compositions of the catches of yellowfin by the Japanese longline fleet in the EPO, 2013-2017. The size distribution has been standardized as a proportion of the total number of measured tuna in each size range. The value at the top of each panel is the average weight.

FIGURA A-10. Composición por tallas estimada de las capturas de aleta amarilla por la flota palangrera japonesa en el OPO, 2013-2017. La distribución de las tallas ha sido estandarizada como proporción del número total de atunes medidos en cada gama de tallas. El valor en cada recuadro representa el peso promedio.

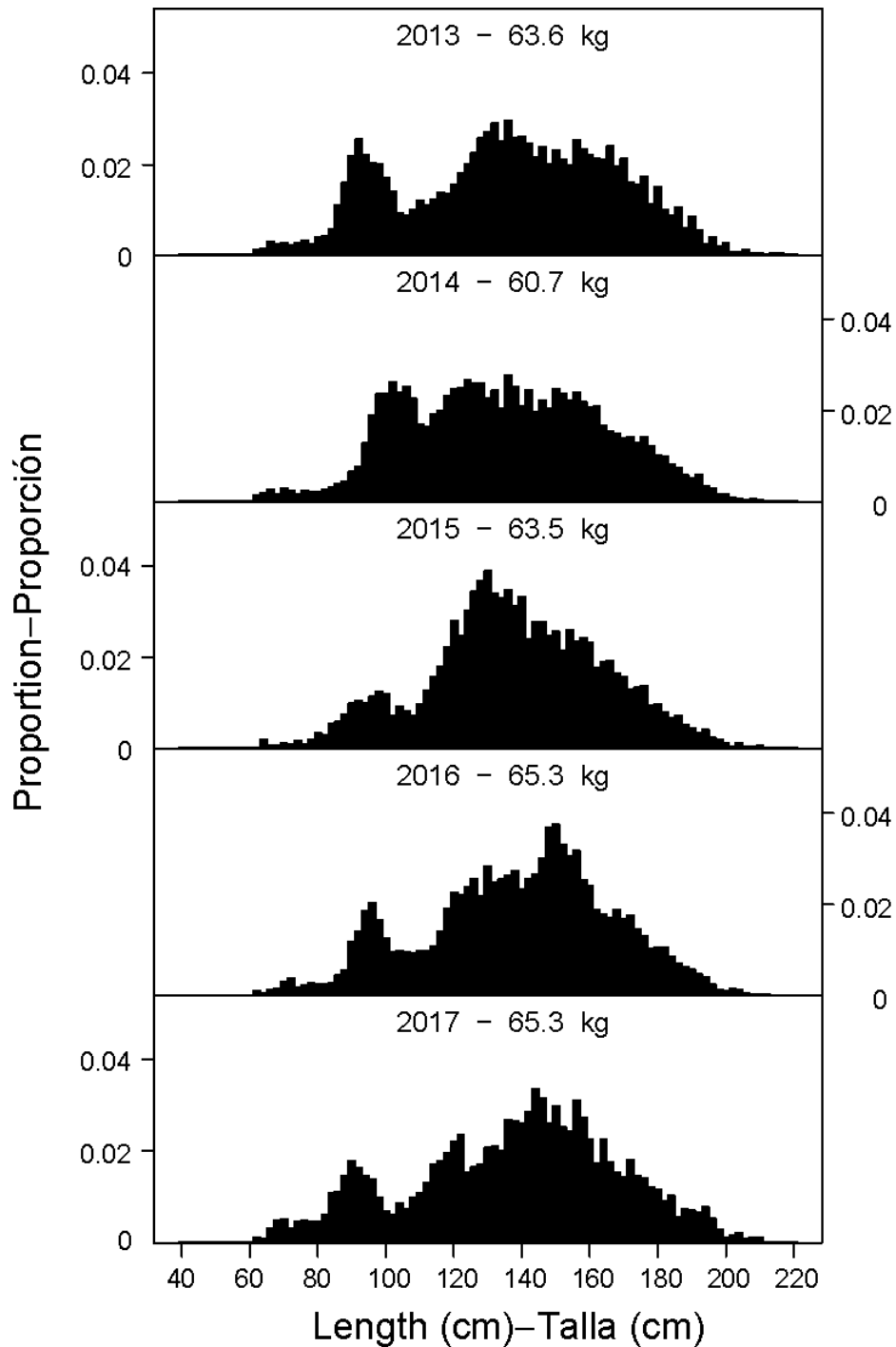


FIGURE A-11. Estimated size compositions of the catches of bigeye by the Japanese longline fleet in the EPO, 2013-2017. The size distribution has been standardized as a proportion of the total number of measured tuna in each size range. The value at the top of each panel is the average weight.

FIGURA A-11. Composición por tallas estimada de las capturas de patudo por la flota palangrera japonesa en el OPO, 2013-2017. La distribución de las tallas ha sido estandarizada como proporción del número total de atunes medidos en cada gama de tallas. El valor en cada recuadro representa el peso promedio.

TABLE A-1. Annual catches of yellowfin, skipjack, and bigeye tunas, by all types of gear combined, in the Pacific Ocean. The EPO totals for 1993-2018 include discards from purse-seine vessels with carrying capacities greater than 363 t.

TABLA A-1. Capturas anuales de atunes aleta amarilla, barrilete, y patudo, por todas las artes combinadas, en el Océano Pacífico. Los totales del OPO de 1993-2018 incluyen los descartes de buques cerqueros de más de 363 t de capacidad de acarreo.

	YFT			SKJ			BET			Total		
	EPO	WCPO	Total	EPO	WCPO	Total	EPO	WCPO	Total	EPO	WCPO	Total
1989	299,436	348,104	647,540	98,921	787,708	886,629	72,994	98,489	171,483	471,351	1,234,301	1,705,652
1990	301,522	390,428	691,950	77,107	857,067	934,174	104,851	116,370	221,221	483,480	1,363,865	1,847,345
1991	265,970	416,609	682,579	65,890	1,077,398	1,143,288	109,121	99,354	208,475	440,981	1,593,361	2,034,342
1992	252,514	424,965	677,479	87,294	971,558	1,058,852	92,000	119,335	211,335	431,808	1,515,858	1,947,666
1993	256,199	365,631	621,830	100,434	926,617	1,027,051	82,843	103,733	186,576	439,476	1,395,981	1,835,457
1994	248,071	405,421	653,492	84,661	990,437	1,075,098	109,331	117,497	226,828	442,063	1,513,355	1,955,418
1995	244,639	409,174	653,813	150,661	1,020,852	1,171,513	108,210	100,642	208,852	503,510	1,530,668	2,034,178
1996	266,928	411,433	678,361	132,335	1,011,907	1,144,242	114,706	112,724	227,430	513,969	1,536,064	2,050,033
1997	277,575	493,038	770,613	188,285	906,376	1,094,661	122,274	158,380	280,654	588,134	1,557,794	2,145,928
1998	280,606	598,998	879,604	165,489	1,169,422	1,334,911	93,954	168,127	262,081	540,049	1,936,547	2,476,596
1999	304,638	512,991	817,629	291,249	1,047,417	1,338,666	93,078	150,842	243,920	688,965	1,711,250	2,400,215
2000	286,863	560,932	847,795	230,479	1,156,160	1,386,639	148,557	137,201	285,758	665,901	1,854,293	2,520,194
2001	425,008	527,859	952,867	157,676	1,080,053	1,237,729	130,546	137,859	268,405	713,230	1,745,771	2,459,001
2002	443,458	482,664	926,122	167,048	1,258,988	1,426,036	132,806	158,153	290,959	743,312	1,899,805	2,643,117
2003	415,933	540,331	956,264	300,470	1,252,996	1,553,466	115,175	128,596	243,771	831,578	1,921,923	2,753,501
2004	296,847	578,045	874,892	217,249	1,348,940	1,566,189	110,722	180,393	291,115	624,818	2,107,378	2,732,196
2005	286,492	547,082	833,574	283,453	1,397,441	1,680,894	110,514	143,482	253,996	680,459	2,088,005	2,768,464
2006	180,519	481,285	661,804	309,090	1,494,070	1,803,160	117,328	152,574	269,902	606,937	2,127,929	2,734,866
2007	182,141	512,270	694,411	216,324	1,647,760	1,864,084	94,260	138,656	232,916	492,725	2,298,686	2,791,411
2008	197,328	606,650	803,978	307,699	1,619,329	1,927,028	103,350	149,059	252,409	608,377	2,375,038	2,983,415
2009	250,413	540,660	791,073	239,408	1,784,286	2,023,694	109,255	147,666	256,921	599,076	2,472,612	3,071,688
2010	261,871	559,625	821,496	153,092	1,688,957	1,842,049	95,408	132,293	227,701	510,371	2,380,876	2,891,247
2011	216,720	520,937	737,657	283,509	1,534,944	1,818,453	89,460	154,391	243,851	589,689	2,210,270	2,799,959
2012	213,310	602,975	816,285	273,519	1,758,388	2,031,907	102,687	155,702	258,389	589,516	2,517,061	3,106,577
2013	231,170	548,716	779,886	284,043	1,835,068	2,119,111	86,029	143,156	229,185	601,909	2,526,993	3,128,902
2014	246,781	589,434	836,215	265,490	2,006,087	2,271,577	96,045	153,876	249,921	608,047	2,749,389	3,357,436
2015	260,433	573,292	833,725	334,066	1,793,172	2,127,238	104,737	135,457	240,194	685,201	2,502,807	3,188,008
2016	255,196	634,187	889,383	342,579	1,795,283	2,137,862	92,829	144,407	237,236	690,142	2,571,609	3,261,751
2017	224,551	676,183	900,734	327,624	1,626,589	1,954,213	102,550	122,630	225,180	637,397	2,425,402	3,062,799
2018	238,778	*	238,778	288,636	*	288,636	86,102	*	86,102	613,516	*	613,516

TABLE A-2a. Estimated retained catches (Ret.), by gear type, and estimated discards (Dis.), by purse-seine vessels with carrying capacities greater than 363 t only, of tunas and bonitos, in metric tons, in the EPO. The purse-seine and pole-and-line data for yellowfin, skipjack, and bigeye tunas have been adjusted to the species composition estimate and are preliminary. The data for 2017-2018 are preliminary.

TABLA A-2a. Estimaciones de las capturas retenidas (Ret.), por arte de pesca, y de los descartes (Dis.), por buques cerqueros de más de 363 t de capacidad de acarreo únicamente, de atunes y bonitos, en toneladas métricas, en el OPO. Los datos de los atunes aleta amarilla, barrilete, y patudo de las pesquerías cerquera y cañera fueron ajustados a la estimación de composición por especie, y son preliminares. Los datos de 2017-2018 son preliminares.

	Yellowfin—Aleta amarilla						Skipjack—Barrilete						Bigeye—Patudo					
	PS		LP	LL	OTR + NK	Total	PS		LP	LL	OTR + NK	Total	PS		LP	LL	OTR + NK	Total
	Ret.	Dis.					Ret.	Dis.					Ret.	Dis.				
1989	277,996	-	4,145	17,032	263	299,436	94,934	-	2,940	28	1,019	98,921	2,030	-	-	70,963	1	72,994
1990	263,253	-	2,676	34,633	960	301,522	74,369	-	823	41	1,874	77,107	5,921	-	-	98,871	59	104,851
1991	231,257	-	2,856	30,899	958	265,970	62,228	-	1,717	36	1,909	65,890	4,870	-	31	104,195	25	109,121
1992	228,121	-	3,789	18,646	1,958	252,514	84,283	-	1,957	24	1,030	87,294	7,179	-	-	84,808	13	92,000
1993	219,492	4,713	4,951	24,009	3,034	256,199	83,830	10,515	3,772	61	2,256	100,434	9,657	653	-	72,498	35	82,843
1994	208,408	4,525	3,625	30,026	1,487	248,071	70,126	10,491	3,240	73	731	84,661	34,899	2,266	-	71,360	806	109,331
1995	215,434	5,275	1,268	20,596	2,066	244,639	127,047	16,373	5,253	77	1,911	150,661	45,321	3,251	-	58,269	1,369	108,210
1996	238,607	6,312	3,762	16,608	1,639	266,928	103,973	24,494	2,555	52	1,261	132,335	61,311	5,689	-	46,958	748	114,706
1997	244,878	5,516	4,418	22,163	600	277,575	153,456	31,338	3,260	135	96	188,285	64,272	5,402	-	52,580	20	122,274
1998	253,959	4,697	5,085	15,336	1,529	280,606	140,631	22,643	1,684	294	237	165,489	44,129	2,822	-	46,375	628	93,954
1999	281,920	6,547	1,783	11,682	2,706	304,638	261,565	26,046	2,044	201	1,393	291,249	51,158	4,932	-	36,450	538	93,078
2000	253,263	6,205	2,431	23,855	1,109	286,863	205,647	24,467	231	68	66	230,479	95,282	5,417	-	47,605	253	148,557
2001	383,936	7,028	3,916	29,608	520	425,008	143,165	12,815	448	1,214	34	157,676	60,518	1,254	-	68,755	19	130,546
2002	412,286	4,140	950	25,531	551	443,458	153,546	12,506	616	261	119	167,048	57,421	949	-	74,424	12	132,806
2003	383,279	5,865	470	25,174	1,145	415,933	273,968	22,453	638	634	2,777	300,470	53,052	2,326	-	59,776	21	115,175
2004	272,557	3,000	1,884	18,779	627	296,847	197,824	17,078	528	713	1,106	217,249	65,471	1,574	-	43,483	194	110,722
2005	268,101	2,771	1,822	11,946	1,852	286,492	263,229	16,915	1,299	231	1,779	283,453	67,895	1,900	-	40,694	25	110,514
2006	166,631	1,534	686	10,210	1,458	180,519	296,268	11,177	435	224	986	309,090	83,838	1,680	-	31,770	40	117,328
2007	170,016	1,725	894	8,067	1,439	182,141	208,295	6,450	276	238	1,065	216,324	63,450	890	-	29,876	44	94,260
2008	185,057	696	814	9,820	941	197,328	296,603	8,249	499	1,185	1,163	307,699	75,028	2,086	-	26,208	28	103,350
2009	236,757	1,262	709	10,444	1,241	250,413	230,523	6,064	151	1,584	1,086	239,408	76,799	1,019	-	31,422	15	109,255
2010	251,009	1,031	460	8,339	1,032	261,871	147,192	2,769	47	1,815	1,269	153,092	57,752	564	-	37,090	2	95,408
2011	206,851	415	276	8,048	1,130	216,720	276,035	5,215	24	1,384	851	283,509	56,512	631	-	32,317	-	89,460
2012	198,017	451	400	12,954	1,488	213,310	266,215	3,511	303	2,381	1,109	273,519	66,020	473	-	36,167	27	102,687
2013	218,187	207	759	10,783	1,234	231,170	278,560	2,254	164	2,024	1,041	284,043	49,487	273	-	36,170	99	86,029
2014	234,066	517	C	8,649	3,549	246,781	261,469	2,596	C	194	1,231	265,490	60,445	83	-	35,340	177	96,045
2015	245,727	334	C	10,804	3,568	260,433	328,907	3,699	C	205	1,255	334,066	62,913	177	-	41,626	21	104,737
2016	242,118	404	-	9,803	2,871	255,196	337,561	4,086	-	214	718	342,579	56,731	541	-	35,535	22	92,829
2017	210,932	412	-	10,523	2,684	224,551	324,812	1,765	-	168	879	327,624	66,967	201	-	35,340	42	102,550
2018	237,307	235	-	1,236	*	238,778	287,476	1,160	-	*	*	288,636	65,305	145	-	20,652	*	86,102

TABLE A-2a. (continued)

TABLA A-2a. (continuación)

	Pacific bluefin—Aleta azul del Pacífico						Albacore—Albacora						Black skipjack—Barrilete negro					
	PS		LP	LL	OTR + NK	Total	PS		LP	LL	OTR + NK	Total	PS		LP	LL	OTR + NK	Total
	Ret.	Dis.					Ret.	Dis.					Ret.	Dis.				
1989	1,103	-	5	4	91	1,203	1	-	21	6,784	2,695	9,501	803	-	-	-	-	803
1990	1,430	-	61	12	103	1,606	39	-	170	6,536	4,105	10,850	787	-	-	-	4	791
1991	419	-	-	5	55	479	-	-	834	7,893	2,754	11,481	421	-	-	-	25	446
1992	1,928	-	-	21	147	2,096	-	-	255	17,080	5,740	23,075	105	-	-	3	-	108
1993	580	-	-	11	316	907	-	-	1	11,194	4,410	15,605	104	3,925	-	31	-	4,060
1994	969	-	-	12	116	1,097	-	-	85	10,390	10,154	20,629	188	857	-	40	-	1,085
1995	659	-	-	25	264	948	-	-	465	6,185	7,427	14,077	202	1,448	-	-	-	1,650
1996	8,333	-	-	19	83	8,435	11	-	72	7,631	8,398	16,112	704	2,304	-	12	-	3,020
1997	2,608	3	2	14	235	2,862	1	-	59	9,678	7,540	17,278	100	2,512	-	11	-	2,623
1998	1,772	-	-	95	516	2,383	42	-	81	12,635	13,158	25,916	489	1,876	39	-	-	2,404
1999	2,553	54	5	151	514	3,277	47	-	227	11,633	14,510	26,417	171	3,404	-	-	-	3,575
2000	3,712	-	61	46	349	4,168	71	-	86	9,663	13,453	23,273	294	1,995	-	-	-	2,289
2001	1,155	3	1	148	378	1,685	3	-	157	19,410	13,727	33,297	2,258	1,019	-	-	-	3,277
2002	1,758	1	3	71	620	2,453	31	-	381	15,289	14,433	30,134	1,459	2,283	8	-	-	3,750
2003	3,233	-	3	87	369	3,692	34	-	59	24,901	20,397	45,391	433	1,535	6	13	117	2,104
2004	8,880	19	-	15	59	8,973	105	-	126	18,444	22,011	40,686	884	387	-	27	862	2,160
2005	4,743	15	-	-	80	4,838	2	-	66	9,350	15,668	25,086	1,472	2,124	-	-	22	3,618
2006	9,928	-	-	-	93	10,021	109	-	1	13,831	18,980	32,921	1,999	1,972	-	-	-	3,971
2007	4,189	-	-	-	14	4,203	187	-	21	11,107	19,261	30,576	2,307	1,625	-	2	54	3,988
2008	4,392	14	15	-	63	4,484	49	-	1,050	9,218	16,505	26,822	3,624	2,251	-	-	8	5,883
2009	3,428	24	-	-	161	3,613	50	2	C	12,072	19,090	31,214	4,256	1,020	-	2	-	5,278
2010	7,746	-	-	3	89	7,838	25	-	C	14,256	19,363	33,644	3,425	1,079	-	8	184	4,696
2011	2,829	4	-	1	244	3,078	10	-	C	16,191	16,074	32,275	2,317	719	-	6	-	3,042
2012	6,705	-	-	1	405	7,111	-	-	C	24,198	18,100	42,298	4,504	440	-	5	7	4,956
2013	3,154	-	-	1	819	3,974	-	-	C	25,401	18,513	43,914	3,580	805	-	10	24	4,419
2014	5,263	66	-	-	442	5,771	-	-	C	29,231	19,437	48,668	4,153	486	-	11	81	4,731
2015	3,168	-	-	33	387	3,588	-	-	C	28,957	17,099	46,056	3,763	356	-	1	111	4,231
2016	3,025	-	-	30	297	3,352	2	-	-	26,778	14,605	41,385	6,606	792	-	-	178	7,576
2017	4,109	-	-	21	370	4,500	-	-	-	25,992	9,570	35,562	5,079	306	-	-	53	5,438
2018	2,879	-	-	*	*	2,879	8	-	-	*	*	8	2,997	889	-	*	*	3,886

TABLE A-2a. (continued)

TABLA A-2a. (continuación)

	Bonitos						Unidentified tunas— Atunes no identificados						Total					
	PS		LP	LL	OTR + NK	Total	PS		LP	LL	OTR + NK	Total	PS		LP	LL	OTR + NK	Total
	Ret.	Dis.					Ret.	Dis.					Ret.	Dis.				
1989	11,278	-	818	-	465	12,561	36	-	-	-	626	662	388,181	-	7,928	94,812	5,161	496,082
1990	13,641	-	215	-	371	14,227	200	-	-	3	692	895	359,640	-	3,946	140,096	8,167	511,850
1991	1,207	-	82	-	242	1,531	4	-	-	29	192	225	300,406	-	5,520	143,057	6,161	455,144
1992	977	-	-	-	318	1,295	24	-	-	27	1,071	1,122	322,617	-	6,001	120,610	10,276	459,504
1993	599	12	1	-	436	1,048	9	1,975	-	10	4,082	6,076	314,271	21,793	8,725	107,814	14,570	467,173
1994	8,331	147	362	-	185	9,025	9	498	-	1	464	972	322,930	18,781	7,311	111,901	13,943	474,867
1995	7,929	55	81	-	54	8,119	11	626	-	-	1,004	1,641	396,603	27,028	7,066	85,152	14,096	529,945
1996	647	1	7	-	16	671	37	1,028	-	-	1,038	2,103	413,623	39,827	6,395	71,283	13,183	544,311
1997	1,097	4	8	-	34	1,143	71	3,383	-	7	1,437	4,898	466,483	48,157	7,747	84,588	9,962	616,936
1998	1,330	4	7	-	588	1,929	13	1,233	-	24	18,158	19,428	442,365	33,276	6,897	74,758	34,815	592,111
1999	1,719	-	-	24	369	2,112	27	3,092	-	2,113	4,279	9,511	599,160	44,076	4,059	62,254	24,310	733,859
2000	636	-	-	75	56	767	190	1,410	-	1,992	1,468	5,060	559,095	39,494	2,809	83,305	16,756	701,459
2001	17	-	-	34	19	70	191	679	-	2,448	55	3,373	591,243	22,799	4,523	121,616	14,755	754,935
2002	-	-	-	-	1	1	576	1,863	-	482	1,422	4,343	627,077	21,741	1,958	116,057	17,158	783,992
2003	-	-	1	-	25	26	80	1,238	-	215	750	2,283	714,079	33,416	1,177	110,799	25,600	885,071
2004	15	35	1	8	3	62	256	973	-	349	258	1,836	545,992	23,066	2,539	81,818	25,120	678,536
2005	313	18	-	-	11	342	190	1,922	-	363	427	2,902	605,945	25,664	3,187	62,585	19,865	717,246
2006	3,507	80	12	-	3	3,602	50	1,910	-	29	193	2,182	562,330	18,353	1,134	56,066	21,754	659,636
2007	15,906	628	107	2	-	16,643	598	1,221	-	2,197	301	4,317	464,948	12,540	1,298	51,488	22,179	552,452
2008	7,874	37	9	6	26	7,952	136	1,380	1	727	883	3,127	572,763	14,712	2,388	47,164	19,617	656,644
2009	9,720	15	-	8	77	9,820	162	469	-	1,933	74	2,638	561,695	9,875	860	57,466	21,743	651,640
2010	2,820	19	4	2	70	2,915	136	709	-	1,770	36	2,651	470,105	6,170	511	63,279	22,045	562,111
2011	7,969	45	18	10	11	8,053	108	784	-	3,178	-	4,070	552,631	7,813	318	61,136	18,311	640,208
2012	8,191	156	-	1	64	8,412	41	354	-	196	221	812	549,693	5,385	704	75,900	21,419	653,101
2013	2,067	9	-	13	27	2,116	53	461	-	-	529	1,043	555,088	4,009	923	74,400	22,286	656,706
2014	2,821	38	-	-	154	3,013	113	328	-	269	392	1,102	568,330	4,113	-	73,695	25,463	671,601
2015	789	28	-	-	-	817	85	242	-	-	1,232	1,559	645,352	4,836	-	81,626	23,673	755,487
2016	3,806	15	-	-	1	3,822	129	212	-	-	270	611	649,978	6,050	-	72,360	18,962	747,350
2017	3,438	54	-	-	-	3,492	234	303	-	-	339	876	615,571	3,041	-	72,044	13,937	704,593
2018	2,242	60	-	-	-	2,302	75	573	-	-	*	648	598,289	3,061	-	21,888	*	623,238

TABLE A-2b. Estimated retained catches, by gear type, and estimated discards, by purse-seine vessels with carrying capacities greater than 363 t only, of billfishes, in metric tons, in the EPO. Data for 2017-2018 are preliminary. PS dis. = discards by purse-seine vessels.

TABLA A-2b. Estimaciones de las capturas retenidas, por arte de pesca, y de los descartes, por buques cerqueros de más de 363 t de capacidad de acarreo únicamente, de peces picudos, en toneladas métricas, en el OPO. Los datos de 2017-2018 son preliminares. PS dis. = descartes por buques cerqueros.

	Swordfish—Pez espada					Blue marlin—Marlín azul				Black marlin—Marlín negro				Striped marlin—Marlín rayado						
	PS		LL	OTR	Total	PS		LL	OTR	Total	PS		LL	OTR	Total	PS		LL	OTR	Total
	Ret.	Dis.				Ret.	Dis.				Ret.	Dis.				Ret.	Dis.			
1989	-	-	5,202	6,072	11,274	-	-	5,392	-	5,392	-	-	193	-	193	-	-	3,473	-	3,473
1990	-	-	5,807	5,066	10,873	-	-	5,540	-	5,540	-	-	223	-	223	-	-	3,260	333	3,593
1991	-	17	10,671	4,307	14,995	-	69	6,719	-	6,788	-	58	246	-	304	-	76	2,993	409	3,478
1992	-	4	9,820	4,267	14,091	-	52	6,626	-	6,678	-	95	228	-	323	-	69	3,054	239	3,362
1993	3	1	6,187	4,414	10,605	84	20	6,571	-	6,675	57	31	218	-	306	47	20	3,575	259	3,901
1994	1	-	4,990	3,822	8,813	69	15	9,027	-	9,111	39	23	256	-	318	20	9	3,396	257	3,682
1995	3	-	4,495	2,974	7,472	70	16	7,288	-	7,374	43	23	158	-	224	18	8	3,249	296	3,571
1996	1	-	7,071	2,486	9,558	62	15	3,596	-	3,673	46	24	100	-	170	20	9	3,218	430	3,677
1997	2	1	10,580	1,781	12,364	126	15	5,915	-	6,056	71	22	154	-	247	28	3	4,473	329	4,833
1998	3	-	9,800	3,246	13,049	130	20	4,856	-	5,006	72	28	168	-	268	20	3	3,558	509	4,090
1999	2	-	7,569	1,965	9,536	181	38	3,691	-	3,910	83	42	94	-	219	26	11	2,621	376	3,034
2000	3	-	8,930	2,383	11,316	120	23	3,634	-	3,777	67	21	105	-	193	17	3	1,889	404	2,313
2001	3	1	16,007	1,964	17,975	119	40	4,196	-	4,355	67	48	123	-	238	13	8	1,961	342	2,324
2002	1	-	17,598	2,119	19,718	188	33	3,480	-	3,701	86	30	78	-	194	69	5	2,158	412	2,644
2003	3	1	18,161	354	18,519	185	21	4,015	-	4,221	121	26	73	-	220	31	4	1,904	417	2,356
2004	2	-	15,372	309	15,683	140	21	3,783	-	3,944	62	5	41	-	108	23	1	1,547	390	1,961
2005	2	-	8,935	4,304	13,241	209	14	3,350	-	3,573	95	9	39	-	143	37	4	1,531	553	2,125
2006	7	-	9,890	3,800	13,697	164	21	2,934	105	3,224	124	21	77	-	222	54	3	1,735	490	2,282
2007	4	-	9,639	4,390	14,033	124	13	2,393	106	2,636	74	8	47	-	129	32	4	1,656	1,024	2,716
2008	6	-	12,248	3,071	15,325	125	8	1,705	114	1,952	76	9	100	-	185	33	2	1,291	1,045	2,371
2009	4	-	15,539	3,905	19,448	159	15	2,102	131	2,407	76	8	94	-	178	23	2	1,333	7	1,365
2010	4	-	18,396	4,480	22,880	176	12	2,920	126	3,234	62	9	160	-	231	21	2	2,129	9	2,161
2011	3	-	20,400	5,101	25,504	150	6	2,025	144	2,325	59	7	187	-	253	28	1	2,640	16	2,685
2012	5	-	23,587	7,148	30,740	178	15	3,723	177	4,093	71	4	444	-	519	28	-	2,703	20	2,751
2013	2	-	22,342	5,560	27,904	172	15	4,202	168	4,557	99	4	138	-	241	21	1	2,439	19	2,480
2014	4	-	21,331	6,332	27,667	209	12	4,069	186	4,476	70	4	151	-	225	22	1	1,929	3	1,955
2015	5	1	25,805	6,079	31,890	306	11	4,121	182	4,620	117	14	240	-	371	26	-	1,269	474	1,769
2016	4	-	23,895	7,126	31,025	247	6	3,677	175	4,105	62	3	78	-	143	19	-	1,561	4	1,584
2017	1	2	21,400	6,285	27,688	151	4	3,835	191	4,181	39	1	209	-	249	10	-	1,645	4	1,659
2018	2	-	-	-	2	165	1	-	-	166	23	-	-	-	23	10	1	*	*	11

TABLE A-2b. (continued)

TABLA A-2b. (continuación)

	Shortbill spearfish— Marlín trompa corta					Sailfish— Pez vela					Unidentified istiophorid billfishes—Picudos istiofóridos no identificados					Total billfishes— Total de peces picudos				
	PS		LL	OTR	To- tal	PS		LL	OTR	Total	PS		LL	OTR	Total	PS		LL	OTR	Total
	Ret.	Dis.				Ret.	Dis.				Ret.	Dis.				Ret.	Dis.			
1989	-	-	-	-	-	-	-	192	-	192	-	-	51	-	51	-	-	14,503	6,072	20,575
1990	-	-	-	-	-	-	-	6	-	6	-	-	125	-	125	-	-	14,961	5,399	20,360
1991	-	-	1	-	1	-	-	717	-	717	-	-	112	-	112	-	220	21,459	4,716	26,395
1992	-	1	1	-	2	-	-	1,351	-	1,351	-	-	1,123	-	1,123	-	221	22,203	4,506	26,930
1993	-	-	1	-	1	26	32	2,266	-	2,324	29	68	1,650	-	1,747	246	172	20,468	4,673	25,559
1994	-	-	144	-	144	19	21	1,682	-	1,722	7	16	1,028	-	1,051	155	84	20,523	4,079	24,841
1995	1	-	155	-	156	12	15	1,351	-	1,378	4	9	232	-	245	151	71	16,928	3,270	20,420
1996	1	-	126	-	127	10	12	738	-	760	6	13	308	-	327	146	73	15,157	2,916	18,292
1997	1	-	141	-	142	12	11	1,891	-	1,914	3	5	1,324	-	1,332	243	57	24,478	2,110	26,888
1998	-	-	200	-	200	28	31	1,382	-	1,441	5	7	575	55	642	258	89	20,539	3,810	24,696
1999	1	-	278	-	279	33	8	1,216	-	1,257	6	12	1,136	-	1,154	332	111	16,605	2,341	19,389
2000	1	-	285	-	286	33	17	1,380	-	1,430	3	6	880	136	1,025	244	70	17,103	2,923	20,340
2001	-	-	304	-	304	18	45	1,539	325	1,927	2	5	1,741	204	1,952	222	147	25,871	2,835	29,075
2002	1	-	273	-	274	19	15	1,792	17	1,843	4	5	1,862	14	1,885	368	88	27,241	2,562	30,259
2003	1	4	290	-	295	38	49	1,174	-	1,261	6	5	1,389	-	1,400	385	110	27,006	771	28,272
2004	1	-	207	-	208	19	13	1,400	17	1,449	4	4	1,385	-	1,393	251	44	23,735	716	24,746
2005	1	-	229	-	230	32	11	805	15	863	5	3	901	-	909	381	41	15,790	4,872	21,084
2006	1	-	231	-	232	30	13	1,007	35	1,085	23	4	490	1	518	403	62	16,364	4,431	21,260
2007	1	-	239	-	240	41	8	1,032	64	1,145	13	4	1,171	15	1,203	289	37	16,177	5,599	22,102
2008	1	-	266	-	267	28	7	524	72	631	16	5	1,587	4	1,612	285	31	17,721	4,306	22,343
2009	1	-	446	-	447	17	6	327	8	358	11	1	1,799	12	1,823	291	32	21,640	4,063	26,026
2010	1	-	519	-	520	27	20	655	3	705	8	2	2,604	-	2,614	299	45	27,383	4,618	32,345
2011	-	-	462	-	462	18	5	658	28	709	15	1	2,377	3	2,396	273	20	28,749	5,292	34,334
2012	1	-	551	-	552	14	2	685	15	716	10	1	2,178	-	2,189	307	22	33,871	7,360	41,560
2013	1	-	913	-	914	16	2	614	9	641	15	3	2,743	1	2,762	326	25	33,391	5,757	39,499
2014	-	-	721	-	721	16	1	481	8	506	8	2	213	10	233	329	20	28,895	6,539	35,783
2015	1	-	497	-	498	18	8	1,402	22	1,450	19	1	704	4	728	492	35	34,038	6,761	41,326
2016	1	-	416	-	417	49	9	457	-	515	112	9	624	-	745	494	27	30,708	7,305	38,534
2017	-	-	244	-	244	22	2	561	-	585	164	12	262	15	453	387	21	28,156	6,495	35,059
2018	-	-	*	-	*	13	2	*	-	15	119	6	*	-	125	332	10	*	*	342

TABLE A-2c. Estimated retained catches (Ret.), by gear type, and estimated discards (Dis.), by purse-seine vessels of more than 363 t carrying capacity only, of other species, in metric tons, in the EPO. The data for 2017-2018 are preliminary.

TABLA A-2c. Estimaciones de las capturas retenidas (Ret.), por arte de pesca, y de los descartes (Dis.), por buques cerqueros de más de 363 t de capacidad de acarreo únicamente, de otras especies, en toneladas métricas, en el OPO. Los datos de 2017-2018 son preliminares.

	Carangids—Carángidos					Dorado (<i>Coryphaena</i> spp.)					Elasmobranchs—Elasmobranchios					Other fishes—Otros peces				
	PS		LL	OTR	Total	PS		LL	OTR	Total	PS		LL	OTR	Total	PS		LL	OTR	Total
	Ret.	Dis.				Ret.	Dis.				Ret.	Dis.				Ret.	Dis.			
1989	60	-	-	2	62	211	-	-	1,680	1,891	29	-	66	1,025	1,120	670	-	152	-	822
1990	234	-	-	1	235	63	-	-	1,491	1,554	-	-	280	1,095	1,375	433	-	260	14	707
1991	116	-	-	-	116	57	-	7	613	677	1	-	1,112	1,352	2,465	463	-	458	1	922
1992	116	-	-	-	116	69	-	37	708	814	-	-	2,294	1,190	3,484	555	-	183	-	738
1993	31	43	-	2	76	266	476	17	724	1,483	253	1,153	1,028	916	3,350	142	554	185	2	883
1994	19	28	-	16	63	687	826	46	3,459	5,018	372	1,029	1,234	1,314	3,949	243	567	250	-	1,060
1995	27	32	-	9	68	465	729	39	2,127	3,360	278	1,093	922	1,075	3,368	174	760	211	-	1,145
1996	137	135	-	57	329	548	885	43	183	1,659	239	1,001	1,120	2,151	4,511	152	467	457	-	1,076
1997	38	111	-	39	188	569	703	6,866	3,109	11,247	413	1,232	956	2,328	4,929	261	654	848	-	1,763
1998	83	149	-	4	236	424	426	2,528	9,167	12,545	279	1,404	2,099	4,393	8,175	300	1,133	1,340	-	2,773
1999	108	136	-	1	245	568	751	6,284	1,160	8,763	260	843	5,997	2,088	9,188	242	748	976	-	1,966
2000	97	66	4	4	171	813	785	3,537	1,041	6,176	263	772	8,418	405	9,858	146	408	1,490	-	2,044
2001	15	145	18	26	204	1,028	1,275	15,942	2,825	21,070	183	641	12,540	107	13,471	391	1,130	1,727	-	3,248
2002	20	111	15	20	166	932	938	9,464	4,137	15,471	137	758	12,398	99	13,392	355	722	1,913	-	2,990
2003	12	141	54	-	207	583	346	5,301	288	6,518	118	833	14,498	372	15,821	279	406	4,682	-	5,367
2004	41	103	1	-	145	811	317	3,986	4,645	9,759	157	622	11,273	173	12,225	339	1,031	670	-	2,040
2005	82	79	-	-	161	863	295	3,854	8,667	13,679	199	496	12,117	220	13,032	439	276	636	-	1,351
2006	247	146	-	-	393	1,002	385	3,408	13,127	17,922	235	674	5,869	14,943	21,721	496	381	590	100	1,567
2007	174	183	6	17	380	1,266	350	6,907	7,827	16,350	343	395	8,348	16,892	25,978	828	675	2,321	120	3,944
2008	85	55	5	17	162	933	327	15,845	5,458	22,563	540	357	14,984	15,360	31,241	522	429	1,526	85	2,562
2009	65	42	10	16	133	1,923	476	17,136	51,328	70,863	279	339	14,423	16,721	31,762	1,034	374	2,435	378	4,221
2010	82	15	8	23	128	1,243	253	9,484	47,881	58,861	335	463	26,342	14,433	41,573	881	192	2,341	384	3,798
2011	71	24	8	-	103	1,291	386	12,438	20,935	35,050	280	316	28,978	16,566	46,140	507	219	1,972	507	3,205
2012	53	23	1	-	77	1,805	401	17,254	26,627	46,087	230	278	16,446	15,871	32,825	873	230	2,695	381	4,179
2013	17	17	1	3	38	1,448	489	11,247	22,673	35,857	216	321	18,699	14,596	33,832	1,389	370	2,931	267	4,957
2014	20	11	11	35	77	1,753	369	3,339	20,916	26,377	247	474	15,649	13,738	30,108	1,450	438	2,659	486	5,033
2015	28	15	11	217	271	1,045	169	1,203	17,359	19,776	306	620	16,256	24,093	41,275	696	208	3,181	237	4,322
2016	30	33	11	-	74	894	175	447	12,989	14,505	229	580	16,930	21,088	38,827	991	514	2,205	159	3,869
2017	33	26	-	-	59	1,375	265	1,814	15,046	18,500	65	832	13,480	27,065	41,442	332	151	1,966	109	2,558
2018	33	48	-	-	81	1,178	322	*	*	1,500	3	553	*	*	556	499	102	*	*	601

TABLE A-3a. Catches of yellowfin tuna by purse-seine vessels in the EPO, by vessel flag. The data have been adjusted to the species composition estimate, and are preliminary.

TABLA A-3a. Capturas de atún aleta amarilla por buques de cerco en el OPO, por bandera del buque. Los datos están ajustados a la estimación de composición por especie, y son preliminares.

	COL	CRI	ECU	EU(ESP)	MEX	NIC	PAN	PER	SLV	USA	VEN	VUT	C + OTR ¹	Total
1989	-	C	17,588	C	116,928	-	10,557	1,724	C	73,688	42,944	C	14,567	277,996
1990	C	C	16,279	C	115,898	-	6,391	C	-	50,790	47,490	22,208	4,197	263,253
1991	C	-	15,011	C	115,107	-	1,731	C	-	18,751	45,345	29,687	5,625	231,257
1992	C	-	12,119	C	118,455	-	3,380	45	-	16,961	44,336	27,406	5,419	228,121
1993	3,863	-	18,094	C	101,792	-	5,671	-	-	14,055	43,522	24,936	7,559	219,492
1994	7,533	-	18,365	C	99,618	-	3,259	-	-	8,080	41,500	25,729	4,324	208,408
1995	8,829	C	17,044	C	108,749	-	1,714	-	-	5,069	47,804	22,220	4,005	215,434
1996	9,855	C	17,125	C	119,878	-	3,084	-	-	6,948	62,846	10,549	8,322	238,607
1997	9,402	-	18,697	C	120,761	-	4,807	-	-	5,826	57,881	20,701	6,803	244,878
1998	15,592	-	36,201	5,449	106,840	-	3,330	-	C	2,776	61,425	17,342	5,004	253,959
1999	13,267	-	53,683	8,322	114,545	C	5,782	-	C	3,400	55,443	16,476	11,002	281,920
2000	6,138	-	35,492	10,318	101,662	C	5,796	-	-	4,374	67,672	8,247	13,563	253,262
2001	12,950	-	55,347	18,448	130,087	C	9,552	-	C	5,670	108,974	10,729	32,180	383,937
2002	17,574	-	32,512	16,990	152,864	C	15,719	C	7,412	7,382	123,264	7,502	31,068	412,287
2003	9,770	-	34,271	12,281	172,807	-	16,591	C	C	3,601	96,914	9,334	27,710	383,279
2004	C	-	40,886	13,622	91,442	C	33,563	-	C	C	39,094	7,371	46,577	272,555
2005	C	-	40,596	11,947	110,898	4,838	33,393	-	6,470	C	28,684	C	31,276	268,102
2006	C	-	26,049	8,409	69,449	4,236	22,521	-	C	C	13,286	C	22,679	166,629
2007	C	-	19,749	2,631	65,091	3,917	26,024	-	C	C	20,097	C	32,507	170,016
2008	C	-	18,463	3,023	84,462	4,374	26,993	C	C	C	17,692	C	30,050	185,057
2009	C	-	18,167	7,864	99,785	6,686	35,228	C	C	C	25,298	C	43,729	236,757
2010	20,493	-	34,764	2,820	104,969	9,422	34,538	C	C	-	21,244	C	22,758	251,008
2011	18,643	-	32,946	1,072	99,812	7,781	18,607	-	C	C	18,712	C	9,278	206,851
2012	20,924	-	29,485	1,065	93,323	7,541	15,932	-	C	C	23,408	C	6,339	198,017
2013	16,476	-	27,655	511	114,706	8,261	18,301	C	C	-	24,896	C	7,381	218,187
2014	17,185	-	37,546	760	120,980	8,100	19,349	C	C	1,105	23,025	-	6,016	234,066
2015	17,270	-	50,153	C	106,171	6,876	26,558	783	C	3,212	30,428	-	4,276	245,727
2016	19,280	-	59,280	C	93,928	11,047	23,249	1,647	C	4,578	23,812	-	5,298	242,118
2017	15,102	-	55,685	C	80,862	9,345	19,915	3,348	C	6,497	16,806	-	3,372	210,932
2018	21,772	-	57,484	C	101,511	7,698	22,419	1,466	C	3,298	18,291	-	3,368	237,307

¹ Includes—Incluye: BLZ, BOL, CHN, GTM, HND, UNK

TABLE A-3b. Annual catches of yellowfin tuna by longline vessels, and totals for all gears, in the EPO, by vessel flag. The data for 2017-2018 are preliminary.

TABLA A-3b. Capturas anuales de atún aleta amarilla por buques de palangre en el OPO, y totales de todas las artes, por bandera del buque. Los datos de 2017-2018 son preliminares.

	CHN	CRI	FRA (PYF)	JPN	KOR	MEX	PAN	TWN	USA	VUT	C + OTR ¹	Total LL	Total PS+LL	OTR ²
1989	-	-	-	15,335	1,162	9	-	526	-	-	*	17,032	295,028	4,408
1990	-	-	-	29,255	4,844	-	-	534	-	-	*	34,633	297,886	3,636
1991	-	169	-	23,721	5,688	-	-	1,319	2	-	*	30,899	262,156	3,814
1992	-	119	57	15,296	2,865	-	-	306	3	-	*	18,646	246,767	5,747
1993	-	200	39	20,339	3,257	C	-	155	17	-	2	24,009	243,501	7,985
1994	-	481	214	25,983	3,069	41	-	236	2	-	*	30,026	238,434	5,112
1995	-	542	198	17,042	2,748	7	-	28	31	-	*	20,596	236,030	3,334
1996	-	183	253	12,631	3,491	0	-	37	13	-	*	16,608	255,215	5,401
1997	-	715	307	16,218	4,753	-	-	131	11	-	28	22,163	267,041	5,018
1998	-	1,124	388	10,048	3,624	16	-	113	15	-	8	15,336	269,295	6,614
1999	-	1,031	206	7,186	3,030	10	-	186	7	-	26	11,682	293,602	4,489
2000	-	1,084	1,052	15,265	5,134	153	359	742	10	5	51	23,855	277,118	3,540
2001	942	1,133	846	14,808	5,230	29	732	3,928	29	13	1,918	29,608	413,544	4,436
2002	1,457	1,563	278	8,513	3,626	4	907	7,360	5	290	1,528	25,531	437,817	1,501
2003	2,739	1,418	462	9,125	4,911	365	C	3,477	5	699	1,973	25,174	408,453	1,615
2004	798	1,701	767	7,338	2,997	32	2,802	1,824	6	171	343	18,779	291,336	2,511
2005	682	1,791	530	3,966	532	0	1,782	2,422	7	51	183	11,946	280,047	3,674
2006	246	1,402	537	2,968	928	0	2,164	1,671	21	164	109	10,210	176,841	2,144
2007	224	1,204	408	4,582	353	8	-	745	11	154	378	8,067	178,083	2,333
2008	469	1,248	335	5,383	83	5	-	247	33	175	1,842	9,820	194,877	1,755
2009	629	1,003	590	4,268	780	10	-	636	84	244	2,200	10,444	247,201	1,950
2010	459	3	301	3,639	737	6	-	872	54	269	1,999	8,339	259,348	1,492
2011	1,807	-	349	2,373	754	6	-	647	55	150	1,907	8,048	214,899	1,406
2012	2,591	1,482	538	3,600	631	7	519	749	39	155	2,643	12,954	210,971	1,888
2013	1,874	1,424	410	3,117	928	8	325	572	43	101	1,981	10,783	228,970	1,993
2014	2,120	1,072	567	2,633	704	4	249	896	61	323	20	8,649	242,715	3,549
2015	2,642	1,415	929	2,177	957	20	419	1,287	289	530	139	10,804	256,531	3,568
2016	2,398	1,010	825	1,839	1,124	29	688	1,222	249	166	253	9,803	251,921	2,871
2017	2,907	837	1,252	1,463	1,186	10	712	1,263	534	341	18	10,523	221,455	2,684
2018	*	*	*	1,236	*	*	*	*	*	*	*	1,236	238,543	*

¹Includes—Incluye: BLZ, CHL, ECU, EU(ESP), EU(PRT), GTM, HND, NIC, SLV

²Includes gillnets, pole-and-line, recreational, troll and unknown gears—Incluye red agallera, caña, artes deportivas, y desconocidas

TABLE A-3c. Catches of skipjack tuna by purse-seine and longline vessels in the EPO, by vessel flag. The data have been adjusted to the species composition estimate, and are preliminary.

