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TUNAS, BILLFISHES AND OTHER PELAGIC SPECIES IN THE EASTERN PACIFIC OCEAN IN, 2015

INTRODUCTION

This report provides a summary of 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, and an evaluation of the pelagic ecosystem in the EPO, in 2015.

The report is based on data available to the IATTC staff in March 2016. As a result, some of the data tables for 2015 are incomplete, and all data for 2014 and 2015 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:

Species:	
ALB	Albacore tuna (*Thunnus alalunga*)
BET	Bigeye tuna (*Thunnus obesus*)
BIL	Unidentified istiophorid billfishes
BKJ	Black skipjack (*Euthynnus lineatus*)
BLM	Black marlin (*Makaira indica*)
BUM	Blue marlin (*Makaira nigricans*)
BZX	Bonito (*Sarda* spp.)
CAR	Chondrichthyes, cartilaginous fishes nei[1]
CGX	Carangids (Carangidae)
DOX	Dorado (*Coryphaena* spp.)
MLS	Striped marlin (*Kajikia audax*)
MZZ	Osteichthyes, marine fishes nei
PBF	Pacific bluefin tuna (*Thunnus orientalis*)
SFA	Indo-Pacific sailfish (*Istiophorus platypterus)*
SKJ	Skipjack tuna (*Katsuwonus pelamis*)
SKX	Unidentified elasmobranchs
SSP	Shortbill spearfish (*Tetrapturus angustirostris*)
SWO	Swordfish (*Xiphias gladius*)
TUN	Unidentified tunas
YFT	Yellowfin tuna (*Thunnus albacares*)

Fishing gears:	
FPN	Trap
GN	Gillnet

[1] not elsewhere included

HAR	Harpoon
LL	Longline
LP	Pole and line
LTL	Troll
LX	Hook and line
OTR	Other[2]
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
CHN	China
COL	Colombia
CRI	Costa Rica
ECU	Ecuador
EU	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 flags	
CHL	Chile
COK	Cook Islands
CYM	Cayman Islands
NZL	New Zealand
RUS	Russia
VCT	St. Vincent and the Grenadines
UNK	Unknown

Stock assessment:	
B	Biomass
C	Catch
CPUE	Catch per unit of effort
F	Rate of fishing mortality
MSY	Maximum sustainable yield
S	Index of spawning biomass
SBR	Spawning biomass ratio
SSB	Spawning stock biomass

[2] Used to group known gear types

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

This document summarizes the fisheries for species covered by the IATTC Convention (tunas and other fishes caught by tuna-fishing vessels) in the eastern Pacific Ocean (EPO). The most important of these are the scombrids (Family Scombridae), which include tunas, bonitos, seerfishes, and mackerels. The principal species of tunas caught are yellowfin, skipjack, bigeye, and albacore, with lesser catches of Pacific bluefin, black skipjack, and frigate and bullet tunas; other scombrids, such as bonitos and wahoo, are also caught.

This document also covers other species caught by tuna-fishing vessels in the EPO: billfishes (swordfish, marlins, shortbill spearfish, and sailfish) carangids (yellowtail, rainbow runner, and jack mackerel), dorado, elasmobranchs (sharks, rays, and skates), and other fishes.

Most of the catches are made by the purse-seine and longline fleets; the pole-and-line fleet and various artisanal and recreational fisheries account for a small percentage of the total catches.

Detailed data are available for the purse-seine and pole-and-line fisheries; the data for the longline, artisanal, and recreational fisheries are incomplete.

The IATTC Regional Vessel Register contains details of vessels authorized to fish for tunas in the EPO. The IATTC has detailed records of most of the purse-seine and pole-and-line vessels that fish for yellowfin, skipjack, bigeye, and/or Pacific bluefin tuna in the EPO. The Register is incomplete for small vessels. It contains records for most large (overall length >24 m) longline vessels that fish in the EPO and in other areas.

The data in this report are derived from various sources, including vessel logbooks, observer data, unloading records provided by canners and other processors, export and import records, reports from governments and other entities, and estimates derived from the species and size composition sampling program.

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

Estimating the total catch of a species of fish is difficult, for various reasons. Some fish are discarded at sea, and the data for some gear types are incomplete. Data for fish discarded at sea by purse-seine vessels with carrying capacities greater than 363 metric tons (t) have been collected by observers since 1993, which allows for better estimation of the total amounts of fish caught by the purse-seine fleet. Estimates of the total amount of the catch that is landed (hereafter referred to as the retained catch) are based principally on data from unloadings. Beginning with Fishery Status Report 3, which reports on the fishery in 2004, the unloading data for purse-seine and pole-and-line vessels have been adjusted, based on the species composition estimates for yellowfin, skipjack, and bigeye tunas. The current species composition sampling program, described in Section 1.3.1, began in 2000, so the catch data for 2000-2015 are adjusted, based on estimates by flag for each year. The catch data for the previous years were adjusted by applying the average ratio by species from the 2000-2004 estimates, by flag, and summing over all flags. This has tended to increase the estimated catches of bigeye and decrease those of yellowfin and/or skipjack. These adjustments are all preliminary, and may be improved in the future. All of the purse-seine and pole-and-line data for 2014 and 2015 are preliminary.

Data on the retained catches of most of the larger longline vessels are obtained from the governments of the nations that fish for tunas in the EPO. Longline vessels, particularly the larger ones, direct their effort primarily at bigeye, yellowfin, albacore, or swordfish. Data from smaller longliners, artisanal vessels, and other vessels that fish for tunas, billfishes, dorado, and sharks in the EPO were gathered either directly from the governments, from logbooks, or from reports published by the governments. Data for the western and central Pacific Ocean (WCPO) were provided by the Ocean Fisheries Programme of the Secretariat of the Pacific Community (SPC). All data for catches in the EPO by longlines and other gears for 2014 and 2015 are preliminary.

The data from all of the above sources are compiled in a database by the IATTC staff and summarized in this report. In recent years, the IATTC staff has increased its effort toward compiling data on the catches of tunas, billfishes, and other species caught by other gear types, such as trollers, harpooners, gillnetters, and recreational vessels. The estimated total catches from all sources mentioned above of yellowfin, skipjack, and bigeye in the entire Pacific Ocean 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 1986-2015 are shown in Tables A-2a-c. The catches of yellowfin, skipjack, and bigeye tunas by flag, during 1986-2015, are shown in Tables A-3a-e, and the purse-seine and pole-and-line catches of tunas and bonitos during 2014-2015 are summarized by flag in Table A-4a. Purse-seine tuna by country of landing for 2014 and 2015 are summarized in Table A-4b. The country of landing is that in which the fish were unloaded or, in the case of transshipments, the country that received the transshipped fish. It is important to note that, when final information is available, the landings currently assigned to various countries may change due to exports from storage facilities to processors in other nations. There were no restrictions on fishing for tunas in the EPO during 1988-1997, but the catches of most species have been affected by restrictions on fishing during some or all of the last six months of 1998-2015. Furthermore, regulations placed on purse-seine vessels directing their effort at tunas associated with dolphins have affected the way these vessels operate, especially since the late 1980s, as discussed in Section 3.

The catches have also been affected by climate perturbations, such as the major El Niño events that occurred during 1982-1983 and 1997-1998. These events made the fish less vulnerable to capture by purse seiners due to the greater depth of the thermocline, but had no apparent effect on the longline catches. Yellowfin recruitment tends to be greater after an El Niño event.

1.1. Catches by species

1.1.1. Yellowfin tuna

The annual catches of yellowfin during 1986-2015 are shown in Table A-1. The EPO totals for 1993-2015 include discards from purse-seine vessels with carrying capacities greater than 363 t. The El Niño event of 1982-1983 led to a reduction in the catches in those years, whereas the catches in the WCPO were apparently not affected. Although the El Niño episode of 1997-1998 was greater in scope, it did not have the same effect on the yellowfin catches in the EPO. In the EPO, catches increased steadily to a high of 443 thousand t in 2002; they decreased substantially in 2004, reaching their lowest level during 2006-2008, at only 44% of the highest catches of the 2001-2003 period. The 2015 catch of 246 thousand t is greater than the average for the previous 5-year period (234 thousand t). In the WCPO, the catches of yellowfin reached a new high of 611 thousand t in 2014, surpassing the previous record of 600 thousand t in 2008.

The annual retained catches of yellowfin in the EPO by purse-seine and pole-and-line vessels during 1986-2015 are shown in Table A-2a. The average annual retained catch during 2000-2014 was 257 thousand t (range: 167 to 413 thousand t). The preliminary estimate of the retained catch in 2015, 245 thousand t, was 5% larger than that of 2014, but 5% less than the average for 2000-2014. The average amount of yellowfin discarded at sea during 2000-2014 was about 1% of the total purse-seine catch (retained catch plus discards) of yellowfin (range: 0.1 to 2.4%) (Table A-2a).

The annual retained catches of yellowfin in the EPO by longliners during 1986-2015 are shown in Table A-2a. During 1990-2003 catches averaged about 23 thousand t (range: 12 to 35 thousand t), or about 8% of the total retained catches of yellowfin. Longline catches declined sharply beginning in 2005, averaging 10 thousand t per year (range: 8 to 13 thousand t), or about 4% of the total retained catches, through 2014. Yellowfin are also caught by recreational vessels, as incidental catch in gillnets, and by artisanal fisheries. Estimates of these catches are shown in Table A-2a, under "Other gears" (OTR); during 2000-2014 they averaged about 1 thousand t.

1.1.2. Skipjack tuna

The annual catches of skipjack during 1986-2015 are shown in Table A-1. Most of the skipjack catch in the Pacific Ocean is taken in the WCPO. Prior to 1999, WCPO skipjack catches averaged about 900 thousand t. Beginning in 1999, catches increased steadily from 1.1 million t to an all-time high of 2 million t in 2014. In the EPO, the greatest yearly catches occurred between 2003 and 2015, ranging from 153 to 333 thousand t, the record catch in 2015.

The annual retained catches of skipjack in the EPO by purse-seine and pole-and-line vessels during 1986-2015 are shown in Table A-2a. During 2000-2014 the annual retained catch averaged 234 thousand t (range 144 to 297 thousand t). The preliminary estimate of the retained catch in 2015, 329 thousand t, is 41% greater than the average for 2000-2014, and 11% higher than the record-high retained catch of 2008. Discards of skipjack at sea decreased each year during the period, from 11% in 2000 to a low of less than 1% in 2014. During the period about 4% of the total catch of the species was discarded at sea (Table A-2a).

Small amounts of EPO skipjack are caught with longlines and other gears (Table A-2a).

1.1.3. Bigeye tuna

The annual catches of bigeye during 1986-2015 are shown in Table A-1. Overall, the catches in both the EPO and WCPO have increased, but with considerable fluctuations. 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. In the WCPO the catches of bigeye increased to more than 77 thousand t during the late 1970s, decreased during the early 1980s, and then increased steadily to 111 thousand t in 1996. In 1997 the total jumped to 153 thousand t, and reached a high of 178 thousand t in 2004. Since 2004 the catch has fluctuated between 130 and 155 thousand t.

The annual retained catches of bigeye in the EPO by purse-seine and pole-and-line vessels during 1986-2015 are shown in Table A-2a. During 1993-1994 the use of fish-aggregating devices (FADs), placed in the water by fishermen to aggregate tunas, nearly doubled, and continued to increase in the following years. This resulted in greater catches of bigeye by purse-seine vessels. Before this increase, the annual retained catch of bigeye taken by purse-seine vessels in the EPO was about 5 thousand t (Table A-2a). As a result of the development of the FAD fishery, bigeye catches increased from 10 thousand t in 1993 to 35 thousand t in 1994, and further increased to between 44 and 95 thousand t during 1995-2014. The preliminary estimate of the retained catch in the EPO in 2015 is 63 thousand t.

During 2000-2014 the purse-seine catch of the species discarded at sea has steadily decreased, from 5% in 2000 to less than 1% in 2014, for an average discard rate of about 2.1%. No bigeye catch has been reported by pole-and-line vessels in recent years.

From 1986 to 1993, before the increase in the use of FADs, longliners caught an average of 95% of the bigeye in the EPO (average 88 thousand t; range; 71 to 104 thousand t). During 2000-2014 this average dropped to 38%, with a low of 25% in 2008 (average: 42 thousand t; range: 26 to 74 thousand t) (Table A-2a). The preliminary estimate of the longline catch in the EPO in 2015 is 38 thousand t (Table A-2a).

Small amounts of bigeye are caught in the EPO by other gears, as shown in Table A-2a.

1.1.4. Bluefin tuna

The catches of Pacific bluefin in the EPO during 1986-2015, by gear, are shown in Table A-2a. Purse-seine and pole-and-line vessels accounted for over 94% of the total EPO retained catch during 2000-2014. During this period the annual retained catch of bluefin in the EPO by purse-seine vessels averaged 4.7 thousand t (range 1.2 to 9.9 thousand t). The preliminary estimate of the retained purse-seine catch of bluefin in 2015, 3.2 thousand t, is less than the average for 2000-2014 (Table A-2a).

The catches of Pacific bluefin in the entire Pacific Ocean, by flag and gear, are shown in Table A-5a. The data, which were obtained from the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC), are reported by fishing nation or entity, regardless of the area of the Pacific Ocean in which the fish were caught.

Catches of Pacific bluefin by recreational gear in the EPO are reported in numbers of individual tuna caught, whereas all other gears report catch in weight (metric tons). These numbers are then converted to metric tons for inclusion in the EPO catch totals for all gears. The original catch data for 1986-2015, in numbers of fish, are presented in Table A-5b.

1.1.5. Albacore tuna

The catches of albacore in the EPO, by gear and area (north and south of the equator) are shown in Tables A-6. The catches of albacore in the EPO, by gear, are shown in Table A-2a. A significant portion of the albacore catch is taken by troll gear, included under "Other gears" (OTR) in Table A-2a.

1.1.6. Other tunas and tuna-like species

While yellowfin, skipjack, and bigeye tunas comprise the most significant portion of the retained catches of the purse-seine and pole-and-line fleets 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 in this area. The estimated annual retained and discarded catches of these species during 1986-2015 are presented in Table A-2a. The catches reported in the "unidentified tunas" category (TUN) 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 these fisheries was 4.7 thousand t in 2015, which is less than the 2000-2014 average retained catch of 6.8 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.

1.1.7. Billfishes

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

In general, dolphins, sea turtles, whale sharks, and small fish are the only animals captured in the purse-seine fishery that are released alive. In previous versions of this report, all billfishes caught in that fishery were classified as discarded dead. When most of the individuals of species caught incidentally are discarded, the difference between catches and discards is not significant for those species, but as the rate of retention of species formerly discarded increases, part of the bycatch becomes catch, and the distinction becomes important. As a result of a review in 2010, this has been clarified in Table A-2b with the addition of a column for retained catch next to the column for discards.

Swordfish are caught in the EPO with large-scale and artisanal longline gear, gillnets, harpoons, and occasionally with recreational gear. During 1999-2008 the longline catch of swordfish averaged 12 thousand t, but during 2012-2014 the average almost doubled to over 22 thousand t. It is not clear whether this is due to increased abundance of swordfish or increased effort directed toward that species.

Other billfishes are caught with large-scale and artisanal longline gear and recreational gear. The average annual longline catches of blue marlin and striped marlin during 2000-2014 were about 3.2 thousand and 1.9 thousand t, respectively. Smaller amounts of other billfishes are taken by longline.

Unfortunately, little information is available on the recreational catches of billfishes, but they are believed to be substantially less than the commercial catches for all species.

Small amounts of billfishes are caught by purse seiners, some are retained, and others are considered to be discarded although some may be landed but not reported. These data are also included in Table A-2b. During 2000-2014 purse seiners accounted about 1% of the total catch of billfishes in the EPO.

1.1.8. Other species

Data on the catches and discards of carangids (yellowtail, rainbow runner, and jack mackerel), dorado, elasmobranchs (sharks, rays, and skates), and other fishes caught in the EPO are shown in Table A-2c.

Bycatches in the purse-seine fishery are reported in Table A-2c as either retained or discarded. A revision was made to the allocation of catches into those categories as a result of a review in 2010.

Dorado are unloaded mainly in ports in Central and South America. Although the reported catches have been as high as 71 thousand t in recent years, the fishing gears used are often not reported.

1.2. Distributions of the catches of tunas

1.2.1. Purse-seine catches

The average annual distributions of the purse-seine catches of yellowfin, skipjack, and bigeye, by set type, in the EPO during 2010-2014, are shown in Figures A-1a, A-2a, and A-3a, and preliminary estimates for 2015 are shown in Figures A-1b, A-2b, and A-3b.

The majority of the yellowfin catches in 2015 were taken north of the 5°N latitude in sets associated with dolphins, and in the area between Galapagos and the coast of the Americas in all three types of sets. Though yellowfin in unassociated schools is typically found closer to shore, moderate catches were found far offshore around the 135°W longitude south of the equator. As in previous years, most of the yellowfin south of the 5°N latitude was caught in sets on floating objects.

Most of the skipjack catches in 2015 occurred south of the 5°N latitude, in sets on floating objects and inshore unassociated school sets. The area off the coast of Peru produced the greatest 2015 skipjack catches, which were higher than that of previous years. A larger than normal offshore catch of skipjack was found around the 135°W longitude south of the equator in unassociated tuna sets.

Bigeye are not often caught north of about 7°N, and the catches of bigeye have decreased in the inshore areas off South America for several years. With the development of the fishery for tunas associated with FADs, the relative importance of the inshore areas has decreased, while that of the offshore areas has increased. Most of the bigeye catches are taken in sets on FADs between 5°N and 5°S.