TABLA A-3c. Capturas de atún barrilete por buques de cerco y de palangre en el OPO, por bandera del buque. Los datos están ajustados a la estimación de composición por especie, y son preliminares.

	PS													Total	LL+ OTR ²
	COL	CRI	ECU	EU(ESP)	MEX	NIC	PAN	PER	SLV	USA	VEN	VUT	C+OTR ¹		
1989	-	C	22,922	C	14,960	-	4,361	276	-	21,115	16,847	C	14,453	94,934	3,987
1990	C	C	24,071	C	6,696	-	3,425	C	-	13,188	11,362	11,920	3,707	74,369	2,738
1991	C	-	18,438	C	10,916	-	1,720	C	-	13,162	5,217	9,051	3,724	62,228	3,662
1992	C	-	25,408	C	9,188	-	3,724	352	-	14,108	10,226	13,315	7,962	84,283	3,011
1993	3,292	-	21,227	C	13,037	-	1,062	-	-	17,853	7,270	10,908	9,181	83,830	6,089
1994	7,348	-	15,083	C	11,783	-	2,197	-	-	8,947	6,356	9,541	8,871	70,126	4,044
1995	13,081	C	31,934	C	29,406	-	4,084	-	-	14,032	5,508	13,910	15,092	127,047	7,241
1996	13,230	C	32,433	C	14,501	-	3,619	-	-	12,012	4,104	10,873	13,201	103,973	3,868
1997	12,332	-	51,826	C	23,416	-	4,277	-	-	13,687	8,617	14,246	25,055	153,456	3,491
1998	4,698	-	67,074	20,012	15,969	-	1,136	-	C	6,898	6,795	11,284	6,765	140,631	2,215
1999	11,210	-	124,393	34,923	16,767	C	5,286	-	C	13,491	16,344	21,287	17,864	261,565	3,638
2000	10,138	-	104,849	17,041	14,080	C	9,573	-	-	7,224	6,720	13,620	22,399	205,644	365
2001	9,445	-	66,144	13,454	8,169	C	6,967	-	C	4,135	3,215	7,824	23,813	143,166	1,696
2002	10,908	-	80,378	10,546	6,612	C	9,757	C	4,601	4,582	2,222	4,657	19,283	153,546	996
2003	14,771	-	139,804	18,567	8,147	-	25,084	C	C	5,445	6,143	14,112	41,895	273,968	4,049
2004	C	-	89,621	8,138	24,429	C	20,051	-	C	C	23,356	4,404	27,825	197,824	2,349
2005	C	-	140,927	9,224	32,271	3,735	25,782	-	4,995	C	22,146	C	24,149	263,229	3,309
2006	C	-	138,490	16,668	16,790	8,396	44,639	-	C	C	26,334	C	44,952	296,269	1,645
2007	C	-	93,553	2,879	21,542	4,286	28,475	-	C	C	21,990	C	35,571	208,296	1,579
2008	C	-	143,431	4,841	21,638	7,005	43,230	C	C	C	28,333	C	48,125	296,603	2,847
2009	C	-	132,712	6,021	6,847	5,119	26,973	C	C	C	19,370	C	33,481	230,523	2,821
2010	11,400	-	82,280	1,569	3,010	5,242	19,213	C	C	-	11,818	C	12,660	147,192	3,132
2011	23,269	-	149,637	5,238	11,899	3,889	29,837	-	C	C	27,026	C	25,240	276,035	2,259
2012	15,760	-	151,280	15,773	18,058	3,931	25,786	-	C	C	20,829	C	14,798	266,215	3,793
2013	22,168	-	172,002	2,900	17,350	4,345	31,022	C	C	-	17,522	C	11,251	278,560	3,229
2014	22,732	-	172,239	5,581	8,783	6,300	21,776	C	C	521	13,767	-	9,771	261,470	1,425
2015	16,431	-	208,765	C	23,515	1,261	31,427	5,225	C	16,826	4,792	-	20,665	328,907	1,460
2016	20,665	-	190,577	C	13,286	1,971	32,844	6,449	C	40,036	9,067	-	22,666	337,561	932
2017	19,288	-	190,163	C	21,246	6,961	37,425	6,258	C	24,992	7,290	-	11,189	324,812	1,047
2018	15,282	-	177,651	C	16,845	7,700	35,902	4,112	C	11,331	6,582	-	12,071	287,476	*

¹ Includes—Incluye: BLZ, BOL, CHN, EU(CYP), GTM, HND, KOR, LBR, NZL, RUS, VCT, UNK

² Includes gillnets, pole-and-line, recreational, and unknown gears—Incluye red agallera, caña, artes deportivas y desconocidas

TABLE A-3d. Catches of bigeye tuna by purse-seine vessels in the EPO, by vessel flag. The data have been adjusted to the species composition estimate, and are preliminary.

TABLA A-3d. Capturas de atún patudo por buques de cerco en el OPO, por bandera del buque. Los datos están ajustados a la estimación de composición por especie, y son preliminares.

	COL	CRI	ECU	EU(ESP)	MEX	NIC	PAN	PER	SLV	USA	VEN	VUT	C + OTR ¹	Total
1989	-	-	854	C	-	-	-	*	-	172	294	C	710	2,030
1990	-	-	1,619	C	29	-	196	-	-	209	1,405	2,082	381	5,921
1991	-	-	2,224	C	5	-	-	-	-	50	591	1,839	161	4,870
1992	-	-	1,647	C	61	-	38	*	-	3,002	184	1,397	850	7,179
1993	686	-	2,166	C	120	-	10	*	-	3,324	253	1,848	1,250	9,657
1994	5,636	-	5,112	C	171	-	-	*	-	7,042	637	8,829	7,472	34,899
1995	5,815	C	8,304	C	91	-	839	*	-	11,042	706	12,072	6,452	45,321
1996	7,692	C	20,279	C	82	-	1,445	*	-	8,380	619	12,374	10,440	61,311
1997	3,506	-	30,092	C	38	-	1,811	*	-	8,312	348	6,818	13,347	64,272
1998	596	-	25,113	5,747	12	-	12	*	C	5,309	348	4,746	2,246	44,129
1999	1,511	-	24,355	11,703	33	C	1,220	*	C	2,997	10	5,318	4,011	51,158
2000	7,443	-	36,094	12,511	0	C	7,028	*	-	5,304	457	10,000	16,446	95,283
2001	5,230	-	24,424	7,450	0	C	3,858	*	C	2,290	0	4,333	12,933	60,518
2002	5,283	-	26,262	5,108	0	C	4,726	C	2,228	2,219	0	2,256	9,340	57,422
2003	3,664	-	22,896	4,605	0	-	6,222	C	C	1,350	424	3,500	10,390	53,051
2004	C	-	30,817	3,366	0	C	8,294	*	C	C	9,661	1,822	11,511	65,471
2005	C	-	30,507	3,831	0	1,551	10,707	*	2,074	C	9,197	C	10,028	67,895
2006	C	-	39,302	5,264	6	2,652	14,099	*	C	C	8,317	C	14,197	83,837
2007	C	-	40,445	711	0	1,058	7,029	*	C	C	5,428	C	8,780	63,451
2008	C	-	41,177	1,234	327	1,785	11,018	C	C	C	7,221	C	12,266	75,028
2009	C	-	35,646	2,636	1,334	2,241	11,807	C	C	C	8,479	C	14,657	76,800
2010	4,206	-	34,902	579	11	1,934	7,089	C	C	-	4,360	C	4,672	57,753
2011	3,210	-	31,282	4,111	133	2,256	7,953	*	C	C	301	C	7,266	56,512
2012	1,873	-	45,633	3,866	225	1,250	7,238	*	C	C	848	C	5,087	66,020
2013	1,405	-	32,444	1,672	124	2,749	6,118	-	C	-	963	C	4,012	49,487
2014	2,479	-	39,094	2,812	40	3,068	8,168	-	C	129	1,183	-	3,472	60,445
2015	2,470	-	44,063	C	156	774	10,113	-	C	2,384	100	-	2,853	62,913
2016	2,743	-	33,139	C	255	667	8,440	312	C	2,801	345	-	8,029	56,731
2017	3,656	-	38,295	C	358	1,610	10,543	0	C	6,210	1,256	-	5,039	66,967
2018	1,452	-	41,253	C	797	1,494	11,892	102	C	3,268	1,098	-	3,949	65,305

¹ Includes—Incluye: BLZ, BOL, CHN, GTM, HND, UNK

TABLE A-3e. Annual catches of bigeye tuna by longline vessels, and totals for all gears, in the EPO, by vessel flag. The data for 2017-2018 are preliminary.

TABLA A-3e. Capturas anuales de atún patudo por buques de palangre en el OPO, y totales de todas las artes, por bandera del buque. Los datos de 2017-2018 son preliminares.

	CHN	CRI	FRA (PYF)	JPN	KOR	MEX	PAN	TWN	USA	VUT	C + OTR ¹	Total LL	Total PS + LL	OTR ²
1989	-	-	-	67,514	3,138	-	-	311	-	-	*	70,963	72,993	1
1990	-	-	-	86,148	12,127	-	-	596	-	-	*	98,871	104,792	59
1991	-	1	-	85,011	17,883	-	-	1,291	9	-	*	104,195	109,065	56
1992	-	9	7	74,466	9,202	-	-	1,032	92	-	*	84,808	91,987	13
1993	-	25	7	63,190	8,924	*	-	297	55	-	*	72,498	82,155	35
1994	-	1	102	61,471	9,522	-	-	255	9	-	*	71,360	106,259	806
1995	-	13	97	49,016	8,992	-	-	77	74	-	*	58,269	103,590	1,369
1996	-	1	113	36,685	9,983	-	-	95	81	-	*	46,958	108,269	748
1997	-	9	250	40,571	11,376	-	-	256	118	-	*	52,580	116,852	20
1998	-	28	359	35,752	9,731	-	-	314	191	-	*	46,375	90,504	628
1999	-	25	3,652	22,224	9,431	-	-	890	228	-	*	36,450	87,608	538
2000	-	27	653	28,746	13,280	42	14	1,916	162	2,754	11	47,605	142,887	253
2001	2,639	28	684	38,048	12,576	1	80	9,285	147	3,277	1,990	68,755	129,273	19
2002	7,614	19	388	34,193	10,358	-	6	17,253	132	2,995	1,466	74,424	131,845	12
2003	10,066	18	346	24,888	10,272	-	C	12,016	232	1,258	680	59,776	112,828	21
2004	2,645	21	405	21,236	10,729	-	48	7,384	149	407	459	43,483	108,954	194
2005	2,104	23	398	19,113	11,580	-	30	6,441	536	318	151	40,694	108,589	25
2006	709	18	388	16,235	6,732	-	37	6,412	85	960	195	31,771	115,608	40
2007	2,324	15	361	13,977	5,611	-	-	6,057	417	1,013	101	29,876	93,326	44
2008	2,379	16	367	14,908	4,150	-	-	1,852	1,277	790	468	26,207	101,236	28
2009	2,481	13	484	15,490	6,758	-	-	3,396	730	1,032	1,038	31,422	108,221	15
2010	2,490	4	314	15,847	9,244	-	-	5,276	1,356	1,496	1,063	37,090	94,842	2
2011	5,450	-	445	13,399	6,617	-	-	3,957	1,050	694	706	32,318	88,829	-
2012	4,386	3	464	16,323	7,450	-	-	4,999	875	1,063	604	36,167	102,187	27
2013	5,199	-	527	14,258	8,822	-	-	4,162	2,054	604	544	36,170	85,657	99
2014	5,253	9	526	13,634	8,203	-	114	4,511	2,073	897	120	35,340	95,785	177
2015	8,401	8	692	13,079	8,635	-	364	5,181	3,050	1,888	328	41,626	104,539	21
2016	7,052	3	477	10,467	7,692	-	313	6,006	2,084	762	679	35,535	92,266	22
2017	7,093	16	700	8,049	8,818	-	483	6,186	2,690	1,158	147	35,340	102,307	42
2018	3,174	*	*	7,094	5,308	*	*	5,076	*	*	*	20,652	85,957	*

¹ Includes—Incluye: BLZ, CHL, ECU, EU(ESP), HND, SLV

² Includes gillnets, pole-and-line, recreational, and unknown gears—Incluye red agallera, caña, artes deportivas, y desconocidas

TABLE A-4a. Preliminary estimates of the retained catches in metric tons, of tunas and bonitos caught by purse-seine vessels in the EPO in 2017 and 2018, by species and vessel flag. The data for yellowfin, skipjack, and bigeye tunas have been adjusted to the species composition estimates, and are preliminary.

TABLA A-4a. Estimaciones preliminares de las capturas retenidas, en toneladas métricas, de atunes y bonitos por buques cerqueros en el OPO en 2017 y 2018, por especie y bandera del buque. Los datos de los atunes aleta amarilla, barrilete, y patudo fueron ajustados a las estimaciones de composición por especie, y son preliminares.

	YFT	SKJ	BET	PBF	ALB	BKJ	BZX	TUN	Total	%
2017	Retained catches–Capturas retenidas									
COL	15,102	19,288	3,656	-	-	48	-	-	38,094	6.2
ECU	55,685	190,163	38,295	-	-	2,065	1,187	75	287,470	46.7
MEX	80,862	21,246	358	3,643	-	2,822	1,740	157	110,828	18.0
NIC	9,345	6,961	1,610	-	-	-	-	-	17,916	2.9
PAN	19,915	37,425	10,543	-	-	140	-	-	68,023	11.1
PER	3,348	6,258	-	-	-	-	496	-	10,102	1.6
USA	6,497	24,992	6,210	466	-	-	15	-	38,180	6.2
VEN	16,806	7,290	1,256	-	-	3	-	-	25,355	4.1
OTR ¹	3,372	11,189	5,039	-	-	1	-	2	19,603	3.2
Total	210,932	324,812	66,967	4,109	-	5,079	3,438	234	615,571	
2018	Retained catches–Capturas retenidas									
COL	21,772	15,282	1,452	-	-	9	11	4	38,530	6.4
ECU	57,484	177,651	41,253	-	-	501	201	23	277,113	46.3
MEX	101,511	16,845	797	2,840	-	2,482	94	42	124,611	20.8
NIC	7,698	7,700	1,494	-	8	-	-	-	16,900	2.8
PAN	22,419	35,902	11,892	-	-	-	-	1	70,214	11.7
PER	1,466	4,112	102	-	-	-	1,936	-	7,616	1.3
USA	3,298	11,331	3,268	39	-	5	-	-	17,941	3.0
VEN	18,291	6,582	1,098	-	-	-	-	-	25,971	4.3
OTR ²	3,368	12,071	3,949	-	-	-	-	5	19,393	3.2
Total	237,307	287,476	65,305	2,879	8	2,997	2,242	75	598,289	

¹ Includes El Salvador and European Union (Spain) - This category is used to avoid revealing the operations of individual vessels or companies.

¹ Incluye El Salvador y Unión Europea (España) - Se usa esta categoría para no revelar información sobre las actividades de buques o empresas individuales.

² Includes El Salvador and European Union (Spain) - This category is used to avoid revealing the operations of individual vessels or companies.

² Incluye El Salvador y Unión Europea (España) - Se usa esta categoría para no revelar información sobre las actividades de buques o empresas individuales.

TABLE A-4b. Preliminary estimates of the retained landings in metric tons, of tunas and bonitos caught by purse-seine vessels in the EPO in 2017 and 2018, by year, species and country of landing. The data for yellowfin, skipjack, and bigeye tunas have not been adjusted to the species composition estimates, and are preliminary.

TABLA A-4b. Estimaciones preliminares de las descargas, en toneladas métricas, de atunes y bonitos por buques cerqueros en el OPO en 2017 y 2018, por año, especie y país de descarga. Los datos de los atunes aleta amarilla, barrilete, y patudo no fueron ajustados a las estimaciones de composición por especie, y son preliminares.

	YFT	SKJ	BET	PBF	ALB	BKJ	BZX	TUN	Total	%
2017	Landings-Descargas									
COL	14,738	16,357	3,130	-	-	4	-	-	34,229	5.5
ECU	80,885	242,056	44,882	-	-	2,029	456	75	370,383	59.9
MEX	84,470	36,412	4,315	3,643	-	2,801	1,673	162	133,476	21.6
PER	5,489	15,068	1,106	-	-	130	765	1	22,559	3.6
USA	1,797	2,197	383	466	-	-	-	-	4,843	.8
OTR ¹	24,230	20,776	7,595	-	-	134	67	2	52,804	8.5
Total	211,609	332,866	61,411	4,109	-	5,098	2,961	240	618,294	
2018	Landings-Descargas									
COL	20,398	10,783	1,191	-	-	-	-	4	32,376	5.4
ECU	88,762	228,280	44,898	-	8	501	689	18	363,156	60.9
MEX	101,957	16,717	810	2,840	-	2,533	94	45	124,996	21.0
PER	4,479	18,150	1,595	-	-	3	1,936	1	26,164	4.4
USA	1,831	6,664	1,649	39	-	-	-	-	10,183	1.7
OTR ²	18,912	15,710	4,511	-	-	2	-	5	39,140	6.6
Total	236,339	296,304	54,654	2,879	8	3,039	2,719	73	596,015	

¹ Includes Costa Rica, El Salvador, Guatemala, Kiribati, Unknown and Venezuela - This category is used to avoid revealing the operations of individual vessels or companies.

¹ Incluye Costa Rica, Desconocida, El Salvador, Guatemala, Kiribati y Venezuela - Se usa esta categoría para no revelar información sobre las actividades de buques o empresas individuales.

² Includes Costa Rica, El Salvador, Guatemala, Kiribati, Unknown and Venezuela - This category is used to avoid revealing the operations of individual vessels or companies.

² Incluye Costa Rica, Desconocida, El Salvador, Guatemala, Kiribati y Venezuela - Se usa esta categoría para no revelar información sobre las actividades de buques o empresas individuales.

TABLE A-5a. Annual retained catches of Pacific bluefin tuna, by gear type and flag, in metric tons. The data for 2017 and 2018 are preliminary.

TABLA A-5a. Capturas retenidas anuales de atún aleta azul del Pacífico, por arte de pesca y bandera, en toneladas métricas. Los datos de 2017 y 2018 son preliminares.

PBF	Western Pacific flags—Banderas del Pacífico occidental ¹									EPO flags—Banderas del OPO						Total	
	JPN				KOR		TWN			Sub-total	MEX		USA		Sub-total		OTR
	PS	LP	LL	OTR	PS	OTR	PS	LL	OTR		PS	OTR	PS	OTR			
1989	6,190	754	209	1,934	71	-	259	205	54	9,676	57	-	1,046	96	1,199	-	10,875
1990	2,989	536	309	2,421	132	-	149	189	315	7,040	50	-	1,380	164	1,594	-	8,634
1991	9,808	286	218	4,204	265	-	-	342	119	15,242	9	-	410	55	474	-	15,716
1992	7,162	166	513	3,204	288	-	73	464	8	11,878	-	-	1,928	148	2,076	-	13,954
1993	6,600	129	812	1,759	40	-	1	471	3	9,815	-	-	579	316	896	-	10,710
1994	8,131	162	1,206	5,667	50	-	-	559	-	15,775	63	2	906	115	1,086	-	16,861
1995	18,909	270	678	7,223	821	-	-	335	2	28,238	11	-	649	275	935	-	29,173
1996	7,644	94	901	5,359	102	-	-	956	-	15,056	3,700	-	4,633	90	8,423	-	23,479
1997	13,152	34	1,300	4,354	1,054	-	-	1,814	-	21,708	367	-	2,240	245	2,852	-	24,560
1998	5,391	85	1,255	4,450	188	-	-	1,910	-	13,279	1	-	1,771	597	2,369	-	15,648
1999	16,173	35	1,157	5,246	256	-	-	3,089	-	25,956	2,369	35	184	617	3,205	-	29,161
2000	16,486	102	953	7,031	2,401	-	-	2,780	2	29,755	3,019	99	693	353	4,164	-	33,919
2001	7,620	180	791	5,614	1,176	10	-	1,839	4	17,234	863	-	292	384	1,539	131	18,904
2002	8,903	99	841	4,338	932	1	-	1,523	4	16,641	1,708	2	50	622	2,382	67	19,090
2003	5,768	44	1,237	3,345	2,601	-	-	1,863	21	14,879	3,211	43	22	372	3,648	42	18,569
2004	8,257	132	1,847	3,855	773	-	-	1,714	3	16,581	8,880	14	-	59	8,953	-	25,534
2005	12,817	549	1,925	6,363	1,318	9	-	1,368	2	24,351	4,542	-	201	80	4,823	-	29,174
2006	8,880	108	1,121	4,058	1,012	3	-	1,149	1	16,332	9,927	-	-	93	10,020	-	26,352
2007	6,840	236	1,762	4,983	1,281	4	-	1,401	10	16,517	4,147	-	42	14	4,203	-	20,720
2008	10,221	64	1,390	5,505	1,866	10	-	979	2	20,037	4,392	15	-	63	4,470	-	24,507
2009	8,077	50	1,080	4,814	936	4	-	877	11	15,849	3,019	-	410	161	3,590	-	19,439
2010	3,742	83	890	3,681	1,196	16	-	373	36	10,017	7,746	-	-	89	7,835	-	17,852
2011	8,340	63	837	3,754	670	14	-	292	24	13,994	2,730	1	99	244	3,074	-	17,068
2012	2,462	113	673	2,846	1,421	2	-	210	4	7,731	6,667	1	38	405	7,111	-	14,842
2013	2,771	8	784	2,848	604	1	-	331	3	7,350	3,154	-	-	819	3,973	-	11,323
2014	5,456	5	683	3,429	1,305	6	-	483	42	11,409	4,862	-	401	442	5,705	-	17,114
2015	3,645	8	618	2,086	676	1	-	552	26	7,612	3,082	-	86	412	3,580	-	11,192
2016	5,095	44	688	2,514	1,025	5	-	454	-	9,825	2,709	-	316	327	3,352	-	13,177
2017	4,540	86	887	3,523	734	9	-	415	-	10,194	3,643	-	466	388	4,497	-	14,691
2018	*	*	*	*	*	*	*	*	*	*	2,840	-	39	-	2,879	-	2,879

¹ Source: International Scientific Committee, 18th Plenary Meeting, PBFWG workshop report on Pacific Bluefin Tuna, July 2018—Fuente: Comité Científico Internacional, 18ª Reunión Plenaria, Taller PBFWG sobre Atún Aleta Azul del Pacífico, julio de 2018

TABLE A-5b. Reported catches of Pacific bluefin tuna in the EPO by recreational gear, in number of fish, 1989-2018.

TABLA A-5b. Capturas reportadas de atún aleta azul del Pacifico en el OPO por artes deportivas, en número de peces, 1989-2018.

PBF-RG			
1989	6,519	2004	3,391
1990	3,755	2005	5,757
1991	5,330	2006	7,473
1992	8,586	2007	1,028
1993	10,535	2008	10,187
1994	2,243	2009	12,138
1995	16,025	2010	8,453
1996	2,739	2011	31,494
1997	8,338	2012	40,012
1998	20,466	2013	63,158
1999	36,797	2014	27,889
2000	20,669	2015	28,661
2001	21,913	2016	12,312
2002	33,399	2017	16,493
2003	22,291	2018	10,414

TABLE A-6. Annual retained catches of albacore in the EPO, by gear and area (north and south of the equator), in metric tons. The data for 2016 and 2017 are preliminary.

TABLA A-6. Capturas retenidas anuales de atún albacora en el OPO, por arte y zona (al norte y al sur de la línea ecuatorial), en toneladas. Los datos de 2016 y 2017 son preliminares.

ALB	North—Norte				South—Sur				Total
	LL	LTL ¹	OTR	Subtotal	LL	LTL	OTR	Subtotal	
1989	952	1,873	161	2,986	5,832	593	90	6,515	9,501
1990	1,143	2,610	63	3,816	5,393	1,336	305	7,034	10,850
1991	1,514	2,617	6	4,137	6,379	795	170	7,344	11,481
1992	1,635	4,770	2	6,407	15,445	1,205	18	16,668	23,075
1993	1,772	4,332	25	6,129	9,422	35	19	9,476	15,605
1994	2,356	9,666	106	12,128	8,034	446	21	8,501	20,629
1995	1,380	7,773	102	9,255	4,805	2	15	4,822	14,077
1996	1,675	8,267	99	10,041	5,956	94	21	6,071	16,112
1997	1,365	6,115	1,019	8,499	8,313	466	0	8,779	17,278
1998	1,730	12,019	1,250	14,999	10,905	12	0	10,917	25,916
1999	2,701	11,028	3,668	17,397	8,932	81	7	9,020	26,417
2000	1,880	10,960	1,869	14,709	7,783	778	3	8,564	23,273
2001	1,822	11,727	1,638	15,187	17,588	516	6	18,110	33,297
2002	1,227	12,286	2,388	15,901	14,062	131	40	14,233	30,134
2003	1,129	17,808	2,260	21,197	23,772	419	3	24,194	45,391
2004	854	20,288	1,623	22,765	17,590	331	0	17,921	40,686
2005	405	13,807	1,741	15,953	8,945	181	7	9,133	25,086
2006	3,671	18,515	408	22,594	10,161	48	118	10,327	32,921
2007	2,708	17,948	1,415	22,071	8,399	19	87	8,505	30,576
2008	1,160	17,137	308	18,605	8,058	0	159	8,217	26,822
2009	91	17,933	996	19,020	11,981	0	213	12,194	31,214
2010	1,134	18,246	892	20,272	13,122	3	247	13,372	33,644
2011	1,833	15,437	426	17,696	14,357	0	222	14,579	32,275
2012	4,580	16,633	1,224	22,437	19,616	35	210	19,861	42,298
2013	6,771	17,398	844	25,013	18,630	0	271	18,901	43,914
2014	3,342	18,077	1,045	22,464	25,889	72	243	26,204	48,668
2015	2,474	15,949	927	19,350	26,483	0	223	26,706	46,056
2016	1,596	13,638	678	15,912	25,181	0	290	25,471	41,383
2017	2,544	8,992	372	11,908	23,447	0	206	23,653	35,561
2018	*	*	*	*	*	*	*	*	*

¹ Includes pole-and-line—Incluye caña

TABLE A-7. Estimated numbers of sets, by set type and vessel capacity category, and estimated retained catches, in metric tons, of yellowfin, skipjack, and bigeye tuna by purse-seine vessels in the EPO. The data for 2017 and 2018 are preliminary. The data for yellowfin, skipjack, and bigeye tunas have been adjusted to the species composition estimate and are preliminary.

TABLA A-7. Números estimados de lances, por tipo de lance y categoría de capacidad de buque, y capturas retenidas estimadas, en toneladas métricas, de atunes aleta amarilla, barrilete, y patudo por buques cerqueros en el OPO. Los datos de 2017 y 2018 son preliminares. Los datos de los atunes aleta amarilla, barrilete, y patudo fueron ajustados a la estimación de composición por especie, y son preliminares.

	Number of sets—Número de lances			Retained catch—Captura retenida		
	Vessel capacity— Capacidad del buque		Total	YFT	SKJ	BET
	≤363 t	>363 t				
DEL	Sets associated with dolphins Lances asociados a delfines					
2003	0	13,760	13,760	265,874	13,347	1
2004	0	11,783	11,783	177,513	10,706	2
2005	0	12,173	12,173	167,224	12,321	1
2006	0	8,923	8,923	91,800	4,801	0
2007	0	8,871	8,871	97,075	3,272	7
2008	0	9,246	9,246	122,107	8,388	4
2009	0	10,910	10,910	178,291	2,683	1
2010	0	11,646	11,646	170,028	1,365	0
2011	0	9,604	9,604	134,926	4,387	2
2012	0	9,220	9,220	133,825	2,122	0
2013	0	10,736	10,736	157,432	4,272	0
2014	0	11,382	11,382	167,780	4,413	3
2015	0	11,020	11,020	160,595	5,608	2
2016	0	11,219	11,219	146,836	3,196	4
2017	0	8,864	8,864	112,508	1,656	1
2018	0	9,774	9,774	144,633	2,374	1
OBJ	Sets associated with floating objects Lances asociados a objetos flotantes					
2003	792	5,457	6,249	30,178	181,273	51,301
2004	723	4,986	5,709	28,312	117,212	64,001
2005	796	4,992	5,788	25,752	132,937	66,256
2006	1,313	6,862	8,175	34,111	191,006	82,176
2007	1,605	5,857	7,462	29,412	122,119	62,187
2008	1,958	6,655	8,613	34,763	157,324	73,851
2009	2,142	7,077	9,219	36,147	157,023	75,889
2010	2,432	6,399	8,831	37,850	114,659	57,059
2011	2,538	6,921	9,459	42,176	171,193	55,587
2012	3,067	7,610	10,677	37,487	177,055	65,035
2013	3,081	8,038	11,119	35,089	194,372	48,337
2014	3,857	8,777	12,634	46,049	199,696	59,797
2015	3,455	9,385	12,840	43,603	206,515	60,975
2016	4,214	10,377	14,591	58,306	248,713	55,264
2017	4,535	11,147	15,682	67,151	224,458	65,438
2018	4,935	11,871	16,806	68,428	211,782	64,395

TABLE A-7. (continued)

TABLA A-7. (continuación)

	Number of sets—Número de lances			Retained catch—Captura retenida		
	Vessel capacity— Capacidad del buque		Total	YFT	SKJ	BET
	≤363 t	>363 t				
NOA	Sets on unassociated schools Lances sobre cardúmenes no asociados					
2003	8,139	5,131	13,270	87,227	79,348	1,750
2004	5,637	5,696	11,333	66,732	69,906	1,468
2005	6,922	7,816	14,738	75,125	117,971	1,638
2006	7,180	8,443	15,623	40,720	100,461	1,662
2007	5,480	7,211	12,691	43,529	82,904	1,256
2008	5,204	6,210	11,414	28,187	130,891	1,173
2009	3,822	4,109	7,931	22,319	70,817	909
2010	2,744	3,885	6,629	43,131	31,168	693
2011	2,840	5,182	8,022	29,749	100,455	923
2012	2,996	5,369	8,365	26,705	87,038	985
2013	3,064	4,156	7,220	25,666	79,916	1,150
2014	2,427	3,369	5,796	20,237	57,360	645
2015	3,116	6,201	9,317	41,529	116,784	1,936
2016	2,300	5,101	7,401	36,976	85,652	1,463
2017	2,012	4,959	6,971	31,273	98,698	1,528
2018	1,780	4,163	5,943	24,246	73,320	909
ALL	Sets on all types of schools Lances sobre todos tipos de cardumen					
2003	8,931	24,348	33,279	383,279	273,968	53,052
2004	6,360	22,465	28,825	272,557	197,824	65,471
2005	7,718	24,981	32,699	268,101	263,229	67,895
2006	8,493	24,228	32,721	166,631	296,268	83,838
2007	7,085	21,939	29,024	170,016	208,295	63,450
2008	7,162	22,111	29,273	185,057	296,603	75,028
2009	5,964	22,096	28,060	236,757	230,523	76,799
2010	5,176	21,930	27,106	251,009	147,192	57,752
2011	5,378	21,707	27,085	206,851	276,035	56,512
2012	6,063	22,199	28,262	198,017	266,215	66,020
2013	6,145	22,930	29,075	218,187	278,560	49,487
2014	6,284	23,528	29,812	234,066	261,469	60,445
2015	6,571	26,606	33,177	245,727	328,907	62,913
2016	6,514	26,697	33,211	242,118	337,561	56,731
2017	6,547	24,970	31,517	210,932	324,812	66,967
2018	6,715	25,808	32,523	237,307	287,476	65,305

TABLE A-8. Types of floating objects involved in sets by vessels of >363 t carrying capacity, 2003-2018. The 2018 data are preliminary.

TABLA A-8. Tipos de objetos flotantes sobre los que realizaron lances buques de >363 t de capacidad de acarreo, 2003-2018. Los datos de 2018 son preliminares.

OBJ	Flotsam Naturales		FADs Plantados		Unknown Desconocido		Total
	No.	%	No.	%	No.	%	
2003	715	13.1	4,722	86.5	20	0.4	5,457
2004	586	11.8	4,370	87.6	30	0.6	4,986
2005	603	12.1	4,281	85.8	108	2.2	4,992
2006	697	10.2	6,123	89.2	42	0.6	6,862
2007	597	10.2	5,188	88.6	72	1.2	5,857
2008	560	8.4	6,070	91.2	25	0.4	6,655
2009	322	4.5	6,728	95.1	27	0.4	7,077
2010	337	5.3	6,038	94.3	24	0.4	6,399
2011	563	8.1	6,342	91.6	16	0.2	6,921
2012	286	3.8	7,321	96.2	3	< 0.1	7,610
2013	274	3.4	7,759	96.5	5	0.1	8,038
2014	283	3.2	8,490	96.7	4	< 0.1	8,777
2015	273	2.9	9,093	96.9	19	0.2	9,385
2016	278	2.7	10,070	97.0	29	0.3	10,377
2017	271	2.4	10,877	97.6	0	0	11,148
2018	322	2.7	11,549	97.3	0	0	11,871

TABLE A-9. Reported nominal longline fishing effort (E; 1000 hooks), and catch (C; metric tons) of yellowfin, skipjack, bigeye, Pacific bluefin, and albacore tunas only, by flag, in the EPO.

TABLA A-9. Esfuerzo de pesca palangrero nominal reportado (E; 1000 anzuelos), y captura (C; toneladas métricas) de atunes aleta amarilla, barrilete, patudo, aleta azul del Pacífico, y albacora solamente, por bandera, en el OPO.

LL	CHN		JPN		KOR		FRA(PYF)		TWN		USA		OTR ¹
	E	C	E	C	E	C	E	C	E	C	E	C	C
1989	-	-	170,370	84,961	43,365	4,879	-	-	16,360	4,962	-	-	9
1990	-	-	178,414	117,923	47,167	17,415	-	-	12,543	4,755	-	-	-
1991	-	-	200,374	112,337	65,024	24,644	-	-	17,969	5,862	42	12	173
1992	-	-	191,300	93,011	45,634	13,104	199	89	33,025	14,142	325	106	128
1993	-	-	159,956	87,977	46,375	12,843	153	79	18,064	6,566	415	81	227
1994	-	-	163,999	92,606	44,788	13,250	1,373	574	12,588	4,883	303	25	523
1995	-	-	129,599	69,435	54,979	12,778	1,776	559	2,910	1,639	828	180	562
1996	-	-	103,649	52,298	40,290	14,121	2,087	931	5,830	3,553	510	182	185
1997	-	-	96,385	59,325	30,493	16,663	3,464	1,941	8,720	5,673	464	215	752
1998	-	-	106,568	50,167	51,817	15,089	4,724	2,858	10,586	5,039	1,008	406	1,176
1999	-	-	80,950	32,886	54,269	13,294	5,512	4,446	23,247	7,865	1,756	469	1,157
2000	-	-	79,311	45,216	33,585	18,759	8,090	4,382	18,152	7,809	737	204	4,868
2001	13,056	5,162	102,219	54,775	72,261	18,201	7,445	5,086	41,920	20,060	1,438	238	15,612
2002	34,889	10,398	103,919	45,401	96,273	14,370	943	3,238	78,018	31,773	613	138	10,258
2003	43,289	14,548	101,227	36,187	71,006	15,551	11,098	4,101	74,460	28,328	1,314	262	11,595
2004	15,889	4,033	76,824	30,936	55,861	14,540	13,757	3,030	49,979	19,535	1,049	166	9,193
2005	16,896	3,681	65,081	25,712	15,798	12,284	13,356	2,515	38,536	12,229	2,397	557	5,244
2006	588	969	56,525	21,432	27,472	7,892	11,786	3,220	38,134	12,375	234	121	10,027
2007	12,226	2,624	45,972	20,514	10,548	6,037	9,672	3,753	22,244	9,498	2,689	436	6,424
2008	11,518	2,984	44,547	21,375	3,442	4,256	10,255	3,017	12,544	4,198	6,322	1,369	9,231
2009	10,536	3,435	41,517	21,492	18,364	7,615	10,686	4,032	13,904	6,366	5,141	852	11,731
2010	11,905	3,590	47,807	21,017	25,816	10,477	8,976	3,139	24,976	10,396	8,879	1,480	11,400
2011	37,384	9,983	52,194	18,682	25,323	7,814	9,514	3,192	21,065	9,422	7,359	1,233	7,616
2012	55,508	14,462	55,587	22,214	20,338	8,286	8,806	3,589	20,587	11,924	5,822	986	14,237
2013	70,411	18,128	48,825	19,097	31,702	10,248	9,847	3,303	19,198	11,722	10,765	2,127	9,754
2014	78,851	24,282	40,735	17,235	22,695	9,132	10,572	3,291	17,047	10,435	11,276	2,168	6,874
2015	99,131	25,559	35,290	16,046	22,394	9,879	13,661	4,509	15,334	11,274	13,868	3,432	10,924
2016	66,404	25,756	30,910	13,242	23,235	9,457	13,677	3,954	20,941	11,432	11,312	2,398	6,121
2017	82,461	27,341	27,892	10,612	27,500	10,604	11,641	3,425	24,164	11,811	15,266	3,276	4,975

¹ Includes the catches of—Incluye las capturas de: BLZ, CHL, COK, CRI, ECU, EU(ESP), GTM, HND, MEX, NIC, PAN, EU(PRT), SLV, VUT

TABLE A-10. Numbers and well volumes, in cubic meters, of purse-seine and pole-and line vessels of the EPO tuna fleet. The data for 2017 and 2018 are preliminary.

TABLA A-10. Número y volumen de bodega, en metros cúbicos, de buques cerqueros y cañeros de la flota atunera del OPO. Los datos de 2017 and 2018 son preliminares.

	PS		LP		Total	
	No.	Vol. (m ³)	No.	Vol. (m ³)	No.	Vol. (m ³)
1989	176	141,956	32	3,181	208	145,137
1990	172	143,877	23	1,975	195	145,852
1991	152	124,062	22	1,997	174	126,059
1992	158	116,619	20	1,807	178	118,426
1993	151	117,593	15	1,550	166	119,143
1994	166	120,726	20	1,726	186	122,452
1995	175	123,798	20	1,784	195	125,582
1996	180	130,774	17	1,646	197	132,420
1997	194	147,926	23	2,127	217	150,053
1998	202	164,956	22	2,216	224	167,172
1999	208	178,724	14	1,642	222	180,366
2000	205	180,679	12	1,220	217	181,899
2001	204	189,088	10	1,259	214	190,347
2002	218	199,870	6	921	224	200,791
2003	214	202,381	3	338	217	202,719
2004	218	206,473	3	338	221	206,811
2005	220	212,419	4	498	224	212,917
2006	225	225,166	4	498	229	225,664
2007	227	225,359	4	380	231	225,739
2008	219	223,804	4	380	223	224,184
2009	221	224,632	4	380	225	225,012
2010	202	210,025	3	255	205	210,280
2011	208	213,237	3	339	211	213,576
2012	209	217,687	4	464	213	218,151
2013	203	212,087	3	268	206	212,355
2014	226	230,379	2	226	228	230,605
2015	244	248,428	1	125	245	248,553
2016	250	261,474	0	0	250	261,474
2017	254	263,018	0	0	254	263,018
2018	250	262,226	0	0	250	262,226

TABLE A-11a. Estimates of the numbers and well volume (cubic meters) of purse-seine (PS) and pole-and-line (LP) vessels that fished in the EPO in 2017, by flag and gear. Each vessel is included in the total for each flag under which it fished during the year, but is included only once in the “Grand total”; therefore, the grand total may not equal the sums of the individual flags.

TABLA A-11a. Estimaciones del número y volumen de bodega (metros cúbicos) de buques cerqueros (PS) y cañeros (LP) que pescaron en el OPO en 2017 por bandera y arte de pesca. Se incluye cada buque en los totales de cada bandera bajo la cual pescó durante el año, pero solamente una vez en el “Total general”; por consiguiente, los totales generales no equivalen necesariamente a las sumas de las banderas individuales.

Flag Bandera	Gear Arte	Well volume —Volumen de bodega (m ³)					Total	
		<401	401-800	801-1300	1301-1800	>1800	No.	Vol. (m ³)
		Number—Número						
COL	PS	2	2	7	3	-	14	14,860
ECU	PS	37	33	22	10	12	114	92,391
EU(ESP)	PS	-	-	-	-	2	2	4,120
MEX	PS	5	4	19	23	-	51	60,551
NIC	PS	-	-	3	3	1	7	10,648
PAN	PS	-	2	5	5	4	16	22,649
PER	PS	4	5	-	-	-	9	4,325
SLV	PS	-	-	-	-	2	2	4,473
USA	PS	9	-	2	9	7	27	30,677
VEN	PS	-	-	5	6	2	13	19,066
Grand total— Total general	PS	57	45	63	59	30	254	
Well volume—Volumen de bodega (m ³)								
Grand total— Total general	PS	14,987	27,117	70,532	88,901	61,481		263,018

- : none—ninguno

TABLE A-11b. Estimates of the numbers and well volumes (cubic meters) of purse-seine (PS) vessels that fished in the EPO in 2018, by flag and gear. Each vessel is included in the total for each flag under which it fished during the year, but is included only once in the “Grand total”; therefore, the grand total may not equal the sums of the individual flags.

TABLA A-11b. Estimaciones del número y volumen de bodega (metros cúbicos) de buques cerqueros (PS) que pescaron en el OPO en 2018, por bandera y arte de pesca. Se incluye cada buque en los totales de cada bandera bajo la cual pescó durante el año, pero solamente una vez en el “Total general”; por consiguiente, los totales generales no equivalen necesariamente a las sumas de las banderas individuales.

Flag Bandera	Gear Arte	Well volume —Volumen de bodega (m ³)					Total	
		<401	401-800	801-1300	1301-1800	>1800	No.	Vol. (m ³)
		Number—Número						
COL	PS	2	2	7	3	-	14	14,860
ECU	PS	38	31	22	10	12	113	91,658
EU(ESP)	PS	-	-	-	-	2	2	4,120
MEX	PS	5	4	21	23	-	53	62,659
NIC	PS	-	-	3	2	1	6	9,066
PAN	PS	-	1	5	5	4	15	21,907
PER	PS	5	4	-	-	-	9	4,175
SLV	PS	-	-	-	1	2	3	6,202
USA	PS	4	-	3	8	6	21	27,215
VEN	PS	-	-	6	6	2	14	20,364
Grand total— Total general	PS	54	42	67	58	29	250	
Well volume—Volumen de bodega (m³)								
Grand total— Total general	PS	14,944	28,843	73,246	88,505	59,688		262,226

- : none—ninguno

TABLE A-12. Minimum, maximum, and average capacity, in thousands of cubic meters, of purse-seine and pole-and-line vessels at sea in the EPO during 2008-2017 and in 2018, by month.

TABLA A-12. Capacidad mínima, máxima, y media, en miles de metros cúbicos, de los buques cerqueros y cañeros en el mar en el OPO durante 2008-2017 y en 2018, por mes.

Month Mes	2008-2017			2018
	Min	Max	Ave.-Prom.	
1	86.9	129.6	103.1	104.4
2	150.7	192.3	164.4	189.5
3	135.4	189.7	155.7	181.6
4	143.4	200.8	162.8	177.3
5	139.8	196.9	159.6	184.9
6	154.9	198.6	166.6	192.0
7	154.1	200.4	168.4	180.1
8	102.9	148.7	119.7	120.8
9	105.5	142.2	119.3	119.9
10	150.7	188.9	168.9	185.6
11	102.9	150.8	127.7	120.9
12	45.9	77.7	58.0	66.4
Ave.-Prom.	122.8	168.0	139.5	151.9

B. YELLOWFIN TUNA

For the full version of this analysis, see document [SAC-10-08](#).

Yellowfin are distributed across the Pacific Ocean, but the bulk of the catch is made in the eastern and western regions. Purse-seine catches in the vicinity of the western boundary of the EPO at 150°W are relatively low, but have been increasing, mainly in sets on floating objects (Figure A-1a and A-1b, Tables A-1, A-2). The majority of the catch in the eastern Pacific Ocean (EPO) is taken in purse-seine sets associated with dolphins and floating objects (Figure B-1). Tagging studies of yellowfin throughout the Pacific indicate that they tend to stay within 1,800 km of their release positions. This regional fidelity, along with the geographic variation in phenotypic and genotypic characteristics of yellowfin shown in some studies, suggests that there might be multiple stocks of yellowfin in the EPO and throughout the Pacific Ocean. However, movement rates between these putative stocks, as well as across the 150°W meridian, cannot be estimated with currently-available tagging data.

The model used for the current update assessment of yellowfin in the EPO ([SAC-10-07](#)) was unable to reconcile data that apparently carry contradictory signals about the status of the stock ([SAC-10 INF-F](#)). This needs to be resolved before the model can be used as a basis for management advice, and a workplan has been developed in preparation for the scheduled benchmark assessment in 2020. In the meantime, the staff developed data-based indicators to monitor the relative status of the stock ([SAC-10-08](#)).

Both the number of floating-object sets and the number of days fished in such sets generally increased during the entire period, and in 2018 were at and above, respectively, the upper reference level (Figures [B-2](#) and [B-3](#)). The reported longline effort peaked twice, around 1990 and in the early 2000s, and has increased again since 2010; it is currently above the median ([Figure B-2](#)). Prior to 2000, the Japanese fleet, whose index of abundance and length-frequency data are used to represent all the longline fleets, exerted 50% or more of the total longline effort in the EPO, but this proportion has declined continuously since then, and in 2017 was 14%.

The indicators for three of the purse-seine fisheries on floating objects (OBJ-S, OBJ-C, and OBJ-N; [Figure B-3](#)) are very similar, with catch, effort, and mean length increasing in the 1990s as the floating-object fishery expanded. The catch and effort of these fisheries are currently at or above the upper reference value, except for the OBJ-N effort, which fell substantially in 2018. The indicators for the OBJ-I fishery do not show any major trends, but have wide fluctuations and are currently around the median. The average length for all fisheries is currently around the median.

The catches of the unassociated (NOA) purse-seine fisheries have been between the lower reference level and the median since 2008, and are at the lower reference level in 2018 for NOA-N and slightly below the median for NOA-S ([Figure B-4](#)). The lower catches in recent years coincide with the lower effort for NOA-N, but not for NOA-S, where the effort has been around the median ([Figure B-4](#)). The recent CPDFs (catch per days fished) have fluctuated at or above the median for NOA-N, and at or below the median level for NOA-S. The average length for NOA-N has been fluctuating between the lower and the upper reference levels, while NOA-S has fluctuated between the median and the upper reference level in the last ten years.

The indicators for the northern and inshore purse-seine fisheries associated with dolphins (DEL-N and DEL-I) are similar, and have generally fluctuated around the median, with low catch, effort, and CPUE in the late 1970s and early 1980s ([Figure B-4](#)). They are currently around the median, except for the DEL-I catch and effort, which are below the median, and the average length, which in DEL-I is at the lower reference level, but in DEL-N, where it has been high since at least 2010, it is above the upper reference level. The DEL-S fishery has much lower catch and effort, with a peak in catch in the early 2000s. The average length in the DEL-S fishery increased from almost the lower reference level to the upper reference level in during 2010-2017, with a decrease towards the median in 2018.

In contrast to the nominal CPDF, the spatiotemporal model-derived indices of abundance for the DEL-N and DEL-I areas have been fluctuating below the median since 2006, and in 2017 reached some of their lowest values, with a slight increase in 2018 (Figure B-5). These spatiotemporal indices take into account the “patchiness” of fisheries data (fishers tend to fish where there are good catches), the area weighting, and increase in efficiency of purse-seine vessels in the recent years, but not changes in the length composition of the catches.

The catches of both longline fisheries (LL-N and LL-S) have shown some increase in recent years, mostly due to increased effort ([Figure B-2](#)) from the expansion of the Chinese fleet in the EPO (Table A-3). The standardized CPUE for LL-N has been above the median in recent years, while that for LL-S has been around the lower reference level since 2010, coinciding with a steady increase in the average length of the fish in the catches (Figure B-6). Because the Japanese proportion of the total longline effort has been declining ([Figure B-2](#)), the representativeness of the standardized CPUE and average length for the Japanese fleet, used to represent all the longline fisheries for yellowfin in the EPO, needs to be further investigated (see also [WSBET-02 Meeting](#)).

Indicators of relative abundance, such as the standardized CPUE for LL-S and the spatiotemporal indices for DEL-N and DEL-I, have been at low levels since 2010 (LL-S) or earlier (DEL-N, DEL-I), which might indicate a low population size for yellowfin in the EPO, and may be of concern, especially given the steady increase of the number of floating-object sets. However, a decrease in population size is not consistent with the increase in the average length of the fish in the catch observed in recent years in several fisheries (LL-S, DEL-N, NOA-S, DEL-S). This increase may indicate that older, larger fish are being caught because recent strong cohorts are being harvested (DEL-N, DEL-S); alternatively, it may indicate lower natural or fishing mortality, discarding/high-grading of catches, or changes in selectivity and/or availability, which can hinder the interpretation of CPUE indicators as indices of abundance. Because the average length increased in several fisheries simultaneously, it may be an indication that a change in the population may be happening, instead of, or in addition to, changes in selectivity and/or availability.

In conclusion, it is not clear from the indicators whether yellowfin abundance is reduced, or the fisheries are changing. Several hypotheses will be explored in preparation for the benchmark assessment in 2020 ([SAC-10-01](#), [SAC-10-INF-F](#).)

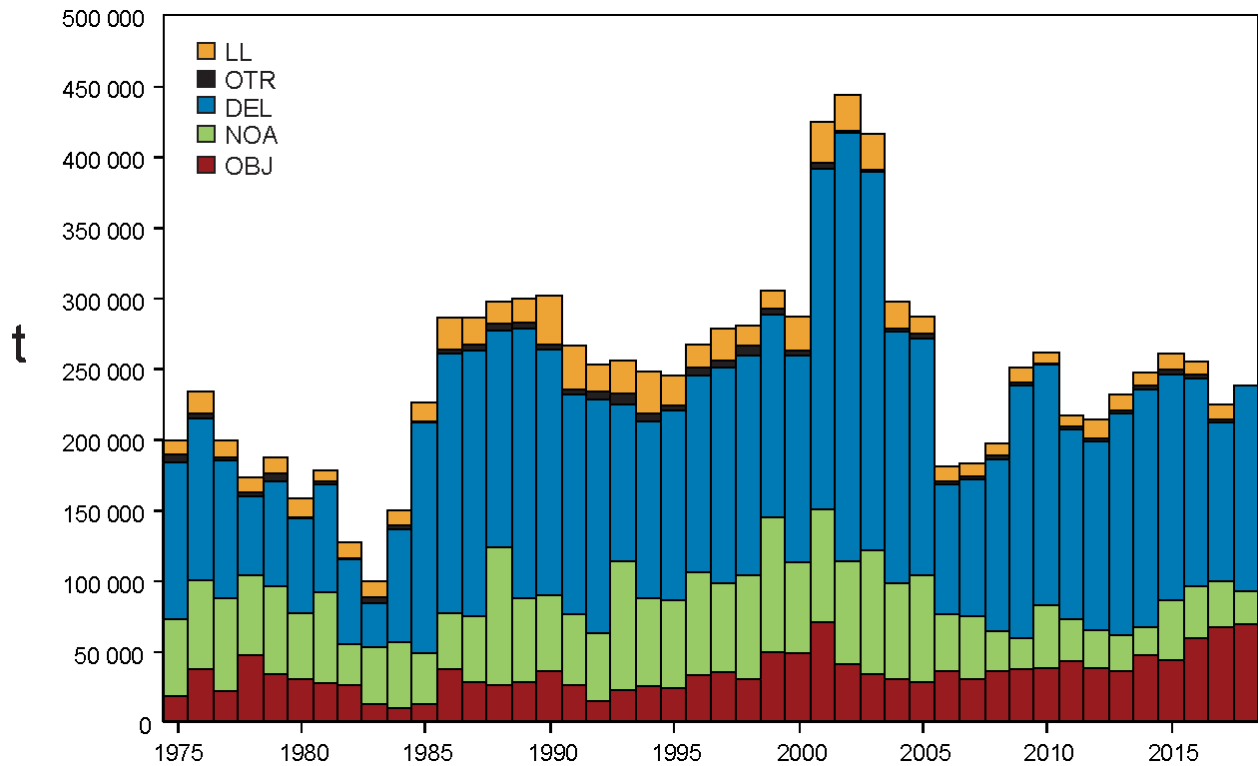


FIGURE B-1. Total catches (retained catches plus discards) for the purse-seine fisheries, by set type (DEL, NOA, OBJ), and retained catches for the longline (LL) and other (OTR) fisheries, of yellowfin tuna in the eastern Pacific Ocean, 1975-2018. The purse-seine catches are adjusted to the species composition estimate obtained from sampling the catches. The 2018 data are preliminary.

FIGURA B-1. Capturas totales (capturas retenidas más descartes) en las pesquerías de cerco, por tipo de lance (DEL, NOA, OBJ), y capturas retenidas de las pesquerías de palangre (LL) y otras (OTR), de atún aleta amarilla en el Océano Pacífico oriental, 1975-2018. Se ajustan las capturas de cerco a la estimación de la composición por especie obtenida del muestreo de las capturas. Los datos de 2018 son preliminares.

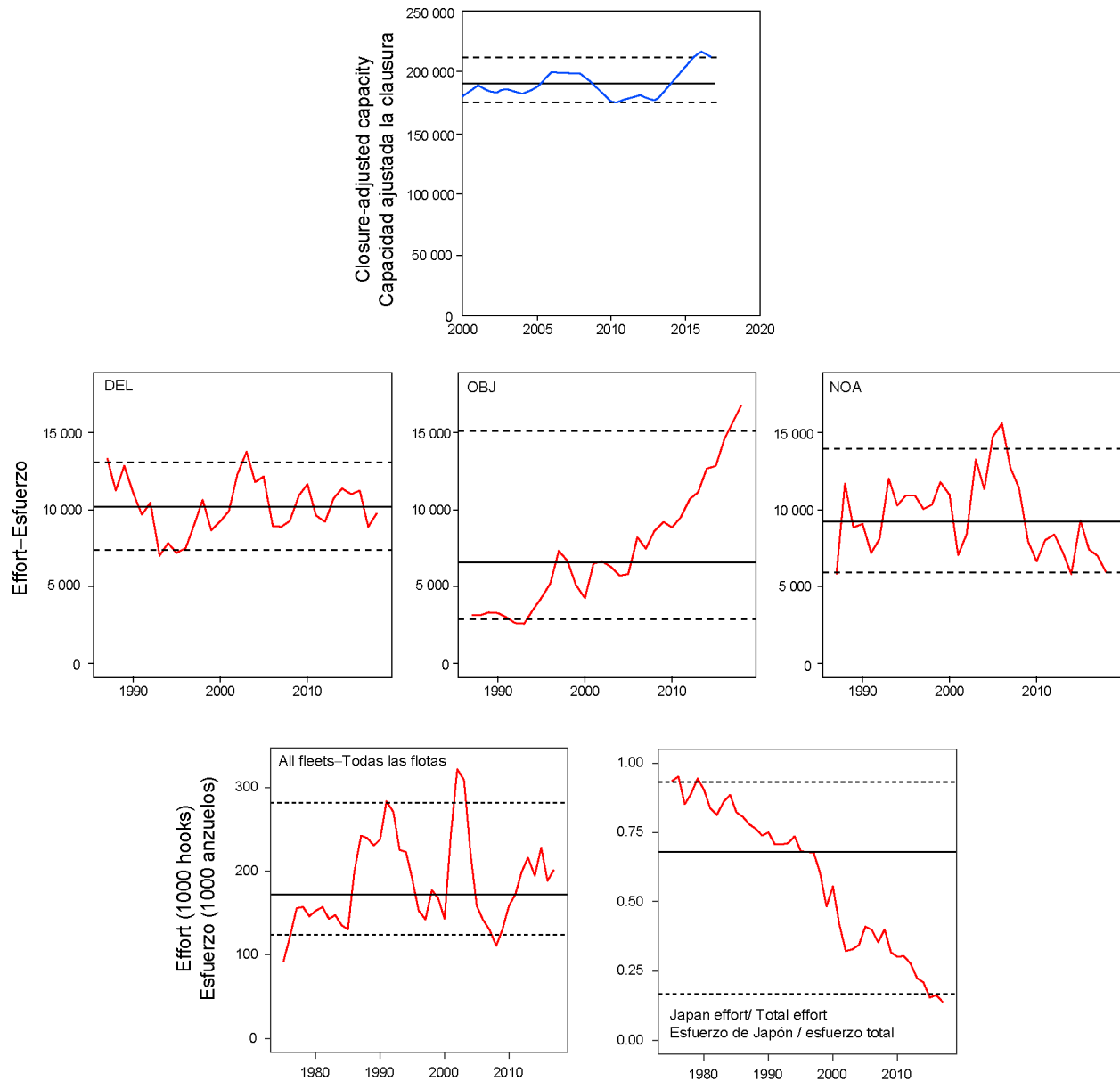


FIGURE B-2. Indicators of total effort in the EPO, based on purse-seine data (closure-adjusted capacity, 2000-2018; annual total number of sets, by type, 1987-2018) and based on longline data for 1975-2017 (effort reported by all fleets, in total numbers of hooks; proportion of the effort corresponding to Japan). The dashed horizontal lines are the 5th and 95th percentiles, the solid horizontal line is the median.

FIGURA B-2. Indicadores del esfuerzo total en el OPO, basados en datos de cerco (capacidad ajustada por veda, 2000-2018; número total anual de lances, por tipo, 1987-2018) y en datos de palangre de 1975-2017 (esfuerzo notificado por todas las flotas, en número total de anzuelos; proporción del esfuerzo correspondiente a Japón). Las líneas horizontales de trazos representan los percentiles de 5 y 95%, y la línea horizontal sólida la mediana.

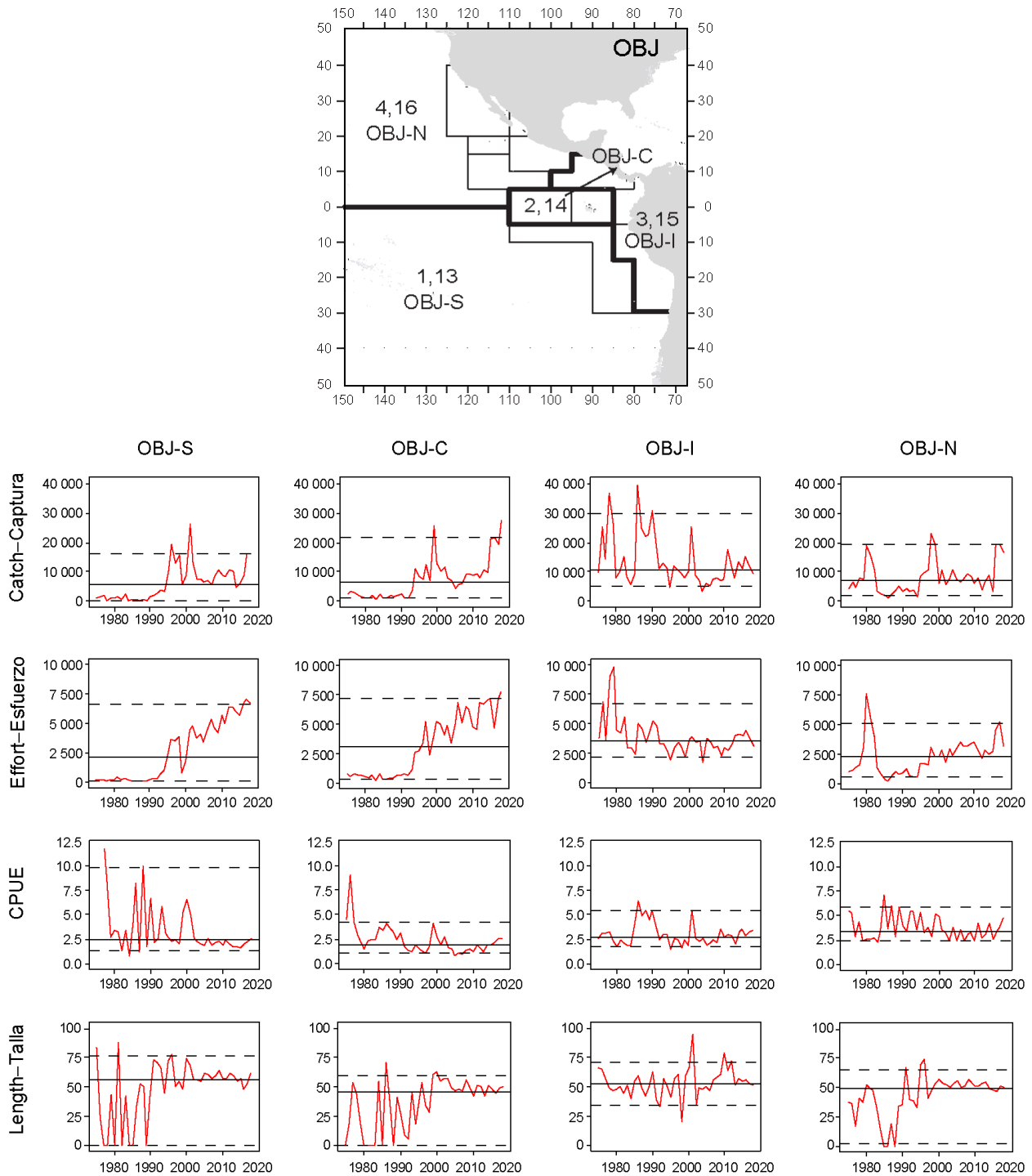


FIGURE B-3. Indicators (catch (t); effort (days fished); CPUE (t/day fished); average length (cm)) for the yellowfin tuna stock in the eastern Pacific Ocean, from purse-seine fisheries on floating objects (OBJ).
FIGURA B-3. Indicadores (captura (t); esfuerzo (días de pesca); CPUE (t/día de pesca); talla promedio (cm)) para la población de atún aleta amarilla en el Océano Pacífico oriental, de las pesquerías de cerco sobre objetos flotantes (OBJ).

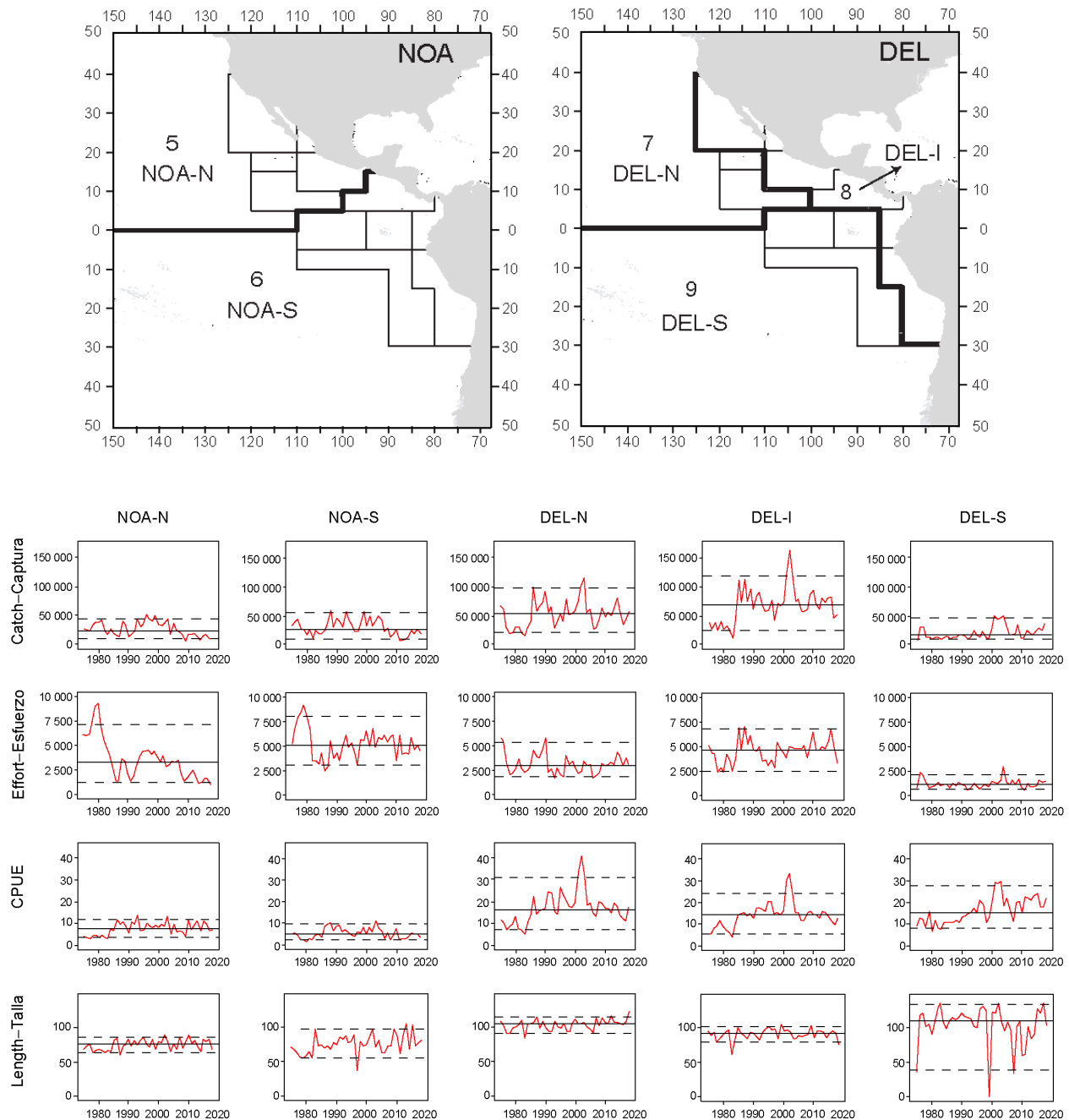


FIGURE B-4. Indicators (catch (t); effort (days fished); CPUE (t/day fished); average length (cm)) for the yellowfin tuna stock in the eastern Pacific Ocean, from the unassociated (NOA) and dolphin-associated (DEL) fisheries.

FIGURA B-4. Indicadores (captura (t); esfuerzo (días de pesca); CPUE (t/día de pesca); talla promedio (cm)) para la población de atún aleta amarilla en el Océano Pacífico oriental, de las pesquerías no asociadas (NOA) y asociadas a delfines (DEL).

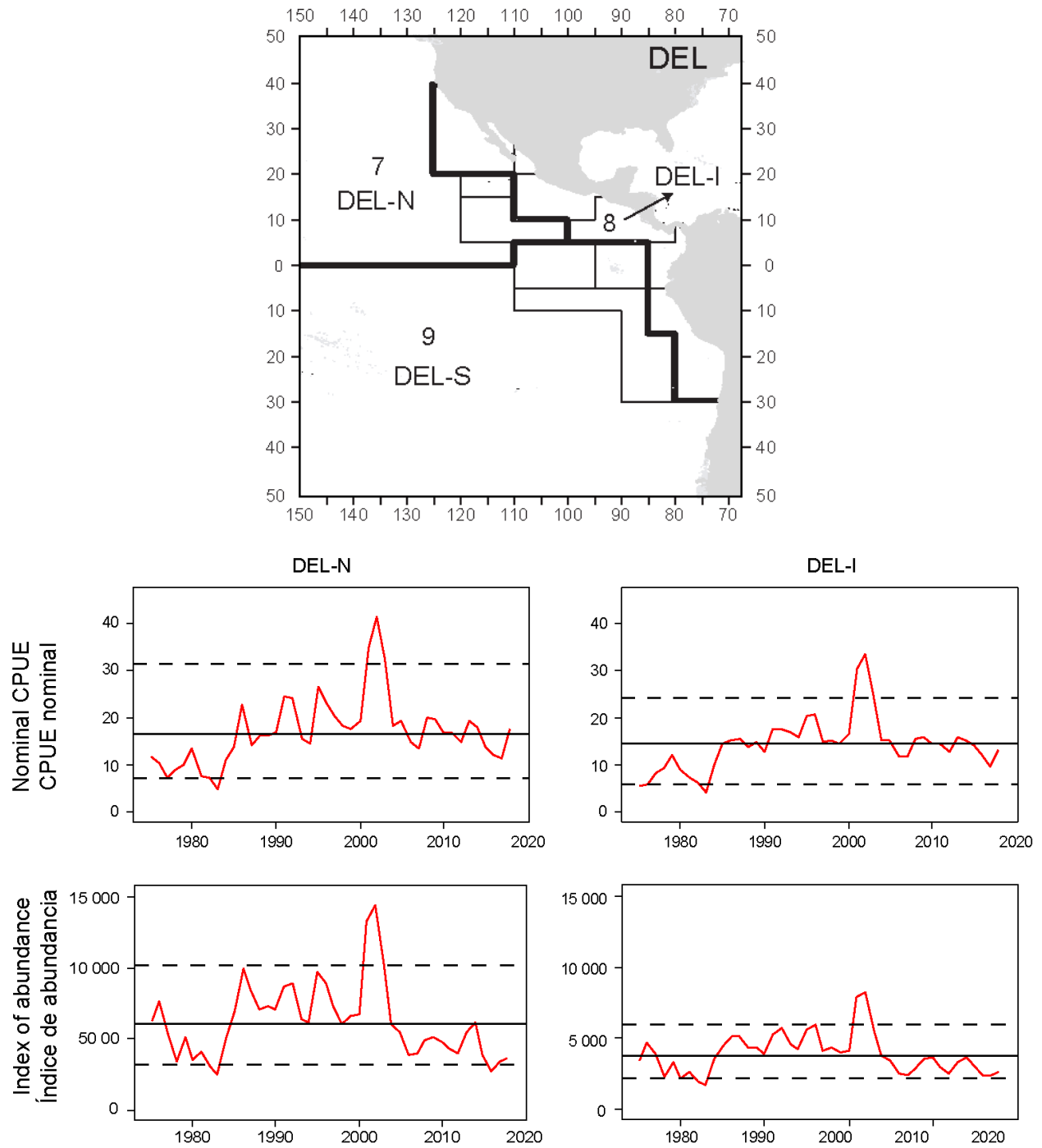


FIGURE B-5. Indicators for the yellowfin tuna stock in the eastern Pacific Ocean: nominal catch per days fished (CPDF) and spatiotemporal model-derived indices of abundance.

FIGURA B-5. Indicadores para la población de atún aleta amarilla en el Océano Pacífico oriental: captura nominal por día de pesca (CPDP) e índices de abundancia derivados del modelo espaciotemporal.

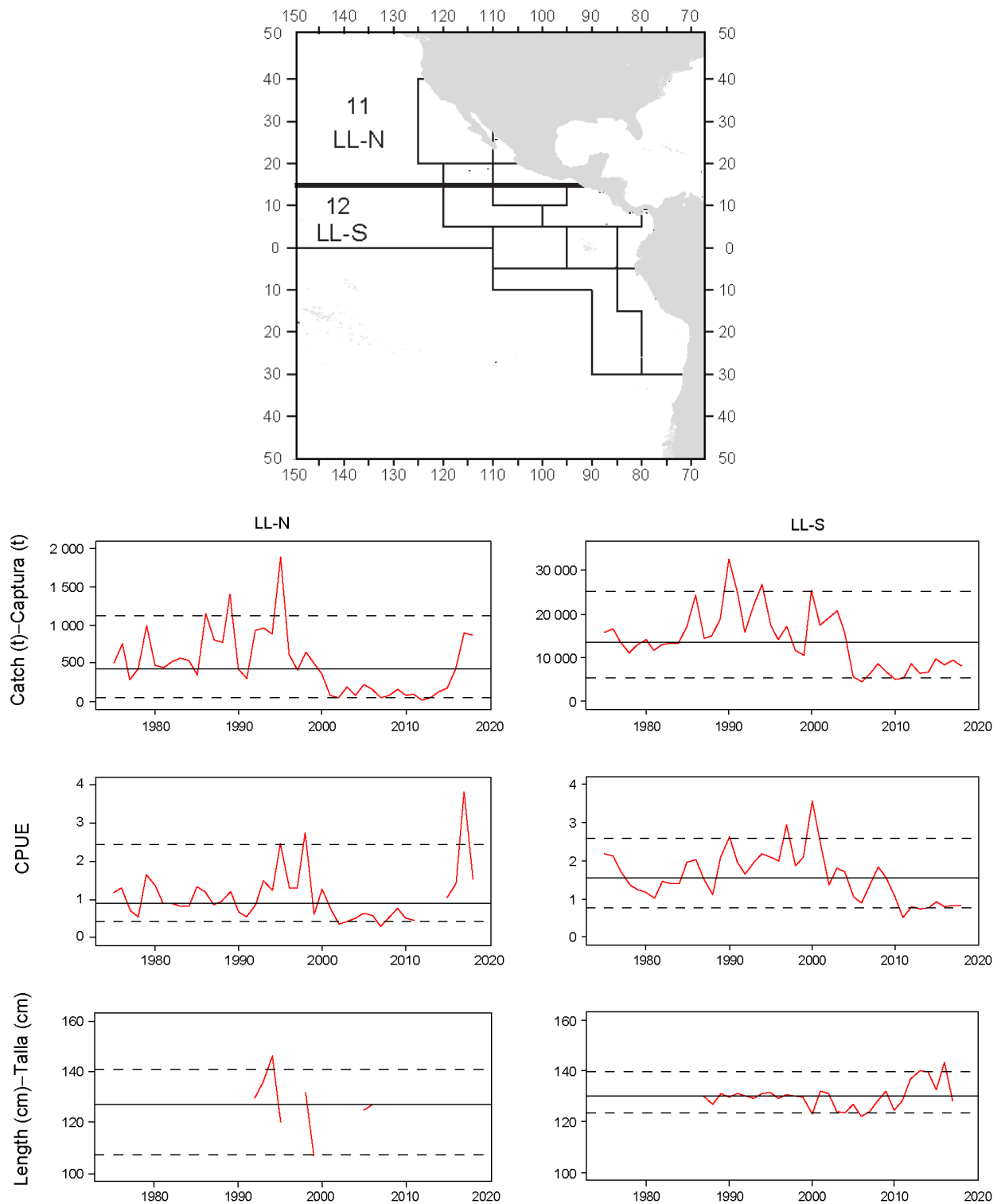


FIGURE B-6. Indicators for the yellowfin tuna stock in the eastern Pacific Ocean, from longline fisheries
FIGURA B-6. Indicadores para la población de atún aleta amarilla en el Océano Pacífico oriental, de las pesquerías de palangre.

C. SKIPJACK TUNA

This analysis was originally presented in document [SAC-10-09](#)

A major management objective for tunas in the eastern Pacific Ocean (EPO) is to keep stocks at levels capable of producing maximum sustainable yields (MSYs). Management objectives based on MSY or related reference points (*e.g.* fishing mortality that produces MSY (F_{MSY}); spawner-per-recruit proxies) are in use for many species and stocks worldwide. However, these objectives require that reference points and quantities to which they are compared be available. The various reference points require different amounts and types of information, ranging from biological information (*e.g.* natural mortality, growth, and stock-recruitment relationship) and fisheries characteristics (*e.g.* age-specific selectivity), to absolute estimates of biomass and exploitation rates. These absolute estimates generally require a formal stock assessment model. For many species, the information required to estimate these quantities is not available, and alternative approaches are needed. Even more data are required if catch quotas are to be used as the management tool.

Skipjack tuna is a notoriously difficult species to assess. Due to its high and variable productivity (*i.e.* annual recruitment is a large proportion of total biomass), it is difficult to detect the effect of fishing on the population with standard fisheries data and stock assessment methods. This is particularly true for the stock of the EPO, due to the lack of age-composition data, and especially tagging data, without which a conventional stock assessment of skipjack is not possible. The continuous recruitment and rapid growth of skipjack mean that the temporal stratification needed to observe modes in length-frequency data make the current sample sizes inadequate. Previous assessments have had difficulty in estimating the absolute levels of biomass and exploitation rates, due to the possibility of a dome-shaped selectivity curve, which would mean that there is a cryptic biomass of large skipjack that cannot be estimated. The most recent assessment of skipjack in the EPO is considered preliminary because it is not known whether the catch per day fished for purse-seine fisheries is proportional to abundance. Analysis of currently available tagging data is unlikely to improve the skipjack stock assessment and a fully length-structured model produced unrealistic estimates. In addition to the problems listed above, the levels of age-specific natural mortality are uncertain, if not unknown, and current yield-per-recruit (YPR) calculations indicate that the YPR would be maximized by catching the youngest skipjack in the model. Therefore, neither the biomass- nor fishing mortality-based reference points, nor the indicators to which they are compared, are available for skipjack in the EPO.

One of the major problems mentioned above is the uncertainty as to whether the catch per unit of effort (CPUE) of the purse-seine fisheries is an appropriate index of abundance for skipjack, particularly when the fish are associated with fish-aggregating devices (FADs). Purse-seine CPUE data are particularly problematic, because it is difficult to identify the appropriate unit of effort. In the current analysis, effort is defined as the amount of searching time required to find a school of fish on which to set the purse seine, and this is approximated by number of days fished. Few skipjack are caught in the longline fisheries or dolphin-associated purse-seine fisheries ([Figure C-1](#)), so these fisheries cannot be used to develop reliable indices of abundance for skipjack. Within a single trip, purse-seine sets on unassociated schools are generally intermingled with floating-object or dolphin-associated sets, complicating the CPUE calculations. Maunder and Hoyle (2007) developed a novel method to generate an index of abundance, using data from the floating-object fisheries. This method used the ratio of skipjack to bigeye in the catch and the “known” abundance of bigeye based on stock assessment results. Unfortunately, the method was of limited usefulness, and more research is needed to improve it. Currently, there is no reliable index of relative abundance for skipjack in the EPO. Therefore, other indicators of stock status, such as the average weight of the fish in the catch, should be investigated.

Since the stock assessments and reference points for skipjack in the EPO are so uncertain, developing

alternative methods to assess and manage the species that are robust to these uncertainties would be beneficial. Full management strategy evaluation (MSE) for skipjack would be the most comprehensive method to develop and test alternative assessment methods and management strategies; however, developing MSE is time-consuming, and has not yet been conducted for skipjack. In addition, higher priority for MSE is given to yellowfin and bigeye tuna, as available data indicate that these species are more susceptible to overfishing than skipjack. Therefore, Maunder and Deriso (2007) investigated some simple indicators of stock status based on relative quantities. Rather than using reference points based on MSY, they compared current values of indicators to the distribution of indicators observed historically. They also developed a simple stock assessment model to generate indicators for biomass, recruitment, and exploitation rate. We update their results to include data up to 2018. To evaluate the current values of the indicators in comparison to historical values, we use reference levels based on the 5th and 95th percentiles, as the distributions of the indicators are somewhat asymmetric. Indicators of number of sets and catch-per-set are also presented. Additional relevant indicators are also presented in [SAC-10-06](#).

Eight data- and model-based indicators are shown in Figure C-2. The standardized effort, which is a measure of exploitation rate, is calculated as the sum of the effort, in days fished, for the floating-object (OBJ) and unassociated (NOA) fisheries. The floating-object effort is standardized to be equivalent to the unassociated effort by multiplying by the ratio of the average floating-object CPUE to the average unassociated CPUE. The purse-seine catch started increasing substantially in the mid-1990s, and has been above average since 2003; during 2015-2017 it was above the upper reference level, but fell below it in 2018. The floating-object CPUE has generally been above average since the early 1990s, and was above the upper reference level in 2016. The unassociated CPUE has been increasing since the early 2000s; it has been above average since about 2003, and was above the upper reference level in 2017, but fell below it in 2018. The standardized effort indicator of exploitation rate increased starting in the early 1990s, and has been above the average level since about 2000. The average weight of skipjack has been declining since 2000, and in 2015 and 2016 was below the lower reference level, but increased slightly to above that level in 2017, then fell back to the reference level in 2018. Both biomass and recruitment have been increasing over the past 20 years, and were above their respective upper reference levels in 2015 and 2016. The exploitation rate started increasing in the mid-1980s, and has fluctuated around the average since the mid-1990s.

The number of sets by both large and small purse-seine vessels in the floating-object fishery has increased consistently for at least the past 15 years (Figure C-3), and at the same time the catch per set has fallen. The number of days fished has not increased at the same rate, and the increased number of sets is therefore likely the cause of the increased catch and catch per day fished (CPDF). The CPDF is used to create the model-based indicators and therefore the estimated increases in recruitment and abundance are probably an artifact caused by the increased number of sets.

The data- and model-based indicators have yet to detect any adverse impacts of the fishery. However, the model-based indicators are probably biased and should not be considered reliable. The average weight was at or below its lower reference level during 2015-2017, which can be a consequence of over-exploitation, but can also be caused by recent recruitments being greater than past recruitments or expansion of the fishery into areas occupied by smaller skipjack. The average length is less in the western part of the EPO, but it has been declining in all areas (Figure C-4). The long-term pattern in reduced average weight is probably due to increasing fishing mortality resulting from the increasing number of sets. However, it is unknown if the current fishing mortality levels are appropriate because there are no reference points for skipjack tuna in the EPO; however, any continued decline in average length is a concern.

Productivity and susceptibility analysis (PSA; see [IATTC Fishery Status Report 12](#), Figure L-4) shows that skipjack has substantially higher productivity than bigeye. Biomass (B) and the fishing mortality that corresponds to MSY (F_{MSY}) are, respectively, negatively and positively correlated with productivity. Therefore,

since skipjack and bigeye have about the same susceptibility, and susceptibility is related to fishing mortality, the status of skipjack can be inferred from the status of bigeye, but only if the fishing mortality of bigeye is below the MSY level (*i.e.*, $F < F_{MSY}$). Since an assessment of bigeye is not available, no inferences can be made at this stage about the status of skipjack. A conventional assessment of skipjack is necessary to ascertain the status of the stock, but, as noted above, this is not possible without much more extensive tagging data. The large-scale tagging program (Project [E.4.a](#)) that commenced in 2019 is therefore critical.

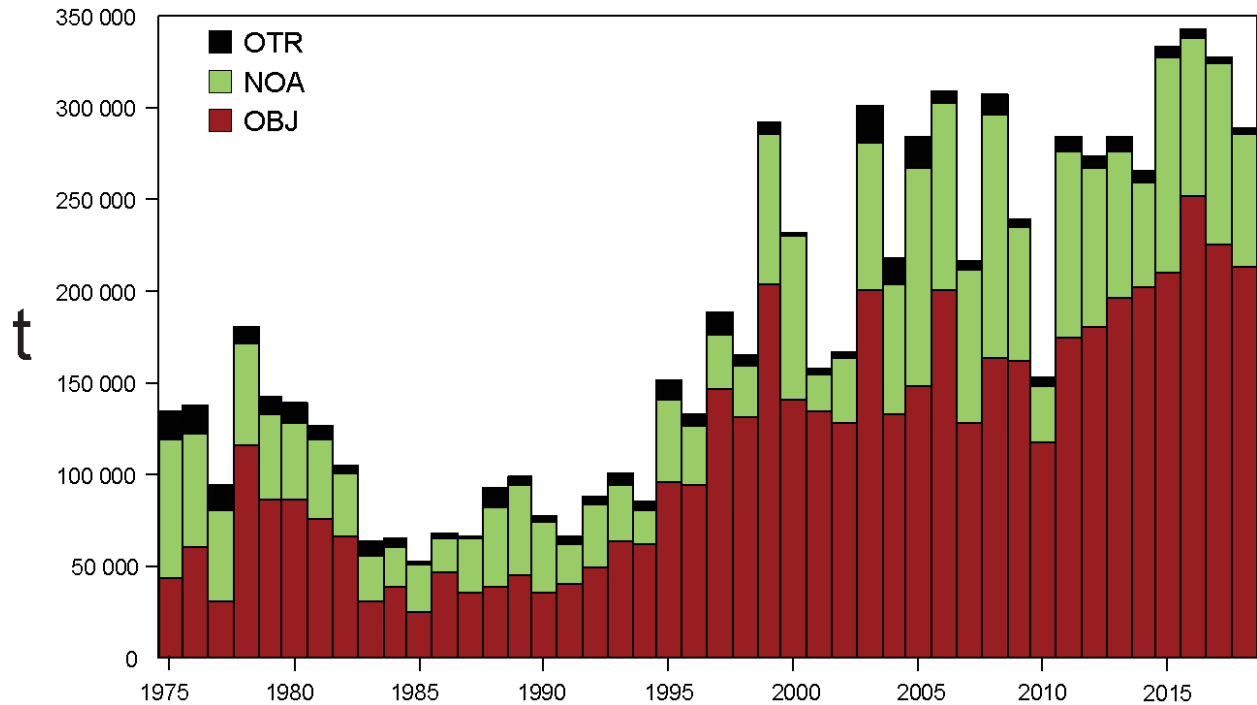


FIGURE C-1. Total catches (retained catches plus discards) for the purse-seine fisheries, by set type (NOA, OBJ) and retained catches for the other (OTR) fisheries, of skipjack tuna in the eastern Pacific Ocean, 1975-2018. The purse-seine catches are adjusted to the species composition estimate obtained from sampling the catches. The 2018 catch data are preliminary.

FIGURA C-1. Capturas totales (capturas retenidas más descartes) en las pesquerías de cerco, por tipo de lance (NOA, OBJ), y capturas retenidas de las otras pesquerías (OTR), de atún barrilete en el Océano Pacífico oriental, 1975-2018. Se ajustan las capturas de cerco a la estimación de la composición por especie obtenida del muestreo de las capturas. Los datos de captura de 2018 son preliminares.

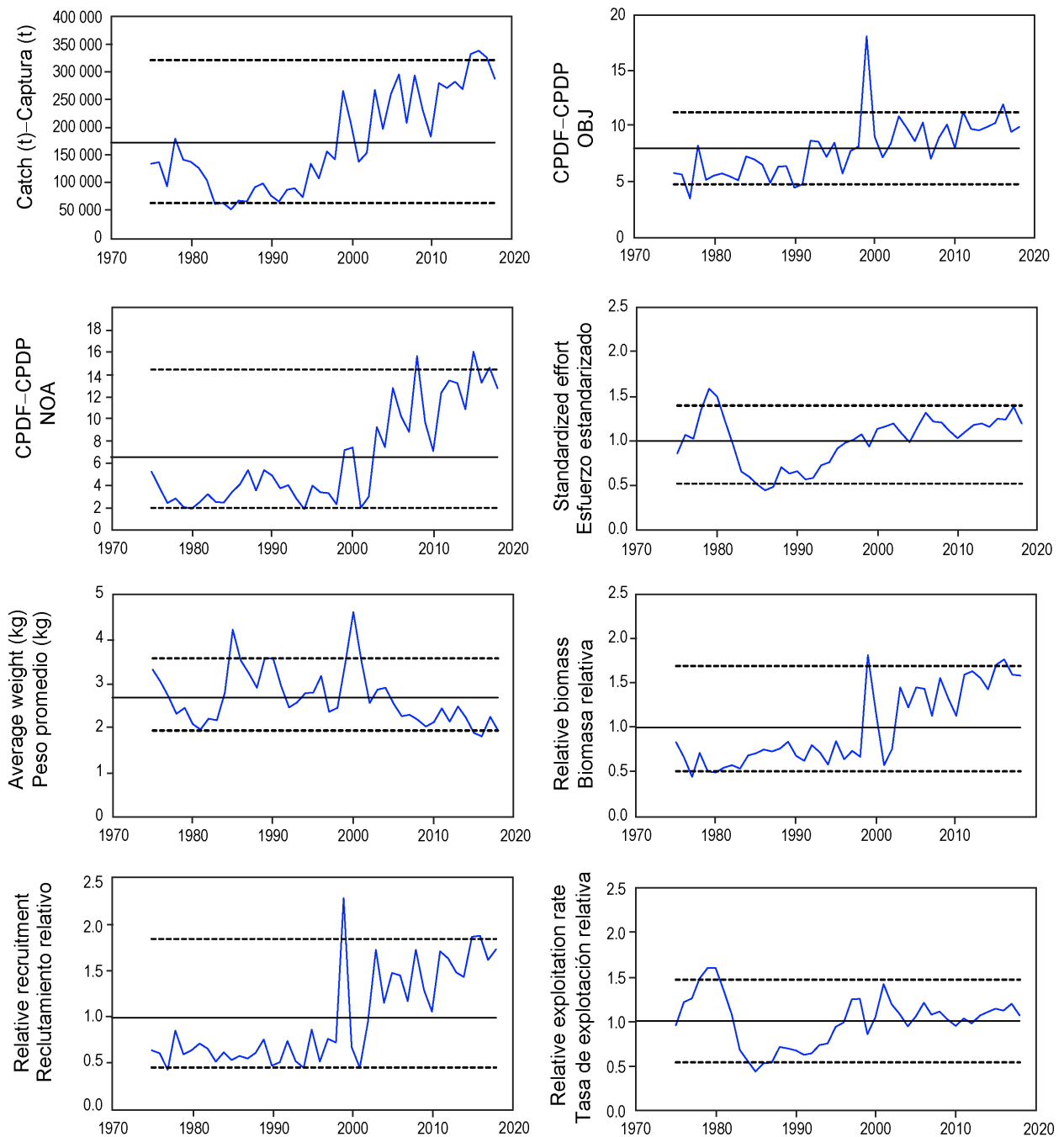


FIGURE C-2. Indicators of stock status for skipjack tuna in the eastern Pacific Ocean. OBJ: floating-object fishery; NOA: unassociated fishery; CPDF: catch per day fished. All indicators are scaled so that their average equals one.

FIGURA C-2. Indicadores de condición de la población de atún barrilete en el Océano Pacífico oriental. OBJ: pesquería sobre objetos flotantes; NOA: pesquería no asociada; CPDP: captura por día de pesca. Se ajusta la escala de todos los indicadores para que su promedio equivalga a uno.