1.2.2. Longline catches

Data on the spatial and temporal distributions of the catches in the EPO by the distant-water longline fleets of China, French Polynesia, Japan, the Republic of Korea, Spain, Chinese Taipei, the United States, and Vanuatu are maintained in databases of the IATTC. 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 tunas in the Pacific Ocean by Chinese, Japanese, Korean, and Chinese Taipei longline vessels during 2010-2014 are shown in Figure A-4. Data for the Japanese longline fishery in the EPO during 1956-2007 are available in IATTC Bulletins describing that fishery.

1.3. Size compositions of the catches of tunas

1.3.1. 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, including the integrated modeling that the staff has employed during the last several years. The results of such studies have been described in several IATTC Bulletins, in its Annual Reports for 1954-2002, and in its Stock Assessment Reports.

Length-frequency samples of yellowfin, skipjack, bigeye, Pacific bluefin, and, occasionally, black skipjack from the catches of purse-seine, pole-and-line, and recreational vessels in the EPO are collected by IATTC personnel at ports of landing in Ecuador, Mexico, Panama, the USA, and Venezuela. The catches of yellowfin and skipjack were first sampled in 1954, bluefin in 1973, and bigeye in 1975. Sampling has continued to the present.

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. Briefly, the fish in a well of a purse-seine or pole-and-line vessel are selected for sampling only if all the fish in the well were caught during the same calendar month, in the same type of set (floating-object, unassociated school, or dolphin), and in the same sampling area. These data are then categorized by fishery (Figure A-5), based on the staff's most recent stock assessments.

Data for fish caught during the 2010-2015 period are presented in this report. Two sets of length-frequency histograms are presented for each species, except bluefin and black skipjack; the first shows the data by stratum (gear type, set type, and area) for 2015, and the second shows the combined data for each year of the 2010-2015 period. For bluefin, the histograms show the 2007-2012 catches by commercial and recreational gear combined. For black skipjack, the histograms show the 2010-2015 catches by commercial gear. Only a small amount of catch was taken by pole-and-line vessels in 2013, 2014 and 2015, and no samples were obtained from these vessels.

For stock assessments of yellowfin, nine purse-seine fisheries (four associated with floating objects, three associated with dolphins, and two unassociated) and one pole-and-line fishery are defined (Figure A-5). The last fishery includes all 13 sampling areas. Of the 958 wells sampled during 2015, 686 contained yellowfin. The estimated size compositions of the fish caught are shown in Figure A-6a. The majority of the yellowfin catch was taken in sets associated with dolphins in the Northern and Inshore dolphin fisheries, primarily in the second quarter. Most of the larger yellowfin (>110 cm) were caught in the Northern and Inshore dolphin fisheries in the second and third quarters, and in the Southern unassociated fishery in the fourth quarter. Smaller yellowfin (<50 cm) were caught primarily in the Equatorial floating object fishery during the fourth quarter.

The estimated size compositions of the yellowfin caught by all fisheries combined during 2010-2015 are shown in Figure A-6b. The average weight of the yellowfin caught in 2015 (9.0 kg) was among the lowest for the 6 year period, much less than the high of 13.3 kg in 2012.

For stock assessments of skipjack, seven purse-seine fisheries (four associated with floating objects, two unassociated, one associated with dolphins) and one pole-and-line fishery are defined (Figure A-5). The last two fisheries include all 13 sampling areas. Of the 958 wells sampled, 628 contained skipjack. The estimated size compositions of the fish caught during 2015 are shown in Figure A-7a. Large amounts of skipjack in the 35- to 50-cm size range were caught in the Southern floating-object fishery in all four quarters, and to a lesser extent in the Northern, Equatorial and Inshore floating-object fisheries in the first, second and third quarters, as well as in the Southern unassociated fishery during the first and second quarters. Larger skipjack in the 65- to 80-cm size range were taken in the Southern unassociated fishery during the third and fourth quarters.

The estimated size compositions of the skipjack caught by all fisheries combined during 2010-2015 are shown in Figure A-7b. The average weight of skipjack in 2015 (1.9 kg) was the lowest for the 6-year period, and much less than the high of 2.5 kg in 2013.

For stock assessments of bigeye, six purse-seine fisheries (four associated with floating objects, one unassociated, one associated with dolphins) and one pole-and-line fishery are defined (Figure A-5). The last three fisheries include all 13 sampling areas. Of the 958 wells sampled, 209 contained bigeye. The estimated size compositions of the fish caught during 2015 are shown in Figure A-8a. Smaller bigeye in the 40- to 80-cm size range was taken primarily in the Northern floating-object fishery during the second quarter, and in the Southern floating-object fishery in the fourth quarter. Larger bigeye (>100 cm) were caught primarily in the Southern floating-object fishery in the fourth quarter.

The estimated size compositions of bigeye caught by all fisheries combined during 2010-2015 are shown in Figure A-8b. The average weight of bigeye in 2015 (4.7 kg) was the lowest for the 6 year period, much less than the high of 8.0 kg in 2011.

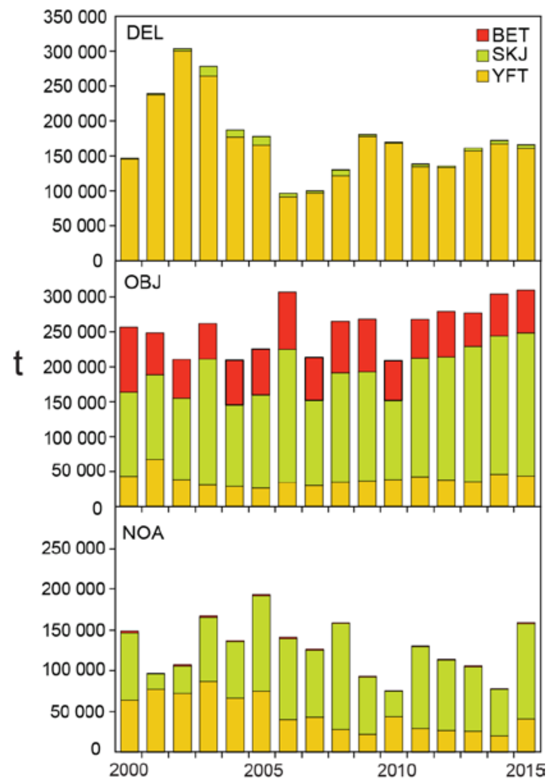

Figure 1. Purse-seine catches of tunas, by species and set type, 2000-2015

Pacific bluefin are caught by purse-seine and recreational gear off California and Baja California from about 23°N to 35°N, with most of the catch being taken during May through October. During 2012 bluefin were caught between 28°N and 32°N from June through August. The majority of the catches of bluefin by both commercial and recreational vessels were taken during July and August. Prior to 2004, the sizes of the fish in the commercial and recreational catches have been reported separately. During 2004-2012, however, small sample sizes made it infeasible to estimate the size compositions separately. Therefore, the sizes of the fish in the commercial and recreational catches of bluefin were combined for each year of the 2004-2012 period. The average weight of the fish caught during 2012 (14.2 kg) was less than that of 2011 (15.4 kg), but very close to the average weights in 2009 and 2010. The estimated size compositions are shown in Figure A-9. Prior to 2013, IATTC staff collected length-frequency samples from recreational vessels with landings in San Diego and from purse seiners. Beginning in 2013, sampling of recreational vessels was taken over by the U.S. National Marine Fisheries Service (NMFS). Very few samples were collected from commercial purse-seiners in 2013, 2014 and 2015. The size composition estimates for bluefin will be updated after development of a methodology that will incorporate the changes in sampling.

Black skipjack are caught incidentally by fishermen who direct their effort toward yellowfin, skipjack, and bigeye tuna. The demand for this species is low, so most of the catches are discarded at sea, but small amounts, mixed with the more desirable species, are sometimes retained. The estimated size compositions for each year of the 2010-2015 period are shown in Figure A-10.

1.3.2. Longline fishery

The estimated size compositions of the catches of yellowfin and bigeye by the Japanese longline fishery in the EPO during 2010-2014 are shown in Figures A-11 and A-12. The average weight of yellowfin in 2014 (62.7 kg) was greater than the previous 4 years (44.7 to 62.1 kg). The average weight of bigeye in 2014 was consistent with the previous four years at 56.3 kg. Information on the size compositions of fish caught by the Japanese longline fishery in the EPO during 1958-2008 is available in IATTC Bulletins describing that fishery.

1.4. Catches of tunas and bonitos, by flag and gear

The annual retained catches of tunas and bonitos in the EPO during 1986-2015 by flag and gear, are shown in Tables A-3a-e. These tables include all of the known catches of tunas and bonitos compiled from various sources, including vessel logbooks, observer data, unloading records provided by canners and other processors, export and import records, estimates derived from the species and size composition sampling program, reports from governments and other entities, and estimates derived from the species- and size-composition sampling program. Similar information on tunas and bonitos prior to 2001, and historical data for tunas, billfishes, sharks, carangids, dorado, and miscellaneous fishes are available on the IATTC website. The purse-seine catches of tunas and bonitos in 2014 and 2015, by flag, are summarized in Table A-4. Of the 646 thousand t of tunas and bonitos caught in 2015, 47% were caught by Ecuadorian vessels, and 21% by Mexican vessels. Other countries with significant catches of tunas and bonitos in the EPO included Panama (10 %), Venezuela (6%), Colombia (6%) and United States (4%).

2. FISHING EFFORT

2.1. Purse seine

Estimates of the numbers of purse-seine sets of each type (associated with dolphins, associated with floating objects, and unassociated) in the EPO during the 2000-2015 period, and the retained catches of these sets, are shown in Table A-7 and in Figure 1. The estimates for vessels ≤363 t carrying capacity were calculated from logbook data in the IATTC statistical data base, and those for vessels >363 t carrying capacity were calculated from the observer data bases of the IATTC, Colombia, Ecuador, the European Union, Mexico, Nicaragua, Panama, the United States, and Venezuela. The greatest numbers of sets associated with floating objects and unassociated sets were made from the mid-1970s to the early 1980s. Despite opposition to fishing for tunas associated with dolphins and the refusal of U.S. canners to accept tunas caught during trips during which sets were made on dolphin-associated fish, the numbers of sets associated with dolphins decreased only moderately during the mid-1990s, and in 2003 were the greatest recorded.

There are two types of floating objects, flotsam and fish-aggregating devices (FADs). The occurrence of the former is unplanned from the point of view of the fishermen, whereas the latter are constructed by fishermen specifically for the purpose of attracting fish. The use of FADs increased sharply in 1994, with the percentage of FADs almost doubling from the previous year, to almost 69% of all floating-object sets. Their relative importance has continued to increase since then, reaching 97% of all floating-object sets by vessels with >363 t carrying capacity in recent years, as shown in Table A-8.

2.2. 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.

3. THE FLEETS

3.1. The purse-seine and pole-and-line fleets

The IATTC staff maintains detailed records of gear, flag, and fish-carrying capacity for most of the vessels that fish with purse-seine or pole-and-line gear for yellowfin, skipjack, bigeye, and/or Pacific bluefin tuna in the EPO. The fleet described here includes purse-seine and pole-and-line vessels that have fished all or part of the year in the EPO for any of these four species.

Historically, the owner's or builder's estimates of carrying capacities of individual vessels, in tons of fish, were used until landing records indicated that revision of these estimates was required.

Since 2000, the IATTC has used well volume, in cubic meters (m^3), instead of weight, in metric tons (t), to measure the carrying capacities of the vessels. Since a well can be loaded with different densities of fish, measuring carrying capacity in weight is subjective, as a load of fish packed into a well at a higher density weighs more than a load of fish packed at a lower density. Using volume as a measure of capacity eliminates this problem.

The IATTC staff began collecting capacity data by volume in 1999, but has not yet obtained this information for all vessels. For vessels for which reliable information on well volume is not available, the estimated capacity in metric tons was converted to cubic meters.

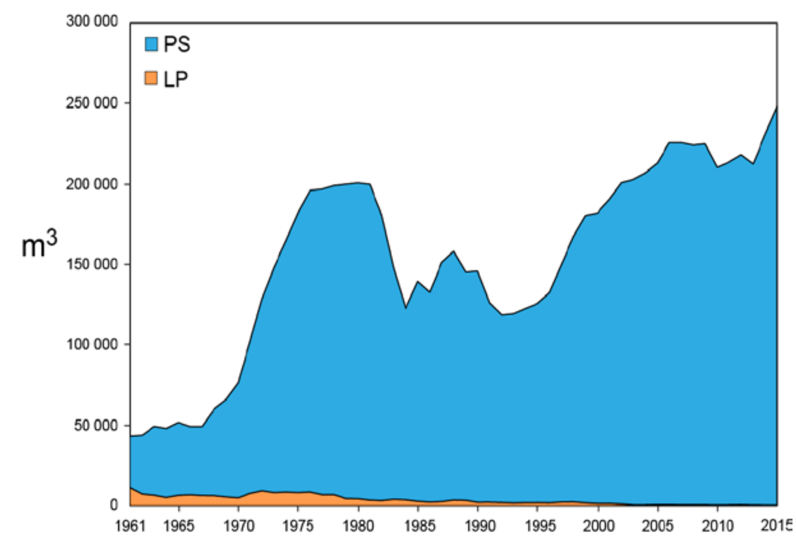

Figure 2. Carrying capacity, in cubic meters of well volume, of the purse-seine and pole-and-line fleets in the EPO, 1961-2015

Until about 1960, fishing for tunas in the EPO was dominated by pole-and-line vessels operating in coastal regions and in the vicinity of offshore islands and banks. During the late 1950s and early 1960s most of the larger pole-and-line vessels were converted to purse seiners, and by 1961 the EPO fishery was dominated by these vessels. From 1961 to 2015 the number of pole-and-line vessels decreased from 93 to 1, and their total well volume from about 11 thousand to about 125 m^3. During the same period the number of purse-seine vessels increased from 125 to 243, and their total well volume from about 32 thousand to about 248 thousand m^3, an average of about 1,021 m^3 per vessel. An earlier peak in numbers and total well volume of purse seiners occurred from the mid-1970s to the early 1980s, when the number of vessels reached 282 and the total well volume about 195 thousand m^3, an average of about 700 m^3 per vessel (Table A-10; Figure 2).

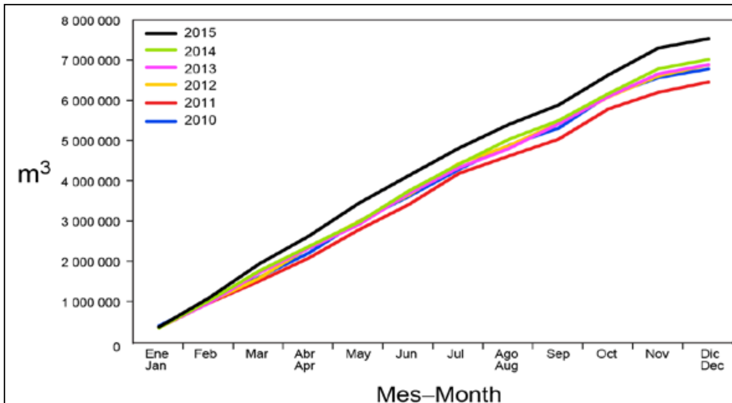

Figure 3. Cumulative capacity of the purse-seine and pole-and-line fleet at sea, by month, 2010-2015

The catch rates in the EPO were low during 1978-1981, due to concentration of fishing effort on small fish, and the situation was exacerbated by a major El Niño event, which began in mid-1982 and persisted until late 1983 and made the fish less vulnerable to capture. The total well volume of purse-seine and pole-and-line vessels then declined as vessels were deactivated or left the EPO to fish in other areas, primarily the western Pacific Ocean, and in 1984 it reached its lowest level since 1971, about 119 thousand m^3. In early 1990 the U.S. tuna-canning industry adopted a policy of not purchasing tunas caught during trips during which sets on tunas associated with dolphins were made. This caused many U.S.-flag vessels to leave the EPO, with a consequent reduction in the fleet to about 117 thousand m^3 in 1992. With increases in participation of vessels of other nations in the fishery, the total well volume has increased steadily since 1992, and in 2015 was 248 thousand m^3.

The 2014 and preliminary 2015 data for numbers and total well volumes of purse-seine and pole-and-line vessels that fished for tunas in the EPO are shown in Tables A-11a and A-11b. During 2015, the fleet was dominated by vessels operating under the Ecuadorian and Mexican flags, with about 37% and 23%, respectively, of the total well volume; they were followed by Venezuela (8%), Panama (8%), United States (7%), Colombia (6%), European Union (Spain) (4%), Nicaragua (3%), El Salvador (2%), and

Guatemala and Peru (1% each). The sum of the percentages may not add up to 100% due to rounding.

The cumulative capacity at sea during 2015 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 2005-2014, and the 2015 values, are shown in Table A-12. The monthly values are averages of the VAS estimated at weekly intervals by the IATTC staff. The fishery was regulated during some or all of the last four months of 2000-2015, so the VAS values for September-December 2015 are not comparable to the average VAS values for those months of 2000-2015. The average VAS values for 2005-2014 and 2015 were 136 thousand m^3 (62% of total capacity) and 145 thousand m^3 (58% of total capacity), respectively.

3.2. Other fleets of the EPO

Information on other types of vessels that fish for tunas in the EPO is available in the IATTC's Regional Vessel Register, on the IATTC website. The Register is incomplete for small vessels. 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 2015, or ever.