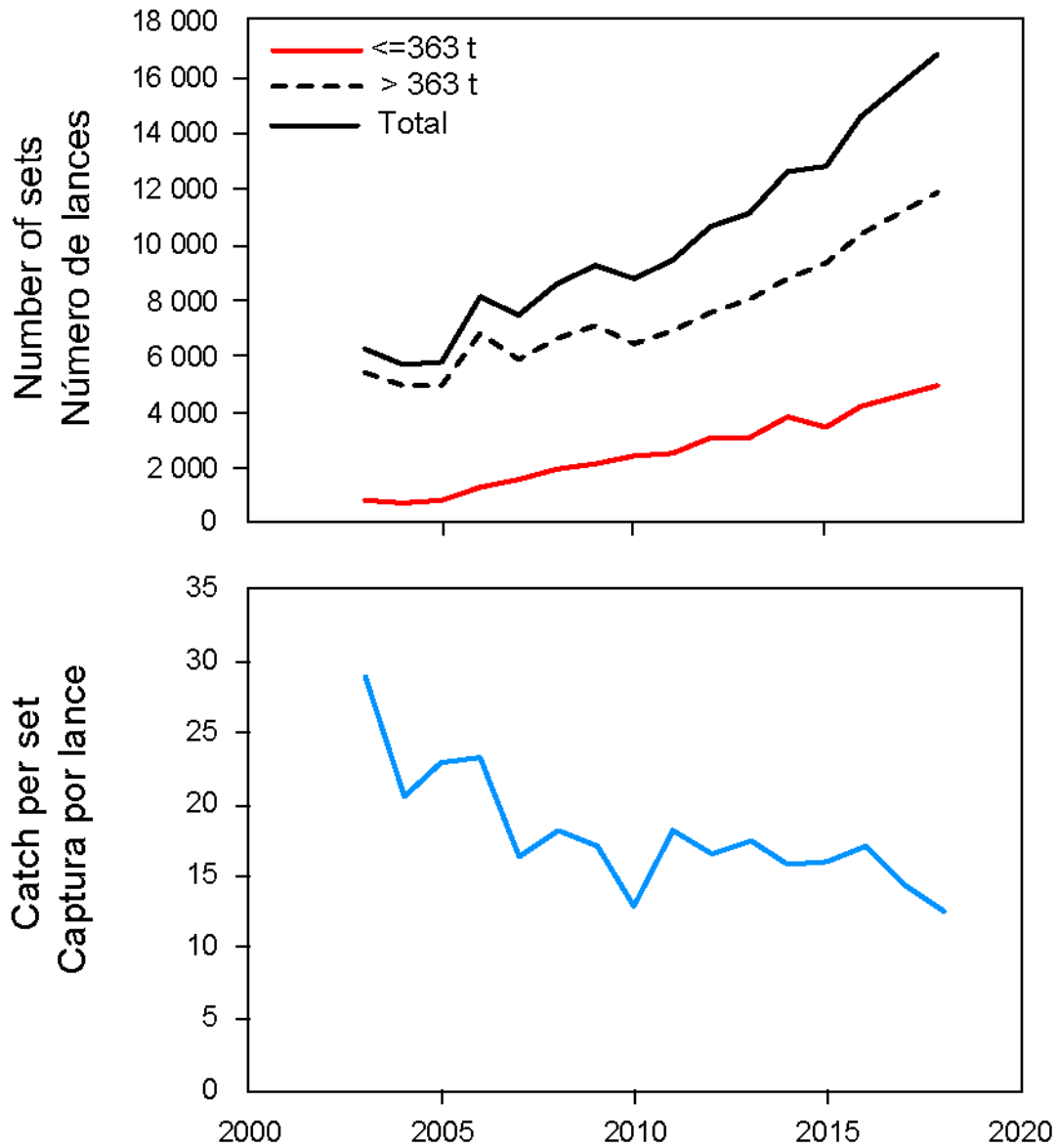


FIGURE C-3. Number of floating-object sets, by vessel carrying capacity and total (top panel), and catch per set in the floating-object fishery (bottom panel).

FIGURA C-3. Número de lances sobre objetos flotantes, por capacidad de acarreo del buque y total (recuadro superior), y captura por lance en la pesquería sobre objetos flotantes (recuadro inferior).

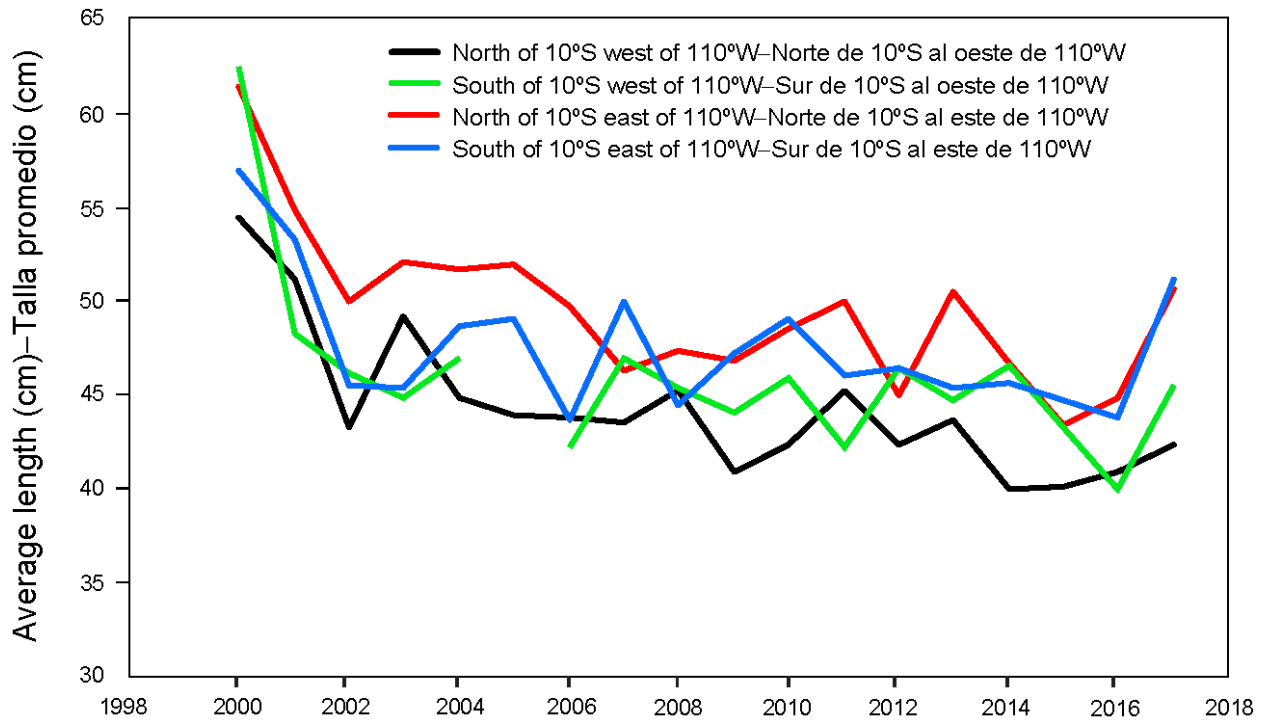


FIGURE C-4. Mean length of skipjack tuna caught in the floating-object fishery in four areas in the EPO.
FIGURA C-4. Talla promedio del atún barrilete capturado en la pesquería sobre objetos flotantes en cuatro zonas del OPO.

D. BIGEYE TUNA

For the full version of this analysis, see document [SAC-10-06](#).

Various uncertainties were identified in the update assessment of bigeye tuna conducted in 2018 ([SAC-09-05](#), [SAC-09 INF-B](#)), and its usefulness for management has been questioned. Therefore, the staff developed stock status indicators (SSIs) for bigeye, similar to those used for skipjack tuna ([SAC-09-07](#)), as an alternative basis for management advice and to monitor the stock and the fishery in the future until the uncertainties in the stock assessment are resolved (see [work plan to improve the assessments of tropical tunas](#)). The indicators are based on relative quantities; *i.e.*, instead of comparing a value with a reference point based on the maximum sustainable yield (MSY) of a species, it is compared with the distribution of its historical values.

The six purse-seine indicators are based on data for all purse-seine vessels that fished during 2000-2018, in order to exclude the period prior to the mid-1990s when purse-seine catches of bigeye were negligible (Figure D-1). The distributions of the historical values of these indicators are somewhat skewed; therefore, in order to estimate the current value of each indicator relative to its historical values, the 5th and 95th percentiles are used as reference levels.

All purse-seine SSIs, except catch, show strong trends over time, and in 2018 were at, or near, the respective reference levels, indicating high rates of exploitation, increased fishing mortality and reduced abundance of juveniles (Figure D-2). Initially, the **total purse-seine catch** of bigeye fell from its high level in 2000, resulting from favorable environmental conditions, increased during 2002-2006, and has fallen since then, except for an increase to its average level in 2018. The **catch per day fished** (CPDF) of bigeye in floating-object sets generally fell during 2000-2018, reaching the lower reference level in 2018. The **capacity of the purse-seine fleet**, adjusted for the closures, has fluctuated since 2000, but has increased in recent years, and is now at its upper reference level. Both the **number of floating-object sets** and the **number of days fished in such sets** generally increased during the whole period, and in 2018 were above the upper reference level, while the **average weight of the bigeye in the catch** has been generally decreasing, and has been at the lower reference level since 2015.

The increasing number of floating-object sets, particularly on fish-aggregating devices (FADs), and the decreasing average weight of the bigeye in the catch continue to indicate that the bigeye stock in the EPO is under increasing fishing pressure, and that measures additional to the current seasonal closures, such as limits on the number of floating-object sets, are necessary.

The staff also developed two indicators for bigeye in the EPO based on longline data: (a) **abundance indices**, standardized with a generalized linear model ([SAR-7-07](#)), and (b) **average length of the fish in the catch**. The abundance indices for the LL-C and LL-S fisheries from the last update assessment of bigeye ([SAC-09-05](#)) were updated with data for the last quarter of 2017 and the first three quarters of 2018 (Figure D-3). The resulting indices for both fisheries, but especially the LL-S fishery, are much lower than in 2017, suggesting that the abundance of adults in the EPO continues to decline. In particular, one of the three updated indices for the LL-C fishery is below that lower reference level, and all four updated indices for the LL-S fishery LL-S are near, or below, the lower reference level. It is important to note that longline indices of abundance for recent years are highly uncertain, due mainly to the decrease in both the fishing effort and spatial coverage of the Japanese longline fleet.

For the second longline indicator, in all four longline fisheries, the time series of average length of fish in the catch do not show an apparent long-term trend, and the most recent values are within the reference limits (Figure D-4).

Some analyses suggested that the method used to calculate the number of days fished on floating objects is biased towards an increasing trend in days fished, which would also bias the CPDF. The number of days

fished by set type is not easy to determine, since a vessel can make several set types in the same day, and has to be estimated using the multiple regression method. This method indicates a close correlation between the number of days fished assigned to the floating-object fishery and the number of floating-object sets ([Figure D-2](#)).

To investigate this relationship, data for vessels that made more than 50% of their sets on floating objects during 2000-2018 were analyzed. In this data set, the total number of sets and the number of floating-object sets showed a similar increasing trend over time ([Figure D-5](#)). The number of days fished and the number of vessels also increased over time, but less rapidly than the number of sets. Since the early 2000s, bigeye catch-per-set has decreased, but the CPDF has remained fairly stable. The number of days fished per vessel has declined, while the number of floating-object sets per vessel has increased. This is manifested mainly in an increase in the number of days fished with one or more sets rather than in the number of sets conducted in a single day ([Figure D-6](#)).

The reasons for the increase in the number of floating-object sets, per day and per vessel, are not clear, but it is probably due to the vessels' increased efficiency in finding FADs with tuna, thanks to the greater number of FADs and the increased use of satellite-linked fish-detecting sonar buoys ([Figure D-6](#)), and to the greater number of floating-object by vessels with DMLs ([SAC-10 INF-D](#)). This should be further investigated. The reason for the reduction in the catch per set is also not clear; it may be due to several factors, among them reduced abundance, more FADs that distribute the stock into smaller schools, or a change in fishing strategy (*e.g.* vessels choosing to fish on smaller schools).

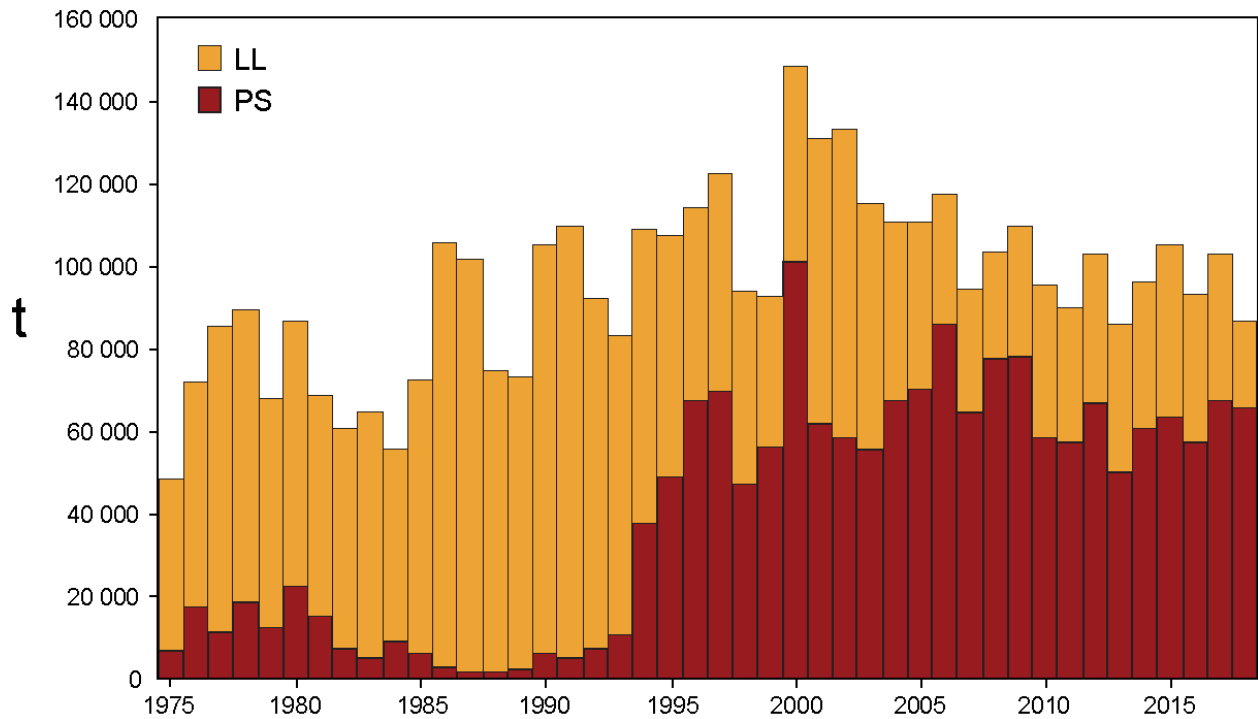


FIGURE D-1. Total catches (retained catches plus discards) by the purse-seine (PS) fisheries, and retained catches by the longline (LL) fisheries, of bigeye tuna in the eastern Pacific Ocean, 1975-2018. The purse-seine catches are adjusted to the species composition estimate obtained from sampling the catches. 2018 data are preliminary.

FIGURA D-1. Capturas totales (capturas retenidas más descartes) de las pesquerías de cerco (PS), y capturas retenidas de las pesquerías de palangre (LL), de atún patudo en el Océano Pacífico oriental, 1975-2018. Se ajustan las capturas de cerco a la estimación de la composición por especie obtenida del muestreo de las capturas. Los datos de 2018 son preliminares.

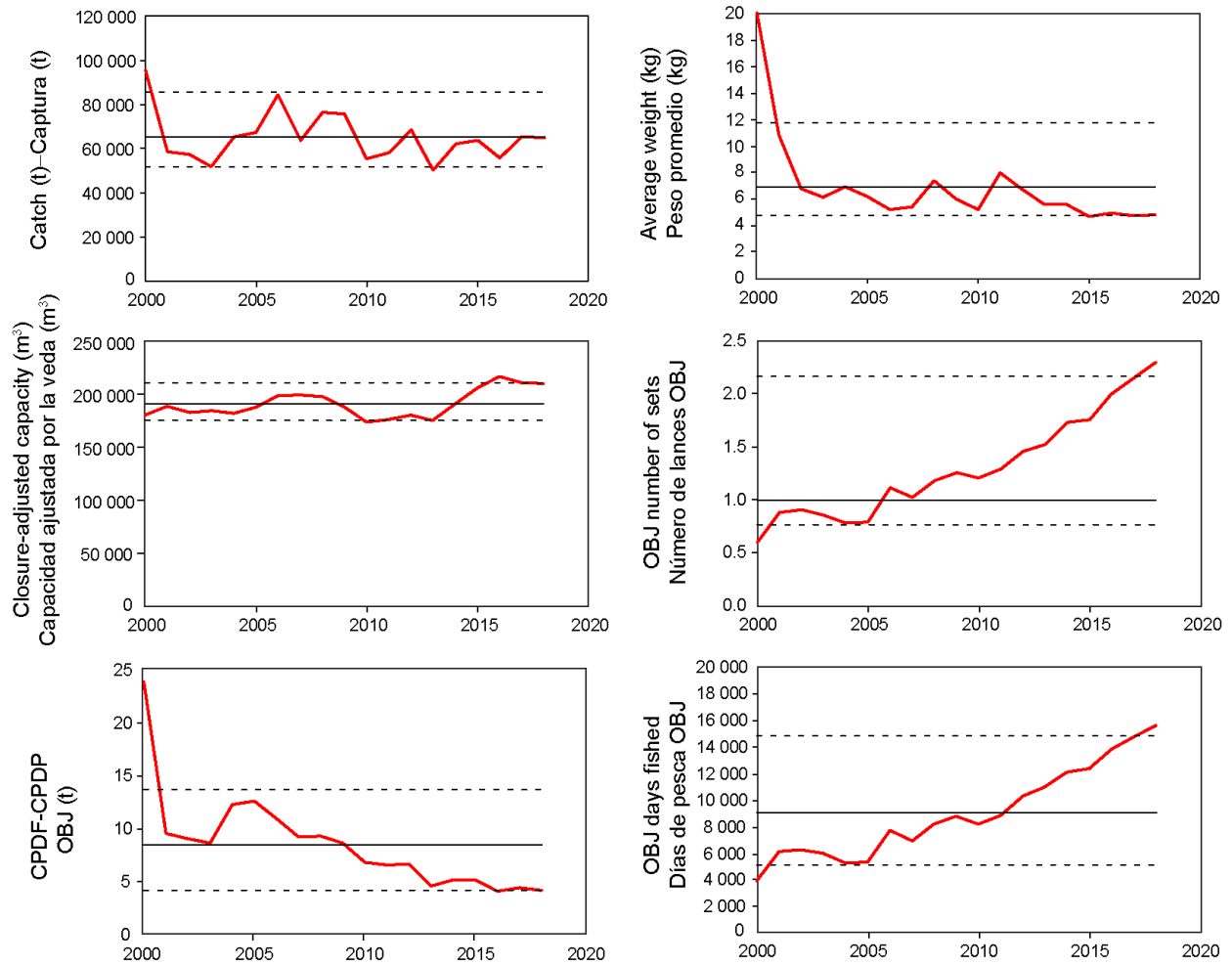


FIGURE D-2. Stock status indicators for bigeye tuna in the EPO, based on purse-seine data, 2000-2018. The dashed horizontal lines are the 5th and 95th percentiles, the solid horizontal line is the median. CPDF: catch per day fishing; OBJ: sets on floating objects.

FIGURA D-2. Indicadores de condición de población del atún patudo en el OPO, basados en datos de cerco, 2000-2018. Las líneas horizontales de trazos representan los percentiles de 5 y 95%, la línea horizontal sólida la mediana. CPDP: captura por día de pesca; OBJ: lances sobre objetos flotantes.

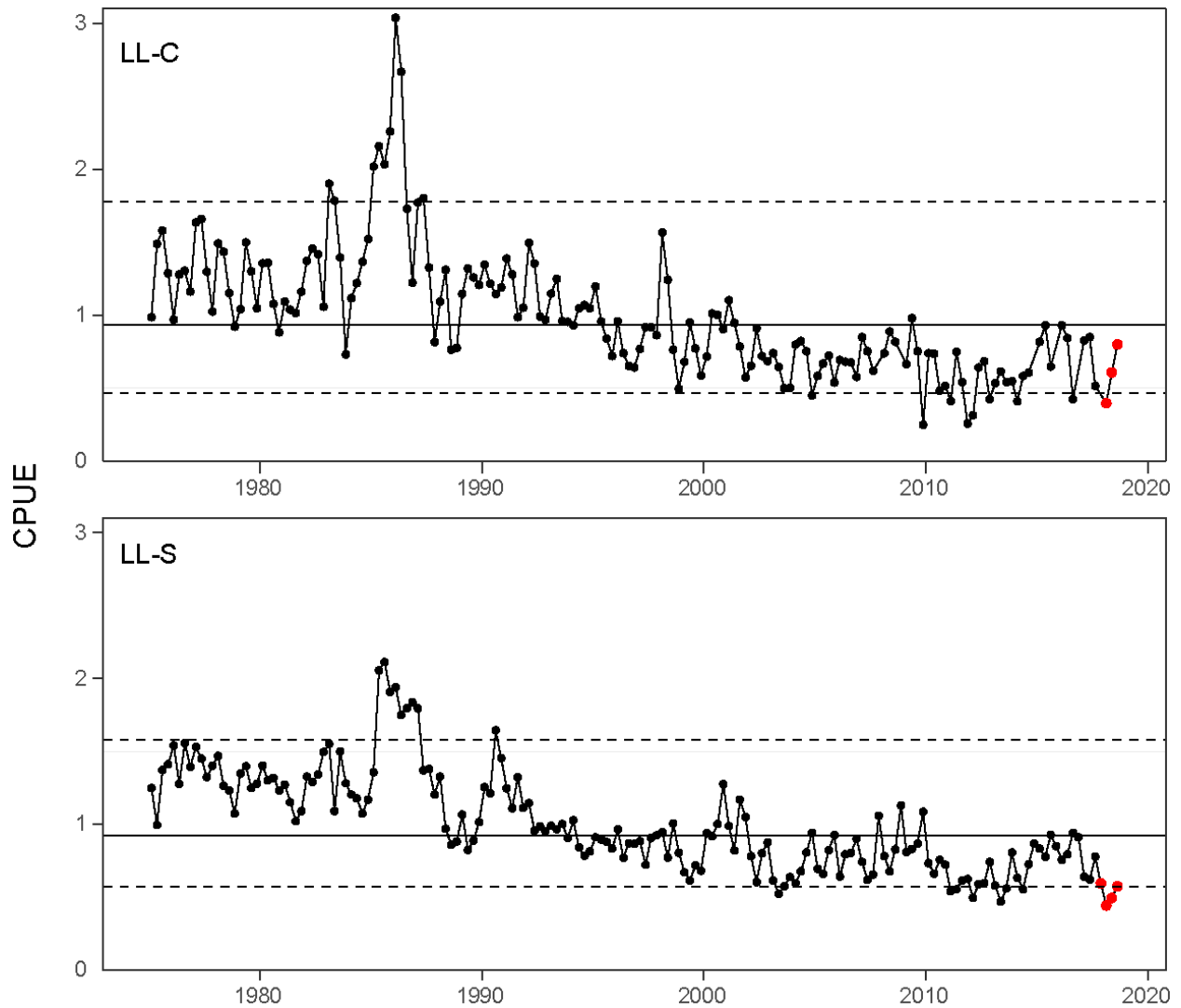


FIGURE D-3. Indices of abundance for bigeye tuna in the central (LL-C) and southern (LL-S) longline fisheries, 1975-2018. The red dots represent updated values for the the first three quarters of 2018 and, for the LL-S fishery, also the last quarter of 2017. The solid horizontal line is the median, and the two dashed horizontal lines are the 5th and 95th percentiles.

FIGURA D-3. Índices de abundancia del atún patudo en las pesquerías palangreras central (LL-C) y del sur (LL-S), 1975-2018. Los puntos rojos representan valores actualizados para los tres primeros trimestres de 2018 y, en el caso de la pesquería LL-S, el último trimestre de 2017 también. La línea horizontal sólida representa la mediana, y las dos líneas de trazos los percentiles de 5 y 95%.

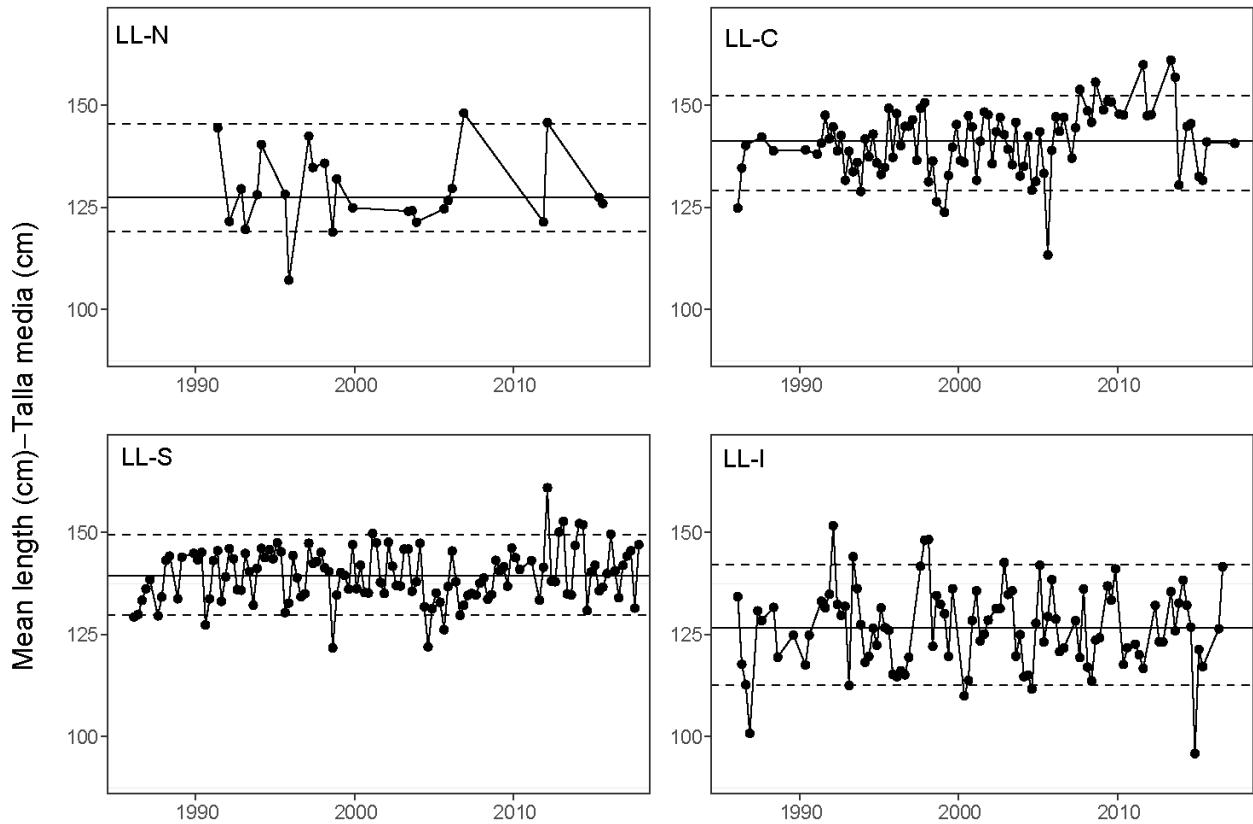


FIGURE D-4. Mean length of bigeye tuna caught in the four EPO longline fisheries, 1975-2018. The solid horizontal line is the median and the two dashed horizontal lines are the 5th and 95th percentiles.

FIGURA D-4. Talla promedio del atún patudo capturado en las cuatro pesquerías palangreras en el OPO, 1975-2018. La línea horizontal sólida representa la mediana, y las dos líneas de trazos los percentiles de 5 y 95%.

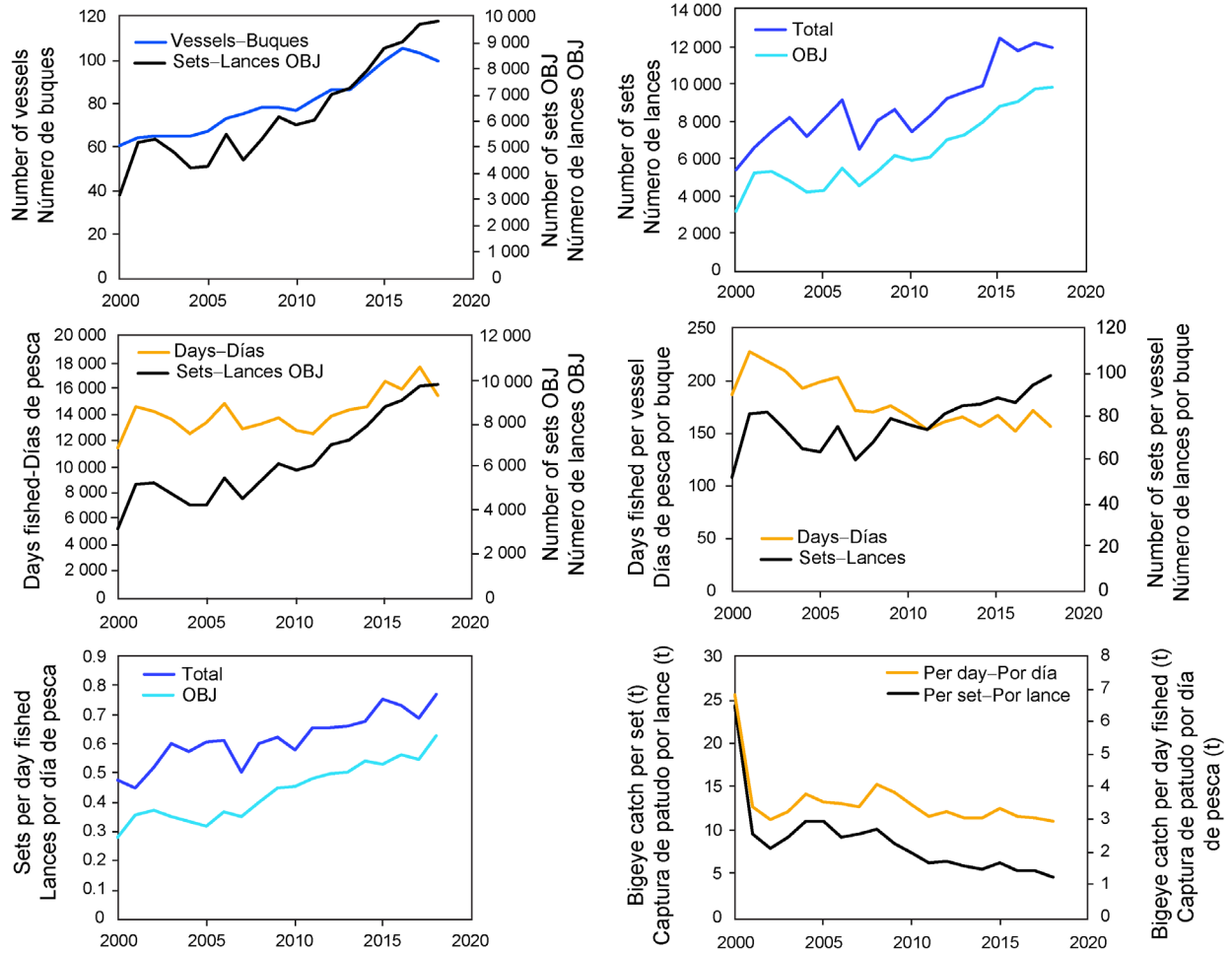


FIGURE D-5. Quantities used to investigate the relationship between days fished and the number of floating-object (OBJ) sets, 2000-2018, based on data from purse-seine vessels that made more than 50% of their sets on floating objects.

FIGURA D-5. Cantidades usadas para investigar la relación entre días de pesca y el número de lances sobre objetos flotantes (OBJ), 2000-2018, basados en datos de buques cerqueros que realizaron más del 50% de sus lances sobre objetos flotantes.

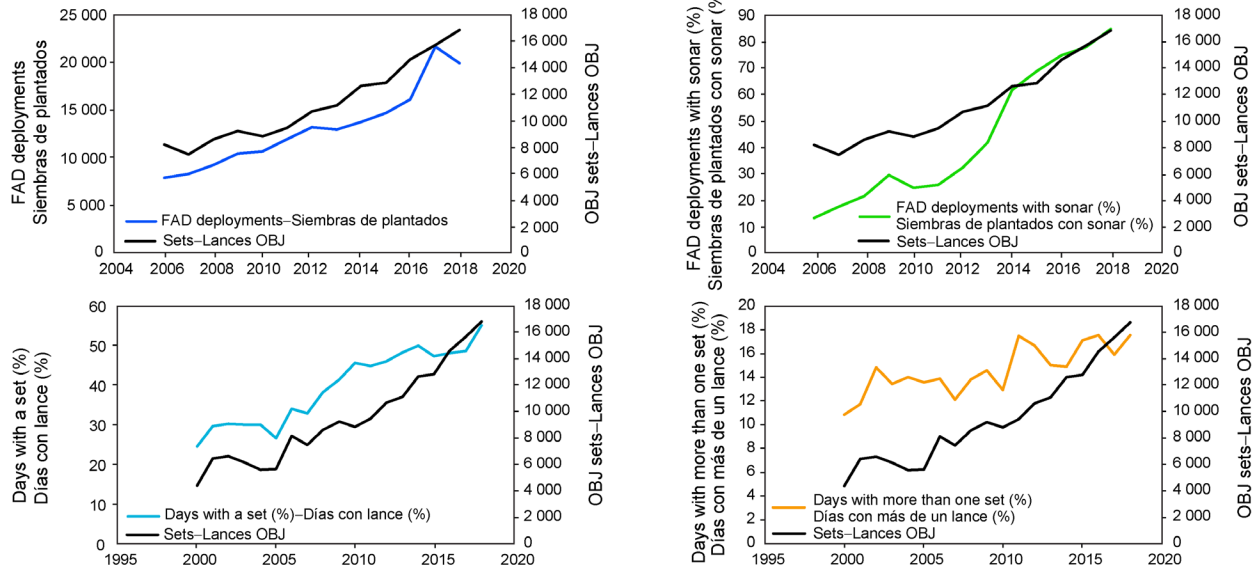


FIGURE D-6. Various quantities used to investigate the reason for the increasing number of sets. The proportion of days with a set was calculated as the annual average, for all vessels, of the proportion of days fished with one or more floating-object sets.

FIGURA D-6. Varias cantidades usadas para investigar la razón del número creciente de lances. La proporción de días con lance fue calculada como el promedio anual, para todos los buques, de la proporción de días de pesca con un lance sobre objeto flotante o más.

E. PACIFIC BLUEFIN TUNA

Tagging studies have shown that there is exchange of Pacific bluefin between the eastern and western Pacific Ocean. Larval, post larval, and early juvenile bluefin have been caught in the western Pacific Ocean (WPO), but not in the eastern Pacific Ocean (EPO), so it is likely that there is a single stock of bluefin in the Pacific Ocean (or possibly two stocks in the Pacific Ocean, one spawning in the vicinity of Taiwan and the Philippines and the other spawning in the Sea of Japan).

Most of the commercial catches of bluefin in the EPO are taken by purse seiners. Nearly all of the purse-seine catches have been made west of Baja California and California, within about 100 nautical miles of the coast, between about 23°N and 35°N. Ninety percent of the catch is estimated to have been between about 60 and 100 cm in length, representing mostly fish 1 to 3 years of age. Aquaculture facilities for bluefin were established in Mexico in 1999, and some Mexican purse seiners began to direct their effort toward bluefin during that year. During recent years, most of the catches have been transported to holding pens, where the fish are held for fattening and later sale to sashimi markets. Lesser amounts of bluefin are caught by recreational, gillnet, and longline gear. Bluefin have been caught in the EPO during every month of the year, but most of the fish are taken from May through October.

Bluefin are exploited by various gears in the WPO from Taiwan to Hokkaido, Japan. Age-0 fish, about 15 to 30 cm in length, are caught by the Japanese troll fishery during July-October south of Shikoku Island and south of Shizuoka Prefecture. During November-April, age-0 fish about 35 to 60 cm in length are taken in troll fisheries south and west of Kyushu Island. Age-1 and older fish are caught by purse seining, mostly during May-September, between about 30°-42°N and 140°-152°E. Bluefin of various sizes are also caught by traps, gillnets, and other gear, especially in the Sea of Japan. Additionally, small amounts of bluefin are caught near the southeastern coast of Japan by longlining. The Chinese Taipei small-scale longline fishery, which has expanded since 1996, takes bluefin tuna more than 180 cm in length from late April to June, when they are aggregated for spawning in the waters east of the northern Philippines and Taiwan.

The high-seas longline fisheries are directed mainly at tropical tunas, albacore, and billfishes, but small amounts of Pacific bluefin are caught by these fisheries. Small amounts of bluefin are also caught by Japanese pole-and-line vessels on the high seas.

Tagging studies, conducted with conventional and archival tags, have revealed a great deal of information about the life history of bluefin. Some fish apparently remain their entire lives in the WPO, while others migrate to the EPO. These migrations begin mostly during the first and second years of life. The first- and second-year migrants are exposed to various fisheries before beginning their journey to the EPO. Then, after crossing the ocean, they are exposed to commercial and recreational fisheries off California and Baja California. Eventually, the survivors return to the WPO.

Bluefin more than about 50 cm in length are most often found in waters where the sea-surface temperatures (SSTs) are between 17° and 23°C. Fish 15 to 31 cm in length are found in the WPO in waters where the SSTs are between 24° and 29°C. The survival of larval and early juvenile bluefin is undoubtedly strongly influenced by the environment. Conditions in the WPO probably influence recruitment, and thus the portions of the juvenile fish there that migrate to the EPO, as well as the timing of these migrations. Likewise, conditions in the EPO probably influence the timing of the return of the juvenile fish to the WPO.

The total catches of bluefin have fluctuated considerably during the last 50 years ([Figure E-1](#)). The consecutive years of above-average catches (mid-1950s to mid-1960s) and below-average catches (early 1980s to early 1990s) could be due to consecutive years of above-average and below-average recruitments. The estimated impact of the fisheries on the bluefin population for the entire time period modeled (1952-2016) is substantial ([Figure E-2](#)). The WPO fisheries have had a greater impact than the EPO fisheries, and their impact increased starting in 1980s only leveling off in 2000s.

An update stock assessment was carried out by the Pacific Bluefin Working Group of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC) in 2018. The assessment was conducted with Stock Synthesis 3, an integrated statistical age-structured stock assessment model. The base-case model results show that: (1) spawning stock biomass (SSB) fluctuated throughout the assessment period, (2) the SSB declined steadily from 1996 to 2010; and (3) the stock has been increasing slowly since 2010. Historical recruitment estimates have fluctuated since 1952 without an apparent trend. The low recruitment levels estimated in 2010-2014 were a concern in the 2016 assessment. The 2018 assessment estimate of 2015 recruitment is low, and similar to estimates from previous years, while the 2016 recruitment estimate is higher than the historical average. Initial data indicates that the 2017 recruitment is also high. There is no evidence of a stock-recruitment relationship. A substantial decrease in 2015-2016 in the estimated fishing mortality of fish of ages 0-2 was observed. Note that stricter management measures in WCPFC and IATTC have been in place since 2015.

The point estimate of the 2016 SSB was 3.3% of the SSB in the absence of fishing ($3.3\%SSB_{F=0}$), and the 2016 fishing mortality (F) corresponds to $F6.7\%SPR$. Because the harvest strategy contains catch limits, fishing mortality is expected to decline, *i.e.*, $Fx\%SPR$ will increase as biomass increases. No biomass-based limit or target reference points have been adopted to evaluate whether Pacific bluefin is overfished. However, the stock is overfished relative to common target reference points and to the IATTC limit reference point used for tropical tunas. Also, no fishing intensity-based limit or target reference points have been adopted to evaluate whether overfishing of Pacific bluefin is occurring, but the stock is subject to overfishing relative to most common fishing intensity-based reference points.

Resolution C-16-08 states that the Commission recognizes that the management objective of the IATTC is to maintain or restore fish stocks at levels capable of producing MSY, and shall implement a provisional rebuilding plan in part by adopting an initial (first) rebuilding target of $SSB_{med, 1952-2014}$ (the median point estimate for 1952-2014) to be achieved by 2024 with at least 60% probability. The IATTC has adopted resolutions to restrict the catch of bluefin tuna in the EPO. Resolution C-16-08 limits the commercial catches in the IATTC Convention Area by all CPCs to a combined total of 6,600 t during 2017-2018, respectively. No CPC shall exceed 3,500 t in 2017. In the event that the total actual catch in 2017 is either above or below 3,300 t, the catch limit for 2018 shall be adjusted accordingly to ensure that the total catch for both years does not exceed 6,600 t. Resolution C-16-08 requires that in 2018, and taking into account the outcomes of the 2nd IATTC-WCPFC NC Joint Working Group Meeting, the Commission shall adopt a second rebuilding target, to be achieved by 2030. Resolution C-16-08 also requires that no later than the IATTC meeting in 2018, taking into account the outcomes of the Joint IATTC-WCPFC NC Working Group, the Commission shall consider and develop reference points and harvest control rules for the long-term management of Pacific bluefin tuna, which should be comparable to those adopted by the WCPFC.

The harvest strategy proposed at the Joint WCPFC NC-IATTC WG meeting guided projections conducted by the ISC to provide catch reduction options if the projection results show that the initial rebuilding target will not be achieved with at least 60% probability by 2024 or to provide relevant information for a potential increase in catch if the probability of achieving the initial rebuilding target exceeds 75% by 2024. The projection based on the base-case model mimicking the current management measures by the WCPFC (CMM 2017-08) and IATTC (C-16-08) under the low recruitment scenario resulted in an estimated 98% probability of achieving the initial rebuilding target by 2024. This estimated probability is above the threshold (75% or above in 2024) prescribed by the harvest strategy. The low recruitment scenario is more precautionary than the recent 10 years recruitment scenario. In the harvest strategy, the recruitment scenario is switched from the low recruitment to the average recruitment scenario beginning in the year after achieving the initial rebuilding target. The estimated probability of achieving the second rebuilding target 10 years after the achievement of the initial rebuilding target or by 2034, whichever is earlier, is 96%. This estimate is above the threshold (60% or above in 2034) prescribed by the harvest strategy.

However, it should be recognized that these projection results are strongly influenced by the inclusion of the relatively high, but uncertain, recruitment estimate for 2016, and do not include the initial estimates of high recruitment in 2017.

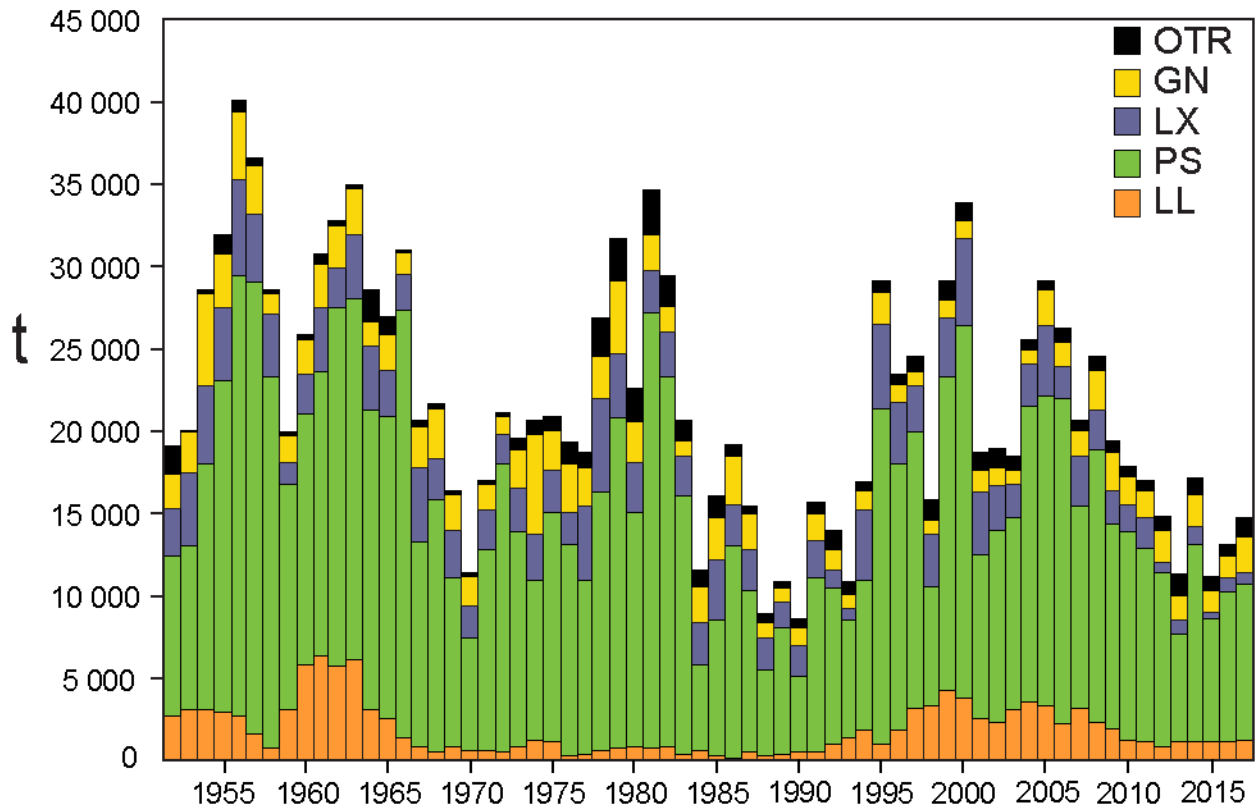


FIGURE E-1. Retained catches of Pacific bluefin tuna, by gear, 1952-2017. GN: gillnet; LL: longline; LX: hook and line; OTR: other; PS: purse seine.

FIGURA E-1. Capturas retenidas de atún aleta azul del Pacífico, por arte, 1952-2017. GN: red agallera; LL: palangre; LX: sedal y anzuelo; OTR: otras; PS: red de cerco.

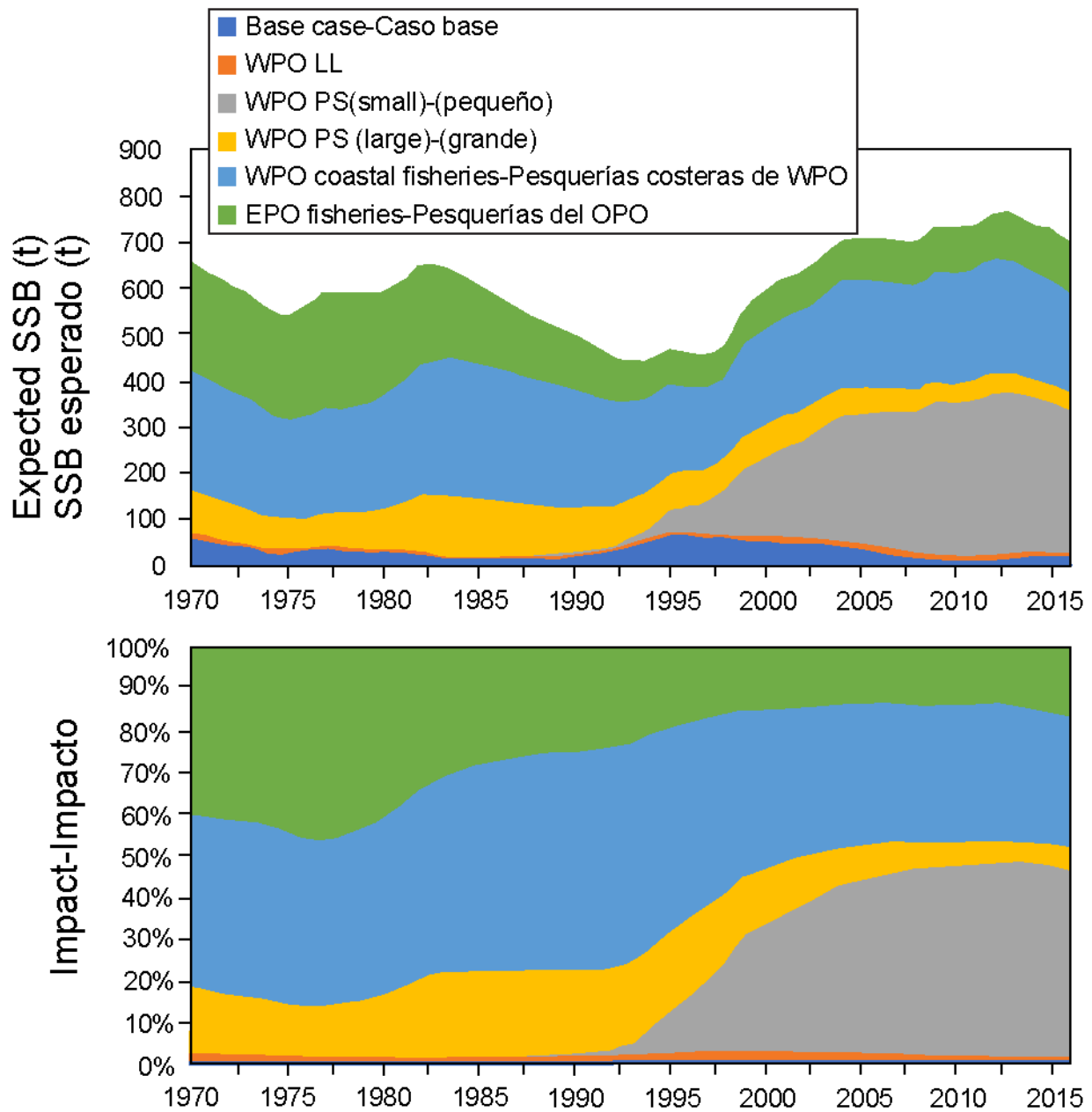


FIGURE E-2. Estimates of the impact on the Pacific bluefin tuna population of fisheries in the EPO and in the WPO (upper panel). The dashed line represents the estimated hypothetical unfished spawning biomass, and the solid line the estimated actual spawning biomass. The shaded areas indicate the impact attributed to each fishery. The lower panel presents the proportion of impact attributed to the EPO and WPO. (Figure from the draft Executive Summary of ISC 2018 stock assessment; subject to change and approval by the ISC Plenary.)

FIGURA E-2. Estimaciones del impacto sobre la población de atún aleta azul del Pacífico de las pesquerías en el OPO y en el WPO (panel superior). La línea de trazos representa la biomasa reproductora no pescada hipotética estimada, y la línea sólida la biomasa reproductora real estimada. Las áreas sombreadas indican el impacto atribuido a cada pesquería. El panel inferior ilustra la proporción del impacto atribuida al OPO y al WPO. (Figura del borrador de resumen ejecutivo de la evaluación de 2018 del ISC; sujeta a cambio y aprobación por la plenaria del ISC.)

F. ALBACORE TUNA

There are two stocks of albacore in the Pacific Ocean, one in the northern hemisphere and the other in the southern hemisphere. Albacore are caught by longline gear in most of the North and South Pacific, but not often between about 10°N and 5°S, by trolling gear in the eastern and central North and South Pacific, and by pole-and-line gear in the western North Pacific. In the North Pacific in 2017, 43% of the catch was taken by pole-and-line and troll fisheries that catch smaller, younger albacore, and about 50% was taken by longline. In the South Pacific, 97% of the albacore was taken by longline in 2017. The total annual catches of South Pacific albacore ranged from about 25,000 to 50,000 t during the 1980s and 1990s, but increased after that, and during 2015–2017 averaged about 81,000 t ([Figure F-1a](#)), of which about 30% was taken in the eastern Pacific Ocean (EPO). The total annual catches of North Pacific albacore peaked in 1976 at about 125,000 t, declined to about 38,000 t in 1991, and then increased to about 122,000 t in 1999 ([Figure F-1b](#)). They declined again in the early 2000s, then recovered, but since 2012 they have declined from about 92,000 to about 55,000 t in 2017, averaging about 62,000 t in 2015–2017, of which 26% was taken in the EPO.

Juvenile and adult albacore are caught mostly in the Kuroshio Current, the North Pacific Transition Zone, and the California Current in the North Pacific and in the Subtropical Convergence Zone in the South Pacific, but spawning occurs in tropical and subtropical waters, centering around 20°N and 20°S latitudes. North Pacific albacore are believed to spawn between March and July in the western and central Pacific.

The movements of North Pacific albacore are strongly influenced by oceanic conditions, and migrating albacore tend to concentrate along oceanic fronts in the North Pacific Transition Zone. Most of the catches are made in water temperatures between about 15° and 19.5°C. Details of the migration remain unclear, but juvenile fish (2- to 5-year-olds) are believed to move into the eastern Pacific Ocean (EPO) in the spring and early summer, and return to the western and central Pacific, perhaps annually, in the late fall and winter, where they tend to remain as they mature. This pattern may be complicated by sex-related movements of large adult fish (fork length >125 cm), which are predominately male, to areas south of 20°N. The significance of such movements for the demographic dynamics of this stock are uncertain at present.

Less is known about the movements of albacore in the South Pacific Ocean. The juveniles move southward from the tropics when they are about 35 cm long, and then eastward along the Subtropical Convergence Zone to about 130°W. When the fish approach maturity they return to tropical waters, where they spawn. Recoveries of tagged fish released in areas east of 155°W were usually made at locations to the east and north of the release site, whereas those of fish released west of 155°W were usually made at locations to the west and north of the release site.

The most recent published stock assessments for the South and North Pacific stocks of albacore are from 2018 and 2017, respectively. The assessments indicate that it is not likely that either stock is overfished or that overfishing is taking place.

South Pacific albacore

The [assessment of South Pacific albacore](#) carried out in 2018 by scientists of the Secretariat of the Pacific Community, using MULTIFAN-CL, covered the 1960–2016 period, and incorporated catch-and-effort, length-frequency, and tagging data, and information on biological parameters. As in the [2015 assessment](#), the eastern boundary is at 130°W, so not all the catches from the EPO are included. A summary of the conclusions can be found [here](#). The changes from the previous assessment include simplifying the regional structure (from eight to five regions), the inclusion of abundance indices based on standardized operational-level longline data (including Japan) using indices of abundance derived from CPUE standardized using spatiotemporal models and updates maturity at length. Results were reported for a diagnostic case and for an uncertainty grid, which considers key sensitivities. Contradictory signals about stock status

were found: a strong signal in the size data that fishing has no impact, and a strong signal in the CPUE data that abundance is declining. The results in the uncertainty grid were highly variable, but no model suggested overfishing or an overfished state, according to the WCPFC [limit reference point](#) of 20% of the spawning stock biomass (SSB) in the absence of fishing ($20\%SSB_{F=0}$). Fishing mortality (F) generally increased up to about 2012, but has declined sharply in recent years, and is below the MSY level ($F_{2012-2015}/F_{MSY}$ ranged from 0.06 to 0.53). The SSB has declined over time, but increased slightly recently, and in 2016 was above the MSY level (base case SSB_{2016}/SSB_{MSY} ranged from 1.45 to 10.74). It is important to note that SSB_{MSY} is lower than the WCPFC limit reference point ($SSB_{MSY}/SSB_{F=0}$ ranges from 0.06 to 0.22). Notwithstanding these results, the assessment recommended that the WCPFC consider reducing longline fishing mortality and longline catches to avoid a decline in the vulnerable biomass and maintain economically-viable catch rates. The IATTC staff plans to undertake an assessment of south Pacific albacore in collaboration with the SPC during 2021-2022 ([SAC-10-01](#)), pending funding ([IATTC-93-06c](#)).

North Pacific albacore

Resolution C-05-02 on North Pacific albacore, supplemented by Resolution C-13-03 (amended by Resolution C-18-03), requires that the total level of fishing effort for North Pacific albacore tuna in the EPO not be increased beyond 2002-2004 levels. During 2015-2017 the total effort was 17,489 vessel-days (53% of the 2002-2004 reference level), and the average number of vessels operating was 696 (77% of the 2002-2004 level).

An assessment of North Pacific albacore, using fisheries data through 2015, was conducted in April 2017 at a workshop of the Albacore Working Group (ALBWG) of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC). The stock was assessed using an age- and sex-structured Stock Synthesis (SS version 3.24AB) model fitted to time series of standardized CPUE and size-composition data.

The stock assessment results allowed for the following conclusions:

1. The base-case model estimates that the spawning stock biomass (SSB) declines during 1993-2000, after which it becomes relatively stable. The SSB has likely fluctuated between 70,000 and 140,000 t during the assessment period (1993-2015), although those estimates are highly uncertain (coefficient of variation \approx 40%, [Figure F-2](#)), and the recruitment has averaged about 204 million fish annually during this period. Female SSB was estimated to be approximately 81,000 t (95% confidence interval 16,500 -145,000) in the terminal year of the assessment (2015), and stock depletion is estimated to be about 47% of unfished SSB.
2. The estimated current (2015) spawning potential ratio (SPR; the ratio of the expected lifetime reproductive potential of an average recruit with and without fishing) is 0.53, which corresponds to a relatively low exploitation level (*i.e.*, $1-SPR = 0.47$). Instantaneous fishing mortality at age (F -at-age) is similar for both sexes through age 5, peaking at age 4 and declining to a low at age 6, after which males experience higher F -at-age than females up to age 13. Juvenile albacore (aged 2 to 4 years) comprised, on average, 70% of the annual catch during 1993-2015, reflecting the larger impact of the surface fisheries (primarily troll and pole-and-line), which catch juvenile fish, relative to longline fisheries, which catch mainly adult fish.
3. The Kobe plot ([Figure F-3](#)) depicts the status of the stock in relation to MSY-based and MSY proxy reference points from the base-case model. The plot is presented for illustrative purposes only, since the IATTC has not established biological reference points for north Pacific albacore. The ISC Working Group concluded that the stock is likely not overfished at present, as there is little evidence from the assessment that fishing has reduced SSB below reasonable biomass-based reference points, including the limit reference point adopted by the WCPFC ($20\%SSB_{F=0}$).

4. Under the base-case model, the point estimate of MSY is 132,072 t, and the point estimate of the spawning biomass that will produce MSY (SSB_{MSY}) is 24,770 t. The ratio of current (2012-2014 average) F to F at the MSY level (F_{MSY}) is estimated to be 0.61, indicating that overfishing is not occurring. That ratio is also below the 2002-2004 level of 0.65 used as reference for IATTC conservation and management measures for North Pacific albacore
5. The Working Group concluded that the north Pacific albacore stock is likely not overfished and not experiencing overfishing, based on several potential reference points. The current level of fishing mortality ($F_{2012-2014}$) is estimated to be below that of $F_{2002-2004}$, which had led previously to conservation and management measures for the stock (IATTC Resolutions C-05-02 and C-13-03 and WCPFC CMM 2005-03). There is no evidence that fishing has reduced SSB below the WCPFC limit reference point, and population dynamics in the north Pacific albacore stock are largely driven by recruitment, which is affected by both environmental changes and the stock-recruitment relationship. The Working Group concluded that the north Pacific albacore stock is healthy, and that current productivity is sufficient to sustain recent fishing mortality levels, assuming average historical recruitment in both the short and long term.

The Working Group is currently undertaking a Management Strategy Evaluation (MSE) for the North Pacific albacore stock with the assistance of an analyst hired by the United States. An [overview of the MSE work \(SAC-10 INF-L\)](#) was presented during the 10th Meeting of the Scientific Advisory Committee in May 2019. The next North Pacific albacore stock assessment will be conducted in 2020.

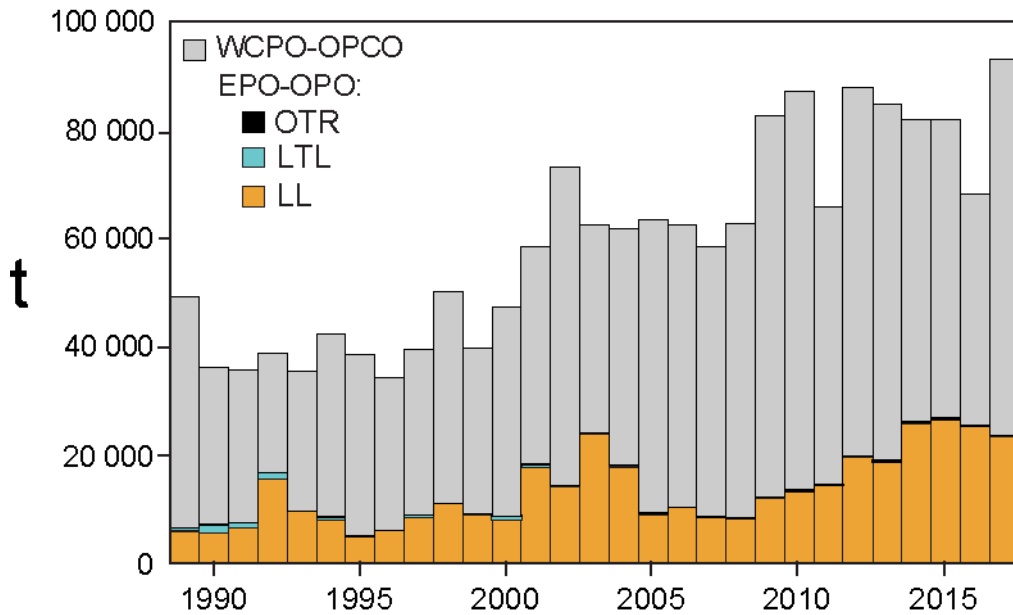


FIGURE F-1a. Retained catches of South Pacific albacore, by region. EPO catches broken down by gear: LL: longline; LTL: troll; OTR: other

FIGURA F-1a. Capturas retenidas de albacora del Pacífico sur, por región. Capturas del OPO desglosadas por arte: LL: palangre; LTL: curricán; OTR: otro.

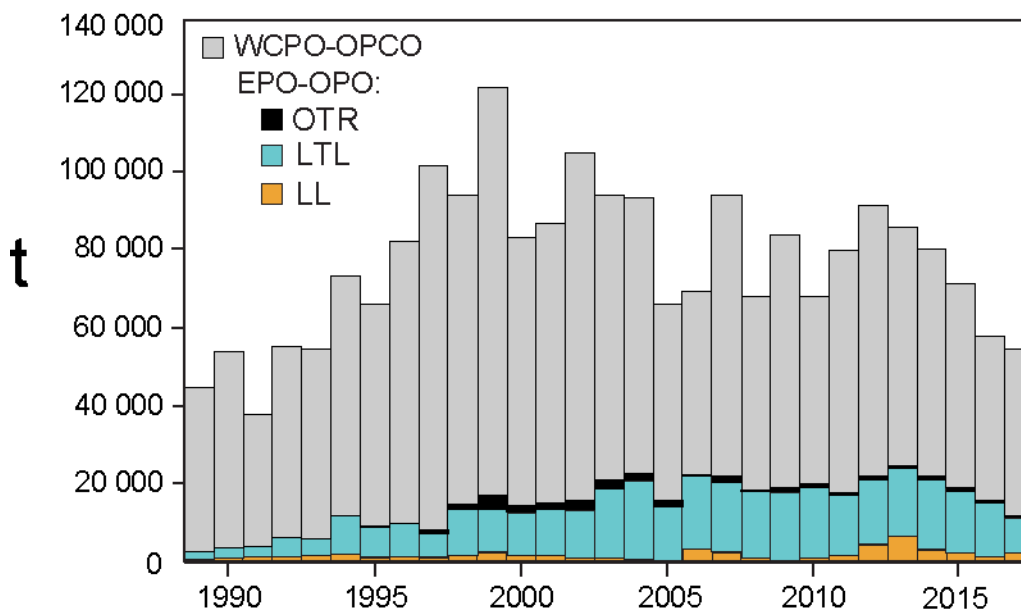


FIGURE F-1b. Retained catches of North Pacific albacore, by region. EPO catches broken down by gear: LL: longline; LTL: troll; OTR: other.

FIGURA F-1b. Capturas retenidas de albacora del Pacífico norte, por región. Capturas del OPO desglosadas por arte: LL: palangre; LTL: curricán; OTR: otro.

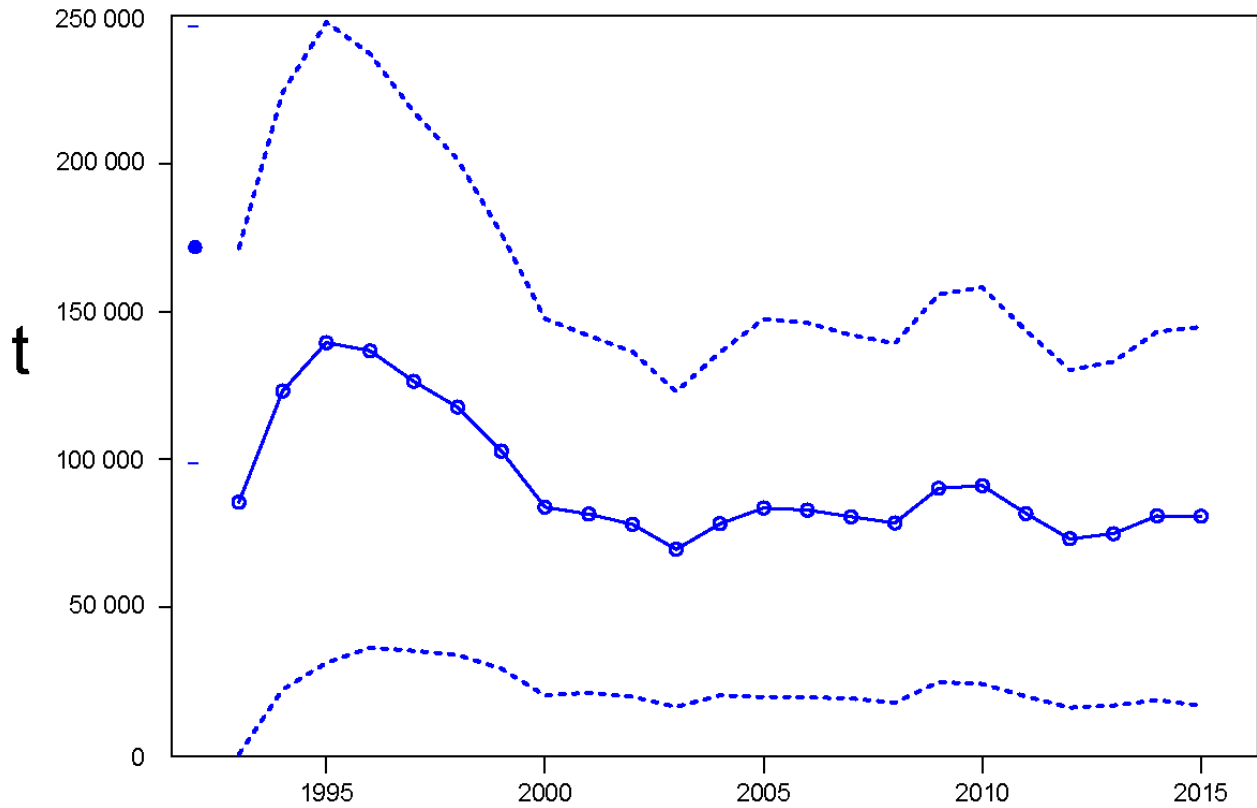


FIGURE F-2. Spawning stock biomass of North Pacific albacore tuna estimated from the North Pacific albacore base-case model for the 2017 stock assessment. Solid line: point estimate; dashed lines: 95% confidence intervals.

FIGURA F-2. Biomasa de la población reproductora del atún albacora del Pacífico norte, estimada del modelo de caso base de la evaluación de 2017. Línea sólida: estimación puntual; líneas de trazos: intervalos de confianza de 95%.

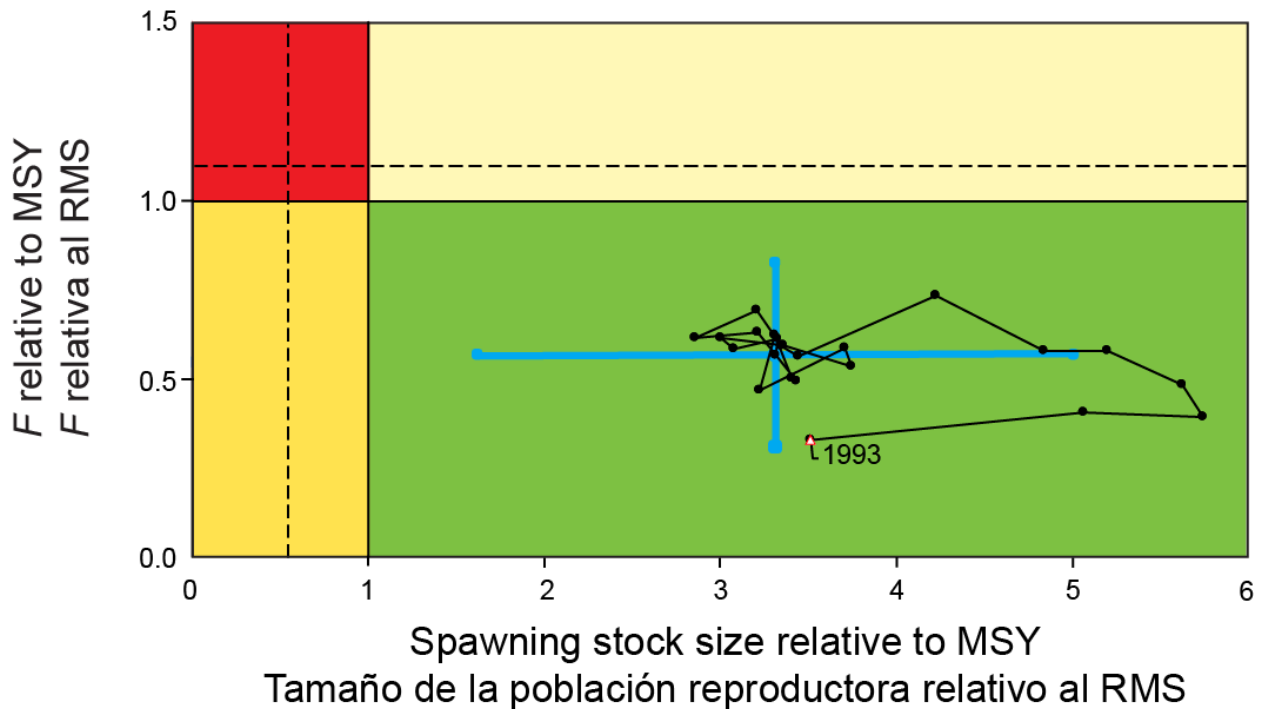


FIGURE F-3. Kobe (phase) plot for the North Pacific albacore stock from the base-case assessment model (which assumes a steepness value of 0.9). The F proxy is computed as $(1 - (\text{Spawning biomass per recruit [year]} / \text{Spawning biomass per recruit [virgin]}))$. The limit and target reference points are those proposed by the IATTC staff and are included here for illustrative purposes. The solid lines represent the proposed target reference point. The dashed lines represent the proposed limit reference points. The limit biomass reference point corresponds to a depletion level that causes a 50% reduction in recruitment from its average unexploited level based on a conservative steepness value ($h = 0.75$). The limit fishing mortality reference point corresponds to the fishing mortality that will drive the population to the limit biomass reference point. The squares around the most recent estimate represent its approximate 95% confidence interval. The triangle is the first estimate (1993).

FIGURA F-3. Gráfica de Kobe (fase) para la población de atún albacora del Pacífico norte del modelo de evaluación de caso base (que supone un valor de inclinación de 0.9). Se computa la aproximación de F como $(1 - (\text{Biomasa reproductora por recluta [año]} / \text{Biomasa reproductora por recluta [virgen]}))$. Los puntos de referencia límite y objetivo son los propuestos por el personal de la CIAT, y se incluyen aquí con fines ilustrativos. Las líneas de trazos representan los puntos de referencia límite propuestos. Las líneas de trazos representan los puntos de referencia límite propuestos. El punto de referencia límite basado en biomasa corresponde a un nivel de merma que causa una reducción de 50% del reclutamiento relativo a su nivel medio sin explotación basado en un valor cauteloso de la inclinación ($h = 0.75$). El punto de referencia límite basado en mortalidad por pesca corresponde a la mortalidad por pesca que impulsará a la población al punto de referencia límite basado en biomasa. Los cuadrados alrededor de la estimación más reciente representan su intervalo de confianza de 95% aproximado. El triángulo es la primera estimación (1993).

G. SWORDFISH

Swordfish (*Xiphias gladius*) occur throughout the Pacific Ocean between about 50°N and 50°S. They are caught mostly by the longline fisheries of Far East and Western Hemisphere nations. Lesser amounts are taken by gillnet and harpoon fisheries. They are seldom caught in the recreational fishery.

Swordfish grow in length very rapidly, with both males and the faster-growing females reaching lower-jaw-fork lengths of more than a meter during their first year. Swordfish begin reaching maturity at about two years of age, when they are about 150 to 170 cm in length, and by age four all are mature. They probably spawn more than once per season. For fish greater than 170 cm in length, the proportion of females increases with increasing length.

Swordfish tend to inhabit waters further below the surface during the day than at night, and they tend to inhabit frontal zones. Several of these occur in the eastern Pacific Ocean (EPO), including areas off California and Baja California, off Ecuador, Peru, and Chile, and in the equatorial Pacific. Swordfish tolerate temperatures of about 5° to 27°C, but their optimum range is about 18° to 22°C, and larvae have been found only at temperatures exceeding 24°C.

The stock structure of swordfish in the Pacific is fairly well known. A number of specific spawning regions are known, and analyses of fisheries and genetic data suggest that there is only limited exchange of swordfish between geographical areas, including between the eastern and western, and the northern and southern, Pacific Ocean.

The best available scientific information from genetic and fishery data indicate that the swordfish of the northeastern Pacific Ocean (NEPO) and the southeastern Pacific Ocean (SEPO: south of about 5°S) constitute two distinct stocks. Also, there may be occasional movement of a northwestern Pacific stock of swordfish into the EPO at various times. However, recent electronic tagging of 47 swordfish off the southern California coast suggests that there may be more mixing of fish between northern and southern regions of the EPO—and possibly eastern and western—than previously thought. To this point, however, assessments of eastern Pacific stocks did not include parameters for movements among these or other stocks.

The results of an assessment of a North Pacific swordfish stock in the area north of 10°N and west of 140°W indicate that the biomass level has been stable and well above 50% of the unexploited levels of stock biomass, indicating that these swordfish are not overexploited at current levels of fishing effort. A more recent analysis for the Pacific Ocean north of the equator, using a sex-specific age-structured assessment method, indicated that, at the current level of fishing effort, there is negligible risk of the spawning biomass decreasing to less than 40% of its unfished level. A stock assessment of the western and central North Pacific stock completed by the ISC in 2018 concluded that, relative to MSY-based reference points, in 2016 the stock was probably not overfished and was probably not experiencing overfishing, as the SPR_{MSY} (the spawning potential ratio at MSY) was 18%.

The standardized catches per unit of effort of the longline fisheries in the North EPO and trends in relative abundance obtained from them do not indicate declining abundances. Attempts to fit production models to the data failed to produce estimates of management parameters, such as maximum sustainable yield (MSY), under reasonable assumptions of natural mortality rates, due to lack of contrast in the trends. This lack of contrast suggests that the fisheries in this region have not been of magnitudes sufficient to cause significant responses in the populations. Based on these considerations, and the long period of relatively stable catches (Figure G-1), it appears that swordfish are not overfished in the North EPO.

In the North EPO the annual longline fishing effort, despite an increase from about 23.7 million hooks in 2007 to about 43.9 million in 2011, remains significantly below the 2001–2003 average of 70.4 million hooks. Since about 2006 the catch of swordfish has remained directly proportional to longline fishing effort. Considering the continuing relatively low fishing effort and the direct response of catch to effort, at the current

level of fishing effort there is negligible risk of the spawning biomass decreasing to less than 40% of its unfished level.

The most recent assessment of the stock of swordfish in the South EPO was conducted with Stock Synthesis, using data updated to April 2011. The key results from that assessment were that (1) the swordfish stock in the South EPO was not experiencing overfishing and was not overfished; and (2) the spawning biomass ratio was about 1.45, indicating that the spawning biomass was about 50% above the carrying capacity, and substantially above the level expected to produce catch at the MSY level. There was no indication of a significant impact of fishing on this stock. The results of the assessment did suggest an expansion of the fishery to components of the stock that were previously not, or only lightly, exploited. This subsequently been supported by a metadata analysis of the EPO longline fishery data (SAC-08-07b), which showed that longline effort increased steadily during 2008-2016, from 111 to 174 million hooks.

In the South EPO catches have been steadily increasing since about 2005, and the average annual catch during 2013–2017 (29,232 t) exceeded the estimated MSY (~25,000 t) (Figure G-2).

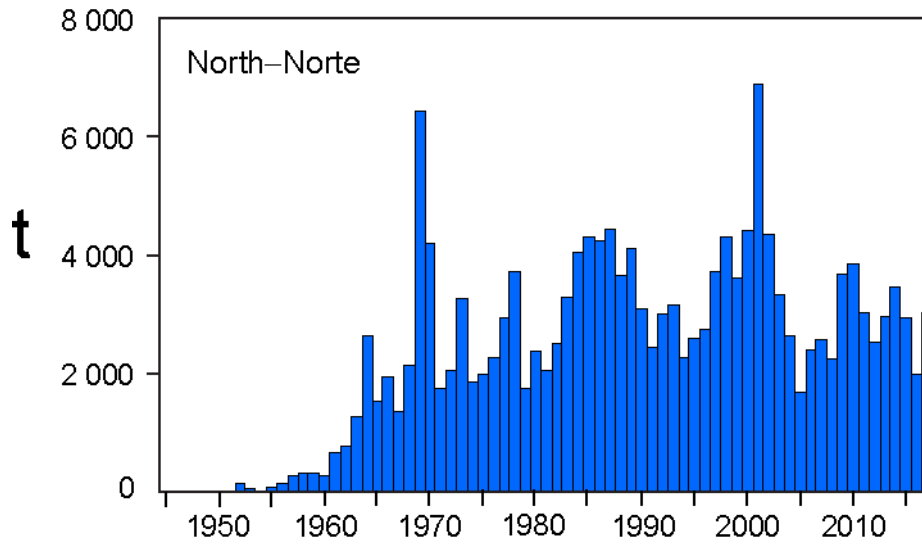


FIGURE G-1. Retained catches of swordfish in the North EPO.
FIGURA G-1. Capturas retenidas de pez espada en el OPO Norte.

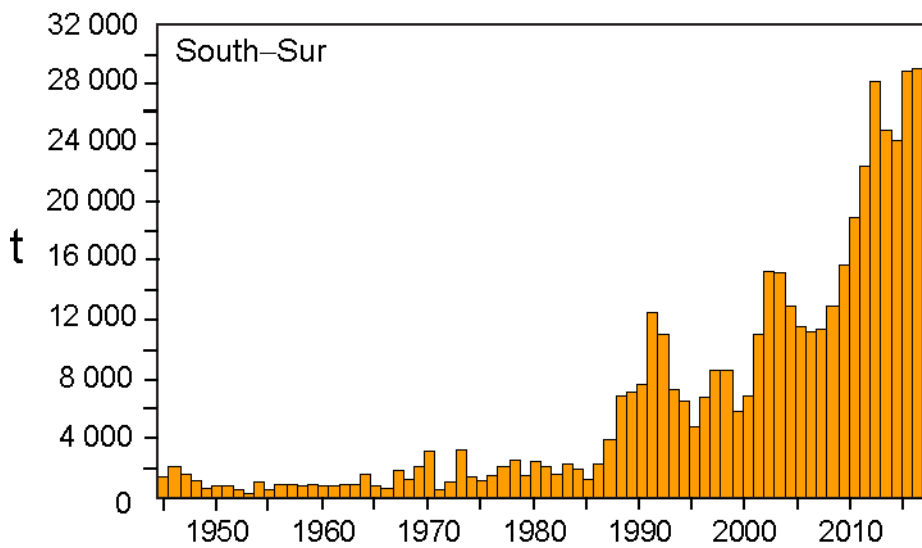


FIGURE G-2. Retained catches of swordfish in the South EPO.
FIGURA G-2. Capturas retenidas de pez espada en el OPO Sur.

H. BLUE MARLIN

The best information currently available indicates that blue marlin constitutes a single world-wide species and that there is a single stock of blue marlin in the Pacific Ocean. For this reason, statistics on catches (Figure H-1) are compiled, and analyses of stock status are made, for the entire Pacific Ocean.

Blue marlin are taken mostly in longline fisheries for tunas and billfishes between about 30°N and 30°S. Lesser amounts are taken by recreational fisheries and by various other commercial fisheries.

Small numbers of blue marlin have been tagged with conventional dart tags, mostly by recreational fishers. A few of these fish have been recaptured long distances from the locations of release. Blue marlin have been tagged in studies of post-release survival and movement, mostly in the Gulf of Mexico and the Atlantic Ocean, using electronic pop-up satellite tags (PSATs) that collected data over periods of about 30-180 days. A number of similar studies are currently being undertaken in the Pacific Ocean as part of the International Gamefish Association's "Great Marlin Race" tagging program.

Blue marlin usually inhabit regions where the sea-surface temperatures (SSTs) are greater than 24°C, and spend about 90% of their time at depths with temperatures within 1° to 2° of the SSTs.

The most recent full assessment of the status and trends of the species was conducted in 2013, and included data through 2011. It indicated that blue marlin in the Pacific Ocean were fully exploited, *i.e.* that the population was being harvested at levels producing catches near the top of the yield curve. Over the past five years (2014-2018), however, annual catches have increased slightly in the EPO, averaging 4,382 t, indicating that catches may currently be exceeding MSY.

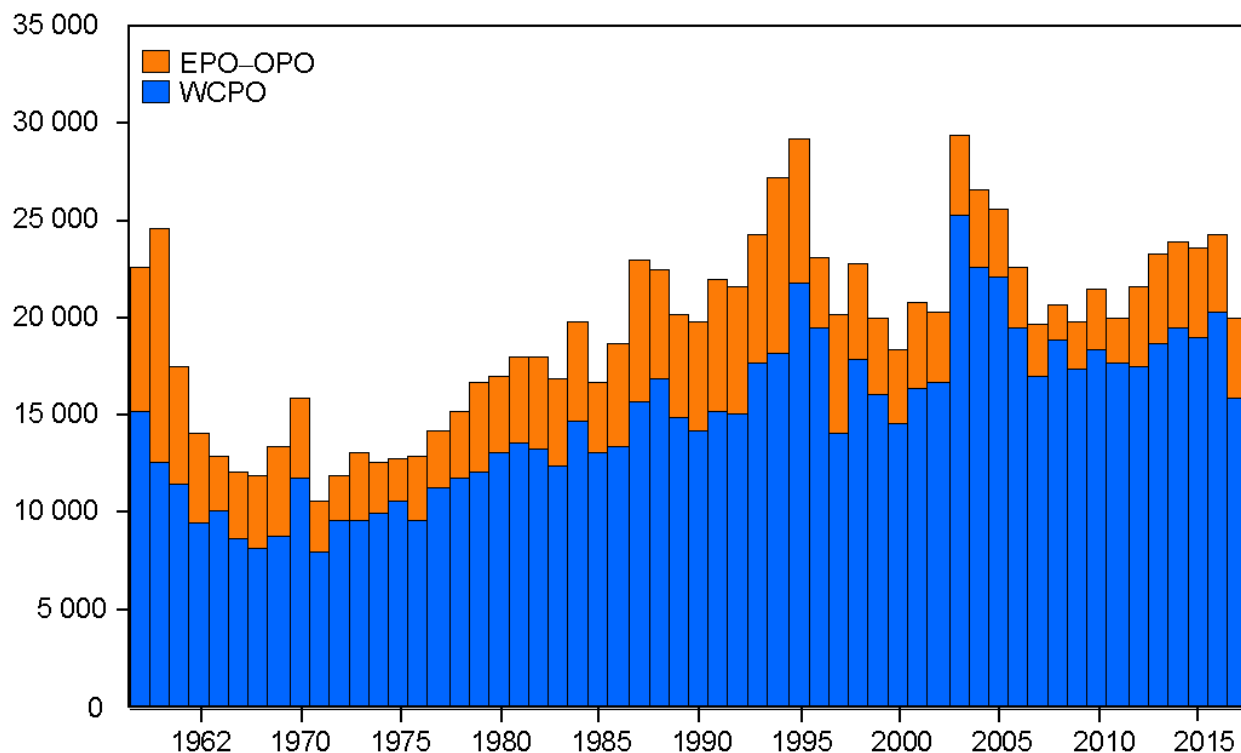


FIGURE H-1. Retained catches of blue marlin in the Pacific Ocean, by region.

FIGURA H-1. Capturas retenidas de marlín azul en el Océano Pacífico, por región.

I. STRIPED MARLIN

Striped marlin (*Kajikia audax*) occur throughout the Pacific Ocean between about 45°N and 45°S. The assessment on which this report is based is for the stock of striped marlin in the eastern Pacific Ocean (EPO) north of 10°S, east of about 145°W north of the equator, and east of about 165°W south of the equator. Although not included in the assessment model, there may be limited exchange of fish between this stock and stocks in adjacent regions.

Significant effort has been devoted to understanding the stock structure of striped marlin in the Pacific Ocean, which is moderately well known. It is clear that there are a number of stocks. Information on movements is limited: striped marlin tagged with conventional dart tags and released off the tip of Baja California were generally recaptured near where they were tagged, but some were recaptured around the Revillagigedo Islands, a few around Hawaii, and one near Norfolk Island, off Australia. Tagging studies in the Pacific, using pop-off satellite tags, indicated that there is essentially no mixing among tagging areas, and that striped marlin maintain site fidelity. Analyses of fisheries and genetic data indicate that the northern EPO is home to a single stock, though there may be a seasonal low-level presence of juveniles from a more westerly Hawaii/Japan stock.

Historically, the majority of the catch in the EPO was taken by longline fisheries, which began expanding into the EPO in the mid-1950s, and extended throughout the region by the late 1960s. Except for a few years in the late 1960s to early 1970s in the northern EPO, these fisheries did not target billfish. More recently, catches by recreational fisheries have become important, although most fish caught are released ([Figure I-1](#)).

Fishing by artisanal longline vessels targeting tuna and other species off Central America, for which data availability is limited, appears to have increased, over the past decade at least. The shifting patterns of areas fished and targeting practices increase the difficulties encountered when using fisheries data in analyses of stock status and trends. These difficulties are exacerbated when analyzing species which are not principal targets of the fishery, and further exacerbated when the total catch of the species by all fisheries is not known.

The last full assessment of striped marlin was conducted in 2008, using Stock Synthesis, and later updated with data through October 2010. Key results were that (1) the stock was not overfished; (2) overfishing was not occurring; and (3) the spawning stock biomass was above the level that would support MSY. Average annual catches during 2013–2017 (1,889 t) were at about half the MSY level. If fishing effort and catches continue at the 2010 level (2,161 t), it is expected that the biomass of the stock will continue to increase over the near term.

The fishing effort by large longline vessels in the North EPO has increased by about 20% since 2010, but the catch of striped marlin has remained largely unchanged. The ISC has begun a full assessment of the North Pacific stock of striped marlin, and results are expected to be available in late 2019.

The recreational fishery is believed to take most of the catch of striped marlin in the North EPO. However, the most recent catch report was for 1990-2007, with preliminary data for 2008, and this paucity of data probably means that the catches of striped marlin in the EPO have been significantly underestimated since 2008. Also, it appears that catches of billfishes, including striped marlin, by the artisanal longline fishery operating off Central America are not reported, at least not to the IATTC. Therefore, the total catch of striped marlin in the EPO, and thus the total impact of fishing on the stock since about 2008-2009, are not known.

Efforts continue to obtain reliable catch data from all fisheries. Until the data are available and updated, and a review of the status of striped marlin in the EPO is completed, it is recommended that, as a precautionary measure, fishing effort by fisheries that take the majority of the striped marlin catch in the EPO not be increased.

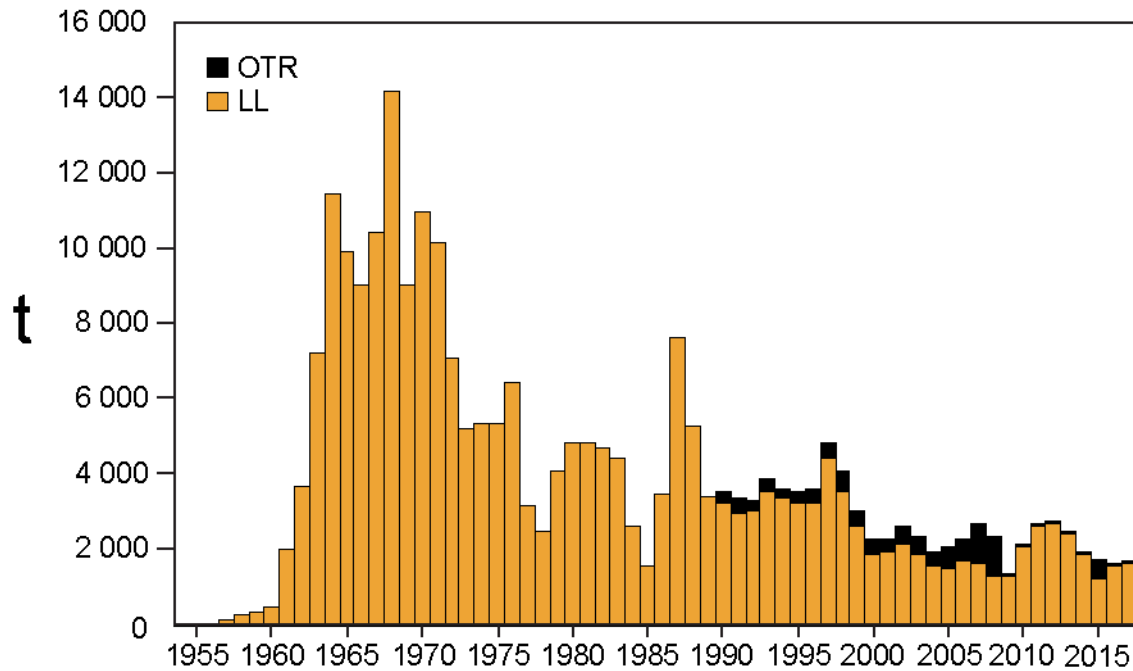


FIGURE I-1. Total reported catches of striped marlin in the North EPO by longline (LL) and other (OTR) fisheries (primarily recreational, 1954-2017. Due to unreported catches by recreational fisheries, estimates for 2009-2016 are minimums.

FIGURA I-1. Capturas totales reportadas de marlín rayado en el OPO Norte por las pesquerías palan-greras (LL) y otras (OTR, principalmente recreativas), 1954-2017. Debido a capturas no reportadas por pesquerías recreativas, las estimaciones de 2009-2016 son mínimas.

J. SAILFISH

The stock structure of sailfish (*Istiophorus platypterus*) in the Pacific Ocean is well known. The species is most abundant in waters relatively near the continents and the Indo-Pacific land masses bordering the Pacific, and infrequent in the high seas separating them. The populations in the EPO and in the western Pacific are genetically distinct.