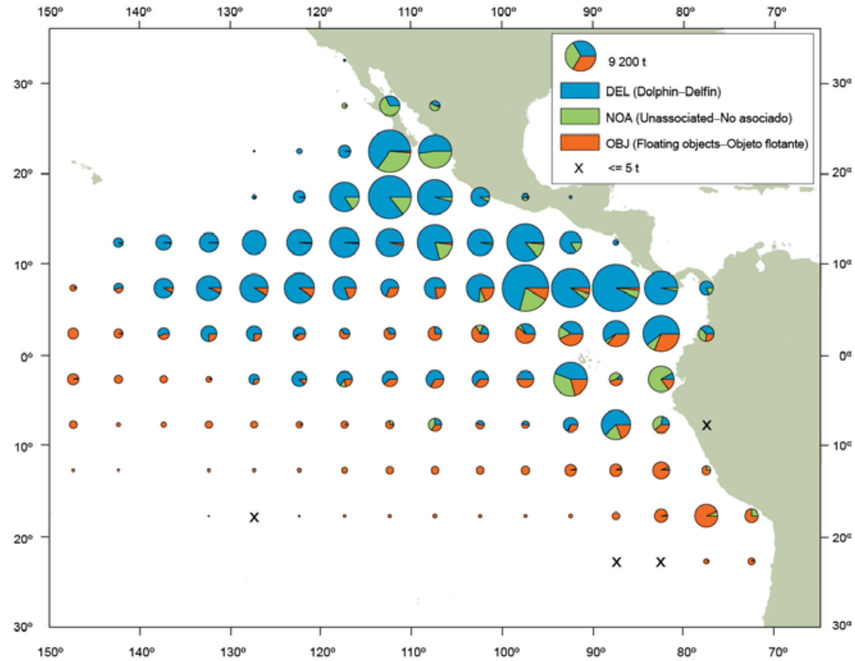

FIGURE A-1a. Average annual distributions of the purse-seine catches of yellowfin, by set type, 2010-2014. The sizes of the circles are proportional to the amounts of yellowfin caught in those 5° by 5° areas.
FIGURA A-1a. Distribución media anual de las capturas cerqueras de aleta amarilla, por tipo de lance, 2010-2014. El tamaño de cada círculo es proporcional a la cantidad de aleta amarilla capturado en la cuadrícula de 5° x 5° correspondiente.

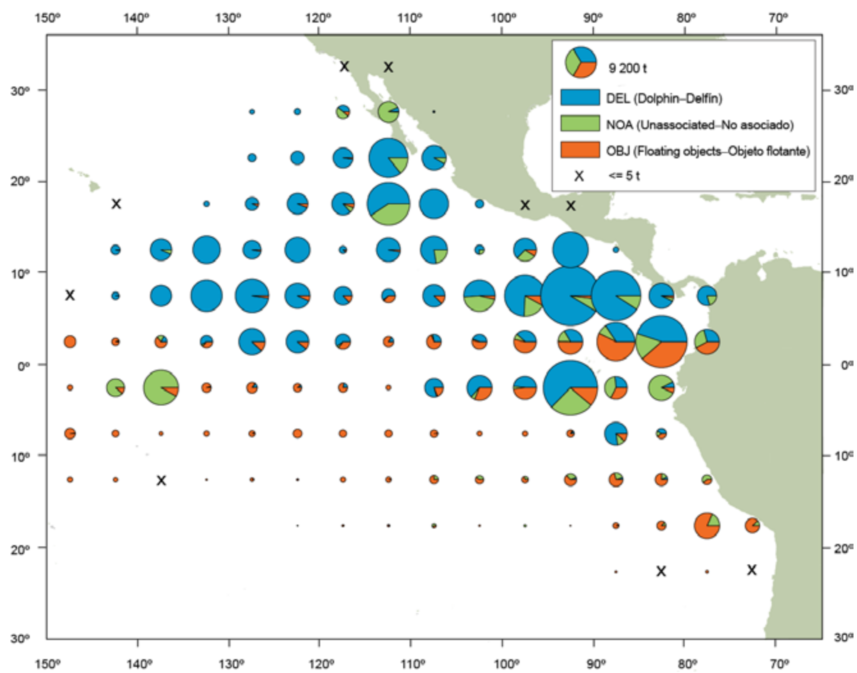

FIGURE A-1b. Annual distributions of the purse-seine catches of yellowfin, by set type, 2015. The sizes of the circles are proportional to the amounts of yellowfin caught in those 5° by 5° areas.
FIGURA A-1b. Distribución anual de las capturas cerqueras de aleta amarilla, por tipo de lance, 2015. El tamaño de cada círculo es proporcional a la cantidad de aleta amarilla capturado en la cuadrícula de 5° x 5° correspondiente.

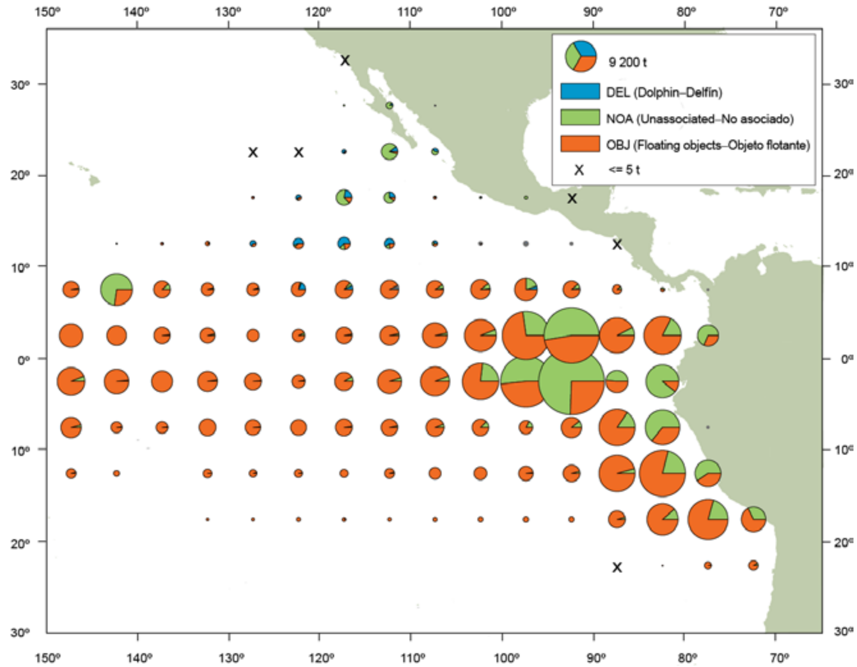

FIGURE A-2a. Average annual distributions of the purse-seine catches of skipjack, by set type, 2010-2014. The sizes of the circles are proportional to the amounts of skipjack caught in those 5° by 5° areas.
FIGURA A-2a. Distribución media anual de las capturas cerqueras de barrilete, por tipo de lance, 2010-2014. El tamaño de cada círculo es proporcional a la cantidad de barrilete capturado en la cuadrícula de 5° x 5° correspondiente.

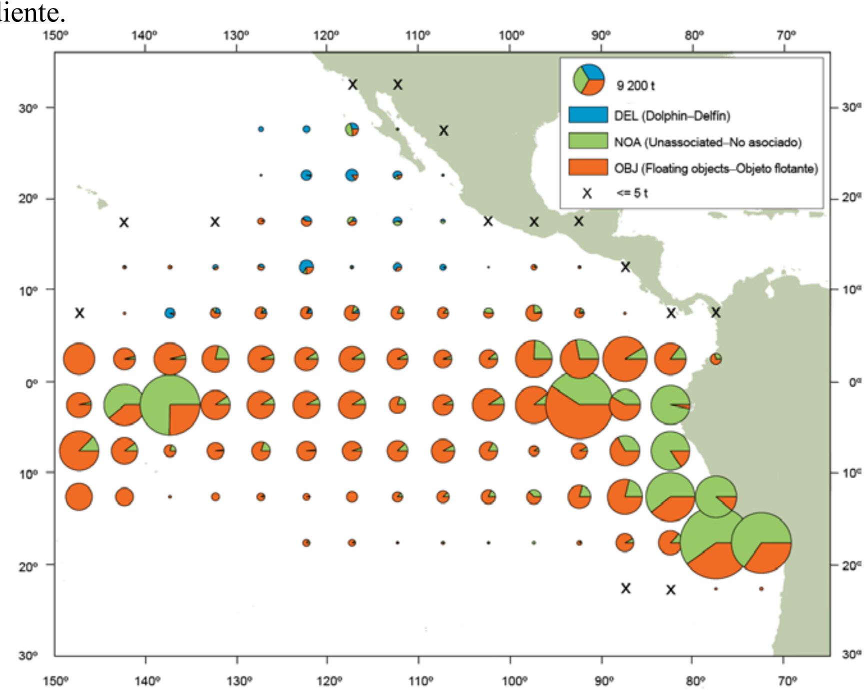

FIGURE A-2b. Annual distributions of the purse-seine catches of skipjack, by set type, 2015. The sizes of the circles are proportional to the amounts of skipjack caught in those 5° by 5° areas.
FIGURA A-2b. Distribución anual de las capturas cerqueras de barrilete, por tipo de lance, 2015. El tamaño de cada círculo es proporcional a la cantidad de barrilete capturado en la cuadrícula de 5° x 5° correspondiente.

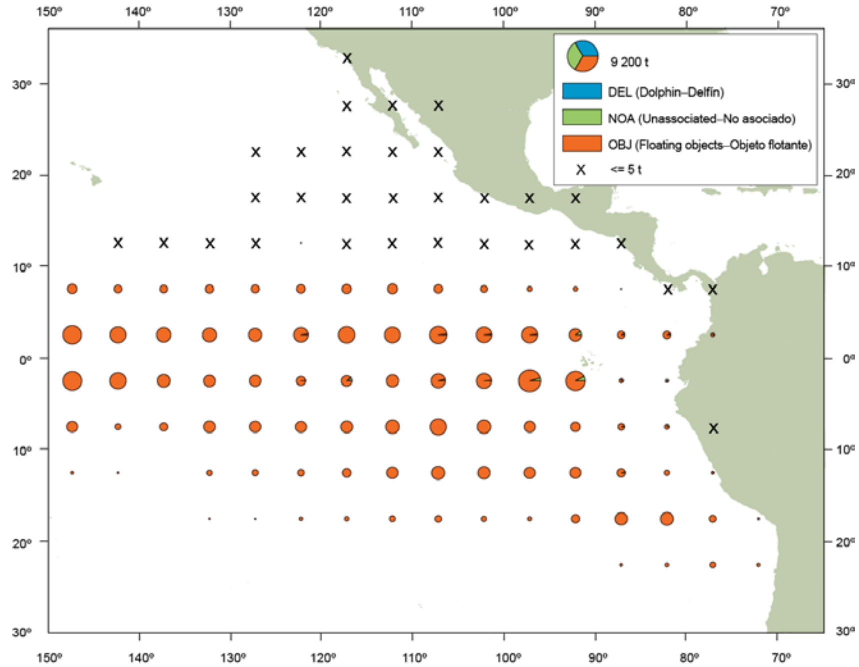

FIGURE A-3a. Average annual distributions of the purse-seine catches of bigeye, by set type, 2010-2014. The sizes of the circles are proportional to the amounts of bigeye caught in those 5° by 5° areas.
FIGURA A-3a. Distribución media anual de las capturas cerqueras de patudo, por tipo de lance, 2010-2014. El tamaño de cada círculo es proporcional a la cantidad de patudo capturado en la cuadrícula de 5° x 5° correspondiente.

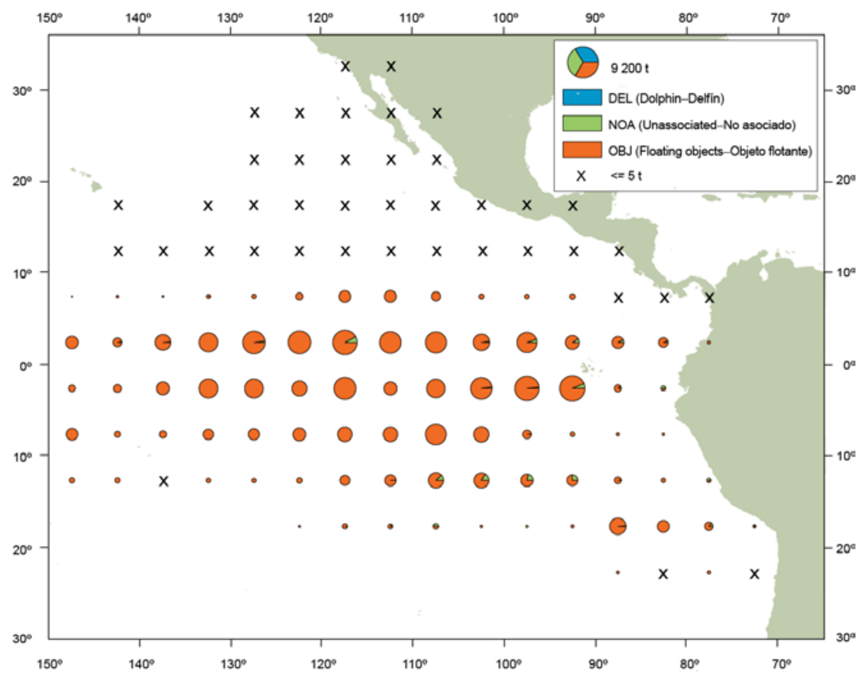

FIGURE A-3b. Annual distributions of the purse-seine catches of bigeye, by set type, 2015. The sizes of the circles are proportional to the amounts of bigeye caught in those 5° by 5° areas.
FIGURA A-3b. Distribución anual de las capturas cerqueras de patudo, por tipo de lance, 2015. El tamaño de cada círculo es proporcional a la cantidad de patudo capturado en la cuadrícula de 5° x 5° correspondiente.

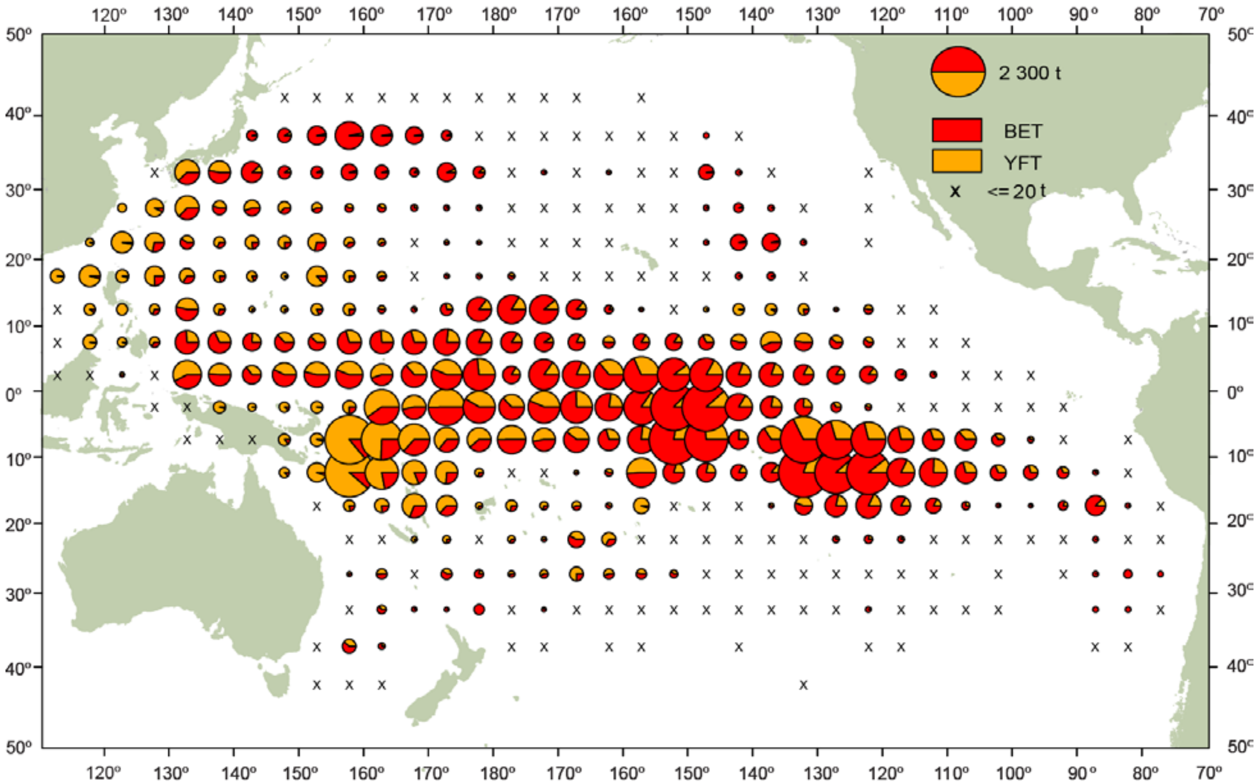

FIGURE A-4. Distributions of the average annual catches of bigeye and yellowfin tunas in the Pacific Ocean, in metric tons, by Chinese, Japanese, Korean, and Chinese Taipei longline vessels, 2010-2014. The sizes of the circles are proportional to the amounts of bigeye and yellowfin caught in those 5° by 5° areas.

FIGURA A-4. Distribución de las capturas anuales medias de atunes patudo y aleta amarilla en el Océano Pacifico, en toneladas métricas, por buques palangreros de China, Corea, Japón, y Taipei Chino, 2010-2014. El tamaño de cada círculo es proporcional a la cantidad de patudo y aleta amarilla capturado en la cuadrícula de 5° x 5° correspondiente.

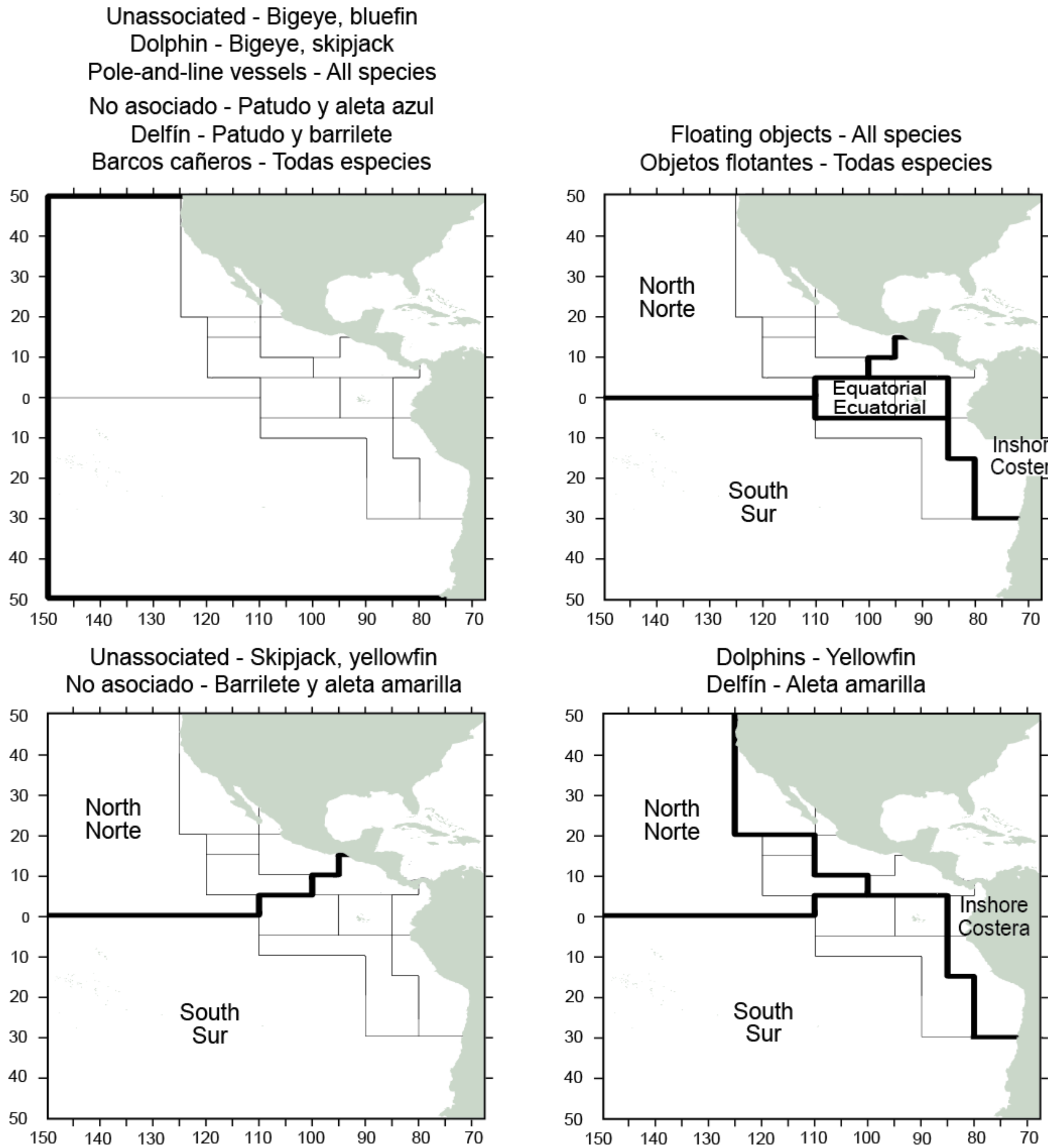

FIGURE A-5. The fisheries defined by the IATTC staff for stock assessment of yellowfin, skipjack, and bigeye in the EPO. The thin lines indicate the boundaries of the 13 length-frequency sampling areas, and the bold lines the boundaries of the fisheries.

FIGURA A-5. Las pesquerías definidas por el personal de la CIAT para la evaluación de las poblaciones de atún 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.

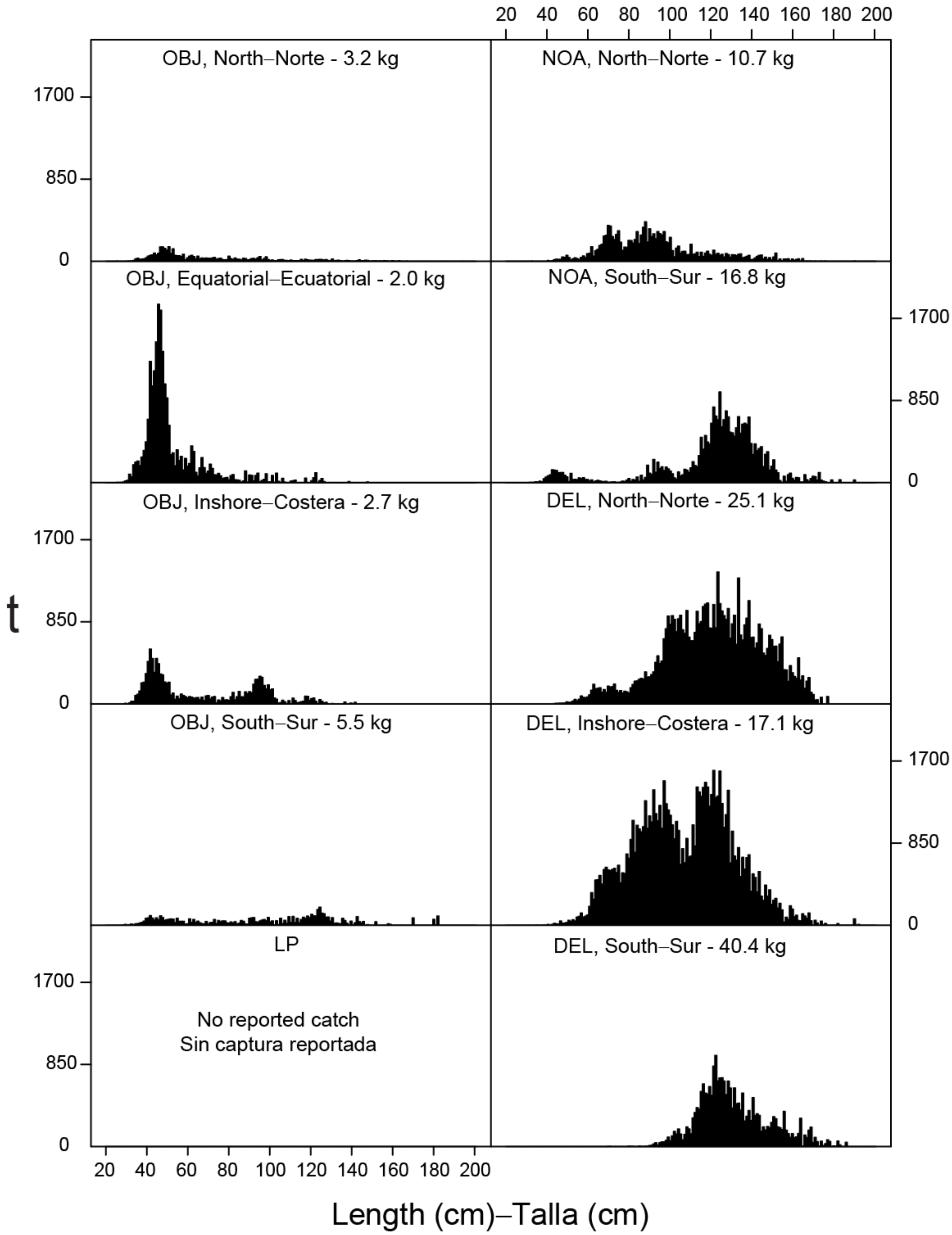

FIGURE A-6a. Estimated size compositions of the yellowfin caught in the EPO during 2015 for each fishery designated in Figure A-5. The average weights of the fish in the samples are given at the tops of the panels.

FIGURA A-6a. Composición por tallas estimada del aleta amarilla capturado en el OPO durante 2015 en cada pesquería ilustrada en la Figura A-5. En cada recuadro se detalla el peso promedio de los peces en las muestras.

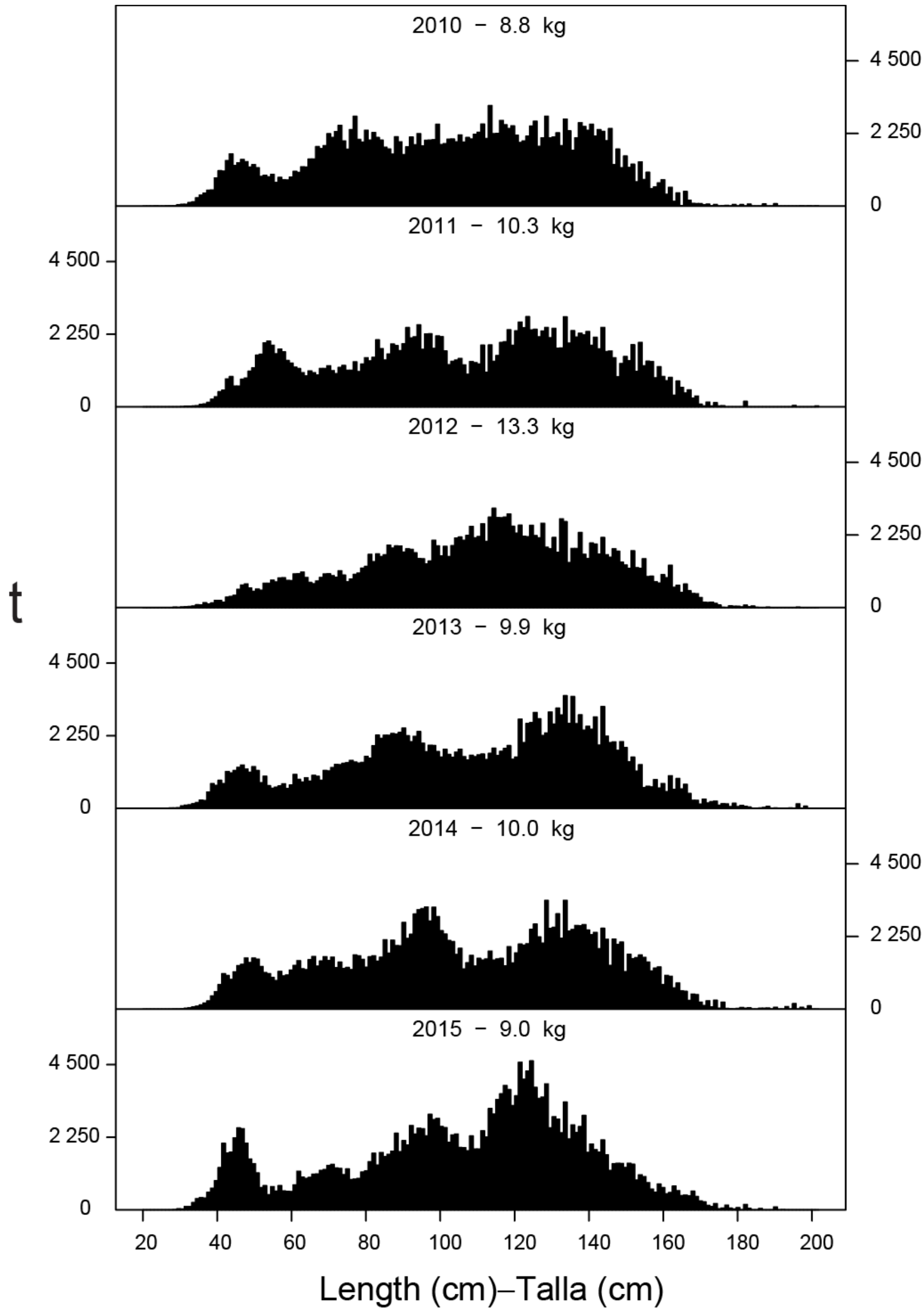

FIGURE A-6b. Estimated size compositions of the yellowfin caught by purse-seine and pole-and-line vessels in the EPO during 2010-2015. The average weights of the fish in the samples are given at the tops of the panels.

FIGURA A-6b. Composición por tallas estimada del aleta amarilla capturado por buques cerqueros y cañeros en el OPO durante 2010-2015. En cada recuadro se detalla el peso promedio de los peces en las muestras.

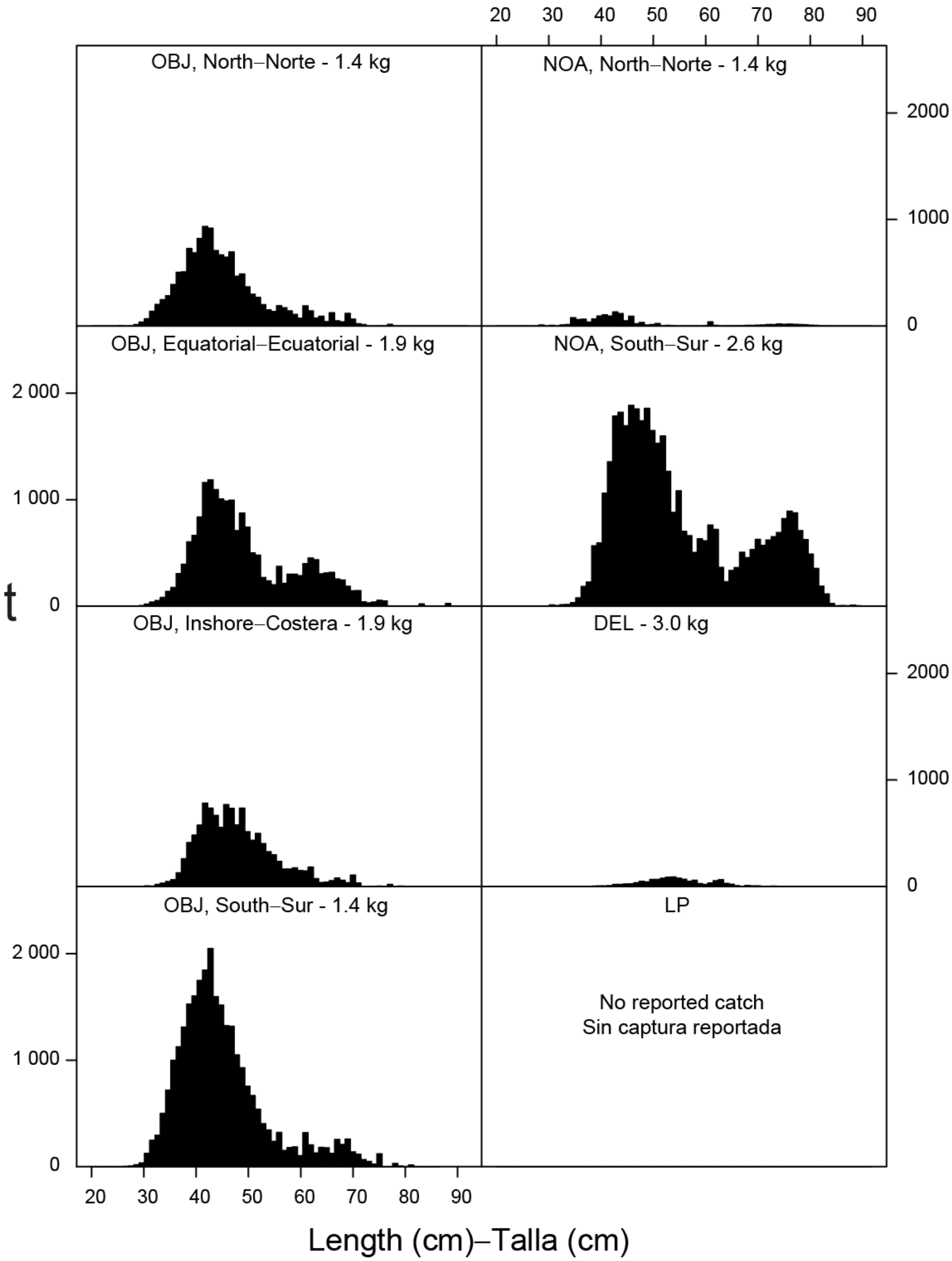

FIGURE A-7a. Estimated size compositions of the skipjack caught in the EPO during 2015 for each fishery designated in Figure A-5. The average weights of the fish in the samples are given at the tops of the panels.

FIGURA A-7a. Composición por tallas estimada del barrilete capturado en el OPO durante 2015 en cada pesquería ilustrada en la Figura A-5. En cada recuadro se detalla el peso promedio de los peces en las muestras.