The centers of sailfish distribution along the coast of the Americas shift in response to seasonal changes in surface and mixed-layer water temperature. Sailfish are found most often in waters warmer than about 28°C, and are present in tropical waters nearer the equator in all months of the year. Spawning takes place off the coast of Mexico during the summer and fall, and off Costa Rica during winter, and perhaps year-round in areas with suitable conditions. The sex ratio is highly skewed towards males during spawning. The known shifts in sex ratios among spawning areas, and the spatial-temporal distributions of gonad indices and size-frequency distributions, which show smaller fish offshore, suggest that there may be maturity-dependent patterns in the distribution of the species in the EPO. Sailfish can reach an age of about 11 years in the EPO.

The principal fisheries that capture sailfish in the EPO include the large-scale tuna longline fishery primarily consisting of China, Chinese Taipei, Japan, and Korea; the smaller-vessel longline fisheries targeting tuna and other species, particularly those operating off Central America; and the artisanal and recreational fisheries of Central and South America. Sailfish are also taken occasionally in the purse-seine fisheries targeting tropical tunas, particularly in more coastal regions.

The first assessment of sailfish in the EPO was conducted in 2013. Initial analyses indicated that either this stock had uncharacteristically low productivity and high standing biomass, or—more probably—that a large amount of catch was missing in the data compiled for the assessment. We were unable to identify a means to satisfactorily estimate this catch in order to obtain reliable estimates of stock status and trends using Stock Synthesis, the preferred model for assessments. As a result, the assessment was conducted using a surplus production model, which provided results consistent with those obtained with Stock Synthesis and simplified the illustration of the issues in the assessment.

Key results:

1. It is not possible to determine the status of the sailfish stock in the EPO with respect to specific management parameters, such as maximum sustained yield (MSY), because the parameter estimates used in making these determinations in this case cannot be derived from the model results.
2. Average annual reported catches during 2013-2017 were about 740 t ([Figure J-1](#)), significantly less than the 1993-2007 average of about 2,100 t.
3. Sailfish abundance trended downward during 1994-2009, since when it has been relatively constant or slightly increasing ([Figure J-2](#)).
4. Model results suggest that there are significant levels of unreported catch, and the actual catch in earlier years was probably higher than those reported for 1993-2007. Assuming that this level of harvest has existed for many years, it is expected that the stock condition will not deteriorate if catch is not increased above current levels.
5. A precautionary approach that does not increase fishing effort directed at sailfish, and that closely monitors catch until sufficient data are available to conduct another assessment, is recommended.
6. A reliable assessment of the sailfish resources in the EPO cannot be obtained without reliable estimates of catch. It is therefore recommended that:
 - a. historical data on catches of sailfish be obtained wherever possible

- b. fisheries currently reporting sailfish catches commingled with other species be required to report catches by species.
- c. existing data from small-scale fisheries, such as local longline fleets, artisanal and recreational fisheries, be compiled and that, where necessary, catch monitoring programs to identify catches by species be implemented.

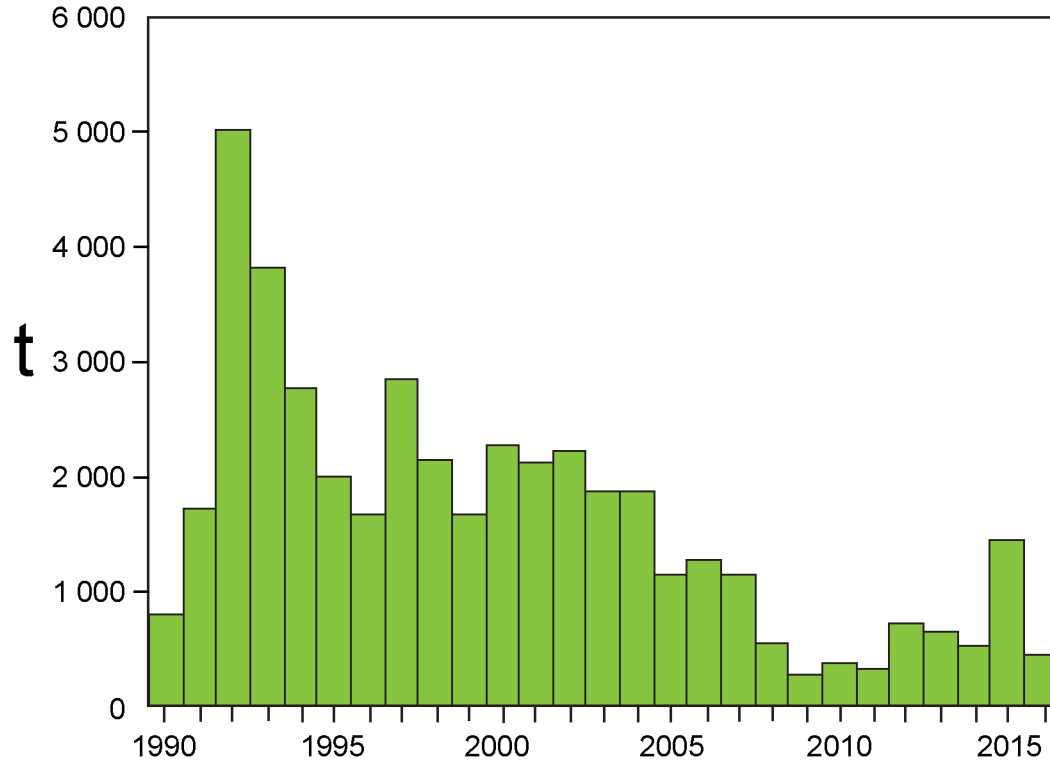


FIGURE J-1. Total reported catches of sailfish in the EPO, 1990-2016. (The actual catches were probably greater.)
FIGURA J-1. Capturas totales reportadas de pez vela en el OPO, 1990-2016. (Las capturas reales fueron probablemente mayores).

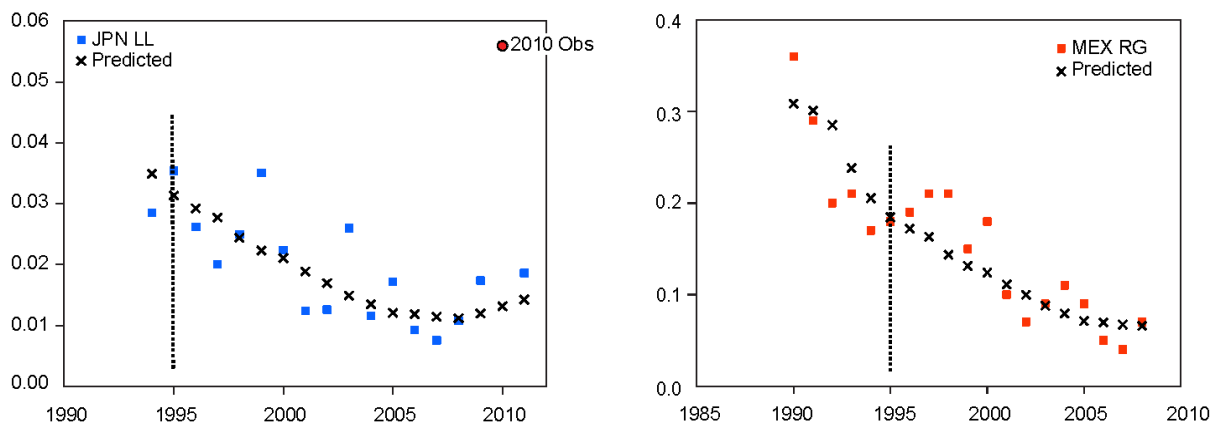


FIGURE J-2. Observed and predicted indices of relative abundance of sailfish in the EPO from Japanese longline (JPN LL) and Mexican recreational (MEX RG) fisheries. The 2010 observation in the JPN LL series was not included in the analyses.
FIGURA J-2. Índices observados y predichos de abundancia relativa del pez vela en el OPO, basados en las pesquerías palangrera japonesa (JPN LL) y recreacional mexicana (MEX RG). No se incluyó en los análisis la observación de 2010 en la serie JPN LL.

K. SILKY SHARK

Updated stock status indicators for silky sharks in the eastern Pacific Ocean (1994-2018)

The indices of relative abundance for large silky sharks (*Carcharhinus falciformis*) in the eastern Pacific Ocean (EPO), developed from bycatch-per-set data from purse-seine sets on floating objects and presented at the 9th meeting of the Scientific Advisory Committee (SAC-09) in May 2018 (Document [SAC-09-13](#)), were updated with data from 2018 ([Figure K-1](#); [SAC-10-17](#)). Previous analyses ([SAC-08-08a\(i\)](#)¹⁰) identified a correlation between North EPO indices, particularly for small and medium silky sharks, and interannual variability in oceanographic conditions, and thus the indices for those size categories, and for all silky sharks, were not updated because of concerns about bias. Because of recent increases in the live release of silky sharks, two indices for large silky sharks were computed, one including live release data (dead + live) and the other not. Taken together, the indices likely bracket the trend that would have resulted in both the north and south EPO if “finning”⁶, shark handling, and data recording practices had continued unchanged since 1994. The real trend is considered to be closer to the dead + live index because sharks recorded as released alive in recent years would probably have been recorded as dead previously, and thus the dead + live index is likely a more consistent indicator. The terminal point of these indices suggests relatively stable abundance for over a decade, with a decrease in the indices in 2018 to about the 2016 level following an increase in 2017. However, the observers’ estimates of the sizes of sharks released alive may be unreliable, and thus the increased live releases could bias the indices by size. A survey of observers will be conducted to determine, among other things, where on vessels sharks are released, and how well the observer can see sharks recorded as released alive.

The IATTC staff reiterates its previous recommendation ([SAC-07-06b\(i\)](#), [SAC-07-06b\(iii\)](#), [SAC-08-11](#)) that improving shark fishery data collection in the EPO is critical. This will facilitate the development of other stock status indicators and/or conventional stock assessments to better inform the management of the silky shark and other co-occurring shark species.

⁶ Cutting the fins off sharks and discarding the carcass

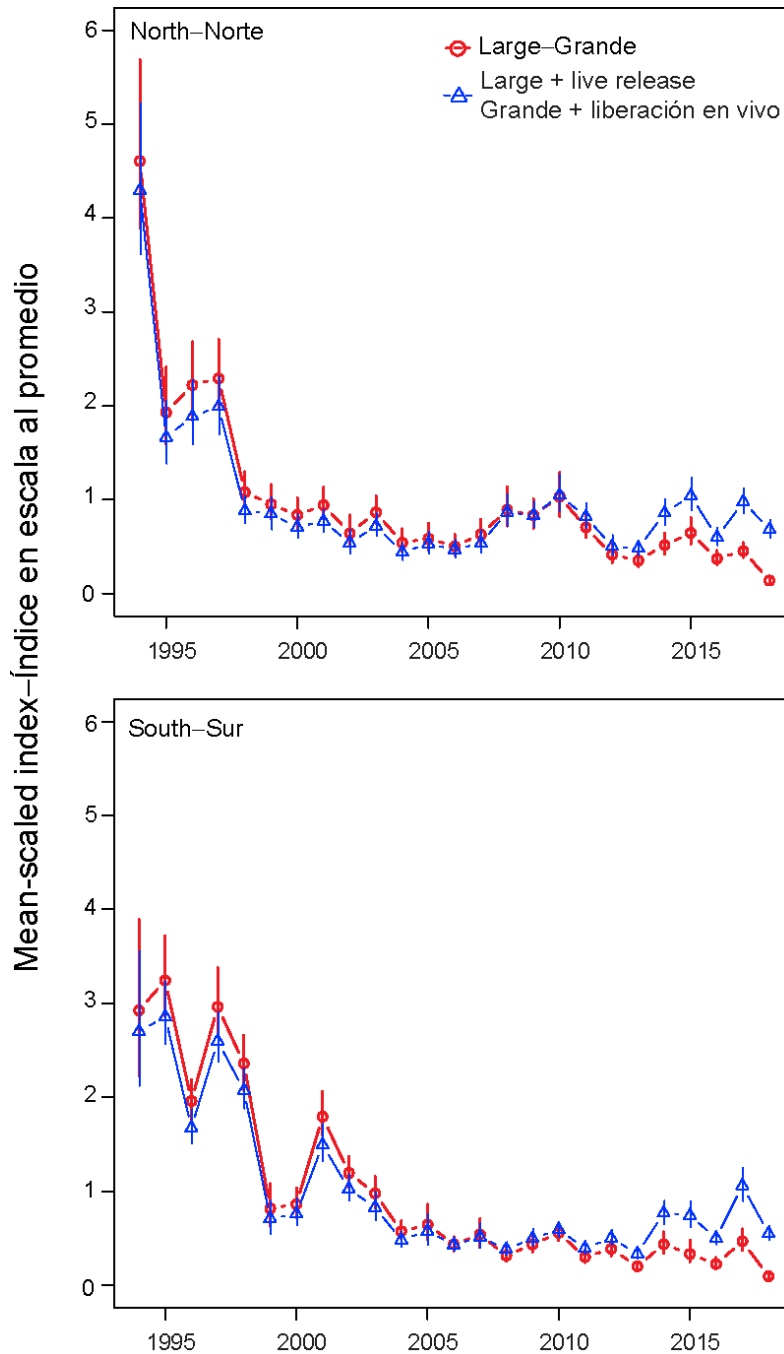


FIGURE K-1. Mean-scaled standardized silky shark bycatch-per-set (BPS; in numbers of sharks per set) in sets on floating objects for large sharks, with and without live release, in the north (top) and south (bottom) EPO. Vertical bars indicate pointwise approximate 95% confidence intervals.

FIGURA K-1. Captura incidental por lance (CIPL, en número de tiburones por lance) estandarizada en lances sobre objetos flotantes de tiburones sedosos grandes, con y sin liberación en vivo, en el OPO norte (arriba) y sur (abajo). Las barras verticales indican los intervalos de confianza de 95% puntuales aproximados.

L. ECOSYSTEM CONSIDERATIONS

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1. Introduction

The 1995 FAO Code of Conduct for Responsible Fisheries stipulates that “*States and users of living aquatic resources should conserve aquatic ecosystems*” and that “*management measures should not only ensure the conservation of target species, but also of species belonging to the same ecosystem or associated with or dependent upon the target species*”⁷. In 2001, the Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem elaborated these principles with a commitment to incorporate an ecosystem approach into fisheries management.

Consistent with these instruments, one of the functions of the IATTC under the 2003 Antigua Convention is to “*adopt, as necessary, conservation and management measures and recommendations for species belonging to the same ecosystem and that are affected by fishing for, or dependent on or associated with, the fish stocks covered by this Convention, with a view to maintaining or restoring populations of such species above levels at which their reproduction may become seriously threatened*”.

Consequently, the IATTC has recognized ecosystem issues in many of its management decisions since 2003. This report provides a brief summary of what is known about the direct and indirect impacts of tuna fisheries in the eastern Pacific Ocean (EPO) on the populations of species and ecological functional groups and the structure of the ecosystem, as controlled by the strength of predator-prey interactions.

This report does not suggest objectives for the incorporation of ecosystem considerations into the management of fisheries for tunas or billfishes, nor any new management measures. Rather, its main purpose is to quantify and evaluate the Commission’s ecosystem approaches to fisheries (EAF)—through current tools available to assess the state of the ecosystem—and to demonstrate how ecosystem research can contribute to management advice and the decision-making process.

However, the view that we have of the ecosystem is based on the recent past; there is almost no information available about the ecosystem before exploitation began. Also, the environment is subject to change on a variety of time scales, including the well-known El Niño Southern Oscillation (ENSO) fluctuations and longer-term changes, such as the Pacific Decadal Oscillation (PDO) and other climate-related changes including *e.g.* ocean warming, anoxia and acidification.

⁷ The Code also provides that management measures should ensure that “biodiversity of aquatic habitats and ecosystems is conserved and endangered species are protected”, and that “States should assess the impacts of environmental factors on target stocks and species belonging to the same ecosystem or associated with or dependent upon the target stocks, and assess the relationship among the populations in the ecosystem.”

In addition to reporting the catches of the principal species of tunas and billfishes, the staff estimates catches (retained and discarded) of non-target species. In this report, data on those species are presented in the context of the effect of the fishery on the ecosystem. While relatively good information is available for catches of tunas and billfishes across the entire fishery, this is not the case for bycatch species. The information is comprehensive for large⁸ purse-seine vessels, which carry on-board observers under the Agreement on the International Dolphin Conservation Program (AIDCP). Detailed information on retained and discarded bycatch by the smaller purse-seine fleet and much of the longline fleet is limited, while virtually no information exists on bycatches and discards by fishing vessels that use other gear types (*e.g.* gillnet, harpoon, and recreational gear ([SAC-07-INF-C\(d\)](#); [SAC-08-07b](#))).

Detailed information on past ecosystem studies can be found in documents for previous meetings of the Scientific Advisory Committee (*e.g.* [SAC-08-07a](#)), and current and planned ecosystem-related work by the IATTC staff is summarized in the proposed Strategic Science Plan ([IATTC-93-06a](#)) and the Staff Activities and Research report (SAC-10-01).

2. IMPACT OF CATCHES

2.1. Single-species assessments and description of available data

An ecosystem perspective requires a focus on how a fishery may have altered various components of an ecosystem. This report presents current information on the effects of the tuna fisheries on the stocks of individual species in the EPO. Sections 2.2 and 2.3 of this report refer to information on the current biomass of each stock. The influences of predator and prey abundances are not explicitly described. Sections 2.4-2.7 include catch data for vessels of the large purse-seine and large-scale tuna longline (herein ‘longline fisheries’) fisheries reported to the IATTC.

On-board observer data available to the IATTC staff as of March 2019 were used to provide estimates of total catches (retained and discards) by large purse-seine vessels in the EPO on floating objects (OBJ), unassociated schools (NOA), and dolphins (DEL). Data for 2017 and 2018 should be considered preliminary.

Complete data are not available for small purse-seine, longline, and other types of vessels. For example, there has been considerable variability in reporting formats of longline data by individual CPCs⁹ through time, thereby limiting application of catch and effort data to scientific analyses ([SAC-08-07b](#), [SAC-08-07d](#), [SAC-08-07e](#)). Some catches of non-tuna species by the longline fisheries in the EPO are reported to the IATTC, but often in a highly summarized form (*e.g.* monthly aggregation of catch by broad taxonomic group (*e.g.* “Elasmobranchii”), often without verification of whether the reported catch has been raised to total catch ([SAC-08-07b](#)). Such non-tuna catch data for longline fisheries were obtained using “Task I Catch Statistics” of gross annual removals reported to IATTC in accordance with the specifications for the provision of these data described in Annex A of Memorandum ref. 0144-410, dated 27 March 2019 pursuant to Resolution [C-03-05](#) on data provision. Because of data limitations described above, herein these data are considered “sample data” and therefore, such estimates should be regarded as minimum estimates. Preliminary sample data was available for 2017 as of March 2019.

Due to these limitations of catch data for the longline fishery, a report on establishing minimum data standards and reporting requirements for longline observer programs was discussed at SAC-08 ([SAC-08-07e](#)). Pursuant to paragraph 7 of Resolution [C-11-08](#), the SAC adopted a [requirement](#) for CPCs to supply operational-level observer data. Some progress in longline data reporting has been made and a few CPCs have provided IATTC with operational-level, set-by-set observer data. For example, a summary of longline observer reporting by CPCs was presented at SAC-09, and IATTC staff noted only two CPCs had

⁸ Carrying capacity greater than 363 t

⁹ Members and Cooperating Non-Members of the IATTC

submitted observer data for 2013—the year in which Resolution [C-11-08](#) entered into force—through 2017 ([SAC-09 INF A](#), Table 3). IATTC staff also noted inconsistencies with reporting units for fishing effort and recommended the use of number of hooks fished, as opposed to the currently reported “effective days fished”, which would allow the observer-reported catch data to be extrapolated to the longline fleet, thereby allowing estimates of total catch to be made. As data reporting continues to improve, better estimations of catches by longline vessels are expected to be available in future iterations of the *Ecosystem Considerations* report.

2.2. Tunas

Status reports are provided by IATTC staff for bigeye ([SAC-10-06](#)), yellowfin ([SAC-10-07](#); [SAC-10-08](#)), and skipjack ([SAC-10-09](#)) tunas. The Pacific Bluefin Tuna Working Group of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC) completed its [stock assessment](#) in 2018, and the ISC Northern Albacore Working Group completed its [stock assessment](#) in 2017. Updates from these ISC working groups were presented at SAC-10.

Preliminary estimates of the catches of tunas and bonitos in the EPO during 2018 are found in Table A-2a of Document [SAC-10-03](#).

2.3. Billfishes

Information on the effects of the tuna fisheries on swordfish, blue marlin, striped marlin, and sailfish is presented in Sections G-J of IATTC [Fishery Status Report 16](#). Stock assessments for swordfish (south EPO 2011, north EPO 2014), striped marlin (2010), eastern Pacific sailfish (2013) and blue marlin (2013, 2016) were completed by the [IATTC staff](#). Stock assessments of [striped marlin \(2015\)](#), [Pacific blue marlin \(2016\)](#), and [north Pacific swordfish \(2018\)](#) have been completed by the ISC Billfish Working Group, with a 2019 assessment of western and central Pacific striped marlin currently in progress.

No stock assessments have been conducted for black marlin and shortbill spearfish, although historical data published pre-2008 in the [IATTC Bulletin series](#) showed trends in catches, effort, and catches per unit of effort (CPUEs).

Preliminary estimates of the catches of billfishes in the EPO during 2018 are found in Table A-2b of Document [SAC-10-03](#).

2.4. Marine mammals

Marine mammals, especially spotted dolphins (*Stenella attenuata*), spinner dolphins (*S. longirostris*), and common dolphins (*Delphinus delphis*), are frequently found associated with yellowfin tuna in the EPO. Purse-seine fishers commonly set their nets around herds of dolphins and the associated schools of yellowfin tuna, and then release the dolphins while retaining the tunas. The incidental mortality of dolphins was high during the early years of the fishery, but has been minimal since the early 1980s.

Preliminary estimates of the incidental mortality

TABLE 1. Incidental mortality of dolphins and other marine mammals caused by the purse-seine fishery in the EPO, 2018.

Species and stock	Incidental mortality	
	Numbers	t
Offshore spotted dolphin		
Northeastern	99	6.5
Western-southern	197	12.9
Spinner dolphin		
Eastern	252	11.2
Whitebelly	205	12.4
Common dolphin		
Northern	41	2.9
Central	1	0.1
Southern	18	1.3
Other mammals*	6	0.4
Total	819	47.5

*“Other mammals” includes the following species and stocks, whose observed mortalities were as follows: Central American spinner dolphin 3 (0.1 t), bottlenose dolphin (*Tursiops truncatus*) 2 (0.2 t) unidentified dolphins 1 (0.1 t).

of marine mammals in the purse-seine fishery in 2018 are shown in [Table 1](#). Estimated dolphin mortalities (numbers) for 1993–2018 are shown in [Figure L-1](#). Decreasing mortalities were observed for northeastern spotted dolphins, western-southern spotted dolphins, whitebelly spinner dolphins, central common dolphins, and other Delphinidae. Numbers of mortalities were variable for northern common dolphins and eastern spinner dolphins, and those of southern common dolphins were generally less than 60 individuals, with the exception of peaks to 225 in 2004, 154 in 2005 and 137 in 2008

2.5. Sea turtles

Sea turtles are caught on longlines when they take the bait on hooks, are snagged accidentally by hooks, or are entangled in the lines. Estimates of incidental mortality of turtles due to longline and gillnet fishing are few. The mortality rates in the EPO industrial longline fishery are likely to be lowest in “deep” sets (around 200-300 m) targeting bigeye tuna, and highest in “shallow” sets (<150 m) for albacore and swordfish. In addition, there is a sizeable fleet of artisanal longline vessels from coastal nations that also impact sea turtles.

Sea turtles are occasionally caught in purse seines in the EPO tuna fishery, generally when the turtles associate with floating objects, and are captured when the object is encircled. Also, sets on unassociated tunas or tunas associated with dolphins may capture sea turtles that happen to be at those locations. Sea turtles sometimes become entangled in the webbing under fish-aggregating devices (FADs) and drown, although Resolution [C-07-03](#) was adopted in 2007 to mitigate the impact of fishing on sea turtles. In some cases, they are entangled by the fishing gear and may be injured or killed.

The olive Ridley turtle (*Lepidochelys olivacea*) is, by far, the species of sea turtle taken most often by purse seiners. It is followed by green sea turtles (*Chelonia mydas*) and, very occasionally, by loggerhead (*Caretta caretta*) and hawksbill (*Eretmochelys imbricata*) turtles ([Figure L-2](#)). Since 1990, when IATTC observers began recording this information, only three mortalities of leatherback (*Dermochelys coriacea*) turtles have been recorded. Some of the turtles are unidentified because they were too far from the vessel or it was too dark for the observer to identify them.

Preliminary numbers of sea turtle mortalities and interactions in sets by large purse-seine vessels on floating objects (OBJ), unassociated tunas (NOA), and dolphins (DEL) during 2018 are shown in [Table 2](#), and for 1993–2018 in [Figure L-2](#). Data on sea turtle interactions or mortality was deficient in the IATTC longline sample data ([SAC-08-07b](#)), although with improvements in data reporting, estimations are expected to be available in future (see section 2.1).

The mortalities of sea turtles due to purse seining for tunas are probably less than those due to other human activities, which include exploitation of eggs and adults, beach development, pollution, entanglement in and ingestion of marine debris, and impacts of other fisheries.

2.6. Sharks and rays

Sharks are caught as by-catch or targeted catch in EPO tuna longline and purse-seine fisheries as well as multi-species and

Species	Interactions				Mortalities			
	Set type			Total	Set type			Total
	OBJ	NOA	DEL		OBJ	NOA	DEL	
Olive Ridley	141	2	39	182	3	-	-	3
Eastern Pacific green	49	12	2	63	1	-	-	1
Loggerhead	11	4	3	18	-	-	-	-
Hawksbill	5	2	-	7	-	-	-	-
Leatherback	3	1	1	5	-	-	-	-
Unidentified	128	21	164	313	-	-	-	-
Total	337	42	209	588	4	-	-	4

multi-gear fisheries of the coastal nations.

Stock assessments or stock status indicators (SSIs) are available for only four shark species in the EPO: silky (*Carcharhinus falciformis*) (Lennert-Cody *et al.* 2019¹⁰; [SAC-10-17](#)), blue (*Prionace glauca*) ([ISC Shark Working Group](#)), shortfin mako (*Isurus oxyrinchus*) ([ISC Shark Working Group](#)), and common thresher (*Alopias vulpinus*) (NMFS). As part of the [FAO Common Oceans Tuna Project](#), Pacific-wide assessments of the porbeagle shark¹¹ (*Lamna nasus*) in the southern hemisphere, and the bigeye thresher shark¹² (*Alopias superciliosus*) were completed in 2017, while that for silky shark¹³ and a risk assessment for the Indo-Pacific whale shark population¹⁴ were completed in 2018. Whale shark interactions with the tuna purse-seine fishery in the EPO are summarized in Document [BYC-08 INF-A](#). The impacts of tuna fisheries on the stocks of other shark species in the EPO are unknown.

A quantitative ecological risk assessment on the impacts of the EPO tuna fishery on the spinetail devil ray (*Mobula mobular*)—using IATTC’s newly developed Ecological Assessment for the Sustainable Impacts of Fisheries (EASI-Fish) approach—was undertaken by IATTC staff to explore the species’ vulnerability status under 18 hypothetical conservation and management measures and was presented at the 9th Meeting of the Working Group on Bycatch ([BYC-09-01](#)).

Preliminary estimates of the catches of sharks and rays reported by observers on large purse-seine vessels in the EPO during 2018 and minimum estimates of catches by longline vessels using sample data (see section 2.1) in 2017 are shown in [Table 3](#). Here, it is important to note Resolution [C-11-10](#) which entered into force in January 2012 prohibits the retention of oceanic whitetip sharks (*Carcharhinus longimanus*), and therefore discarded catch—reported under “Task II Catch and Effort Statistics”, a subset of “Task I Catch Statistics”, pursuant to Resolution [C-03-05](#) and detailed in Annex A of Memorandum ref. 0144-410—was included to provide a better estimate of catch.

Catches of sharks and rays in the purse-seine and minimum estimates by longline fisheries during 1993–2018 are shown in [Figure L-3](#). Silky sharks are the most commonly-caught species of shark in the purse-seine fishery. Shark catches were generally greatest in sets on floating objects (mainly silky, oceanic whitetip, hammerhead (*Sphyrna* spp.) and mako (*Isurus* spp.) sharks), followed by unassociated sets and, at a much lower level, dolphin sets. Until about 2007, thresher sharks (*Alopias* spp.) occurred mostly in unassociated sets. Historically, oceanic whitetip sharks were commonly caught in sets on floating objects, but they became much less common after 2005. In general, the bycatch rates of manta rays (Mobulidae) and stingrays (Dasyatidae) have been greatest in unassociated sets, followed by dolphin sets, and lowest in floating-object sets, although catches by set type can be variable. The numbers of purse-seine sets of each type in the EPO during 2003–2018 are

¹⁰ Lennert-Cody, C.E.; Clarke, S.C.; Aires-da-Silva, A.; Maunder, M.N.; Franks, P.J.S.; Román, M.H.; Miller, A.J.; Minami, M. 2019. The importance of environment and life stage on interpretation of silky shark relative abundance indices for the equatorial Pacific Ocean Fish Oceanogr:43-53

¹¹ Clarke, S. 2017. Southern Hemisphere porbeagle shark (*Lamna nasus*) stock status assessment. WCPFC-SC13-2017/SA-WP-12 (rev. 2). Western and Central Pacific Fisheries Commission Scientific Committee Thirteenth Regular Session. Rarotonga, Cook Islands

¹² Fu, D.; Roux, M.-J.; Clarke, S.; Francis, M.; Dunn, A.; Hoyle, S.; Edwards, C. 2018. Pacific-wide sustainability risk assessment of bigeye thresher shark (*Alopias superciliosus*). WCPFC-SC13-2017/SA-WP-11. Rev 3 (11 April 2018). Western and Central Pacific Fisheries Commission Scientific Committee Thirteenth Regular Session. Rarotonga, Cook Islands

¹³ Clarke, S. 2018. Pacific-wide silky shark (*Carcharhinus falciformis*) Stock Status Assessment. WCPFC-SC14-2018/SA-WP-08. Western and Central Pacific Fisheries Commission. Busan, Korea

¹⁴ Clarke, S. 2018. Risk to the Indo-Pacific Ocean whale shark population from interactions with Pacific Ocean purse-seine fisheries. WCPFC-SC14-2018/SA-WP-12 (rev. 2). Western and Central Pacific Fisheries Commission, Scientific Committee Fourteenth Regular Session. Busan, Korea

shown in Table A-7 of [Document SAC-10-03](#).

The sample data reported to IATTC of minimum estimates of sharks caught by the longline fishery increased for most species after 2005 ([Figure L-3](#)).

TABLE 3. Preliminary catches, in tons, of sharks and rays in the EPO by large purse-seine vessels, by set type, 2018, and by longline vessels, 2017. *Longline sample data should be considered minimum catch estimates due to incomplete data reporting (see section 2.1)

Species	Purse seine				Long-line*
	OBJ	NOA	DEL	Total	
Silky shark (<i>Carcharhinus falciformis</i>)	400	11	20	431	2,626
Oceanic whitetip shark (<i>C. longimanus</i>)	3	-	<1	3	202
Hammerhead sharks (<i>Sphyrna</i> spp.)	24	<1	<1	26	186
Thresher sharks (<i>Alopias</i> spp.)	<1	4	2	7	724
Mako sharks (<i>Isurus</i> spp.)	1	<1	<1	2	1,606
Other sharks	31	4	1	36	1,430
Blue sharks (<i>Prionace glauca</i>)	-	-	-	-	6,908
Manta rays (Mobulidae)	16	20	13	49	-
Stingrays (Dasyatidae)	<1	<1	<1	1	-

and blue sharks were reported as early as 1993 and catches increased sharply after 2008. Catches of blue shark exceeded 10,000 mt in 2011 and 2013 while those of thresher sharks exceeded 8,000 mt in 2010 and 2011 and declined rapidly thereafter. Silky shark catches peaked at about 4,200 mt in 2013 and those of mako sharks at about 2,500 mt in 2014. Catches of oceanic whitetip shark reached nearly 300 mt in 2009 and, as previously mentioned, retention has been prohibited since 2012 under Resolution [C-11-10](#); therefore, reported data since 2012 corresponds to discards ([Figure L-3](#)). However, it is important these sample data are interpreted with caution because they can only be considered as ‘reported minimum estimates’ due to limitations in data-reporting requirements for non-target species caught in the longline fishery resulting from Resolutions [C-03-05](#) and [C-11-08](#) and documented in [SAC-08-07b](#)—also see section 2.1.

The small-scale artisanal longline fisheries of the coastal CPCs target sharks, tunas, billfishes and dorado (*Coryphaena hippurus*), and some of these vessels are similar to industrial longline fisheries in that they operate in areas beyond coastal waters and national jurisdictions¹⁵. However, essential shark data from longline fisheries is lacking, and therefore conventional stock assessments and/or stock status indicators cannot be produced (see data challenges outlined in [SAC-07-06b\(iii\)](#)). A project is ongoing to improve data collection on sharks, particularly for Central America, for the longline fleet through funding from the Food and Agriculture Organization of the United Nations (FAO) and the Global Environmental Facility (GEF) under the framework of the ABNJ Common Oceans program ([SAC-07-06b\(ii\)](#), [SAC-07-06b\(iii\)](#)). A pilot study was initiated in April 2018 to collect additional shark-fishery data and develop and test sampling designs for a long-term sampling program for the shark fishery in Central America (Phase 2 of the project). A progress report on the FAO-GEF ABNJ project was presented at SAC-10 ([SAC-10-16](#)). Data obtained from this project may be included in future iterations of the *Ecosystem Considerations* report to provide better estimates of sharks caught by the various longline fleets

2.7. Other large fishes

Preliminary estimates of the catches of dorado (*Coryphaena* spp.) and other large fishes in the EPO by large purse-seine vessels during 2018 are shown in [Table 4](#), along with minimum estimates from longline sample data in 2017. A time series of catches for these most commonly-caught species during 1993–2018, by set type and fishery, are shown in [Figure L-4](#).

¹⁵ Martínez-Ortiz, J., Aires-da-Silva, A.M., Lennert-Cody, C.E., Maunder, M.N. 2015. The Ecuadorian artisanal fishery for large pelagics: species composition and spatio-temporal dynamics. *PLoS ONE* 10(8): e0135136.

TABLE 4. Preliminary catches, in tons, of large fish species commonly caught in the EPO by large purse-seine vessels, by set type, 2018, and by longline vessels, 2017. *Longline sample data should be considered minimum catch estimates due to incomplete data reporting (see section 2.1)

	Purse-seine				Long-line*
	OBJ	NOA	DEL	Total	
Dorado (<i>Coryphaena</i> spp.)	1,493	4	6	1,503	1814
Wahoo (<i>Acanthocybium solandri</i>)	255	<1	-	227	308
Rainbow runner (<i>Elagatis bipinnulata</i>) & yellowtail (<i>Seriola lalandi</i>)	74	1	-	75	-
Opahs (<i>Lampris</i> spp.)	-	-	-	-	825
Snake mackerels (Gempylidae)	-	-	-	-	395
Pomfrets (Bramidae)	-	-	-	-	126

Dorado is the most commonly reported fish species caught incidentally in the EPO purse-seine and longline fisheries. It is also one of the most important species caught in the artisanal fisheries of the coastal nations of the EPO, which led to an exploratory stock assessment ([SAC-07-06a\(i\)](#)) and management strategy evaluation (MSE) in the south EPO ([SAC-07-06a\(ii\)](#)). An identification of potential reference points and the harvest control rule for dorado in the EPO was presented at SAC-10 ([SAC-10-11](#)).

Purse-seine catches of dorado, wahoo, rainbow runner, and yellowtail were variable, and occurred primarily in sets on floating objects, while opahs, snake mackerels and pomfrets were included solely in catch reports of longline sample data and increasing catches were observed. Longline estimates of wahoo increased after 2002.

3. OTHER FAUNA

3.1. Seabirds

There are approximately 100 species of seabirds in the tropical EPO. Some of them associate with epipelagic predators, such as fishes (especially tunas) and marine mammals, near the ocean surface. Feeding opportunities for some seabird species are dependent on the presence of tuna schools feeding near the surface. Most species of seabirds take prey, mainly squid (primarily Ommastrephidae), within half a meter of the surface, or in the air (flyingfishes, Exocoetidae). Subsurface predators, such as tunas, often drive prey to the surface to trap it against the air-water interface, where it becomes available to the birds, which also feed on injured or disoriented prey, and on scraps of large prey.

Some seabirds, especially albatrosses (waved (*Phoebastria irrorata*), black-footed (*P. nigripes*), Laysan (*P. immutabilis*), and black-browed (*Thalassarche melanophrys*)) and petrels, are susceptible to being caught on baited hooks in pelagic longline fisheries. There is particular concern for the waved albatross, because it is endemic to the EPO and nests only in the Galapagos Islands. Observer data from artisanal vessels have reported no interactions with waved albatross during those vessels' fishing operations. Data from the US pelagic longline fishery in the north EPO indicate that bycatches of black-footed and Laysan albatrosses occur.

The IATTC has adopted two measures on seabirds ([Recommendation C-10-02 and Resolution C-11-02](#)); also, the Agreement on the Conservation of Albatrosses and Petrels (ACAP) and BirdLife International have updated their maps of seabird distribution in the EPO, and have recommended guidelines for seabird identification, reporting, handling, and mitigation measures ([SAC-05 INF-E](#), [SAC-07-INF-C\(d\)](#)).

[SAC-08-INF-D\(a\)](#), [SAC-08-INF-D\(b\)](#), [BYC-08 INF J\(b\)](#)). Additionally, ACAP has reported on the conservation status for albatrosses and large petrels ([SAC-08-INF-D\(c\)](#); [BYC-08 INF J\(a\)](#)).

Data pertaining to interactions with seabirds was deficient in the IATTC longline sample data ([SAC-08-07b](#)), although with improvements in data reporting, estimations are expected to be available in future (see section 2.1).

3.2. Forage species

A large number of taxa occupying the middle trophic levels in the EPO ecosystem—generically referred to as “forage” species—play a key role in providing a trophic link between primary producers at the base of the food web and the upper-trophic-level predators, such as tunas and billfishes. Cephalopods, especially squids, play a central role in many marine pelagic food webs by linking the massive biomasses of micron-ekton, particularly myctophid fishes, to many oceanic predators. For example, the Humboldt squid (*Dosidicus gigas*) is a common prey for yellowfin and bigeye tunas and other predatory fishes but is also a voracious predator of small fishes and cephalopods. Changes in the abundance and geographic range of Humboldt squid could affect the foraging behavior of the tunas and other predators, perhaps affecting their vulnerability to capture and the trophic structure of pelagic ecosystems. Given the high trophic flux passing through the squid community, concerted research on squids is important for understanding their role as key prey and predators.

Some small forage fishes are incidentally caught in the EPO by purse-seine vessels on the high seas, mostly in sets on floating objects, and by coastal artisanal fisheries, but are generally discarded at sea. Frigate and bullet tunas (*Auxis* spp.), for example, are a common prey of many high trophic level predators and can comprise 10% or more of their diet biomass. Preliminary estimates of the catches of small forage fishes by observers onboard large purse-seine vessels in the EPO during 2018 are shown in [Table 5](#), and catches during 1993–2018 are shown in [Figure L-5](#). Declines in catches of bullet and frigate tunas and small teleost fishes over the 26-year period were observed while catches of triggerfish were variable.

TABLE 5. Catches of small fishes, in tons, by large purse-seine vessels in the EPO, 2018 (preliminary data).				
	Set type			Total
	OBJ	NOA	DEL	
Triggerfishes (Balistidae) and filefishes (Monacanthidae)	56	<1	-	56
Other small fishes	18	<1	-	18
Frigate and bullet tunas (<i>Auxis</i> spp.)	315	268	-	583

3.3. Larval fishes and plankton

Larval fishes have been collected in surface net tows in the EPO for many years by personnel of the Southwest Fisheries Science Center of the US National Marine Fisheries Service (NMFS). Of the 314 taxonomic categories identified, 17 were found to be most likely to show the effects of environmental change; however, the occurrence, abundance, and distribution of these key taxa revealed no consistent temporal trends. Research¹⁶ has shown a longitudinal gradient in community structure of the ichthyoplankton assemblages in the eastern Pacific warm pool, with abundance, species richness, and species diversity high in the east (where the thermocline is shallow and primary productivity is high) and low but variable in the

¹⁶ Viilchis, L.I., L.T. Ballance, and W. Watson. 2009. Temporal variability of neustonic ichthyoplankton assemblages of the eastern Pacific warm pool: Can community structure be linked to climate variability? *Deep-Sea Research Part I-Oceanographic Research Papers* 56(1): 125-140

west (where the thermocline is deep and primary productivity is low).

The phytoplankton and zooplankton populations in the tropical EPO are variable. For example, chlorophyll concentrations on the sea surface (an indicator of phytoplankton blooms) and the abundance of copepods were markedly reduced during the El Niño event of 1982–1983, especially west of 120°W. Similarly, surface concentrations of chlorophyll decreased during the 1986–1987 El Niño episode and increased during the 1988 La Niña event due to changes in nutrient availability¹⁷ and abundance of zooplankton predators. The same was true for the El Niño event in 1997 and the La Niña in mid-1998¹⁸.

The species and size composition of zooplankton is often more variable than the zooplankton biomass. When the water temperatures increase, warm-water species often replace cold-water species at particular locations. The relative abundance of small copepods off northern Chile, for example, increased during the 1997–1998 El Niño event, while the zooplankton biomass did not change¹⁹.

4. TROPHIC INTERACTIONS

Tunas and billfishes are wide-ranging, generalist predators with high energy requirements, and, as such, are key components of pelagic ecosystems. The ecological relationships among large pelagic predators, and between them and animals at lower trophic levels, are not well understood, but are required to develop models to assess fishery and climate impacts on the ecosystem. Knowledge of the trophic ecology of predatory fishes in the EPO has been derived from stomach contents analysis, and more recently from chemical indicators. Each species of tuna appears to have a generalized feeding strategy (high prey diversity and low abundance of individual prey types) that varies spatially and ontogenetically.

Stable isotope analysis can complement dietary data for delineating the trophic flows of marine food webs. While stomach contents represent a sample of the most-recent feeding events, stable carbon and nitrogen isotopes integrate all components of the entire diet into the animal's tissues, providing a history of recent trophic interactions. Finer-resolution information is provided by compound-specific isotope analysis of amino acids (AA-CSIA). For example, the trophic position of a predator in the food web can be determined from its tissues by relating "source" amino acids (*e.g.* phenylalanine) to "trophic" amino acids (*e.g.* glutamic acid), which describe the isotopic values for primary producers and the predator, respectively.

Trophic studies have revealed many of the key trophic connections in the tropical pelagic EPO, and have formed the basis for representing food-web interactions in an ecosystem model ([IATTC Bulletin, Vol. 22, No. 3](#)) to explore the ecological impacts of fishing and climate change. The staff aim to continue and improve trophic data collection for many components of the EPO ecosystem, such as small and large meso-pelagic fishes, which will allow the ecosystem dynamics to be better understood, but also enable the development of an improved ecosystem model that represents the entire EPO.

In the meantime, IATTC staff will continue to analyze diet data from several predator species collected during two stomach sampling projects in the EPO—1992–1994 and 2003–2005—to further develop diet

¹⁷ Fiedler, P.C.; Chavez, F.P.; Behringer, D.W.; Reilly, S.B. 1992. Physical and biological effects of Los Niños in the eastern tropical Pacific, 1986–1989. *Deep Sea Research Part A Oceanographic Research Papers*. 39:199-219

¹⁸ Wang, X.; Christian, J.R.; Murtugudde, R.; Busalacchi, A.J. 2005. Ecosystem dynamics and export production in the central and eastern equatorial Pacific: A modeling study of impact of ENSO. *Geophysical Research Letters*. 32, L02608

¹⁹ Fiedler, P.C. 2002. Environmental change in the eastern tropical Pacific Ocean: review of ENSO and decadal variability. Administrative Report LJ-02-16. Southwest Fisheries Science Center. La Jolla, CA: National Marine Fisheries Service, NOAA. 38 p

matrices to be used in ecosystem models for the EPO, such as Project O.2.b ([SAC-10-15](#)).

For example, a new project (SAC-10-01a, Project O.1b) is underway, to improve our understanding of the interplay between space and ontogeny in the trophic ecology of skipjack tuna in the EPO. Early accounts of skipjack stomach contents in the EPO have been limited to measurements of prey volume by size class with sampling strata determined *a priori* based on presumed areas of high skipjack densities²⁰. Other studies have been focused on calculations of prey weight, number and frequency of occurrence of skipjack sampled opportunistically throughout the EPO²¹. Little attention has been placed on quantitatively assessing the potential relationships between oceanography, ontogeny and skipjack food habits. Such information is essential for developing spatially-explicit ecosystem models, including the aforementioned model of the EPO that is planned for development by the IATTC staff. Quantifying trophic linkages using such an approach provide descriptions of the magnitude of biomass transfer through the ecosystem and can assist in more reliably assigning proportions of both predator and prey biomass in spatial strata in spatially-explicit ecosystem models, such as Ecospace.