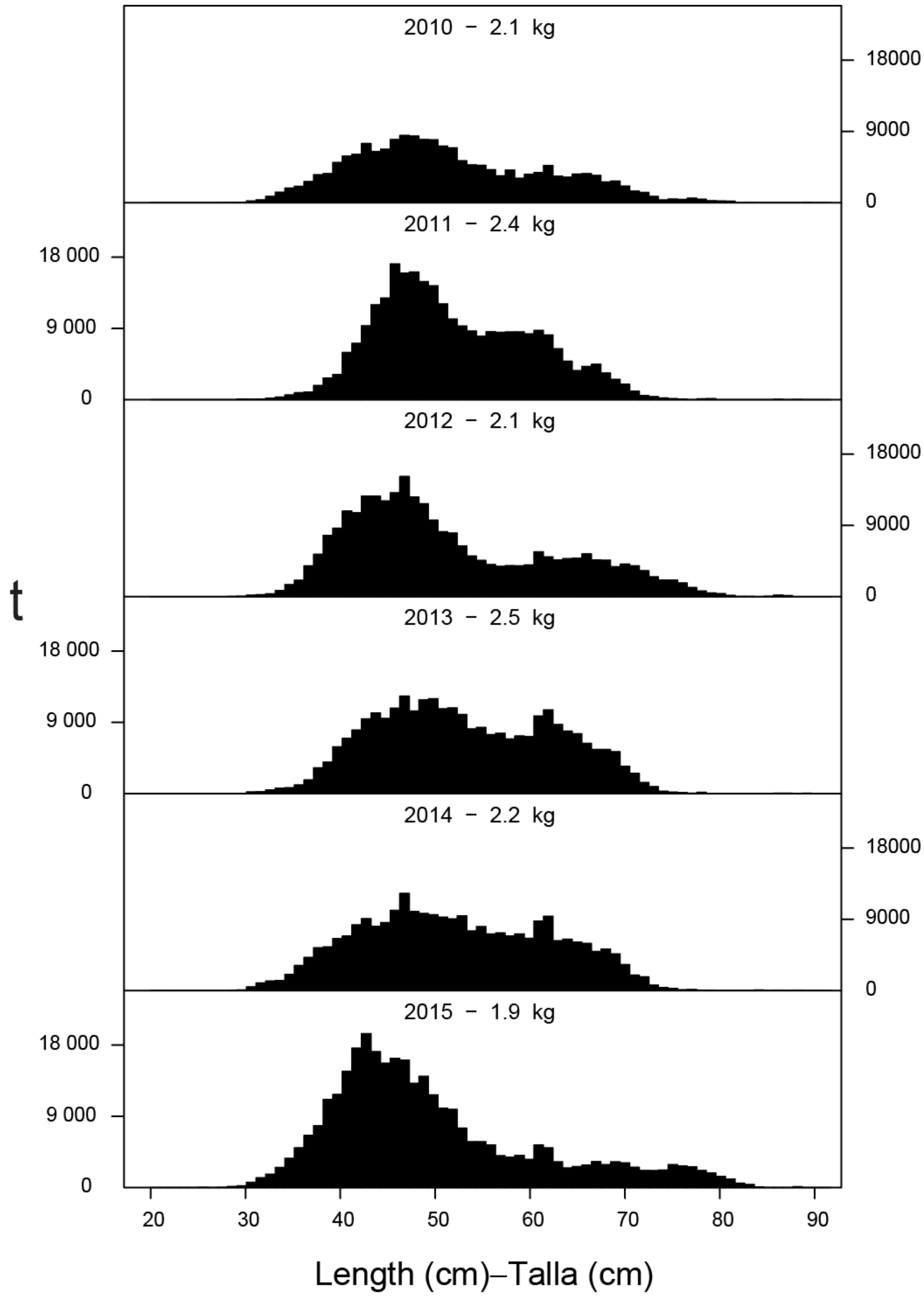

FIGURE A-7b. Estimated size compositions of the skipjack caught by purse-seine and pole-and-line vessels in the EPO during 2010-2015. The average weights of the fish in the samples are given at the tops of the panels.

FIGURA A-7b. Composición por tallas estimada del barrilete capturado por buques cerqueros y cañeros en el OPO durante 2010-2015. En cada recuadro se detalla el peso promedio de los peces en las muestras.

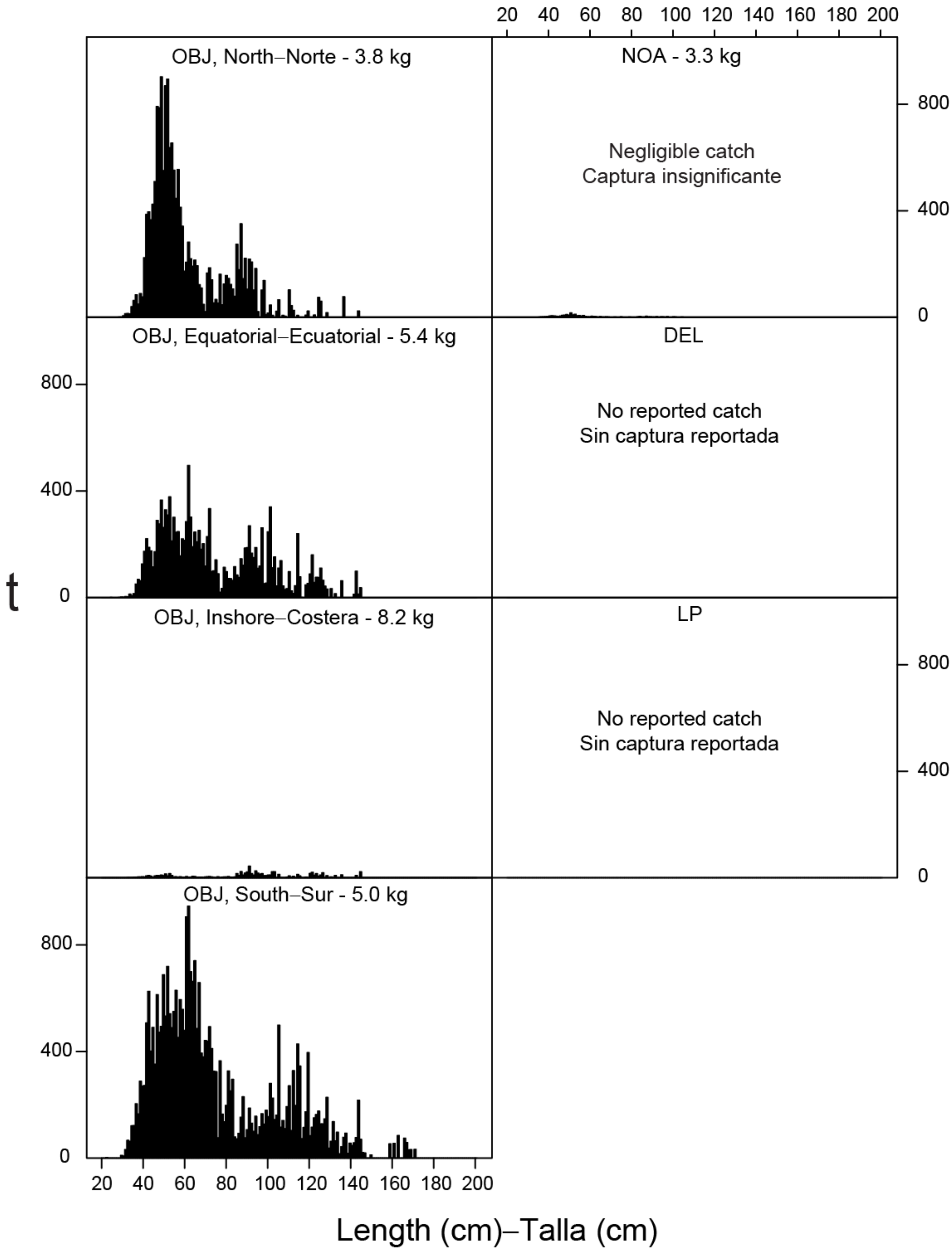

FIGURE A-8a. Estimated size compositions of the bigeye caught in the EPO during 2015 for each fishery designated in Figure A-5. The average weights of the fish in the samples are given at the tops of the panels.

FIGURA A-8a. Composición por tallas estimada del patudo capturado e en el OPO durante 2015 en cada pesquería ilustrada en la Figura A-5. En cada recuadro se detalla el peso promedio de los peces en las muestras.

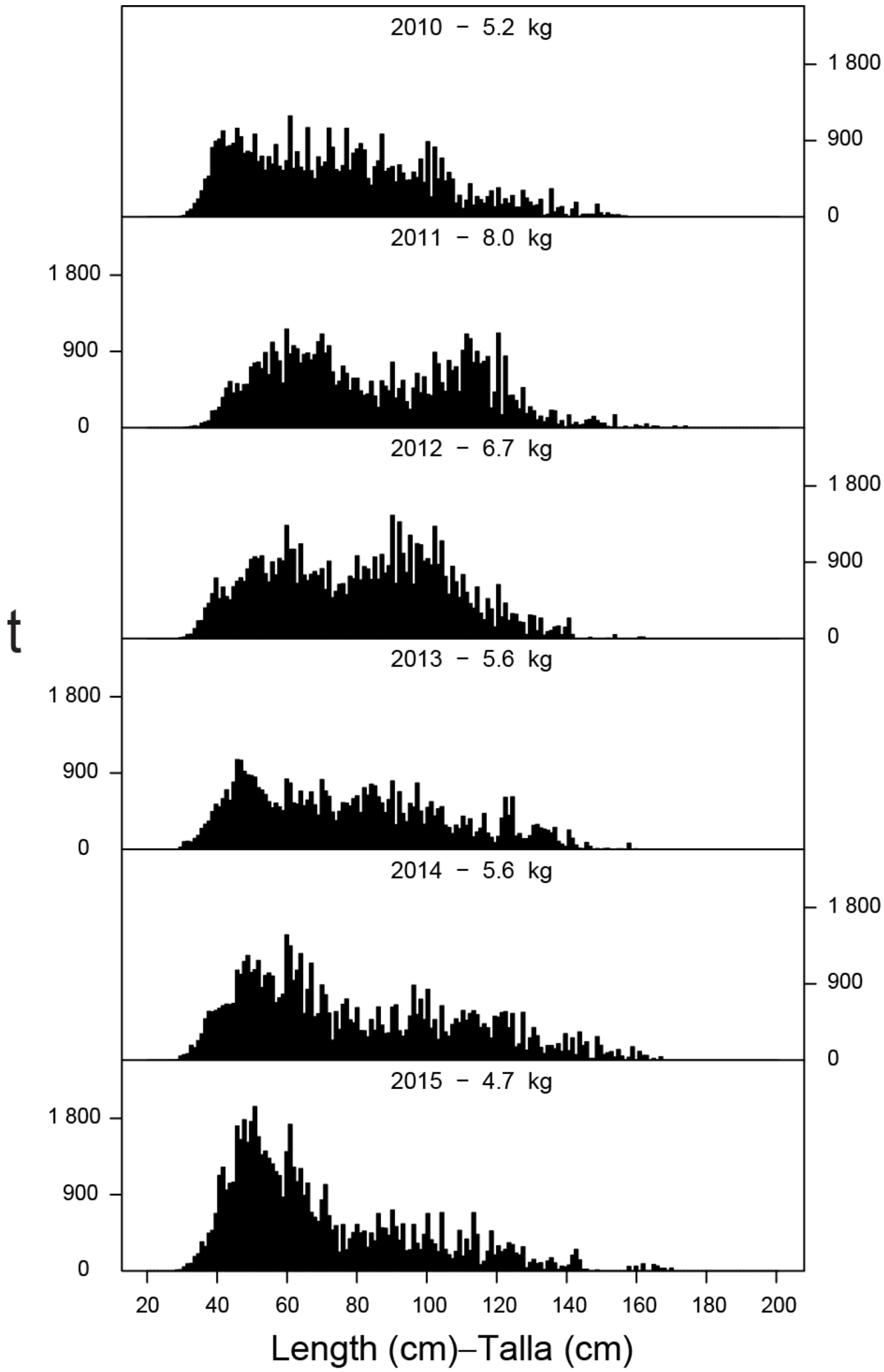

FIGURE A-8b. Estimated size compositions of the bigeye caught by purse-seine vessels in the EPO during 2010-2015. The average weights of the fish in the samples are given at the tops of the panels.
FIGURA A-8b. Composición por tallas estimada del patudo capturado por buques cerqueros en el OPO durante 2010-2015. En cada recuadro se detalla el peso promedio de los peces en las muestras.

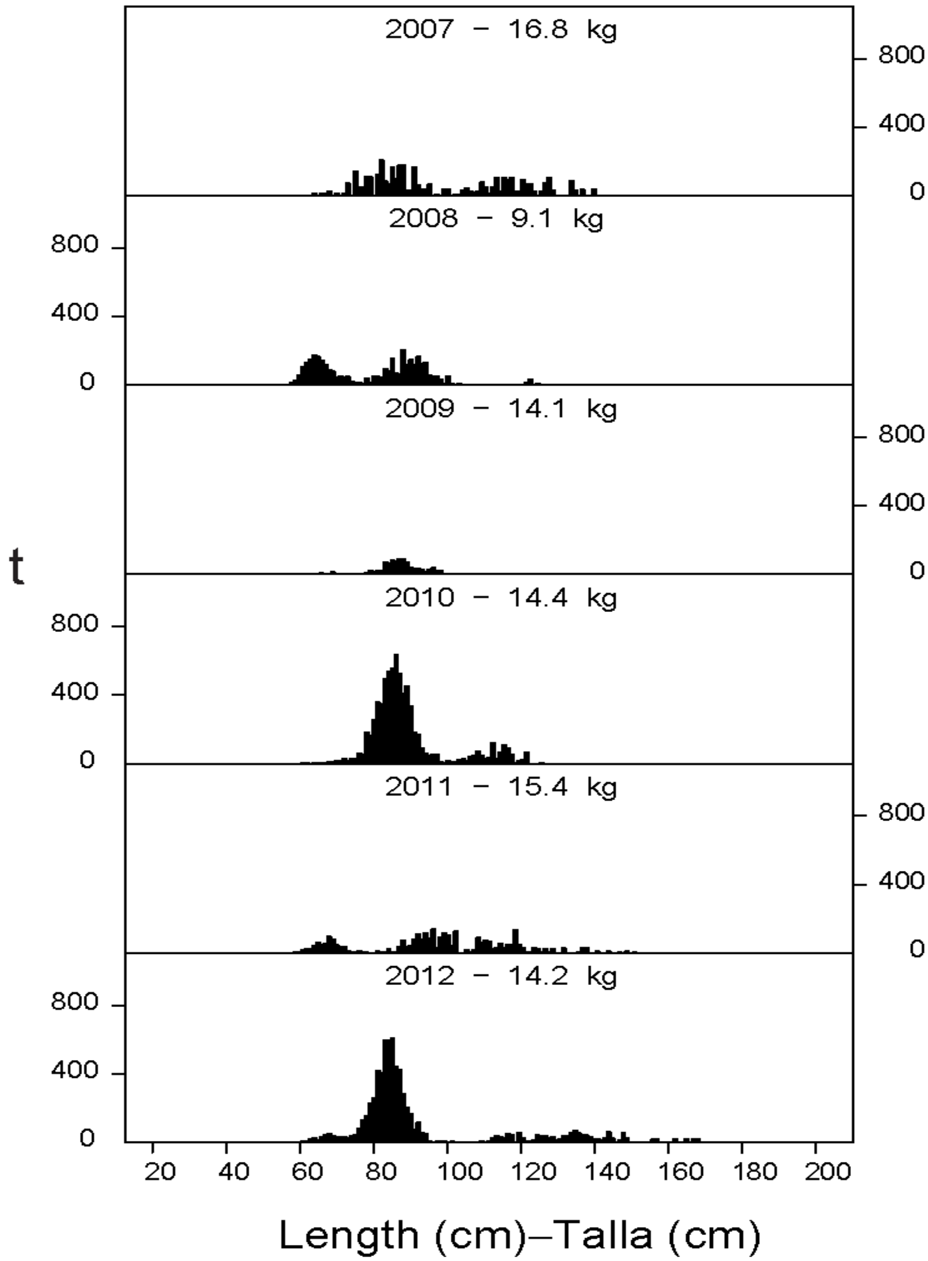

FIGURE A-9. Estimated catches of Pacific bluefin by purse-seine and recreational gear in the EPO during 2007-2012. The values at the tops of the panels are the average weights.

FIGURA A-9. Captura estimada de aleta azul del Pacífico con arte de cerco y deportiva en el OPO durante 2007-2012. El valor en cada recuadro representa el peso promedio.

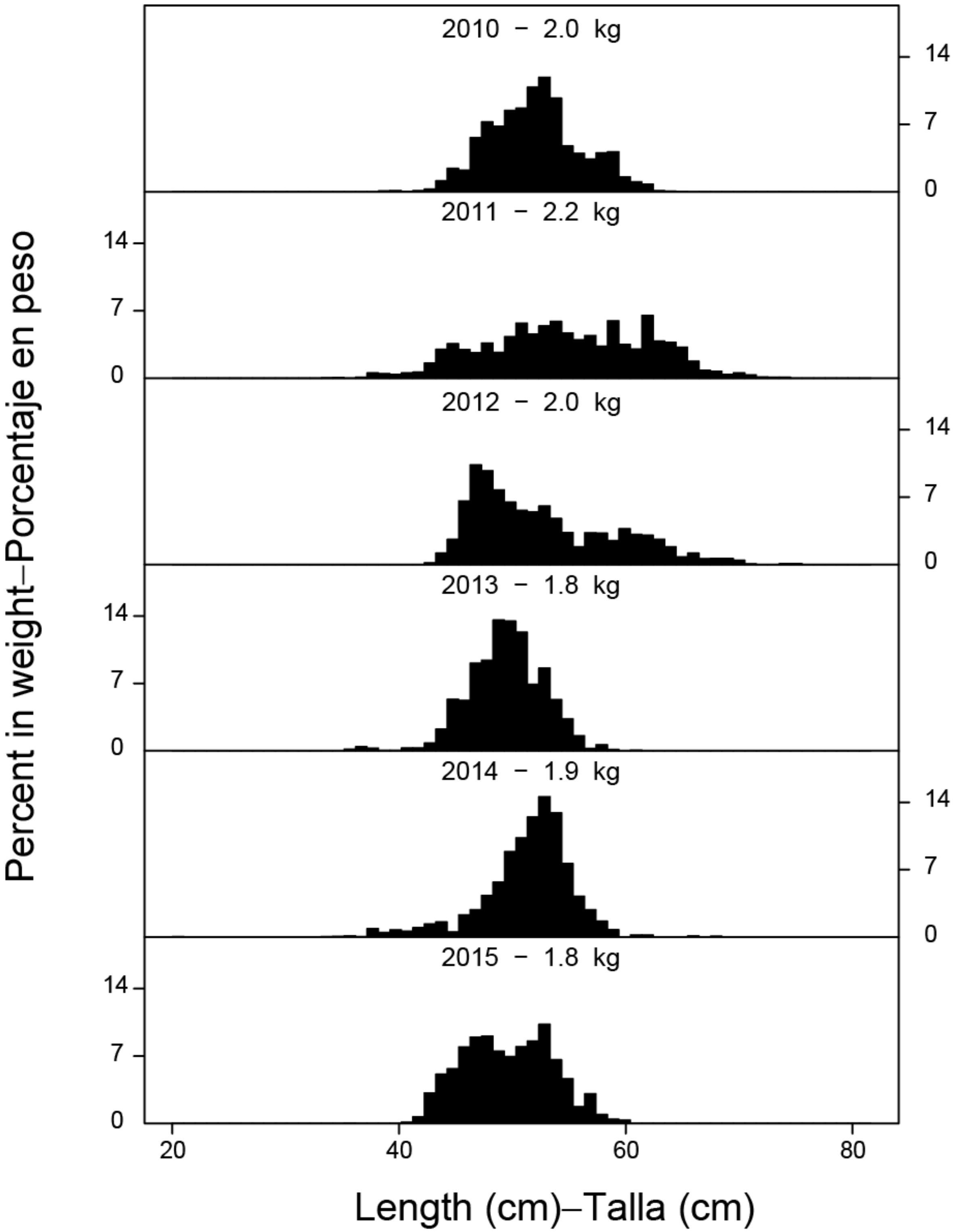

FIGURE A-10. Preliminary size compositions of the catches of black skipjack by purse-seine vessels in the EPO during 2010-2015. The values at the tops of the panels are the average weights.