A separate project ([SAC-10-INF-E](#), Project O.1.c) commenced in 2018 in an attempt to incrementally improve ecosystem model parameter inputs for the EPO. Specifically, a review of methods for estimating prey consumption rates, gastric evacuation, and daily ration, which can be used to estimate the consumption/biomass ratio (Q/B) ([SAC-10 INF-E](#)). This is one of the most influential parameters in mass-balance ecosystem models (*e.g.*, Ecopath with Ecosim) as it determines the extent of trophic biomass flows between predators and prey species, and the standing biomass that is required for these species, after taking into account biomass losses due to mortality and fishing. The review will recommend the most appropriate and feasible method(s) for estimating Q/B in order to develop a collaborative project proposal to experimentally estimate Q/B.

5. PHYSICAL ENVIRONMENT²²

Environmental conditions affect marine ecosystems, the dynamics and catchability of tunas and billfishes, and the activities of fishermen. Tunas and billfishes are pelagic during all stages of their lives, and the physical factors that affect the tropical and sub-tropical Pacific Ocean can have important effects on their distribution and abundance. While a brief description of the physical environment is provided here, the reader is referred to [SAC-04-08](#) section “Physical Environment” and [SAC-06 INF-C](#) for a more comprehensive description of the effects of the physical and biological oceanography on tunas, prey communities, and fisheries in the EPO.

The ocean environment varies on a variety of time scales, from seasonal to inter-annual, decadal, and longer (*e.g.* climate phases or regimes). The dominant source of variability in the upper layers of the EPO is known as the El Niño-Southern Oscillation (ENSO), an irregular fluctuation involving the entire tropical Pacific Ocean and global atmosphere. El Niño events occur at 2- to 7-year intervals, and are characterized by weaker trade winds, deeper thermoclines, and abnormally high sea-surface temperatures (SSTs) in the equatorial EPO. El Niño’s opposite phase, commonly called La Niña, is characterized by stronger trade winds, shallower thermoclines, and lower SSTs. The changes in the physical and chemical environment due to ENSO have a subsequent impact on the biological productivity, feeding, and reproduction of fishes,

²⁰ Alverson, F.G. 1963. The food of yellowfin and skipjack tunas in the eastern tropical Pacific Ocean. Inter-American Tropical Tuna Commission, Bulletin. 7:293-396

²¹ Olson, R.J.; Young, J.W.; Ménard, F.; Potier, M.; Allain, V.; Goñi, N.; Logan, J.M.; Galván-Magaña, F. 2016. Bioenergetics, trophic ecology, and niche separation of tunas. in: Curry B.E., ed. *Adv Mar Biol*. UK: Academic Press. Table 1. p 223

²² Some of the information in this section is from Fiedler, P.C. 2002. Environmental change in the eastern tropical Pacific Ocean: review of ENSO and decadal variability. *Mar. Ecol. Prog. Ser.* 244: 265-283.

birds, and marine mammals.

With respect to commercially important tunas and billfishes, ENSO is thought to cause considerable variability in their availability for capture as well as recruitment. For example, a shallow thermocline in the EPO during La Niña events can contribute to increased success of purse-seine fishing for tunas, by compressing the preferred thermal habitat of small tunas near the sea surface. In contrast, during an El Niño event, when the thermocline is deeper, tunas are likely to be less vulnerable to capture, and catch rates can be expected to decline. Furthermore, warmer- or cooler-than-average SSTs can also cause these mobile fishes to move to more favorable habitats, which may also affect catch rates as fishers potentially expend more effort in locating the fish.

Recruitment of tropical tunas in the EPO is also thought to be affected by ENSO events. For example, strong La Niña events in 2007–2008 may be partly responsible for lower recruitment of bigeye tuna in the EPO while highest recruitment has corresponded to the strongest El Niño events in 1982–1983 and 1998 ([SAC-09-05](#)). Similarly, yellowfin tuna recruitment was low in 2007 while higher recruitment was observed during 2015–2016 which corresponded to the extreme El Niño event in 2014–2016 ([SAC-09-06](#)).

Indices of variability in oceanographic and atmospheric conditions are commonly used to monitor the strength and magnitude of ENSO events in the Pacific Ocean. Several indicators are available to measure ENSO, including air pressure indices (*e.g.*, the Southern Oscillation Index, or SOI, which measures the difference between atmospheric pressure at sea level in Tahiti and Darwin, Australia), sea surface temperature indices (*e.g.* the Oceanic Niño Index, or ONI, which measures SST anomalies), outgoing longwave radiation indices related to thunderstorm activity, and wind indices²³. Here, the ONI is presented to characterize inter-annual variability in SSTs, because it is used by the US National Oceanic and Atmospheric Administration (NOAA) as the primary indicator of warm El Niño (ONI $\geq +0.5$) and cool La Niña (ONI ≤ -0.5) conditions within the Niño 3.4 region in the east-central tropical Pacific Ocean²⁴ ([Figure L-6a](#)). Categories of ENSO events represented by the ONI describe the magnitude of the event from “extreme” to “weak” ([Figure L-6b](#)). For example, an “extreme El Niño” event occurred in 1997–1998 followed by a “strong La Niña” event in 1998–2000. “Strong La Niña” events were also observed in 2007–2008 and 2010–2011. Values of the ONI were greatest (>2.5) in the recent 2015–2016 El Niño event.

Climate-induced variability on a decadal scale (*i.e.* 10 to 30 years) also affects the EPO and has often been described as “regimes” characterized by relatively stable means and patterns in the physical and biological variables. Decadal fluctuations in upwelling coincide with higher-frequency ENSO patterns, and have basin-wide effects on the SSTs and thermocline depth that are similar to those caused by ENSO, but on longer time scales. For example, analyses by the IATTC staff have indicated that yellowfin in the EPO have experienced regimes of lower (1975–1982 and 2003–2014) and higher (1983–2002) recruitment, thought to be due to a shift in the primary productivity regime in the Pacific Ocean ([SAC-09-06](#)).

One such index used to describe longer-term fluctuations in the Pacific Ocean is the Pacific Decadal Oscillation (PDO). The PDO—a long-lived El Niño-like pattern of Pacific climate variability—tracks large-scale interdecadal patterns of environmental and biotic changes, primarily in the North Pacific Ocean²⁵, with

²³ Barnston, A. 2015. Why are there so many ENSO indexes, instead of just one? <https://www.climate.gov/news-features/blogs/enso/why-are-there-so-many-enso-indexes-instead-just-one>. Climategov science & information for a climate-smart nation. USA: National Oceanic and Atmospheric Administration

²⁴ Dahlman, L. 2016. Climate Variability: Oceanic Niño Index. <https://www.climate.gov/news-features/understanding-climate/climate-variability-oceanic-ni%C3%B1o-index>. National Oceanic and Atmospheric Administration

²⁵ Mantua, N.J.; Hare, S.R.; Zhang, Y.; Wallace, J.M.; Francis, R.C. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. *Bull Am Meteorol Soc.* 78:1069-1079

secondary signatures in the tropical Pacific²⁶. Similar to ENSO, PDO phases have been classified as “warm” or “cool” phases. The PDO has been used to explain the influence of environmental drivers on the vulnerability of silky sharks impacted by fisheries in the EPO²⁷. A time series of the PDO index is presented in [Figure L-7](#) to show variability in warm and cool phases of the PDO from 1993–2018. PDO values peaked at 2.79 in August 1997, and at 2.62 in April 2016, both of which coincided with the extreme El Niño events as represented by the ONI.

Time-longitude Hovmöller diagrams are presented for SST ([Figure L-8a](#)) and chlorophyll-a ([Figure L-8b](#)) to aid in the visualization of variability in SSTs and chlorophyll-a concentrations over time. The SST time series show mean monthly values for the period 1993–2018 averaged over the eastern tropical Pacific (ETP) from 5°N to 5°S—the same latitudinal band used in the ONI for the same time series. In contrast, monthly chlorophyll-a concentrations (mg m^{-3}) were averaged over the same spatial area as SST but for 2003–2018 due to data availability. The SST plot ([Figure L-8a](#)) clearly shows the extreme El Niño events of 1997–1998 and 2015–2016 with warmer waters and the strong La Niña events in 1999–2000, 2007–2008 and 2010–2011 with cooler waters extending across the ETP. The chlorophyll-a plot ([Figure L-8b](#)) shows an increase in chlorophyll-a concentrations following the strong La Niña events in 2007–2008 and 2010–2011 due to changes in nutrient availability and abundance of zooplankton predators (see section 3.3 Larval fishes and plankton).

Because this report is also focused on data solely from 2018, information on ENSO conditions—as reported by the [Climate Diagnostics Bulletin of the U.S. National Weather Service](#) for 2018—are provided. Anomalies in oceanic and atmospheric conditions were indicative of La Niña conditions for the beginning of 2018, ENSO neutral conditions from June through August, and developing El Niño conditions from September to December. Although ENSO conditions are determined by various oceanic and atmospheric conditions, this report contains maps of quarterly mean SST data ([Figure L-9a](#)) to provide a general indication of seasonal variability in SST across the EPO during 2018. Warmer waters developed off Central America and extended westwards during quarters 2 (April–June) and 3 (July–September) while cooler waters occurred off South America, particularly south of 20°S in quarter 3.

As changes in biological productivity can impact prey and predator communities, and researchers have provided evidence of declines in primary productivity, here broad-scale variability in quarterly mean chlorophyll-a concentrations (mg m^{-3}) for 2018 is shown in [Figure L-9b](#). An oligotrophic gyre is persistent in the EPO around 20°–40°S that appears to have slightly retracted in quarter 3 relative to the rest of the year while higher chlorophyll concentrations were observed along the coast of the Americas.

6. ECOLOGICAL INDICATORS

Over the past two decades, many fisheries worldwide have broadened the scope of management to consider fishery impacts on non-target species and the ecosystem more generally. This ecosystem approach to fisheries management is important for maintaining the integrity and productivity of ecosystems while maximizing the utilization of commercially important assets. However, demonstrating the ecological sustainability of EPO fisheries is a significant challenge, given the wide range of species with differing life histories with which those fisheries interact. While biological reference points have been used for single-species management of target species, alternative performance measures and reference points are required for the many non-target species for which reliable catch and/or biological data are lacking; for

²⁶ Hare, S.R.; Mantua, N.J. 2000. Empirical evidence for North Pacific regime shifts in 1977 and 1989. *Prog Oceanogr.* 47:103-145

²⁷ Lennert-Cody, C.E.; Clarke, S.C.; Aires-da-Silva, A.; Maunder, M.N.; Franks, P.J.S.; Román, M.H.; Miller, A.J.; Minami, M. 2018. The importance of environment and life stage on interpretation of silky shark relative abundance indices for the equatorial Pacific Ocean *Fish Oceanogr*:1-11

example, incidental mortality limits for dolphins have been set in the EPO purse-seine fishery under the AIDCP.

Another important aspect of assessing ecological sustainability is to ensure that the structure and function of the ecosystem is not negatively impacted by fishing activities. Several ecosystem metrics or indicators have been proposed to address this issue, such as community size structure, diversity indices, species richness and evenness, overlap indices, trophic spectra of catches, relative abundance of an indicator species or group, and numerous environmental indicators.

Given the complexity of marine ecosystems, no single indicator can completely represent their structure and internal dynamics. In order to monitor changes in these multidimensional systems and detect the potential impacts of fishing and the environment, a variety of indicators is required. Therefore, a range of indicators that can be calculated with the ecosystem modelling software *Ecopath with Ecosim* (EwE) are used in this report to describe the long-term changes in the EPO ecosystem. The analysis covers the 1970–2017 period, and the indicators included are: mean trophic level of the catch (TL_c), the Marine Trophic Index (MTI), the Fishing in Balance index (FIB), Shannon’s index, and three indicators that describe the mean trophic level of three ecosystem components, or ‘communities’ (TL 2.0–3.25, ≥3.25–4.0, and >4.0), after fisheries have extracted biomass as catches. These indicators, and the results derived from the ecosystem model of the pelagic eastern tropical Pacific Ocean (ETP)²⁸, are summarized below

Trophic structure of the EPO ecosystem. Ecologically-based approaches to fisheries management require accurate depictions of trophic links and biomass flows through the food web. Trophic levels (TLs) are used in food-web ecology to characterize the functional role of organisms and to estimate energy flows through communities. A simplified food-web diagram, with approximate TLs, from the ETP model is shown in [Figure L-10](#). Toothed whales (Odontoceti, average TL 5.2), large squid predators (large bigeye tuna and swordfish, average TL 5.2), and sharks (average TL 5.0) are top-level predators. Other tunas, large piscivores, dolphins (average TL 4.8), and seabirds (average TL 4.5) occupy slightly lower TLs. Smaller epipelagic fishes (*e.g.* *Auxis* spp. and flyingfishes, average TL 3.2), cephalopods (average TL 4.4), and mesopelagic fishes (average TL 3.4) are the principal forage of many of the upper-level predators in the ecosystem. Small fishes and crustaceans prey on two zooplankton groups, and the herbivorous micro-zooplankton (TL 2) feed on the producers, phytoplankton and bacteria (TL 1).

Ecological indicators. In exploited pelagic ecosystems, fisheries that target large piscivorous fishes act as the system’s apex predators. Over time, fishing can cause the overall size composition of the catch to decrease, and, in general, the TLs of smaller organisms are lower than those of larger organisms. The mean trophic level of the catch (TL_c) by fisheries can be a useful metric of ecosystem change and sustainability, because it integrates an array of biological information about the components of the system. TL_c is also an indicator of whether fisheries are changing their fishing or targeting practices in response to changes in the abundance or catchability of traditional target species. For example, declines in the abundance of large predatory fish by overfishing has resulted in fisheries progressively targeting species at lower trophic levels in order to remain profitable. Studies that have documented this phenomenon, referred to as ‘fishing down the food web’, have shown that the TL_c decreased by around 0.1 of a trophic level per decade.

The Marine Trophic Index (MTI) is essentially the same as TL_c, but it includes only high trophic level species—generally TL>4.0—that are the first indicator of ‘fishing down the food web’. Some ecosystems, however, have changed in the other direction, from lower to higher TL communities, sometimes as a result

²⁸ Olson, R.J., and G.M. Watters. 2003. A model of the pelagic ecosystem in the eastern tropical Pacific Ocean. *Inter-American Tropical Tuna Commission, Bulletin* 22(3): 133-218.

of improved technologies to allow exploitation of larger species—referred to as ‘fishing up the food web’—but it can also result from improved catch reporting, as previously unreported catches of discarded predatory species, such as sharks, are recorded.

The Fishing in Balance (FIB) index indicates whether fisheries are balanced in ecological terms and not disrupting the functionality of the ecosystem (FIB = 0). A negative FIB indicates overexploitation, when catches do not increase as expected given the available productivity in the system, or if the effects of fishing are sufficient to compromise the functionality of the ecosystem, while a positive FIB indicates expansion of a fishery, either spatially, or through increased species richness of the catch.

Shannon’ index measures the diversity and evenness in the ecosystem. Because the number of functional groups defined by an ecosystem model is fixed, a decrease in the index indicates that the relative contribution of each group to the overall biomass has changed relative to a reference year.

In contrast to TL_c , the mean trophic level of the modelled community (TL_{MC}) essentially describes the expected trophic level of components of the ecosystem after fishing has extracted biomass as catches. There are three components—referred to as “communities”—that aggregate the biomass of functional groups in the model by trophic level: 2.0–3.25 ($TL_{2.0}$), ≥ 3.25 –4.0 ($TL_{3.5}$), and >4.0 ($TL_{4.0}$). These indicators can be used in unison to detect trophic cascades, whereby a decline in biomass of $TL_{4.0}$ due to fishing would reduce predation pressure on $TL_{3.5}$ and thus increase its biomass, which would in turn increase predation pressure on $TL_{2.0}$ and reduce its biomass.

Monitoring the EPO ecosystem using ecological indicators. Given the potential utility of combining ecological indicators for describing the various structures and internal dynamics of the EPO ecosystem, annual indicator values were estimated from a 1970–2017 time series of annual catches and discards, by species, for three purse-seine fishing modes, the pole-and-line fishery, and the longline fishery in the EPO. The estimates were made by assigning the annual catch of each species from the IATTC tuna, bycatch, and discard databases to a relevant functional group defined in the ETP ecosystem model, and refitting the Ecosim model to the time series of catches to estimate the aforementioned ecological indicators.

Values for TL_c and MTI increased from 4.65 and 4.67 in 1970 to 4.69 and 4.70 in 1991, respectively, as the purse-seine fishing effort on FADs increased significantly ([Figure L-11](#)). TL_c continued to decrease to a low of 4.65 in 1997, due to the rapid expansion of the fishery from 1993 where there was increasing catches in the intervening period of high trophic level bycatch species that also aggregate around floating objects (e.g. sharks, billfish, wahoo and dorado). This expansion is seen in the FIB index that exceeds zero during the same period, and also a change in the evenness of biomass of the community indicated by Shannon’s index. By the early 2000s, TL_c , MTI, and Shannon’s index all show a gradual decline, while the FIB gradually increased further from zero to its peak in 2017 at 0.66 ([Figure L-11](#)). Both TL_c and MTI reached their lowest historic levels of 4.64 and 4.65 in 2017, respectively. Since its peak in 1991, TL_c declined by 0.05 of a trophic level in the subsequent 27 years, or 0.02 trophic levels per decade.

The above indicators generally describe the change in the exploited components of the ecosystem, whereas community biomass indicators describe changes in the structure of the ecosystem once biomass has been removed due to fishing. The biomass of the $TL_{MC4.0}$ community was at one of its highest values (4.449) in 1993, but has continued to decline to 4.443 in 2017 ([Figure L-11](#)). As a result of changes in predation pressure on lower trophic levels, between 1993 and 2017 the biomass of the $TL_{MC3.25}$ community increased from 3.800 to 3.803, while interestingly, the biomass of the $TL_{MC2.0}$ community also increased from 3.306 to 3.308.

Together, these indicators show that the ecosystem structure has likely changed over the 48-year analysis period. However, these changes, even if they are a direct result of fishing, are not considered ecologically

detrimental, but the patterns of changes, particularly in the mean trophic level of the communities, certainly warrant the continuation, and possible expansion, of monitoring programs for fisheries in the EPO.

7. ECOLOGICAL RISK ASSESSMENT

The primary goal of ecosystem-based fisheries management is to ensure the long-term sustainability of all species impacted—directly or indirectly—by fishing. However, this is a significant challenge for fisheries that interact with many non-target species with diverse life histories, for which sufficiently reliable catch and biological data for single-species assessments are lacking. An alternative approach for such data-limited situations is Ecological Risk Assessment (ERA), a tool for prioritizing management action or further data collection and research for potentially vulnerable species.

‘Vulnerability’ is defined here as the potential for the productivity of a stock to be diminished by direct and indirect fishing pressure. The IATTC staff has applied an ERA approach called ‘productivity-susceptibility analysis’ (PSA) to estimate the vulnerability of data-poor, non-target species caught in the EPO purse-seine fishery by large (Class-6) vessels and in the longline fishery. PSA considers a stock’s vulnerability as a combination of its susceptibility to being captured by, and incur mortality from, a fishery and its capacity to recover, given its biological productivity.

Purse-seine fishery. A manuscript describing the evaluation of three purse-seine “fisheries” in the EPO is in review, using 27 species (3 target tunas, 4 billfishes, 3 dolphins, 7 large fishes, 3 rays, 5 sharks, and 2 small fishes) that comprised the majority of the biomass removed by the purse-seine fleet during 2005-2013 ([Table L-1](#)). The overall productivity (p) and susceptibility (s) values that contributed to the overall vulnerability score (v) are shown in [Table L-1](#). Vulnerability was highest for elasmobranchs, namely the giant manta ray (*Manta birostris*), bigeye and pelagic thresher shark (*Alopias superciliosus* and *A. pelagicus*), smooth and scalloped hammerhead sharks (*Sphyrna mokarran* and *S. lewini*), and silky shark (*Carcharhinus falciformis*). Billfishes, dolphins, other rays, ocean sunfish, and yellowfin and bigeye tunas were classified as moderately vulnerable, while the remaining species, all teleosts had the lowest vulnerability scores ([Table L-1](#); [Figure L-12a](#)).

Large-scale tuna longline fishery. A preliminary assessment of the longline fishery in the EPO was undertaken in 2016 for 68 species that had some level of interaction (captured, discarded, or impacted) with the fishery ([SAC-08-07d](#)). There were 12, 38, and 18 species classified as having low, moderate, and high vulnerability, respectively ([Figure L-12b](#); [Table L-2](#)). Of the 18 highly vulnerable species, 13 were elasmobranchs—with the bigeye thresher, tiger, porbeagle and blue sharks identified as most vulnerable—, and 5 were commercially important tunas and billfishes (albacore, Pacific bluefin, and yellowfin tunas, swordfish, and striped marlin). Other tuna-like and mesopelagic species were classified as either having moderate or low vulnerability in the fishery, although four species—wahoo, snake mackerel, and the two species of dorado—had v scores close to 2.0, in close vicinity to being highly vulnerable ([Figure L-12b](#); [Table L-2](#)).

Cumulative impacts of ‘industrial’ fisheries on EPO species. Because a limitation of PSA is the inability to estimate the cumulative effects of multiple fisheries on data-poor bycatch species, a new flexible spatially-explicit approach—Ecological Assessment of Sustainable Impacts of Fisheries (EASI-Fish)—was developed by the IATTC staff in 2018 ([SAC-09-12](#)) to overcome this issue. EASI-Fish uses a reduced set of parameters that are present in the PSA, and first produces a proxy of the instantaneous fishing mortality rate (F) of each species based on the ‘volumetric overlap’ of each fishery with the stock’s distribution. F is then used in length-structured per-recruit models to assess the vulnerability of each species using conventional biological reference points (e.g. F_{MSY} , $F_{0.1}$ and $SSB_{40\%}$). EASI-Fish has major advantages over PSA including: (i) the capability of quantitatively estimating species-specific vulnerability for the purposes of prioritizing species for data collection, further detailed analysis, research and management, (ii) transferability between species with different life histories (e.g., teleosts to marine mammals), and (iii) the ability to rapidly

and cost-effectively explore hypothetical spatial and/or temporal conservation and management measures that may reduce or mitigate the risk posed by a fishery to a species. EASI-Fish was successfully applied to 14 species representing a range of life histories, including tunas, billfish, tuna-like species and elasmobranchs caught in EPO tuna fisheries as a ‘proof of concept’ in 2018 ([SAC-09-12](#)). Therefore, EASI-Fish will continue to be refined and is planned to supersede the PSA in future ERAs for fisheries operating in the EPO. Given EPO tuna fisheries interact with at least 117 taxa ([SAC-07-INF C\(d\)](#)), the IATTC staff will continue in the coming years to incrementally include more species to the analysis until all impacted species are assessed, as stipulated in the proposed 5-year SSP. This year, the spinetail devil ray was assessed and results were presented at the Ninth Meeting of the Working Group on Bycatch ([BYC-09-01](#)).

8. ECOSYSTEM MODELING

Although ERA approaches can be useful for assessing the ecological impacts of fishing, they generally do not consider changes in the structure and internal dynamics of an ecosystem. As data collection programs improve and ecological studies (*e.g.* on diet) are conducted on components of the ecosystem, more data-rich ecosystem models can be employed that quantitatively represent ecological interactions among species or ecological ‘functional groups’. These models are most useful as descriptive devices for exploring the potential impacts of fishing and/or environmental perturbations on components of the system, or the ecosystem structure as a whole.

The IATTC staff has developed a model of the pelagic ecosystem in the tropical EPO (IATTC Bulletin, [Vol. 22, No. 3](#)) to explore how fishing and climate variation might affect the animals at middle and upper trophic levels. The ecosystem model has 38 components, including the principal exploited species (*e.g.* tunas), functional groups (*e.g.* sharks and flyingfishes), and species of conservation importance (*e.g.* sea turtles). Fisheries landings and discards are included as five fishing “gears”: pole-and-line, longline, and purse-seine sets on tunas associated with dolphins, with floating objects, and in unassociated schools. The model focuses on the pelagic regions; localized, coastal ecosystems are not included.

The model has been calibrated to time series of biomass and catch data for a number of target and non-target species for 1961–1998. There have been significant improvements in data collection programs in the EPO since 1998, and these new data has allowed the model include catch data to 2017. Additionally, simulations using this new data were conducted to assess potential impacts of the FAD fishery on the structure of the ecosystem ([SAC-10-15](#)).

One shortcoming of the model, in its current form, is that its underlying diet matrix—the component of the model that defines the trophic linkages between species in the ecosystem—that is based on stomach content data from fish collected over two decades ago (1992–1994). Furthermore, these data were supplemented with diet data from other regions of the Pacific Ocean and beyond where no local data were available for a particular species or functional group. Given the significant environmental changes that have been observed in the EPO over the past decade, in the form of some of the strongest El Niño events on record, it stands to reason that there is a critical need to collect trophic information from not only species of economic (*e.g.* tunas) or conservation (*e.g.* sharks) importance, but also their prey, and the base of the food web (*i.e.* phytoplankton).

A second limitation of the model is that it describes only the tropical component of the EPO ecosystem, and results cannot be reliably extrapolated to other regions of the EPO. Therefore, future work may aim to update the model to a spatially-explicit model that covers the entire EPO. This is a significant undertaking, but it would allow for an improved representation of the ecosystem and the potential fishery and climate impact scenarios that may be modelled to guide ecosystem-based fisheries management.

9. ACTIONS BY THE IATTC AND THE AIDCP ADDRESSING ECOSYSTEM CONSIDERATIONS

Both the IATTC's Antigua Convention and the AIDCP have objectives that involve the incorporation of ecosystem considerations into the management of the tuna fisheries in the EPO. Actions taken in the past can be found in [Resolutions](#) adopted by the IATTC and AIDCP.

10. FUTURE DEVELOPMENTS

It is unlikely, in the near future at least, that there will be stock assessments for most of the bycatch species. The IATTC staff's experience with dolphins suggests that the task is not trivial if relatively high precision is required. In lieu of formal assessments, it may be possible to develop indices to assess trends in the populations of these species, which is currently undertaken for silky sharks.

An ecosystem-based approach to fisheries management may be best facilitated through a multi-faceted approach involving the monitoring of biologically and ecologically meaningful indicators for key indicator species and ecosystem integrity. Ecological indicators may be aggregate indices describing the structure of the entire ecosystem (*e.g.* diversity), or specific components (*e.g.* trophic level of the catch), as presented in Section 6, "Ecological Indicators". Biological indicators may generally relate to single species—perhaps those of key ecological importance or 'keystone' species—and be in the form of commonly-used fishery reference points (*e.g.* F_{MSY}), CPUE, or other simple measures such as changes in size spectra. However, the indicator(s) used depend heavily on the reliability of the information available at the species to ecosystem level.

The distributions of the fisheries for tunas and billfishes in the EPO are such that several regions with different ecological characteristics may be included. Within them, water masses, oceanographic or topographic features, influences from the continent, *etc.*, may generate heterogeneity that affects the distributions of the different species and their relative abundances in the catches. It would be desirable to increase our understanding of these ecological strata so that they can be used in the analyses.

It is important to continue studies of the ecosystems in the EPO. The power to resolve issues related to fisheries and the ecosystem will increase with the number of habitat variables, taxa, and trophic levels studied and with longer time series of data.

Future ecosystem work is described in the proposed IATTC Strategic Science Plan ([IATTC-93-06a](#)) and staff activities report (SAC-10-01). Briefly, this work will include improving ERAs—using EASI-Fish to identify species at risk and prioritize species-specific research—and developing and maintaining databases of key biological and ecological parameters (*e.g.* growth parameters), continuation of diet studies to update diet matrices in ecosystem models, developing research proposals for biological sampling, ecosystem monitoring and field-based research on consumption and evacuation experiments, development of a spatially-explicit ecosystem model of the EPO and ecological indicators, and continued reporting of bycatch estimates. A review of ecosystem-related research was undertaken to improve IATTC's reporting of ecological research with suggested improvements outlined in SAC-10 INF-B.

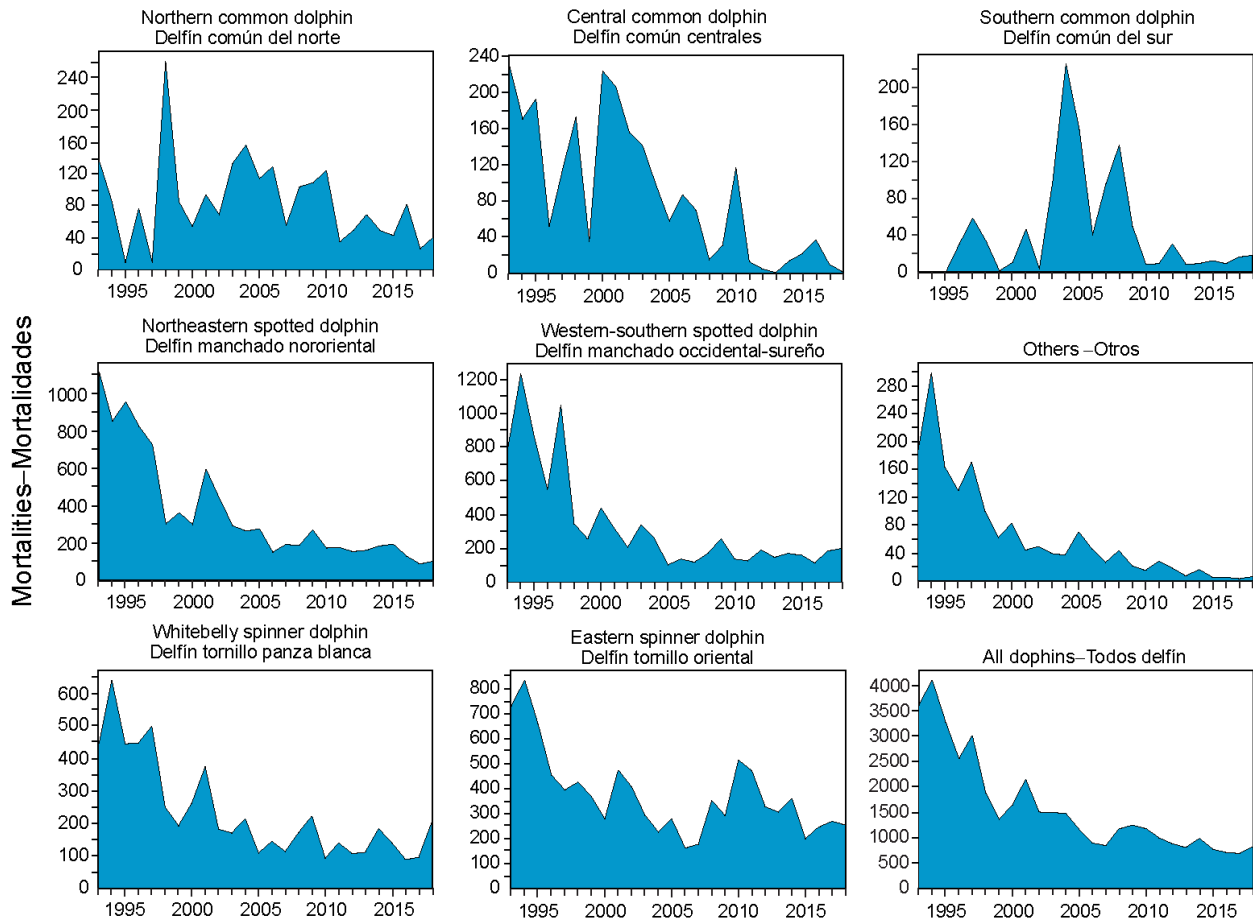


FIGURE L-1. Incidental dolphin mortalities, in numbers of animals by purse-seine vessels, 1993–2018.
FIGURA L-1. Mortalidades incidentales de delfines, en número de animales, 1993–2018.

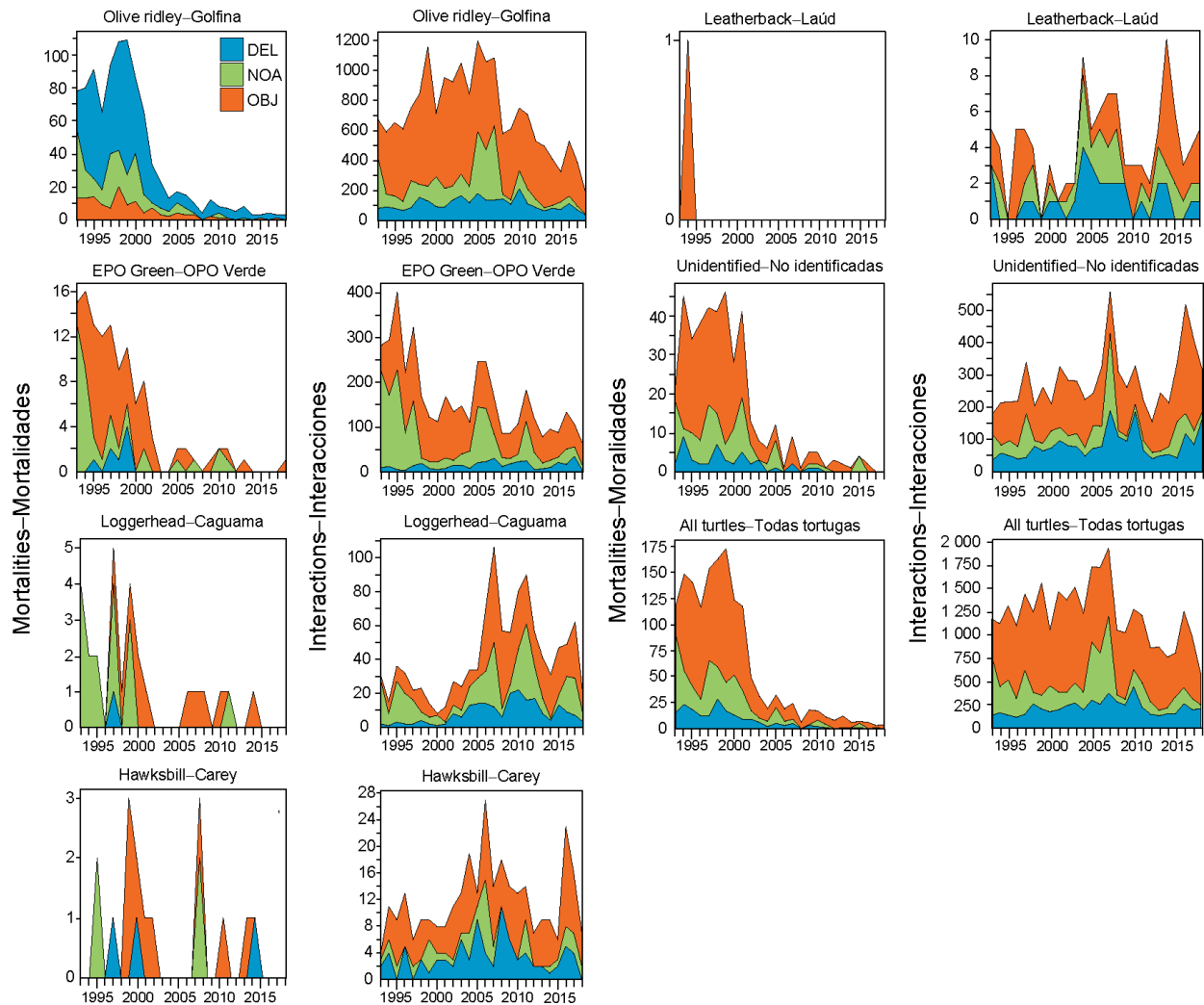


FIGURE L-2. Sea turtle interactions and mortalities, in numbers of animals, for large purse-seine vessels, 1993–2018, by set type (dolphin (DEL), unassociated (NOA), floating object (OBJ)).

FIGURA L-2. Interacciones y mortalidades de tortugas marinas, en número de animales, para buques cerqueros grandes, 1993-2018, por tipo de lance (delfín (DEL), no asociado (NOA), objeto flotante (OBJ)).

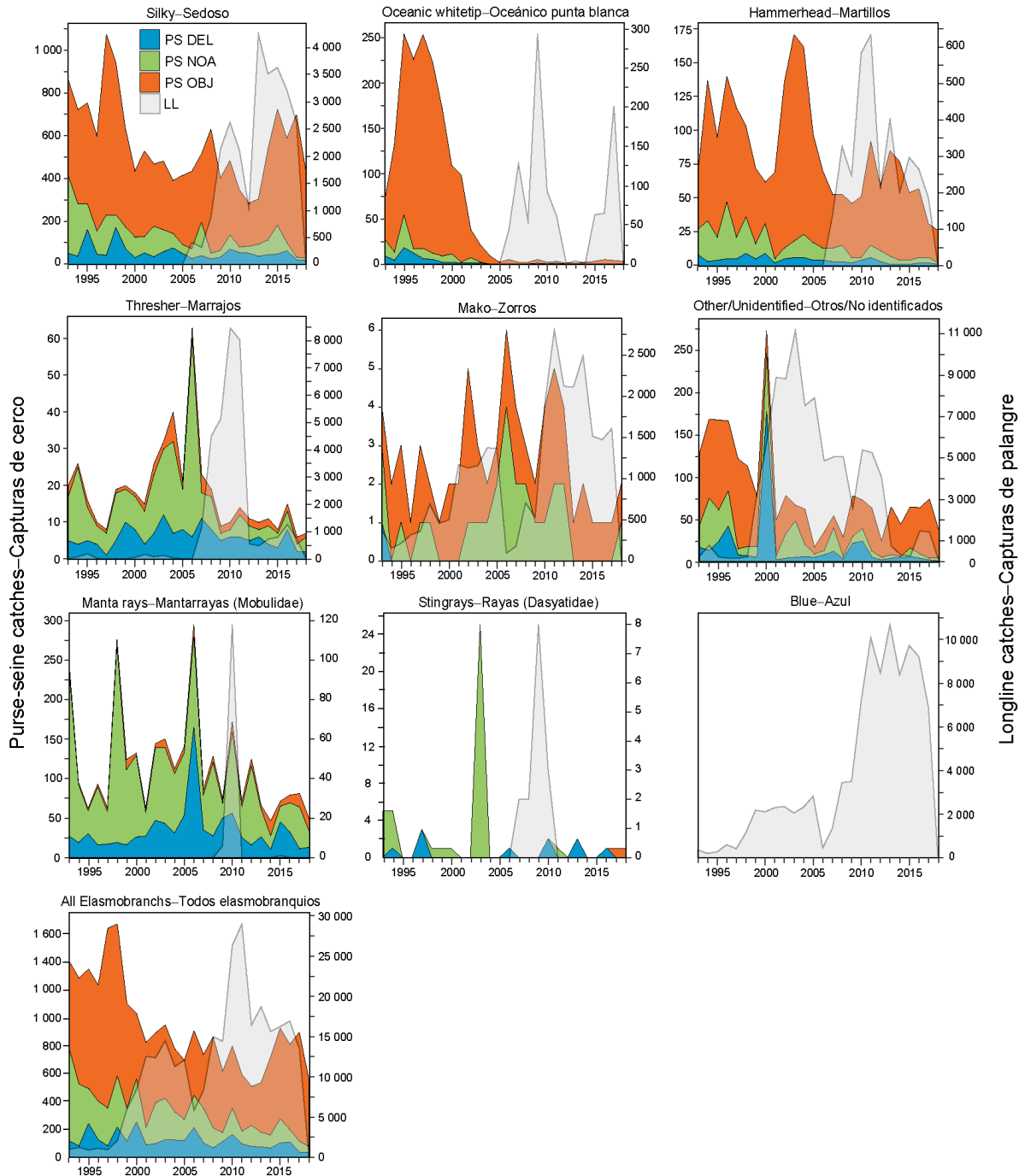


FIGURE L-3. Retained and discarded catches of sharks and rays, in tons, reported by observers aboard large purse-seine vessels, 1993–2018, by set type (dolphin (DEL), unassociated (NOA), floating object (OBJ)) (left y-axis). Longline data (right y-axis) are considered to be minimum catch estimates. Data for the past two years should be considered preliminary; longline data for 2018 not currently available.

FIGURA L-3. Capturas retenidas y descartadas de tiburones y rayas, en toneladas, notificadas por observadores a bordo de buques cerqueros grandes, 1993–2018, por tipo de lance (delfín (DEL), no asociado (NOA), objeto flotante (OBJ)). Los datos de palangre (eje y derecho) se consideran estimaciones mínimas de captura. Los datos de los dos últimos años deben considerarse preliminares; los datos de palangre para 2018 no están disponibles.

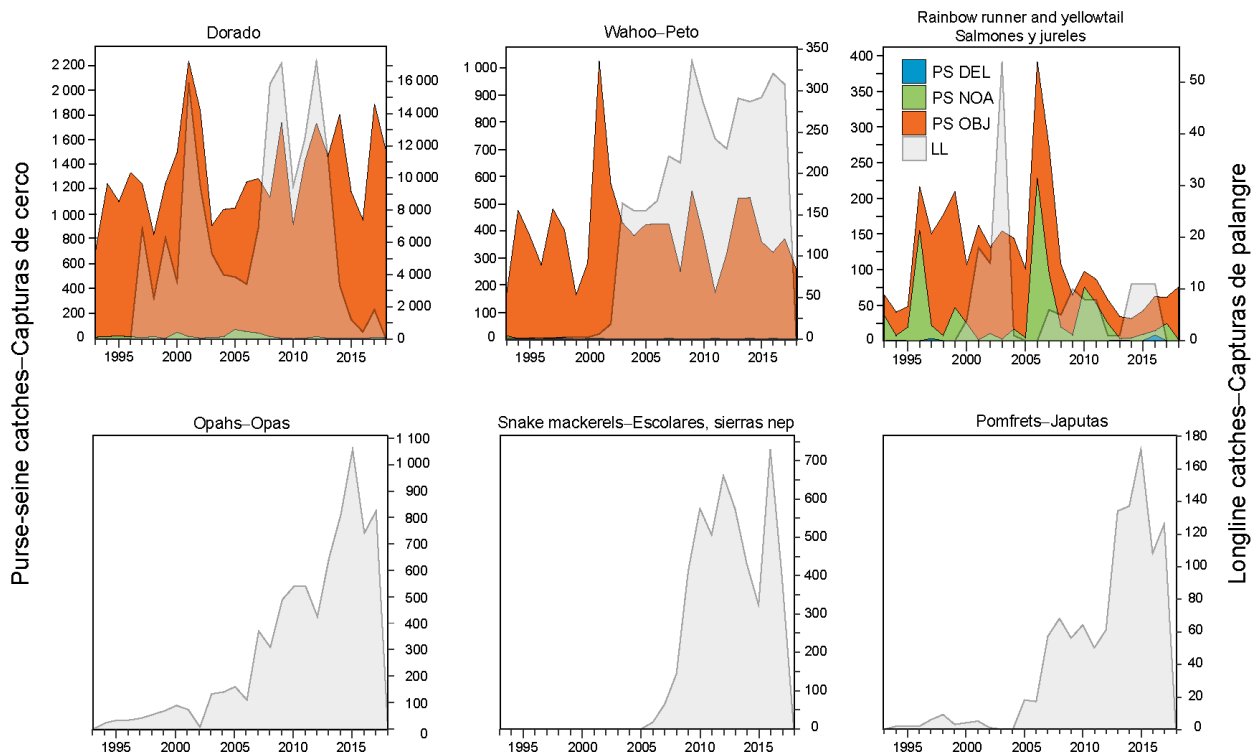


FIGURE L-4. Catches, in tons, of commonly-caught fishes by large purse-seine vessels, 1993–2018, by set type (dolphin (DEL), unassociated (NOA), floating object (OBJ)) (left y-axis). Longline data (right y-axis) are considered to be minimum catch estimates. Data for the past two years should be considered preliminary; longline data for 2018 not currently available.

FIGURA L-4. Capturas, en toneladas, de peces capturados comúnmente por buques cerqueros grandes, 1993-2018, por tipo de lance (delfín (DEL), no asociado (NOA), objeto flotante (OBJ)) (eje y izquierdo). Los datos de palangre (eje y derecho) se consideran estimaciones mínimas de captura. Los datos de los dos últimos años deben considerarse preliminares; los datos de palangre para 2018 no están disponibles.

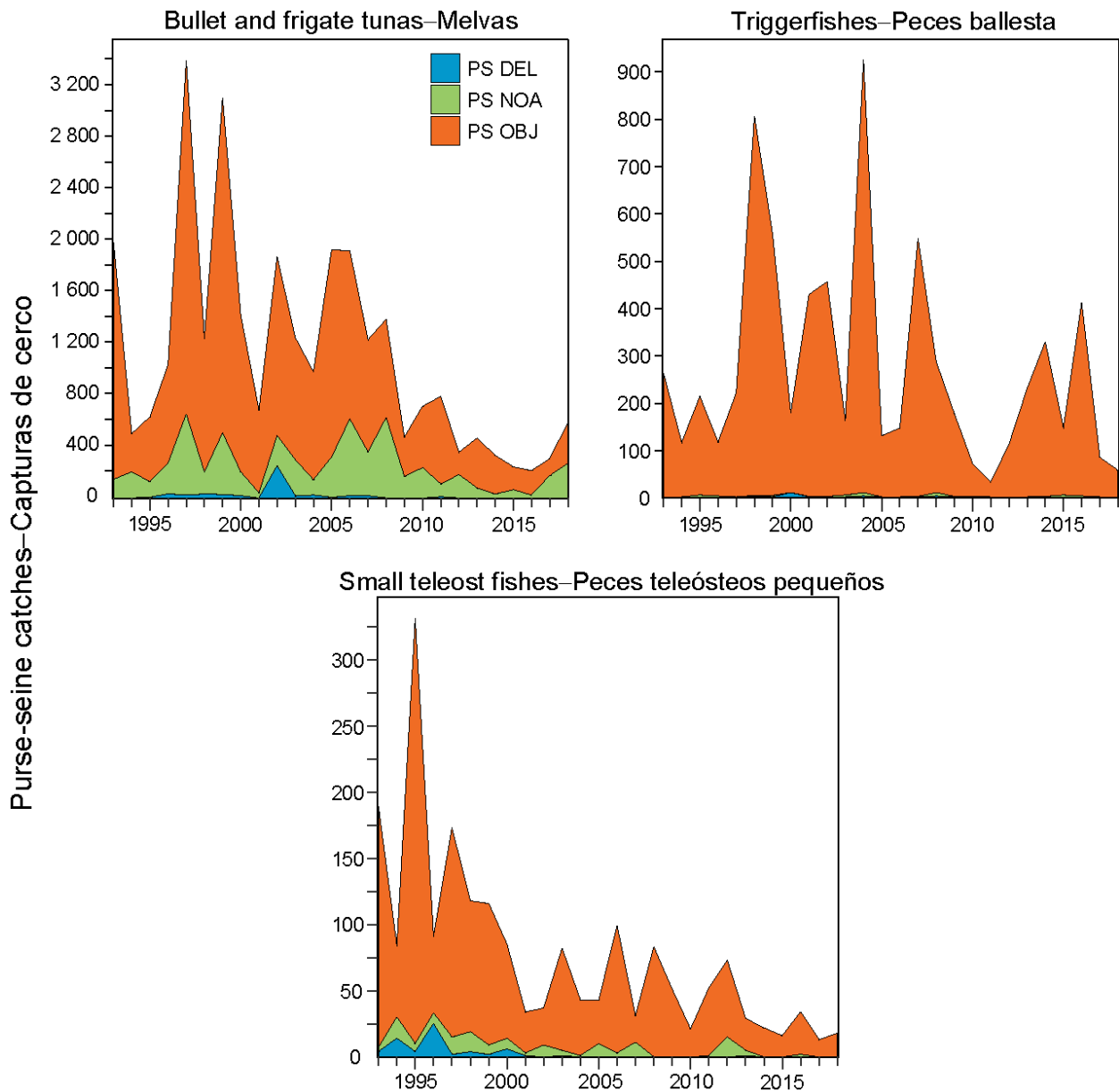


FIGURE L-5. Catches, in tons, of forage fishes by large purse-seine vessels, 1993–2018, by set type (dolphin (DEL), unassociated (NOA), floating object (OBJ)).

FIGURA L-5. Capturas, en toneladas, de peces de alimento por buques cerqueros grandes, 1993–2018, por tipo de lance (delfín (DEL), no asociado (NOA), objeto flotante (OBJ)).

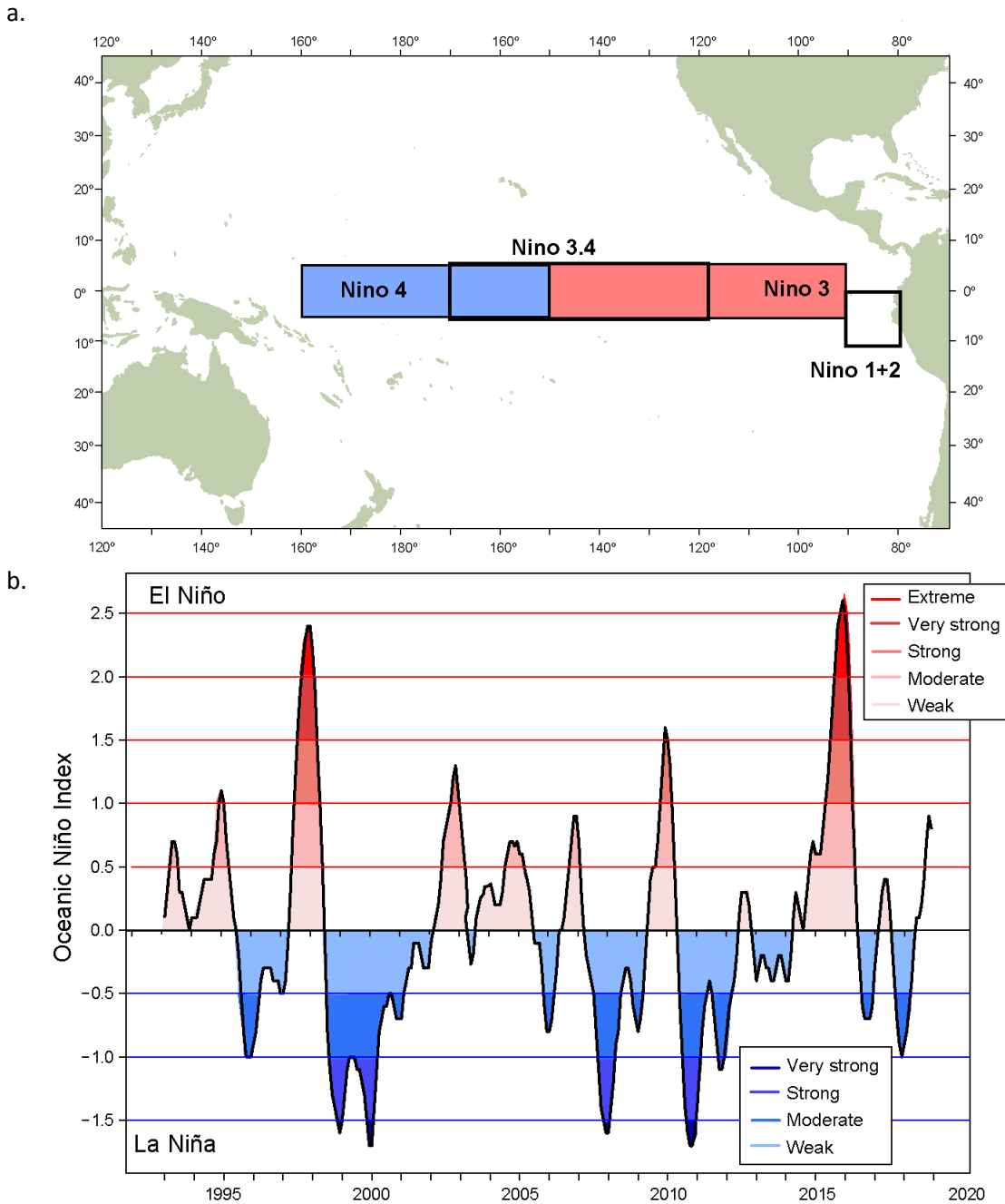


FIGURE L-6. a) El Niño regions used as indicators of El Niño Southern Oscillation (ENSO) events in the Pacific Ocean. The Oceanic Niño Index (ONI) used to monitor ENSO conditions in Niño region 3.4 from 5°N to 5°S and 120°W to 170°W. b) Time series from the start of the IATTC observer program through December 2018 showing the running 3-month mean values of the ONI. ONI data obtained from: http://www.cpc.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml

FIGURA L-6 a) Regiones de El Niño utilizadas como indicadores de los eventos de El Niño-Oscilación del Sur (ENOS) en el Océano Pacífico. El Índice de El Niño Oceánico (ONI) usado para dar seguimiento a las condiciones de ENOS en la región Niño 3.4 de 5°N a 5°S y de 120°O a 170°O. b) Series de tiempo desde el inicio del programa de observadores de la CIAT hasta finales de diciembre de 2018 mostrando los valores del promedio móvil de 3 meses del ONI. Datos del ONI obtenidos de: http://www.cpc.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml

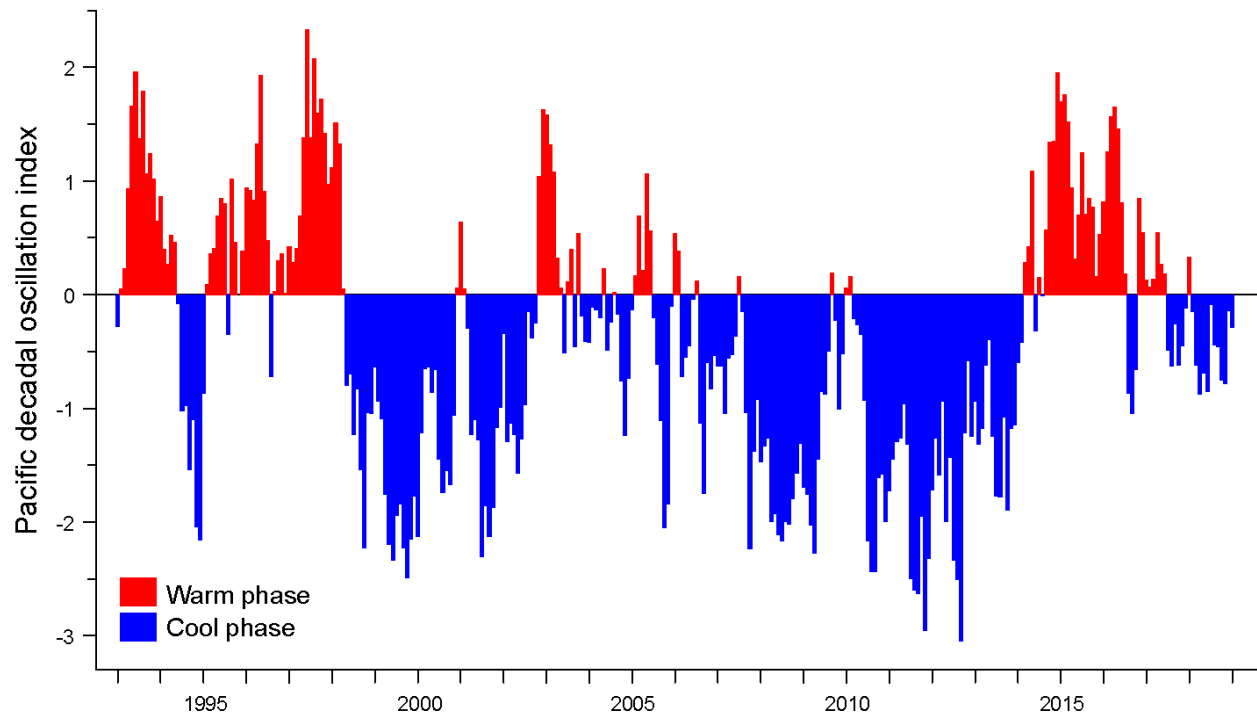


FIGURE L-7. Monthly values of the Pacific Decadal Oscillation (PDO) Index, January 1993–December 2018. PDO data obtained from: <https://www.ncdc.noaa.gov/teleconnections/pdo/data.csv>

FIGURA L-7 Valores mensuales del índice de Oscilación Decadal del Pacífico (PDO), enero de 1993–diciembre de 2018. Datos de la PDO obtenidos de: <https://www.ncdc.noaa.gov/teleconnections/pdo/data.csv>

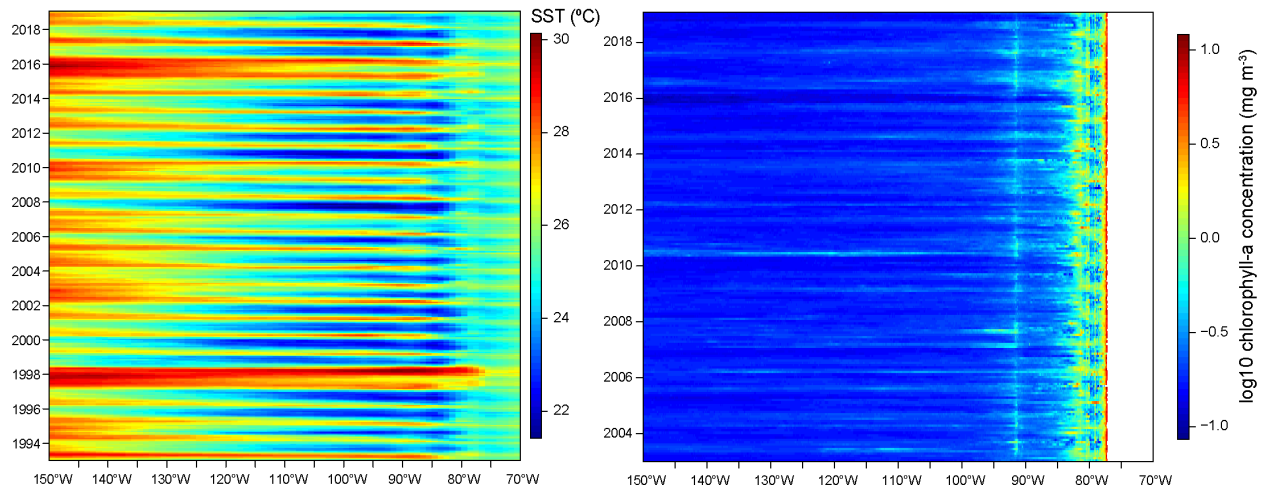


FIGURE L-8. Time-longitude Hovmöller diagram with data averaged across the tropical eastern Pacific Ocean from 5°N to 5°S for a) mean monthly SST for January 1993–January 2019. *NOAA_OI_SST_V2 data provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their Web site at <https://www.esrl.noaa.gov/psd/> and b) mean monthly chlorophyll-a concentration for January 2003–January 2019. Chlorophyll-a concentration data obtained from ERDDAP, NASA/GSFC/OBPG, downloaded on 27 Mar 2019, Chlorophyll-a, Aqua MODIS, NPP, L3SMI, Global, 4km, Science Quality, 2003–present (Monthly Composite), NOAA, NMFS, SWFSC, ERD, <https://coastwatch.pfeg.noaa.gov/erddap/info/erdMH1chlamday/index.html>, DOI: 10.5067/AQUA/MODIS/L3M/CHL/2018.*

FIGURA L-8 Diagrama de Hovmöller tiempo-longitud con datos promediados en el Océano Pacífico tropical oriental de 5°N a 5°S para a) la TSM promedio mensual de enero de 1993 a enero de 2019. Datos NOAA_OI_SST_V2 proporcionados por la NOAA/OAR/ESRL PSD, Boulder, Colorado, EE. UU., de su sitio web: <https://www.esrl.noaa.gov/psd/> y b) concentración promedio mensual de clorofila-a de enero de 2003 a enero de 2019. Datos de concentración de clorofila-a obtenidos de ERDDAP, NASA/GSFC/OBPG, descargados el 27 de marzo de 2019, “Chlorophyll-a, Aqua MODIS, NPP, L3SMI, Global, 4km, Science Quality, 2003–present (Monthly Composite)”, NOAA, NMFS, SWFSC, ERD, <https://coastwatch.pfeg.noaa.gov/erddap/info/erdMH1chlamday/index.html> DOI: 10.5067/AQUA/MODIS/L3M/CHL/2018.

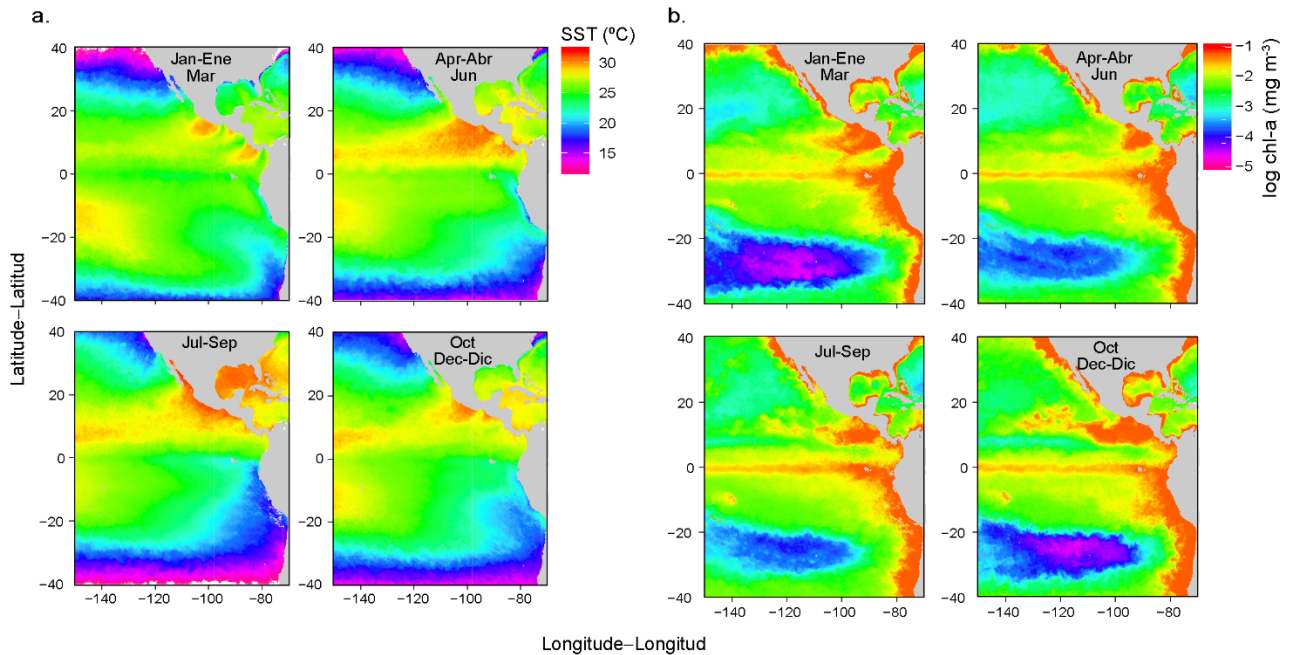


FIGURE L-9. a) Mean sea surface temperature (SST) b) Mean chlorophyll-a concentration mg m^3 for each quarter during 2018. SST data obtained from NOAA NMFS SWFSC ERD on February 11, 2019, “SST, Aqua MODIS, NPP, 4km, Daytime (11 microns), 2003–present (Monthly Composite)”, <https://coastwatch.pfeg.noaa.gov/erddap/info/erdMH1sstdmday/index.html>. Chlorophyll data presented as log chl-a concentration, obtained from NOAA CoastWatch on February 1, 2019, “Chlorophyll, NOAA, VIIRS, Science Quality, Global, Level 3, 2012-present, Monthly”, NOAA NMFS SWFSC ERD, <https://coastwatch.pfeg.noaa.gov/erddap/info/nesdisVHNSQchlaMonthly/index.html>

FIGURA L-9 a) Temperatura superficial del mar (TSM) promedio b) Concentración promedio de clorofila- a mg m^3 para cada trimestre de 2018. Datos de TSM obtenidos de NOAA NMFS SWFSC ERD el 11 de febrero de 2019, “SST, Aqua MODIS, NPP, 4km, Daytime (11 microns), 2003–present (Monthly Composite)”, <https://coastwatch.pfeg.noaa.gov/erddap/info/erdMH1sstdmday/index.html>. Datos de clorofila presentados como concentración log chl-a, obtenidos de NOAA CoastWatch el 1 de febrero de 2019, “Chlorophyll, NOAA, VIIRS, Science Quality, Global, Level 3, 2012-present, Monthly”, NOAA NMFS SWFSC ERD, <https://coastwatch.pfeg.noaa.gov/erddap/info/nesdisVHNSQchlaMonthly/index.html>

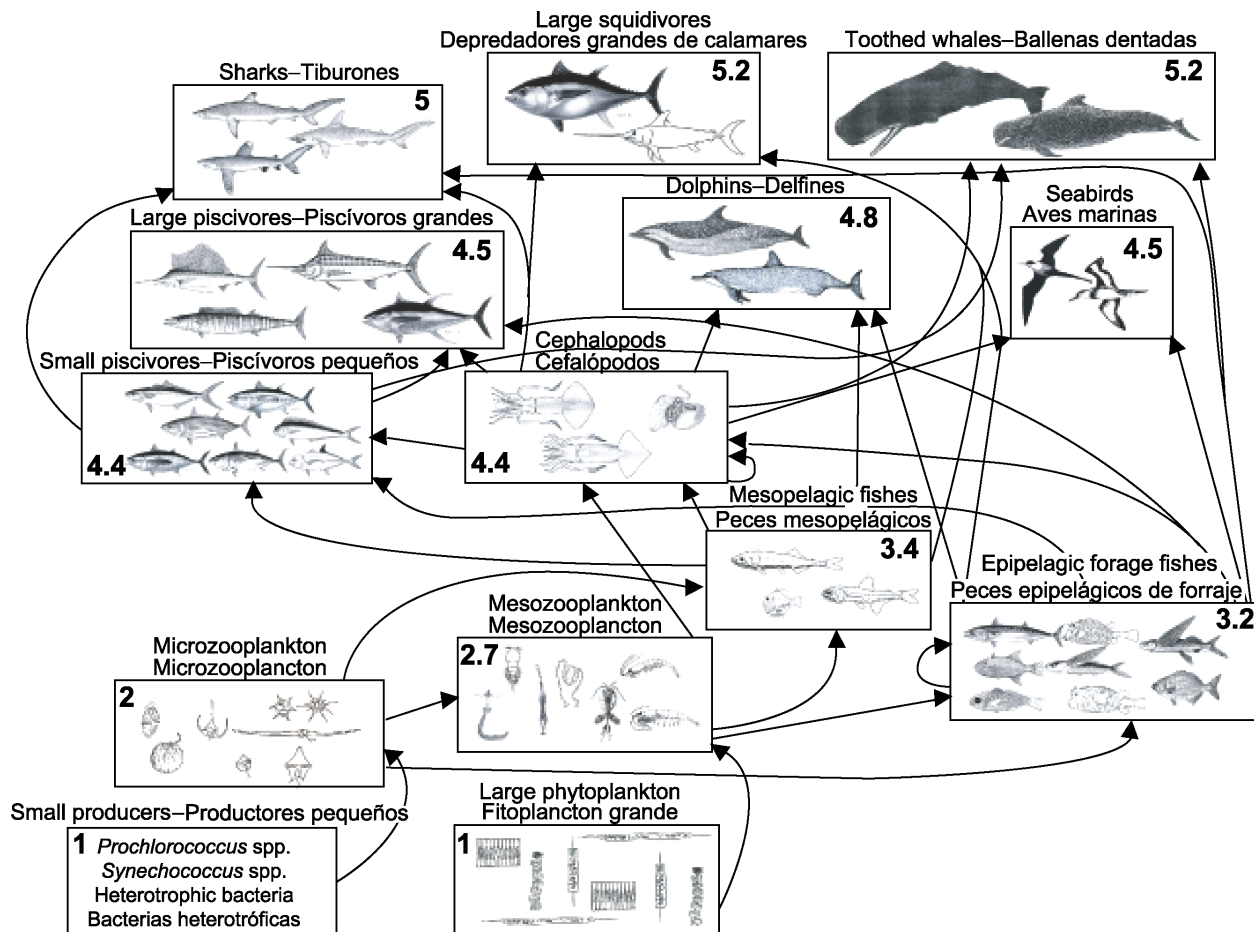


FIGURE L-10. Simplified food-web diagram of the pelagic ecosystem in the tropical EPO. The numbers inside the boxes indicate the approximate trophic level of each group.

FIGURA L-10. Diagrama simplificado de la red trófica del ecosistema pelágico en el OPO tropical. Los números en los recuadros indican el nivel trófico aproximado de cada grupo.

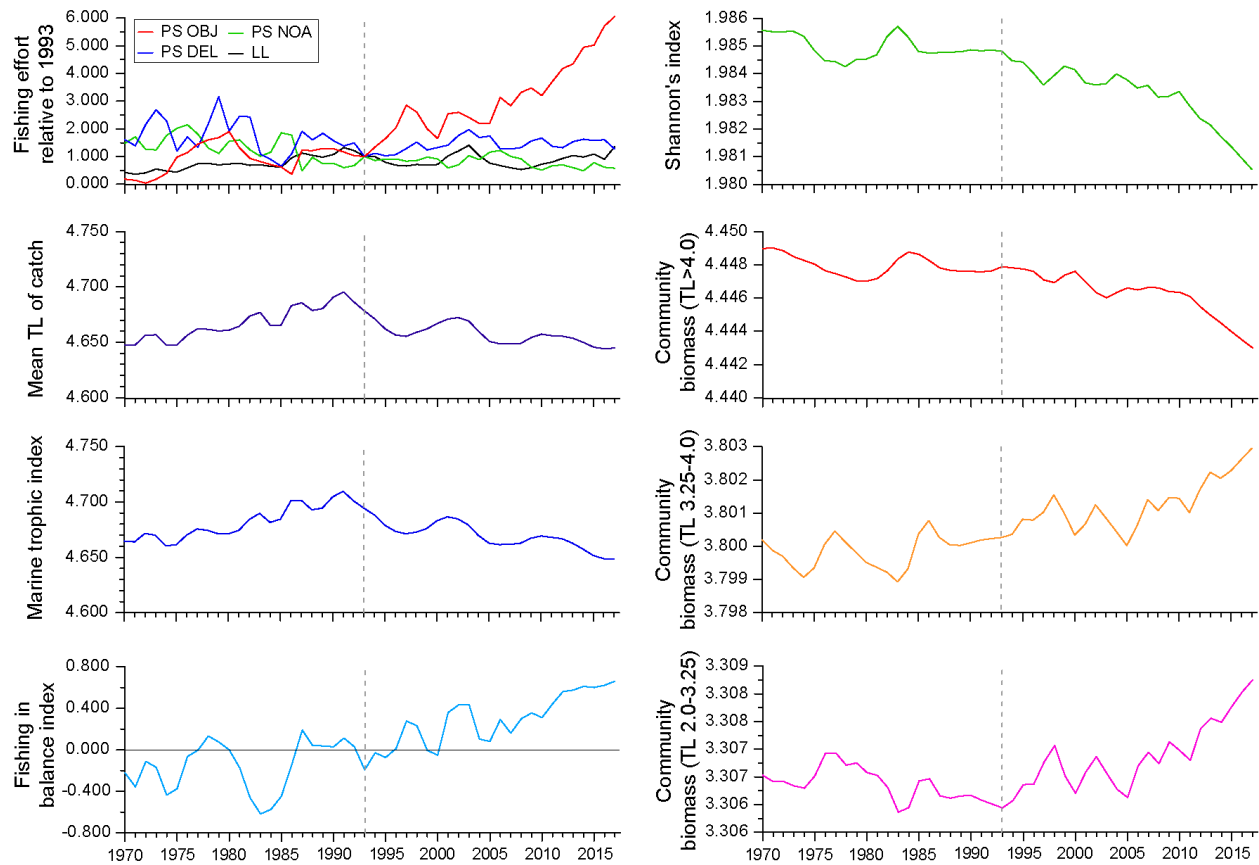


FIGURE L-11. Annual values for seven ecological indicators of changes in different components of the tropical EPO ecosystem, 1970–2017 (see Section 6 of text for details), and an index of longline (LL) and purse-seine (PS) fishing effort, by set type (dolphin (DEL), unassociated (NOA), floating object (OBJ)), relative to the model start year of 1993 (vertical dashed line), when the expansion of the purse-seine fishery on FADs began.

FIGURA L-11. Valores anuales de siete indicadores ecológicos de cambios en diferentes componentes del ecosistema tropical del OPO, 1970–2017 (ver detalles en la sección 6 del texto), y un índice de esfuerzo palangrero (LL) y cerquero (PS), por tipo de lance (delfín (DEL), no asociado (NOA), objeto flotante (OBJ)) relativo al año de inicio del modelo de 1993 (línea de trazos vertical), cuando comenzó la expansión de la pesquería cerquera sobre plantados.

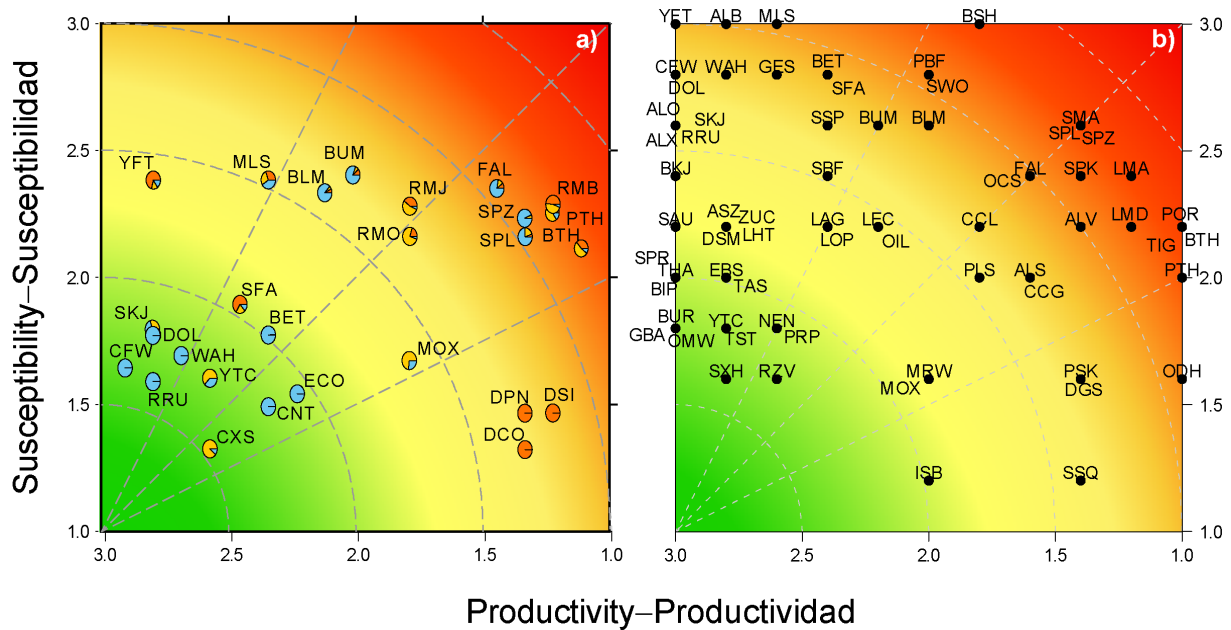


FIGURE L-12. Productivity and susceptibility x-y plot for target and bycatch species caught by the purse-seine fishery (a) with proportion of catch by set type shown in the pie charts, and the longline fishery (b) in the EPO during 2005–2013 and 2017, respectively. Dashed lines represent vulnerability (v) isopleths starting from the origin and have v values of 0.5, 1.0, 1.5, and 2.0 with categories defined as low ($v \leq 1.0$, green), moderate ($1 < v < 2$, yellow), and high ($v \geq 2.0$, red). See Tables [L-1](#) and [L-2](#) for species codes for each fishery.

FIGURA L-12. Gráfica x-y de productividad y susceptibilidad de especies objetivo y de captura incidental capturadas por la pesquería cerquera (a) con proporción de captura por tipo de lance indicada en los gráficos circulares, y la pesquería palangrera (b) en el OPO durante 2005–2013 y 2017, respectivamente. Las líneas de trazos representan isolíneas de vulnerabilidad (v) a partir del origen y tienen valores de v de 0.5, 1.0, 1.5 y 2.0 con categorías definidas como baja ($v \leq 1.0$, verde), moderada ($1 < v < 2$, amarilla) y alta ($v \geq 2.0$, roja). Ver Tablas L-1 y L-2 para los códigos de especies para cada pesquería.

TABLE L-1. Productivity (p) and susceptibility (s) scores used to compute the overall vulnerability measure (v). Susceptibility scores are shown for each fishery (dolphin (DEL), unassociated (NOA), floating object (OBJ)) and as a weighted combination of the individual fishery values. Vulnerability scores rated as low (green), medium (yellow), and high (red). Mean data quality (DQ) scores for susceptibility (s_k) by fishery and productivity DQ p are categorized as green (high: $DQ < 2$), yellow (moderate: $3 < DQ < 2$) and red (low: $DQ \geq 3$).

TABLA L-1. Puntuaciones de productividad (p) y susceptibilidad (s) usadas para computar la medida general de vulnerabilidad v . D. Se señalan las puntuaciones de susceptibilidad para cada pesquería (DEL: delfín; NOA: no asociada; OBJ: objeto flotante) y como combinación ponderada de los valores de las pesquerías individuales. Puntuaciones de vulnerabilidad clasificadas de baja (verde), mediana (amarillo), y alta (rojo). Las puntuaciones promedio de calidad de los datos (DQ) para la susceptibilidad (s_k) por pesquería y productividad DQ p se clasifican en verde (alta: $DQ < 2$), amarillo (moderada: $3 < DQ < 2$) y rojo (baja: $DQ \geq 3$).

Group	Scientific name	Common name	Species code	s_k scores by fishery			p	s	v	DQ s_k scores by fishery			DQ p
				DEL	NOA	OBJ				DEL	NOA	OBJ	
Tunas	<i>Thunnus albacares</i>	Yellowfin tuna	YFT	2.29	2.29	2.57	2.78	2.39	1.41	1.14	1.14	1.14	1.78
	<i>Thunnus obesus</i>	Bigeye tuna	BET	1	2.29	2.57	2.33	1.78	1.03		1.14	1.14	1.78
	<i>Katsuwonus pelamis</i>	Skipjack tuna	SKJ	1	2.29	2.57	2.78	1.78	0.81		1.14	1.14	2
Billfishes	<i>Makaira nigricans</i>	Blue marlin	BUM	2.29	2.14	2.71	2	2.41	1.73	2.14	2.14	2.14	2.33
	<i>Istiompax indica</i>	Black marlin	BLM	2.14	2.14	2.71	2.11	2.34	1.67	2.14	2.14	2.14	2.22
	<i>Kajikia audax</i>	Striped marlin	MLS	2.29	2.29	2.57	2.33	2.39	1.54	2	2	2	1.89
	<i>Istiophorus platypterus</i>	Indo-Pacific sailfish	SFA	2.43	2.29	1	2.44	1.90	1.06	2	2		2.11
Dolphins	<i>Stenella longirostris</i>	Unidentified spinner dolphin	DSI	2	1	1	1.22	1.47	1.84	1.29			2.44
	<i>Stenella attenuata</i>	Unidentified spotted dolphin	DPN	2	1	1	1.33	1.47	1.73	1.29			2.33
	<i>Delphinus delphis</i>	Common dolphin	DCO	1.71	1	1	1.33	1.33	1.70	1.71			2.56
Large fishes	<i>Coryphaena hippurus</i>	Common dolphinfish	DOL	1	2.14	2.71	2.78	1.80	0.83		2.29	2.29	1.89
	<i>Coryphaena equiselis</i>	Pompano dolphinfish	CFW	1	1	2.86	2.89	1.65	0.66			2.43	3.33
	<i>Acanthocybium solandri</i>	Wahoo	WAH	1	1	3	2.67	1.70	0.77			2.29	2.11
	<i>Elagatis bipinnulata</i>	Rainbow runner	RRU	1	1	2.71	2.78	1.60	0.64			2.29	3.33
	<i>Mola mola</i>	Ocean sunfish, Mola	MOX	1	2.29	2.29	1.78	1.68	1.40		2.43	2.43	3.56
	<i>Caranx sexfasciatus</i>	Bigeye trevally	CXS	1	2.86	1	2.56	1.33	0.55		2.71		3.56
	<i>Seriola lalandi</i>	Yellowtail amberjack	YTC	1	2.43	2	2.56	1.61	0.75		2.43	2.43	2.78
Rays	<i>Manta birostris</i>	Giant manta	RMB	2.43	2.57	2	1.22	2.30	2.21	2.57	2.57	2.57	3.11
	<i>Mobula japanica</i>	Spinetail manta	RMJ	2.29	2.57	2.14	1.78	2.29	1.77	2.43	2.43	2.43	3.33
	<i>Mobula thurstoni</i>	Smoothtail manta	RMO	2.14	2.57	2	1.78	2.17	1.77	2.57	2.57	2.57	3.44
Sharks	<i>Carcharhinus falciformis</i>	Silky shark	FAL	2.29	2.14	2.57	1.44	2.36	2.07	2.14	2.29	2.29	2.22
	<i>Sphyrna zygaena</i>	Smooth hammerhead shark	SPZ	2.14	2.14	2.43	1.33	2.24	2.08	2.14	2.29	2.29	3.33
	<i>Sphyrna lewini</i>	Scalloped hammerhead shark	SPL	2.14	2.29	2.14	1.33	2.17	2.04	2.14	2.29	2.29	2.33
	<i>Alopias pelagicus</i>	Pelagic thresher shark	PTH	2.29	2.14	2.29	1.22	2.26	2.18	2.14	2.29	2.29	2.11
	<i>Alopias superciliosus</i>	Bigeye thresher shark	BTH	2.14	2.29	2	1.11	2.12	2.20	2.14	2.29	2.29	2.22
Small fishes	<i>Canthidermis maculatus</i>	Ocean triggerfish	CNT	1	1	2.43	2.33	1.50	0.84			2.71	4
	<i>Sectator ocyurus</i>	Bluestriped chub	ECO	1	1	2.57	2.22	1.55	0.95			2.57	3.33

TABLE L-2. Species included in the productivity-susceptibility analysis for the large-scale tuna longline fishery in the eastern Pacific Ocean, showing average productivity (p) and susceptibility (s) scores used to compute the overall vulnerability score (v) for each species, rated as low (green), medium (yellow), and high (red).

TABLA L-2. Especies incluidas en el análisis de productividad-susceptibilidad de la pesquería atunera palangrera a gran escala en el Océano Pacífico oriental. indicado las puntuaciones promedio de productividad (p) y susceptibilidad (s) usadas para calcular la puntuación general de vulnerabilidad (v) para cada especie, clasificada como baja (verde), mediana (amarillo), y alta (rojo).

Group	Scientific name	Common name	Code	p	s	v	
Grupo	Nombre científico	Nombre común	Código				
Billfishes	<i>Istiompax indica</i>	Black marlin	Marlín negro	BLM	2.00	2.60	1.89
Peces picudos	<i>Istiophorus platypterus</i>	Indo-Pacific sailfish	Pez vela indopacífico	SFA	2.40	2.80	1.90
	<i>Kajikia audax</i>	Striped marlin	Marlín rayado	MLS	2.60	3.00	2.04
	<i>Makaira nigricans</i>	Blue marlin	Marlín azul	BUM	2.20	2.60	1.79
	<i>Tetrapturus angustirostris</i>	Shortbill spearfish	Marlín trompa corta	SSP	2.40	2.60	1.71
	<i>Xiphias gladius</i>	Swordfish	Pez espada	SWO	2.00	2.80	2.06
Tunas	<i>Katsuwonus pelamis</i>	Skipjack	Barrilete	SKJ	3.00	2.60	1.60
Atunes	<i>Thunnus alalunga</i>	Albacore	Albacora	ALB	2.80	3.00	2.01
	<i>Thunnus albacares</i>	Yellowfin	Aleta amarilla	YFT	3.00	3.00	2.00
	<i>Thunnus maccoyii</i>	Southern bluefin	Aleta azul del sur	SBF	2.40	2.40	1.52
	<i>Thunnus obesus</i>	Bigeye	Patudo	BET	2.40	2.80	1.90
	<i>Thunnus orientalis</i>	Pacific bluefin	Aleta azul del Pacífico	PBF	2.00	2.80	2.06
Elasmobranchs	<i>Alopias pelagicus</i>	Pelagic thresher shark	Zorro pelágico	PTH	1.00	2.00	2.24
Elasmobranquios	<i>Alopias superciliosus</i>	Bigeye thresher shark	Zorro ojón	BTH	1.00	2.20	2.33
	<i>Alopias vulpinus</i>	Common thresher shark	Zorro	ALV	1.40	2.20	2.00
	<i>Carcharhinus albimarginatus</i>	Silvertip shark	Tiburón de puntas blancas	ALS	1.60	2.00	1.72
	<i>Carcharhinus falciformis</i>	Silky shark	Tiburón sedoso	FAL	1.60	2.40	1.98
	<i>Carcharhinus galapagensis</i>	Galapagos shark	Tiburón de Galápagos	CCG	1.60	2.00	1.72
	<i>Carcharhinus limbatus</i>	Blacktip shark	Tiburón macuira	CCL	1.80	2.20	1.70
	<i>Carcharhinus longimanus</i>	Oceanic whitetip shark	Tiburón oceánico punta blanca	OCS	1.60	2.40	1.98
	<i>Galeocerdo cuvier</i>	Tiger shark	Tintorera tigre	TIG	1.00	2.20	2.33
	<i>Prionace glauca</i>	Blue shark	Tiburón azul	BSH	1.80	3.00	2.33
	<i>Pteroplatytrygon violacea</i>	Pelagic stingray		PLS	1.80	2.00	1.56
	<i>Isurus oxyrinchus</i>	Shortfin mako shark	Marrajo dientuso	SMA	1.40	2.60	2.26
	<i>Isurus paucus</i>	Longfin mako shark	Marrajo carite	LMA	1.20	2.40	2.28
	<i>Lamna ditropis</i>	Salmon shark	Marrajo salmón	LMD	1.20	2.20	2.16

Group	Scientific name	Common name	Nombre común	Code	ρ	s	v
Grupo	Nombre científico			Código			
	<i>Lamna nasus</i>	Porbeagle shark	Marrajo sardinero	POR	1.00	2.20	2.33
	<i>Odontaspis noronhai</i>	Bigeye sand tiger shark	Solrayo ojigrande	ODH	1.00	1.60	2.09
	<i>Pseudocarcharias kamoharai</i>	Crocodile shark	Tiburón cocodrilo	PSK	1.40	1.60	1.71
		Scalloped hammerhead					
	<i>Sphyrna lewini</i>	shark	Cornuda común	SPL	1.40	2.60	2.26
	<i>Sphyrna mokarran</i>	Great hammerhead	Cornuda gigante	SPK	1.40	2.40	2.13
	<i>Sphyrna zygaena</i>	Smooth hammerhead	Cornuda cruz	SPZ	1.40	2.60	2.26
	<i>Isistius brasiliensis</i>	Cookie cutter shark	Tollo cigarro	ISB	2.00	1.20	1.02
	<i>Squalus acanthias</i>	Picked dogfish, Spiny dogfish	Mielga	DGS	1.40	1.60	1.71
	<i>Zameus squamulosus</i>	Velvet dogfish		SSQ	1.40	1.20	1.61
Mesopelagic fishes	<i>Alepisaurus brevirostris</i>	Short snouted lancetfish		ALO	3.00	2.60	1.60
	<i>Alepisaurus ferox</i>	Long snouted lancetfish	Lanzón picudo	ALX	3.00	2.60	1.60
Peces mesopelágicos	<i>Eumegistus illustris</i>	Brilliant pomfret		EBS	2.80	2.00	1.02
	<i>Taractes asper</i>	Rough pomfret		TAS	2.80	2.00	1.02
	<i>Taractichthys steindchneri</i>	Sickle Pomfret	Tristón segador	TST	2.80	1.80	0.82
	<i>Gempylus serpens</i>	Snake mackerel	Escolar de canal	GES	2.60	2.80	1.84
	<i>Lepidocybium flavobrunneum</i>	Escolar	Escolar negro	LEC	2.20	2.20	1.44
	<i>Nesiarchus nasutus</i>	Black gemfish	Escolar narigudo	NEN	2.60	1.80	0.89
	<i>Promethichthys prometheus</i>	Roudi escolar	Escolar prometeo	PRP	2.60	1.80	0.89
	<i>Ruvettus pretiosus</i>	Oilfish	Escolar clavo	OIL	2.20	2.20	1.44
	<i>Lampris guttatus</i>	Opah	Opa	LAG	2.40	2.20	1.34
	<i>Lophotus capellei</i>	Crestfish		LOP	2.40	2.20	1.34
	<i>Masturus lanceolatus</i>	Sharptail mola		MRW	2.00	1.60	1.17
	<i>Mola mola</i>	Sunfish	Pez luna	MOX	2.00	1.60	1.17
	<i>Ranzania laevis</i>	Slender sunfish		RZV	2.60	1.60	0.72
	<i>Omosudis lowii</i>	Omosudid (Hammerjaw)		OMW	3.00	1.80	0.80
	<i>Scombrobrax heterolepis</i>	Longfin escolar		SXH	2.80	1.60	0.63
	<i>Desmodema polystictum</i>	Polka-dot ribbonfish		DSM	2.80	2.20	1.22
	<i>Zu cristatus</i>	Scalloped ribbonfish		ZUC	2.80	2.20	1.22
	<i>Assurger anzac</i>	Razorback scabbardfish	Sable aserrado	ASZ	2.80	2.20	1.22
	<i>Trachipterus fukuzakii</i>	Tapertail ribbonfish		LHT	2.80	2.20	1.22
Tuna-like species	<i>Elagatis bipinnulata</i>	Rainbow runner	Salmón	RRU	3.00	2.60	1.60
	<i>Seriola lalandi</i>	Yellowtail amberjack	Medregal rabo amarillo	YTC	2.80	1.80	0.82

Group	Scientific name	Common name	Nombre común	Code	p	s	v
Grupo	Nombre científico			Código			
Especies afines a los atunes	<i>Opisthonema oglinum</i>	Atlantic thread herring	Machuelo hebra atlántico	THA	3.00	2.00	1.00
	<i>Sprattus sprattus</i>	European sprat	Espadín	SPR	3.00	2.00	1.00
	<i>Coryphaena equiselis</i>	Pompano dolphinfish	Dorado pompano	CFW	3.00	2.80	1.80
	<i>Coryphaena hippurus</i>	Common dolphinfish	Dorado	DOL	3.00	2.80	1.80
	<i>Pomadasys jubelini</i>	Sompat grunt	Ronco sompat	BUR	3.00	1.80	0.80
	<i>Scomberesox saurus</i>	Atlantic saury	Paparda del Atlántico	SAU	3.00	2.20	1.20
	<i>Acanthocybium solandri</i>	Wahoo	Peto	WAH	2.80	2.80	1.81
	<i>Euthynnus lineatus</i>	Black skipjack	Barrilete negro	BKJ	3.00	2.40	1.40
	<i>Sarda orientalis</i>	Striped bonito	Bonito mono	BIP	3.00	2.00	1.00
	<i>Sphyraena barracuda</i>	Great barracuda	Picuda barracuda	GBA	3.00	1.80	0.80