FIGURA A-10. Composición por tallas preliminar del barrilete negro capturado por buques cerqueros en el OPO durante 2010-2015. El valor en cada recuadro representa el peso promedio.

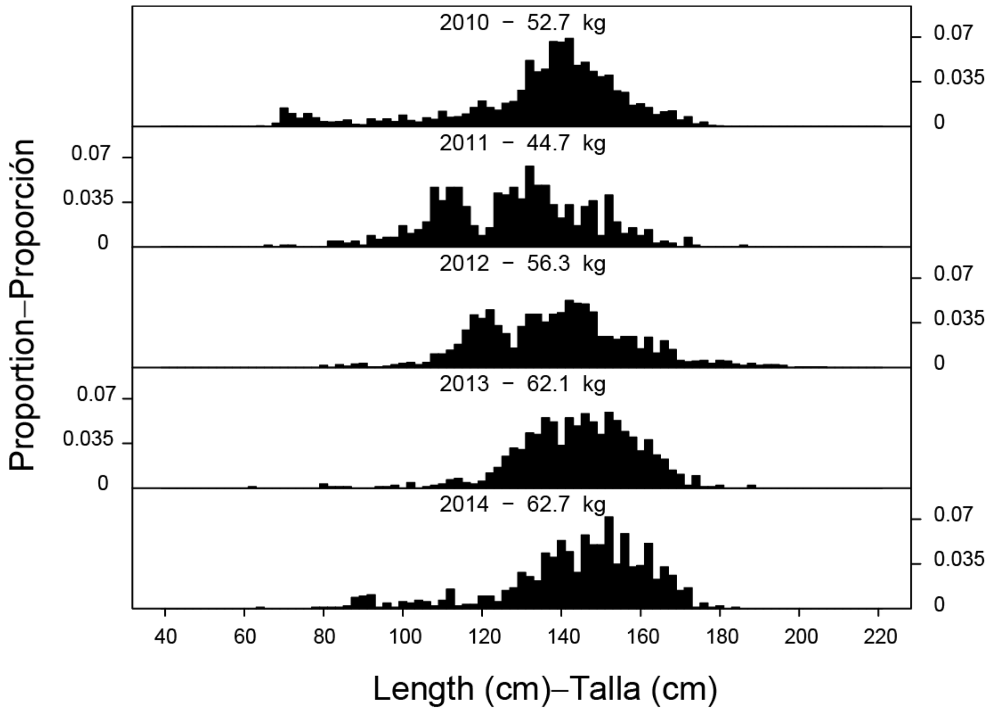

FIGURE A-11. Estimated size compositions of the catches of yellowfin tuna by the Japanese longline fishery in the EPO, 2010-2014.
FIGURA A-11. Composición por tallas estimada de las capturas de atún aleta amarilla por la pesquería palangrera japonesa en el OPO, 2010-2014.

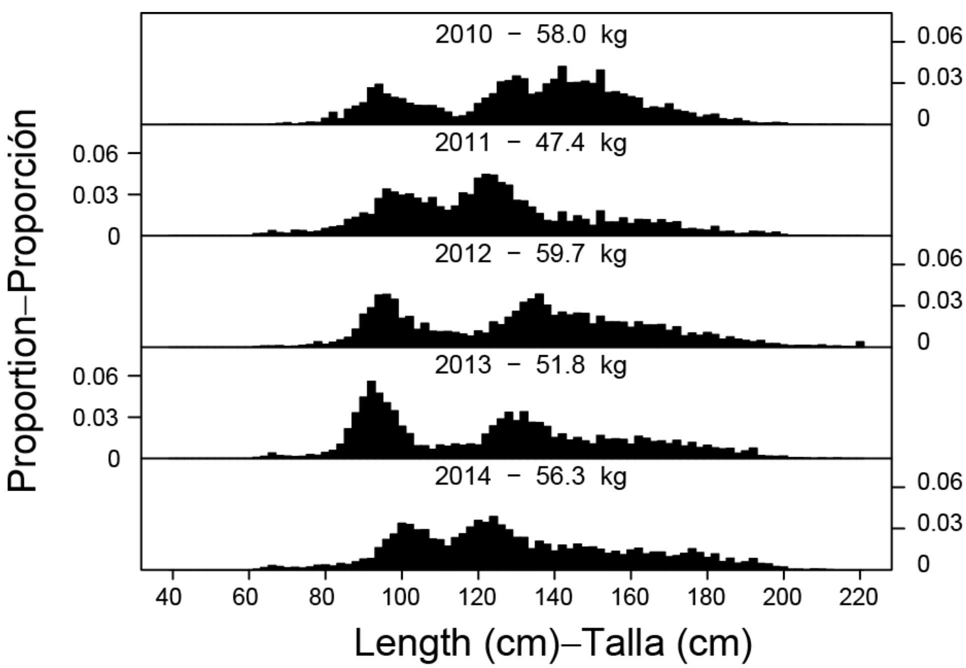

FIGURE A-12. Estimated size compositions of the catches of bigeye tuna by the Japanese longline fishery in the EPO, 2010-2014.
FIGURA A-12. Composición por tallas estimada de las capturas de atún patudo por la pesquería palangrera japonesa en el OPO, 2010-2014.

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 1993-2015 include discards from purse-seine vessels with carrying capacities greater than 363 t. *: data missing or not available; -: no data collected; C: data combined with those of other flags; this category is used to avoid revealing the operations of individual vessels or companies.

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 1993-2015 incluyen los descartes de buques cerqueros de más de 363 t de capacidad de acarreo. *: datos faltantes o no disponibles; -: datos no tomados; C: datos combinados con aquéllos de otras banderas; se usa esta categoría para no revelar información sobre las actividades de buques o empresas individuales.

	YFT			SKJ			BET			Total		
	EPO	WCPO	Total	EPO	WCPO	Total	EPO	WCPO	Total	EPO	WCPO	Total
1986	286,071	261,924	547,995	67,745	724,313	792,058	105,185	84,521	189,706	459,001	1,070,758	1,529,759
1987	286,164	309,133	595,297	66,466	668,025	734,491	101,347	100,805	202,152	453,977	1,077,963	1,531,940
1988	296,428	305,338	601,766	92,127	805,563	897,690	74,313	92,590	166,903	462,868	1,203,491	1,666,359
1989	299,436	353,660	653,096	98,921	781,360	880,281	72,994	99,281	172,275	471,351	1,234,301	1,705,652
1990	301,522	393,720	695,242	77,107	854,147	931,254	104,851	115,998	220,849	483,480	1,363,865	1,847,345
1991	265,970	420,683	686,653	65,890	1,073,169	1,139,059	109,121	99,510	208,631	440,981	1,593,362	2,034,343
1992	252,514	428,646	681,160	87,294	968,767	1,056,061	92,000	118,445	210,445	431,808	1,515,858	1,947,666
1993	256,199	369,497	625,696	100,434	923,772	1,024,206	82,843	102,713	185,556	439,476	1,395,982	1,835,458
1994	248,071	409,241	657,312	84,661	987,223	1,071,884	109,331	116,890	226,221	442,063	1,513,354	1,955,417
1995	244,639	405,168	649,807	150,661	1,019,647	1,170,308	108,210	105,853	214,063	503,510	1,530,668	2,034,178
1996	266,928	408,246	675,174	132,335	1,017,270	1,149,605	114,706	110,547	225,253	513,969	1,536,063	2,050,032
1997	277,575	495,043	772,618	188,285	909,915	1,098,200	122,274	152,836	275,110	588,134	1,557,794	2,145,928
1998	280,606	596,550	877,156	165,489	1,174,372	1,339,861	93,954	165,622	259,576	540,049	1,936,544	2,476,593
1999	304,638	509,888	814,526	291,249	1,053,848	1,345,097	93,078	147,512	240,590	688,965	1,711,248	2,400,213
2000	286,865	557,523	844,388	230,480	1,164,767	1,395,247	148,557	132,005	280,562	665,902	1,854,295	2,520,197
2001	425,008	522,700	947,708	157,676	1,089,463	1,247,139	130,546	133,607	264,153	713,230	1,745,770	2,459,000
2002	443,458	478,462	921,920	167,048	1,265,455	1,432,503	132,806	155,888	288,694	743,312	1,899,805	2,643,117
2003	415,933	534,295	950,228	300,470	1,260,323	1,560,793	115,175	127,306	242,481	831,578	1,921,924	2,753,502
2004	296,847	571,444	868,291	217,249	1,357,963	1,575,212	110,722	177,973	288,695	624,818	2,107,380	2,732,198
2005	286,492	542,796	829,288	283,453	1,404,304	1,687,757	110,514	140,907	251,421	680,459	2,088,007	2,768,466
2006	180,519	473,940	654,459	309,090	1,502,445	1,811,535	117,328	151,544	268,872	606,937	2,127,929	2,734,866
2007	182,141	506,961	689,102	216,324	1,654,655	1,870,979	94,260	137,070	231,330	492,725	2,298,686	2,791,411
2008	197,328	599,881	797,209	307,699	1,627,984	1,935,683	103,350	145,279	248,629	608,377	2,373,144	2,981,521
2009	250,413	534,257	784,670	239,408	1,792,632	2,032,040	109,255	144,552	253,807	599,076	2,471,441	3,070,517
2010	261,871	552,896	814,767	153,092	1,694,169	1,847,261	95,408	130,110	225,518	510,371	2,377,175	2,887,546
2011	216,720	515,378	732,098	283,509	1,539,530	1,823,039	89,460	153,329	242,789	589,689	2,208,237	2,797,926
2012	213,310	585,831	799,141	273,519	1,771,848	2,045,367	102,687	154,391	257,078	589,516	2,512,070	3,101,586
2013	231,803	547,990	779,793	284,043	1,830,821	2,114,864	86,063	142,492	228,555	601,909	2,521,303	3,123,212
2014	246,512	611,307	857,819	265,644	1,972,512	2,238,156	95,809	155,370	251,179	607,965	2,739,189	3,347,154
2015	246,380	*	246,380	333,456	*	333,456	101,652	*	101,652	681,488	*	681,488

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 2014-2015 are preliminary. *: data missing or not available; -: no data collected; C: data combined with those of other flags; this category is used to avoid revealing the operations of individual vessels or companies.

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 2014-2015 son preliminares. *: datos faltantes o no disponibles; -: datos no tomados; C: datos combinados con aquéllos de otras banderas; se usa esta categoría para no revelar información sobre las actividades de buques o empresas individuales.

	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.				
1986	260,512	-	2,537	22,808	214	286,071	65,634	-	1,921	58	132	67,745	2,686	-	-	102,425	74	105,185
1987	262,008	-	5,107	18,911	138	286,164	64,019	-	2,233	37	177	66,466	1,177	-	-	100,121	49	101,347
1988	277,293	-	3,723	14,660	752	296,428	87,113	-	4,325	26	663	92,127	1,535	-	5	72,758	15	74,313
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	6,207	2,431	23,855	1,109	286,865	205,647	24,468	231	68	66	230,480	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	11,416	1,234	231,803	278,560	2,254	164	2,024	1,041	284,043	49,487	273	-	36,204	99	86,063
2014	233,973	517	C	8,522	3,500	246,512	261,578	2,596	C	239	1,231	265,644	60,453	83	-	35,096	177	95,809
2015	245,183	334	C	*	863	246,380	329,280	3,699	C	*	477	333,456	63,229	177	-	38,245	1	101,652

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.				
1986	5,040	-	-	1	64	5,105	47	-	86	6,450	4,701	11,284	569	-	-	-	18	587
1987	980	-	-	3	88	1,071	1	-	320	9,994	2,662	12,977	571	-	-	-	2	573
1988	1,379	-	-	2	52	1,433	17	-	271	9,934	5,549	15,771	956	-	-	-	311	1,267
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	15,679	25,097	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	16,553	26,870	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	19,333	33,614	3,425	1,079	-	8	184	4,696
2011	2,829	4	-	1	244	3,078	10	-	C	16,191	16,105	32,306	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	25,368	18,514	43,882	3,580	805	-	10	24	4,419
2014	5,263	66	-	-	403	5,732	-	-	C	28,874	19,556	48,430	4,153	486	-	11	81	4,731
2015	3,168	-	-	-	14	3,182	-	-	*	*	*	*	3,793	356	-	-	36	4,185

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.				
1986	232	-	258	-	1,889	2,379	177	-	4	-	986	1,167	334,897	-	4,806	131,742	8,078	479,523
1987	3,195	-	121	-	1,782	5,098	481	-	-	-	2,043	2,524	332,432	-	7,781	129,066	6,941	476,220
1988	8,811	-	739	-	947	10,497	79	-	-	-	2,939	3,018	377,183	-	9,063	97,380	11,228	494,854
1989	11,278	-	818	-	465	12,561	36	-	-	-	626	662	388,181	-	7,929	94,811	5,160	496,081
1990	13,641	-	215	-	371	14,227	200	-	-	3	692	895	359,640	-	3,945	140,096	8,168	511,849
1991	1,207	-	82	-	242	1,531	4	-	-	29	192	225	300,406	-	5,520	143,057	6,160	455,143
1992	977	-	-	-	318	1,295	24	-	-	27	1,071	1,122	322,617	-	6,001	120,609	10,277	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	14,569	467,172
1994	8,331	147	362	-	185	9,025	9	498	-	1	464	972	322,930	18,784	7,312	111,902	13,943	474,871
1995	7,929	55	81	-	54	8,119	11	626	-	-	1,004	1,641	396,603	27,028	7,067	85,152	14,095	529,945
1996	647	1	7	-	16	671	37	1,028	-	-	1,038	2,103	413,623	39,828	6,396	71,280	13,183	544,310
1997	1,097	4	8	-	34	1,143	71	3,383	-	7	1,437	4,898	466,483	48,158	7,747	84,588	9,962	616,938
1998	1,330	4	7	-	588	1,929	13	1,233	-	24	18,158	19,428	442,365	33,275	6,896	74,759	34,814	592,109
1999	1,719	-	-	24	369	2,112	27	3,092	-	2,113	4,279	9,511	599,160	44,075	4,059	62,254	24,309	733,857
2000	636	-	-	75	56	767	190	1,410	-	1,992	1,468	5,060	559,095	39,497	2,809	83,304	16,754	701,459
2001	17	-	-	34	19	70	191	679	-	2,448	55	3,373	591,243	22,798	4,522	121,617	14,752	754,932
2002	-	-	-	-	1	1	576	1,863	-	482	1,422	4,343	627,077	21,742	1,958	116,058	17,158	783,993
2003	-	-	1	-	25	26	80	1,238	-	215	750	2,283	714,079	33,417	1,177	110,800	25,601	885,074
2004	15	35	1	8	3	62	256	973	-	349	258	1,836	545,992	23,066	2,539	81,818	25,120	678,535
2005	313	18	-	-	11	342	190	1,922	-	363	427	2,902	605,945	25,665	3,187	62,584	19,875	717,256
2006	3,507	80	12	-	3	3,602	50	1,910	-	29	193	2,182	562,330	18,353	1,134	56,064	21,753	659,634
2007	15,906	628	107	2	-	16,643	598	1,221	-	2,197	301	4,317	464,948	12,539	1,298	51,489	22,178	552,452
2008	7,874	37	9	6	26	7,952	136	1,380	1	727	883	3,127	572,763	14,713	2,388	47,164	19,665	656,693
2009	9,720	15	-	8	77	9,820	162	469	-	1,933	74	2,638	561,695	9,875	860	57,465	21,744	651,639
2010	2,820	19	4	2	70	2,915	136	709	-	1,770	36	2,651	470,105	6,171	511	63,283	22,015	562,085
2011	7,969	45	18	10	11	8,053	108	784	-	3,178	-	4,070	552,631	7,813	318	61,135	18,341	640,238
2012	8,191	156	-	1	64	8,412	41	354	-	196	221	812	549,693	5,385	703	75,903	21,421	653,105
2013	2,067	9	-	13	27	2,116	53	461	-	-	529	1,043	555,088	4,009	923	75,036	22,287	657,343
2014	2,821	38	-	-	154	3,013	113	328	-	269	392	1,102	568,354	4,114	-	73,011	25,494	670,973
2015	789	28	-	*	-	817	81	242	-	*	1,073	1,396	645,523	4,836	-	38,245	2,464	691,068

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 2014-2015 are preliminary. PS dis. = discards by purse-seine vessels. . *: data missing or not available; -: no data collected; C: data combined with those of other flags; this category is used to avoid revealing the operations of individual vessels or companies.

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 2014-2015 son preliminares. PS dis. = descartes por buques cerqueros. *: datos faltantes o no disponibles; -: datos no tomados; C: datos combinados con aquéllos de otras banderas; se usa esta categoría para no revelar información sobre las actividades de buques o empresas individuales.

	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.			
1986	-	-	3,286	3,294	6,580	-	-	5,278	-	5,278	-	-	297	-	297	-	-	3,540	-	3,540
1987	-	-	4,676	3,740	8,416	-	-	7,282	-	7,282	-	-	358	-	358	-	-	7,647	-	7,647
1988	-	-	4,916	5,642	10,558	-	-	5,663	-	5,663	-	-	288	-	288	-	-	5,283	-	5,283
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	-	22,989	5,560	28,551	172	15	4,202	168	4,557	99	4	138	-	241	21	1	2,439	19	2,480
2014	4	-	20,519	6,368	26,891	209	12	4,061	186	4,468	71	4	153	-	228	23	1	1,926	2	1,952
2015	5	-	*	191	196	307	11	*	*	318	117	14	*	-	131	26	9	*	*	35

TABLE A-2b. (continued)
TABLA A-2b. (continuación)

	Shortbill spearfish—Marlín trompa corta					Sailfish—Pez vela					Unidentified istiophorid billfishes—Picudos istioféridos no identificados					Total billfishes—Total de peces picudos				
	PS		LL	OTR	Total	PS		LL	OTR	Total	PS		LL	OTR	Total	PS		LL	OTR	Total
	Ret.	Dis.				Ret.	Dis.				Ret.	Dis.				Ret.	Dis.			
1986	-	-	5	-	5	-	-	583	-	583	-	-	1	-	1	-	-	12,990	3,294	16,284
1987	-	-	15	-	15	-	-	649	-	649	-	-	398	-	398	-	-	21,025	3,740	24,765
1988	-	-	13	-	13	-	-	649	-	649	-	-	368	-	368	-	-	17,180	5,642	22,822
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	613	9	640	15	3	2,702	1	2,721	326	25	33,996	5,757	40,104
2014	-	-	723	-	723	16	1	471	8	496	8	2	128	3	141	331	20	27,981	6,567	34,899
2015	1	-	*	-	1	18	8	*	*	26	19	1	*	*	20	493	43	*	191	727

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 2014-2015 are preliminary. . *: data missing or not available; -: no data collected; C: data combined with those of other flags; this category is used to avoid revealing the operations of individual vessels or companies.

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 2014-2015 son preliminares. *: datos faltantes o no disponibles; -: datos no tomados; C: datos combinados con aquéllos de otras banderas; se usa esta categoría para no revelar información sobre las actividades de buques o empresas individuales.

	Carangids—Carángidos					Dorado (*Coryphaena* spp.)					Elasmobranchs—Elasmobranquios					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.			
1986	188	-	-	19	207	633	-	-	1,828	2,461	29	-	1	1,979	2,009	93	-	-	-	93
1987	566	-	-	5	571	271	-	-	4,272	4,543	95	-	87	1,020	1,202	210	-	535	-	745
1988	825	-	-	1	826	69	-	-	1,560	1,629	1	-	23	1,041	1,065	321	-	361	-	682
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	1,154	1,028	916	3,351	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	11,261	22,673	35,871	216	321	17,724	116	18,377	1,389	370	2,931	267	4,957
2014	20	11	-	35	66	1,762	369	3,282	20,916	26,329	247	474	12,790	16,417	29,928	1,450	438	2,644	486	5,018
2015	28	15	-	-	43	1,045	169	*	15,948	17,162	398	620	*	*	1,018	696	208	*	*	904

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. *: data missing or not available; -: no data collected; C: data combined with those of other flags; this category is used to avoid revealing the operations of individual vessels or companies.

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. *: datos faltantes o no disponibles; -: datos no tomados; C: datos combinados con aquéllos de otras banderas; se usa esta categoría para no revelar información sobre las actividades de buques o empresas individuales.

	COL	CRI	ECU	EU(ESP)	MEX	NIC	PAN	PER	SLV	USA	VEN	VUT	C + OTR[1]	Total
1986	-	C	16,561	C	103,644	-	9,073	C	C	88,617	28,462	C	14,155	260,512
1987	-	-	15,046	C	96,182	-	C	C	C	95,506	34,237	C	21,037	262,008
1988	-	-	23,947	C	104,565	-	7,364	1,430	C	82,231	38,257	C	19,499	277,293
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	17,203	-	37,640	763	120,986	8,119	19,375	C	C	1,106	23,040	-	5,741	233,973
2015	17,422	-	49,039	525	106,522	6,788	26,491	764	C	3,151	30,266	-	4,215	245,183

[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 2013-2014 are preliminary. *: data missing or not available; -: no data collected; C: data combined with those of other flags; this category is used to avoid revealing the operations of individual vessels or companies.

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 2013-2014 son preliminares. *: datos faltantes o no disponibles; -: datos no tomados; C: datos combinados con aquéllos de otras banderas; se usa esta categoría para no revelar información sobre las actividades de buques o empresas individuales.

	CHN	CRI	FRA (PYF)	JPN	KOR	MEX	PAN	TWN	USA	VUT	C + OTR[1]	Total LL	Total PS+LL	OTR[2]
1986	-	-	-	17,770	4,850	68	-	120	-	-	*	22,808	283,320	2,751
1987	-	-	-	13,484	5,048	272	-	107	-	-	*	18,911	280,919	5,245
1988	-	-	-	12,481	1,893	232	-	54	-	-	*	14,660	291,953	4,475
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	2	959	572	43	101	1,986	11,416	229,603	1,993
2014	2,120	1,072	567	2,652	704	1	108	896	60	323	19	8,522	242,495	3,500

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

[2] Includes gillnets, pole-and-line, recreational, troll and unknown gears—Incluye red de transmalle, 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. *: data missing or not available; -: no data collected; C: data combined with those of other flags; this category is used to avoid revealing the operations of individual vessels or companies.

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. *: datos faltantes o no disponibles; -: datos no tomados; C: datos combinados con aquéllos de otras banderas; se usa esta categoría para no revelar información sobre las actividades de buques o empresas individuales.

	PS														LL+OTR[2]
	COL	CRI	ECU	EU(ESP)	MEX	NIC	PAN	PER	SLV	USA	VEN	VUT	C+OTR[1]	Total	
1986	-	C	23,836	C	6,061	-	1,134	C	C	12,978	11,797	C	9,828	65,634	2,111
1987	-	-	20,473	C	4,786	-	C	C	C	13,578	11,761	C	13,421	64,019	2,447
1988	-	-	11,743	C	15,195	-	1,863	714	C	36,792	12,312	C	8,494	87,113	5,014
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	22,740	-	172,510	5,599	8,777	6,309	21,816	C	C	C	13,766	-	10,061	261,578	1,470
2015	16,370	-	210,215	11,545	23,170	1,439	31,005	5,165	C	16,867	4,777	-	8,727	329,280	477

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

[2] Includes gillnets, pole-and-line, recreational, and unknown gears—Incluye red de transmalle, 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. *: data missing or not available; -: no data collected; C: data combined with those of other flags; this category is used to avoid revealing the operations of individual vessels or companies.
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. *: datos faltantes o no disponibles; -: datos no tomados; C: datos combinados con aquéllos de otras banderas; se usa esta categoría para no revelar información sobre las actividades de buques o empresas individuales.

	COL	CRI	ECU	EU(ESP)	MEX	NIC	PAN	PER	SLV	USA	VEN	VUT	C + OTR[1]	Total
1986	-	-	653	C	1	-	-	-	-	266	1,466	C	300	2,686
1987	-	-	319	C	2	-	*	-	C	224	453	C	179	1,177
1988	-	-	385	C	-	-	431	*	C	256	202	C	261	1,535
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	2,453	-	38,749	2,790	40	3,039	8,107	-	C	C	1,170	-	4,105	60,453
2015	2,379	-	43,709	754	149	962	10,596	-	C	2,308	126	-	2,246	63,229

[1] Includes—Incluye: BLZ, BOL, CHN, CYM, EU(CYP), GTM, HND, LBR, NZL, VCT, 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 2014-2015 are preliminary. *: data missing or not available; -: no data collected; C: data combined with those of other flags; this category is used to avoid revealing the operations of individual vessels or companies.

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 2014-2015 son preliminares. *: datos faltantes o no disponibles; -: datos no tomados; C: datos combinados con aquéllos de otras banderas; se usa esta categoría para no revelar información sobre las actividades de buques o empresas individuales.

	CHN	CRI	FRA(PYF)	JPN	KOR	MEX	PAN	TWN	USA	VUT	C + OTR[1]	Total LL	Total PS + LL	OTR[2]
1986	-	-	-	91,981	10,187	0	-	257	-	-	*	102,425	105,111	74
1987	-	-	-	87,913	11,681	1	-	526	-	-	*	100,121	101,298	49
1988	-	-	-	66,015	6,151	1	-	591	-	-	*	72,758	74,293	20
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	0
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	2,056	604	577	36,205	85,691	99
2014	5,253	9	526	13,468	8,203	-	C	4,511	2,100	897	129	35,096	95,549	177
2015	8,486	*	*	13,415	10,107	*	*	5,538	666	*	33	38,245	101,474	1

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

[2] Includes gillnets, pole-and-line, recreational, and unknown gears—Incluye red de transmalle, 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 2014 and 2015, 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 2014 y 2015, 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	%
2014	**Retained catches–Capturas retenidas**									
COL	17,203	22,740	2,453	-	-	10	-	-	42,406	7.4
ECU	37,640	172,510	38,749	-	-	707	1,855	65	251,526	44.2
EU(ESP)	763	5,599	2,790	-	-	-	-	-	9,152	1.6
MEX	120,986	8,777	40	4,862	-	3,428	964	48	139,105	24.5
NIC	8,119	6,309	3,039	-	-	1	-	-	17,468	3.1
PAN	19,375	21,816	8,107	-	-	5	2	-	49,305	8.7
USA	1,106	521	128	401	-	-	-	-	2,156	0.4
VEN	23,040	13,766	1,170	-	-	2	-	-	37,978	6.7
OTR[1]	5,741	9,540	3,977	-	-	-	-	-	19,258	3.4
Total	233,973	261,578	60,453	5,263	-	4,153	2,821	113	568,354	
2015	**Retained catches–Capturas retenidas**									
COL	17,422	16,370	2,379	-	-	20	-	-	36,191	5.6
ECU	49,039	210,215	43,709	-	-	1,032	37	47	304,079	47.1
EU(ESP)	525	11,545	754	-	-	-	-	-	12,824	2.0
MEX	106,522	23,170	149	3,082	-	2,719	626	23	136,291	21.1
NIC	6,788	1,439	962	-	-	1	-	-	9,190	1.4
PAN	26,491	31,005	10,596	-	-	-	-	3	68,095	10.5
PER	764	5,165	-	-	-	-	9	5	5,943	0.9
USA	3,151	16,867	2,308	86	-	-	117	-	22,529	3.5
VEN	30,266	4,777	126	-	-	15	-	3	35,187	5.5
OTR[2]	4,215	8,727	2,246	-	-	6	-	-	15,194	2.4
Total	245,183	329,280	63,229	3,168	-	3,793	789	81	645,523	

[1] Includes El Salvador, Guatemala and Peru. This category is used to avoid revealing the operations of individual vessels or companies.

[1] Incluye El Salvador, Guatemala y Perú. Se usa esta categoría para no revelar información sobre las actividades de buques o empresas individuales.

[2] Includes El Salvador and Guatemala This category is used to avoid revealing the operations of individual vessels or companies.

[2] Incluye El Salvador y Guatemala 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 2014 and 2015, by 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 2014 y 2015, por 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	%
2014	**Landings-Desccargas**									
COL	11,696	6,946	907	-	-	66	-	-	19,615	3.5%
ECU	78,194	221,675	41,061	-	-	630	2,020	65	343,645	61.5%
MEX	120,208	7,072	27	4,862	-	3,428	965	48	136,610	24.4%
USA	1,177	486	92	402	-	-	-	-	2,157	0.4%
VEN	2,234	3,082	71	-	-	-	-	-	5,387	1.0%
OTR[1]	31,542	16,046	3,834	-	-	-	-	-	51,422	9.2%
Total	245,051	255,307	45,992	5,264	-	4,124	2,985	113	558,836	
2015	**Landings-Desccargas**									
COL	8,578	5,101	921	-	-	118	-	-	14,718	2.2%
ECU	97,710	279,105	53,338	-	-	961	35	52	431,149	66.0%
MEX	115,508	27,038	319	3,082	-	2,729	626	23	149,325	22.8%
USA	990	5,328	210	86	-	-	117	-	6,731	1.0%
VEN	3,903	1,109	8	-	-	-	-	3	5,023	0.8%
OTR[2]	25,054	17,867	3,808	-	-	15	11	8	46,763	7.2%
Total	251,743	335,548	58,604	3,168	-	3,823	789	86	653,709	

[1,2] Includes Costa Rica, El Salvador, Guatemala and Peru. This category is used to avoid revealing the operations of individual vessels or companies.

[1,2] Incluye Costa Rica, El Salvador, Guatemala y Perú. 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 2014 and 2015 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 2014 y 2015 son preliminares.

PBF	Western Pacific flags—Banderas del Pacífico occidental[1]										Eastern Pacific flags—Banderas del Pacífico oriental						Total
	JPN				KOR[1]		TWN			Sub-total	MEX		USA		Sub-total	OTR	
	PS	LP	LL	OTR	PS	OTR	PS	LL	OTR		PS	OTR	PS	OTR			
1986	7,412	1,086	102	5,100	344	-	16	70	13	14,143	189	-	4,851	64	5,104	-	19,247
1987	8,653	1,565	211	3,523	89	13	21	365	14	14,454	119	-	861	87	1,067	-	15,521
1988	3,605	907	157	2,465	32	-	197	108	62	7,533	447	1	923	51	1,422	9	8,964
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	-	-	580	316	896	-	10,711
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	2,845	1,421	2	-	210	4	7,730	6,667	1	38	405	7,111	-	14,841
2013	2,771	8	784	2,848	604	1	-	332	3	7,351	3,154	-	-	819	3,973	-	11,324
2014	5,456	5	715	3,429	1,305	6	-	480	3	11,399	4,862	-	401	403	5,666	-	17,065
2015	*	*	*	*	*	*	*	*	*	*	3,082	-	86	14	3,182	-	3,182

[1] Source: International Scientific Committee, 15th Plenary Meeting, PBFWG workshop report on Pacific Bluefin Tuna, July 2015—Fuente: Comité Científico Internacional, 15ª Reunión Plenaria, Taller PBFWG sobre Atún Aleta Azul del Pacífico, julio de 2015

TABLE A-5b. Reported catches of Pacific bluefin tuna in the EPO by recreational gear, in number of fish, 1986-2015.
TABLA A-5b. Capturas reportadas de atún aleta azul del Pacifico en el OPO por artes deportivas, en número de peces, 1986-2015.

PBF			
1986	693	2001	21,913
1987	1,951	2002	33,399
1988	330	2003	22,291
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	26,105
2000	20,669	**2015**	26,077

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 2013 and 2014 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 2013 y 2014 son preliminares.

ALB	North—Norte				South—Sur				Total
	LL	LTL[1]	OTR	Subtotal	LL	LTL	OTR	Subtotal	
1986	698	4,368	243	5,309	5,752	74	149	5,975	11,284
1987	1,114	2,620	172	3,906	8,880	188	3	9,071	12,977
1988	899	4,473	81	5,453	9,035	1,282	1	10,318	15,771
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	13,818	1,741	15,964	8,945	181	7	9,133	25,097
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	17,185	308	18,653	8,058	0	159	8,217	26,870
2009	91	17,933	996	19,020	11,981	0	213	12,194	31,214
2010	1,134	18,216	892	20,242	13,122	3	247	13,372	33,614
2011	1,833	15,468	426	17,727	14,357	0	222	14,579	32,306
2012	4,580	16,633	1,224	22,437	19,616	35	210	19,861	42,298
2013	6,771	17,399	844	25,014	18,597	0	271	18,868	43,882
2014	3,342	18,194	1,052	22,588	25,533	72	237	25,842	48,430

[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 2015 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 2015 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 on fish associated with dolphins Lances sobre peces asociados a delfines**					
2000	0	9,235	9,235	146,533	540	15
2001	0	9,876	9,876	238,629	1,802	6
2002	0	12,290	12,290	301,099	3,180	2
2003	0	13,760	13,760	265,512	13,332	1
2004	0	11,783	11,783	177,460	10,730	3
2005	0	12,173	12,173	166,211	12,127	2
2006	0	8,923	8,923	91,978	4,787	0
2007	0	8,871	8,871	97,032	3,277	7
2008	0	9,246	9,246	122,105	8,382	5
2009	0	10,910	10,910	178,436	2,719	1
2010	0	11,645	11,645	168,984	1,627	4
2011	0	9,604	9,604	134,839	4,372	2
2012	0	9,220	9,220	133,716	2,120	0
2013	0	10,736	10,736	157,432	4,272	0
2014	0	11,382	11,382	168,209	4,436	3
2015	0	11,020	11,020	160,901	5,651	2
OBJ	**Sets on fish associated with floating objects Lances sobre peces asociados a objetos flotantes**					
2000	508	3,713	4,221	42,522	121,723	92,966
2001	827	5,674	6,501	67,200	122,363	59,748
2002	867	5,771	6,638	38,057	116,793	55,901
2003	706	5,457	6,163	30,307	181,214	51,296
2004	615	4,986	5,601	28,340	117,212	64,005
2005	639	4,992	5,631	26,126	133,509	66,257
2006	1,158	6,862	8,020	34,313	191,093	82,136
2007	1,384	5,857	7,241	29,619	122,286	62,189
2008	1,819	6,655	8,474	34,819	157,274	73,855
2009	1,821	7,077	8,898	36,136	157,067	75,888
2010	1,788	6,399	8,187	38,113	113,716	57,167
2011	2,538	6,921	9,459	42,189	170,986	55,589
2012	3,067	7,610	10,677	37,527	177,239	65,040
2013	3,081	8,038	11,119	35,089	194,372	48,337
2014	3,858	8,777	12,635	45,476	199,488	59,803
2015	3,403	9,385	12,788	43,152	205,976	61,277

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**					
2000	5,497	5,472	10,969	64,208	83,384	2,301
2001	4,022	3,024	7,046	78,107	19,000	764
2002	4,938	3,442	8,380	73,130	33,573	1,518
2003	7,274	5,131	12,405	87,460	79,422	1,755
2004	4,969	5,696	10,665	66,757	69,882	1,463
2005	6,109	7,816	13,925	75,764	117,593	1,636
2006	6,189	8,443	14,632	40,340	100,388	1,702
2007	4,845	7,211	12,056	43,365	82,732	1,254
2008	4,771	6,210	10,981	28,133	130,947	1,168
2009	3,308	4,109	7,417	22,200	70,737	910
2010	2,252	3,886	6,138	43,912	31,849	581
2011	2,840	5,182	8,022	29,823	100,677	921
2012	2,996	5,369	8,365	26,774	86,856	980
2013	3,064	4,156	7,220	25,666	79,916	1,150
2014	2,427	3,369	5,796	20,288	57,654	647
2015	3,075	6,201	9,276	41,130	117,653	1,950
ALL	**Sets on all types of schools Lances sobre todos tipos de cardumen**					
2000	6,005	18,420	24,425	253,263	205,647	95,282
2001	4,849	18,574	23,423	383,936	143,165	60,518
2002	5,805	21,503	27,308	412,286	153,546	57,421
2003	7,980	24,348	32,328	383,279	273,968	53,052
2004	5,584	22,465	28,049	272,557	197,824	65,471
2005	6,748	24,981	31,729	268,101	263,229	67,895
2006	7,347	24,228	31,575	166,631	296,268	83,838
2007	6,229	21,939	28,168	170,016	208,295	63,450
2008	6,590	22,111	28,701	185,057	296,603	75,028
2009	5,129	22,096	27,225	236,772	230,523	76,799
2010	4,040	21,930	25,970	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	6,285	23,528	29,813	233,973	261,578	60,453
2015	6,478	26,606	33,084	245,183	329,280	63,229

TABLE A-8. Types of floating objects involved in sets by vessels of >363 t carrying capacity. The 2015 data are preliminary.
TABLA A-8. Tipos de objetos flotantes sobre los que realizaron lances buques de >363 t de capacidad de acarreo. Los datos de 2015 son preliminares.

OBJ	Flotsam Naturales		FADs Plantados		Unknown Desconocido		Total
	No.	%	No.	%	No.	%	
2000	488	13.1	3,187	85.8	38	1.0	3,713
2001	592	10.4	5,058	89.1	24	0.4	5,674
2002	778	13.5	4,966	86.1	27	0.5	5,771
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

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
1986	-	-	160,572	111,672	30,778	17,432	-	-	4,874	2,569	-	-	68
1987	-	-	188,386	104,053	36,436	19,405	-	-	12,267	5,335	-	-	273
1988	-	-	182,709	82,383	43,056	10,172	-	-	9,567	4,590	-	-	234
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	20,519	11,924	5,822	986	14,237
2013	70,411	18,128	48,825	19,096	31,702	10,248	11,189	3,303	18,353	11,722	10,765	2,133	10,388
2014	78,851	24,282	40,410	17,074	22,695	9,132	10,572	3,291	16,830	10,435	11,276	2,194	6,325

[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 2015 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 2015 son preliminares.

	PS		LP		Total	
	No.	Vol. (m^3)	No.	Vol. (m^3)	No.	Vol. (m^3)
1986	165	130,530	17	2,066	182	132,596
1987	173	148,713	29	2,383	202	151,096
1988	185	154,845	39	3,352	224	158,197
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	243	247,978	1	125	244	248,103

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 2014, 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 2014, 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	36	33	22	8	12	111	88,957
EU(ESP)	PS	-	-	-	-	4	4	10,116
GTM	PS	-	-	-	1	-	1	1,475
MEX	PS	3	4	18	20	-	45	54,206
	LP	2	-	-	-	-	2	226
NIC	PS	-	-	3	3	-	6	8,478
PAN	PS	-	2	4	4	4	14	19,865
PER	PS	1	2	-	-	-	3	1,437
SLV	PS	-	-	-	1	3	4	7,892
USA	PS	8	-	1	-	-	9	2,203
VEN	PS	-	-	7	7	1	15	20,890
Grand total—Total general	PS	50	43	62	47	24	226	
	LP	2	-	-	-	-	2	
	PS + LP	52	43	62	47	24	228	
		Well volume—Volumen de bodega (m^3)						
Grand total—Total general	PS	12,757	25,997	69,465	70,687	51,473		230,379
	LP	226	-	-	-	-		226
	PS + LP	12,983	25,997	69,465	70,687	51,473		230,605

- : none—ninguno

TABLE A-11b. Estimates of the numbers and well volumes (cubic meters) of purse-seine (PS) and pole-and-line (LP) vessels that fished in the EPO in 2015 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) y cañeros (LP) que pescaron en el OPO en 2015, 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	35	33	23	8	13	112	91,651
EU(ESP)	PS	-	-	-	-	4	4	10,116
GTM	PS	-	-	-	1	-	1	1,475
MEX	PS	3	4	18	22	-	47	57,502
	LP	1	-	-	-	-	1	125
NIC	PS	-	-	3	3	-	6	8,478
PAN	PS	-	2	4	4	4	14	19,794
PER	PS	3	3	-	-	-	6	2,818
SLV	PS	-	-	-	-	2	2	4,473
USA	PS	11	-	1	7	4	23	17,219
VEN	PS	-	-	6	7	1	14	19,592
Grand total—Total general	PS	54	44	62	55	28	243	
	LP	1	-	-	-	-	1	
	PS + LP	55	44	62	55	28	244	
Well volume—Volumen de bodega (m^3)								
Grand total—Total general	PS	13,543	26,675	69,150	82,095	56,515		247,978
	LP	125	-	-	-	-		125
	PS + LP	13,668	26,675	69,150	82,095	56,515		248,103

- : 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 2005-2014 and in 2015, 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 2005-2014 y en 2015 por mes.

Month Mes	2005-2014			2015
	Min	Max	Ave.-Prom.	
1	86.9	157.7	115.3	92.4
2	150.7	175.3	158.3	181.1
3	135.4	159.9	147.2	168.6
4	142.8	165.0	153.7	173.6
5	139.8	164.4	153.1	163.1
6	154.9	175.0	160.4	173.1
7	154.1	170.4	162.8	169.9
8	62.2	123.6	105.2	117.6
9	105.5	137.7	117.3	121.9
10	150.7	172.2	164.3	186.7
11	102.9	150.8	128.6	134.3
12	45.9	105.8	63.9	57.8
Ave.-Prom.	119.3	154.8	135.8	145.0

B. YELLOWFIN TUNA

This report presents the most current stock assessment of yellowfin tuna (*Thunnus albacares*) in the eastern Pacific Ocean (EPO). An integrated statistical age-structured stock assessment model (Stock Synthesis Version 3.23b) was used in the assessment, which is based on the assumption that there is a single stock of yellowfin in the EPO.

Yellowfin are distributed across the Pacific Ocean, but the bulk of the catch is made in the eastern and western regions. Purse-seine catches of yellowfin are relatively low in the vicinity of the western boundary of the EPO at 150ºW (Figure A-1a and A-1b). The majority of the catch in the EPO is taken in purse-seine sets on yellowfin associated with dolphins and in unassociated schools (Figure B-1). Tagging studies of yellowfin throughout the Pacific indicate that the fish tend to stay within 1800 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. This is consistent with the fact that longline catch-per-unit-of-effort (CPUE) trends differ among areas in the EPO. However, movement rates between these putative stocks, as well as across the 150°W meridian, cannot be estimated with currently-available tagging data.

The assessment of yellowfin tuna in the eastern Pacific Ocean in 2015 is similar to the previous assessment, except that separate series of length-frequency data for Japanese longline commercial and training vessels are now available, and both were used in the assessment. There is uncertainty about recent and future levels of recruitment (Figure B-2) and biomass (Figure B-5). There have been two, and possibly three, different productivity regimes since 1975, and the levels of maximum sustainable yield (MSY) and the biomasses corresponding to the MSY may differ among the regimes. The population may have switched in the last ten years from a high to an intermediate productivity regime. The spawning biomass ratio (SBR) has been below average since 2006, with the exception of 2008-2010, which resulted from a high recruitment in 2006. The recent fishing mortality rates (*F*) are slightly below the MSY level (*F*mult = 1.02), and the recent levels of spawning biomass (*S*) are estimated to be below that level (S_{recent}/S_{MSY} = 0.95) (Table B-1 and Figure B-6). As noted in IATTC Stock Assessment Report 16 and previous assessments, these interpretations are uncertain, and highly sensitive to the assumptions made about the steepness parameter (h) of the stock-recruitment relationship, the average size of the older fish (L_2), and the assumed levels of natural mortality (*M*). The results are more pessimistic if a stock-recruitment relationship is assumed, if a higher value is assumed for L_2, and if lower rates of M are assumed for adult yellowfin. A likelihood profile on the virgin recruitment (R_0) parameter showed that data components diverge on their information about abundance levels. Sensitivity analyses indicated that the results are more pessimistic if the weighting assigned to length-frequency data is changed, using recommended data weighting methods, and more optimistic if the model is fitted closely to the index of relative abundance based on the catch per unit of effort (CPUE) of the northern dolphin-associated purse-seine fishery rather than of the southern longline fishery. The highest fishing mortality (*F*) has been on fish aged 11-20 quarters (2.75-5 years) (Figure B-3). The average annual *F* has been increasing for all age classes since 2009, but in 2015 it showed a slight decline for the 11-20 quarter age group. Historically, the dolphin-associated and unassociated purse-seine fisheries have the greatest impact on the spawning biomass of yellowfin, followed by the floating-object fisheries (Figure B-4). In more recent years, the impact of the floating-object fisheries has been greater than that of the unassociated fisheries. The impacts of the longline and purse-seine discard fisheries are much less, and have decreased in recent years. Increasing the average weight of the yellowfin caught could increase the MSY.

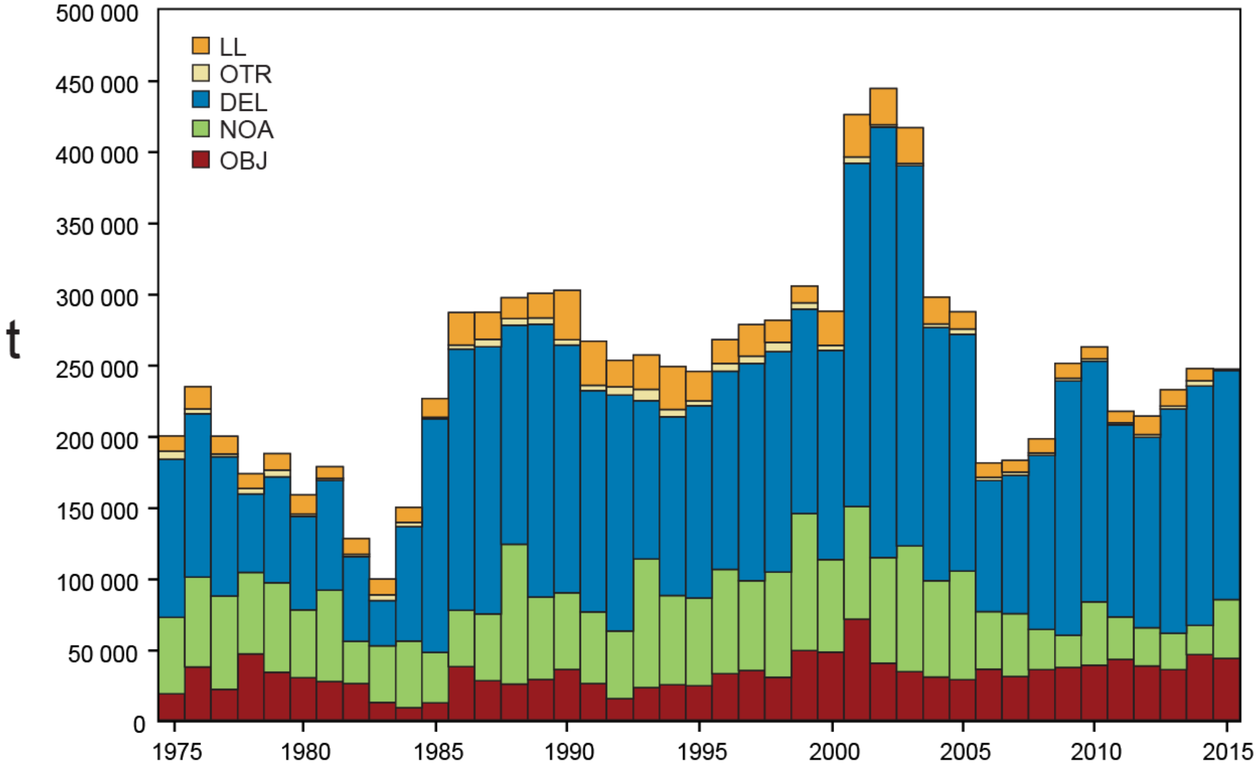

FIGURE B-1. Total catches (retained catches plus discards) for the purse-seine fisheries, and retained catches for the pole-and-line and longline fisheries, of yellowfin tuna in the eastern Pacific Ocean, 1975-2015. The purse-seine catches are adjusted to the species composition estimate obtained from sampling the catches. The 2015 catch data are preliminary.

FIGURA B-1. Capturas totales (capturas retenidas más descartes) en las pesquerías de cerco, y capturas retenidas de las pesquerías de caña y de palangre, de atún aleta amarilla en el Océano Pacífico oriental, 1975-2015. 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 2015 son preliminares.

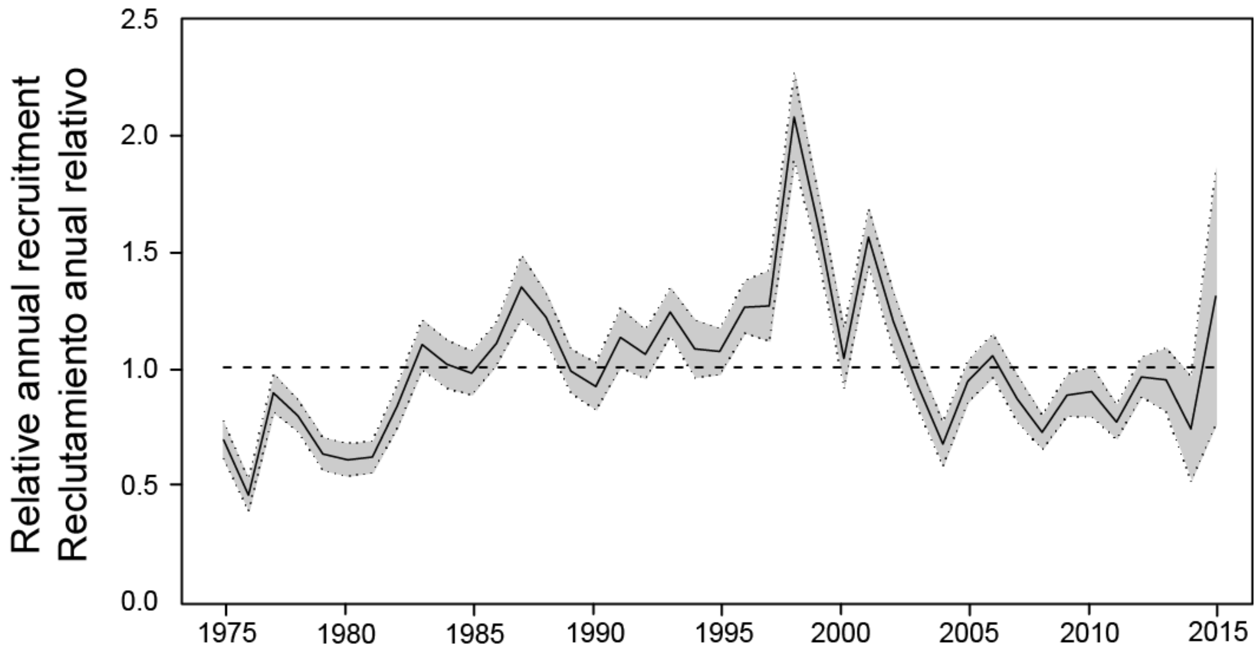

FIGURE B-2. Estimated annual recruitment at age zero of yellowfin tuna to the fisheries of the EPO. The estimates are scaled so that the average recruitment is equal to 1.0 (dashed horizontal line). The solid line illustrates the maximum likelihood estimates of recruitment, and the shaded area indicates the approximate 95% confidence intervals around those estimates.

FIGURA B-2. Reclutamiento anual estimado a edad cero de atún aleta amarilla a las pesquerías del OPO. Se ajusta la escala de las estimaciones para que el reclutamiento medio equivalga a 1.0 (línea de trazos horizontal). La línea sólida ilustra las estimaciones de verosimilitud máxima del reclutamiento, y la zona sombreada los límites de confianza de 95% aproximados de las estimaciones.

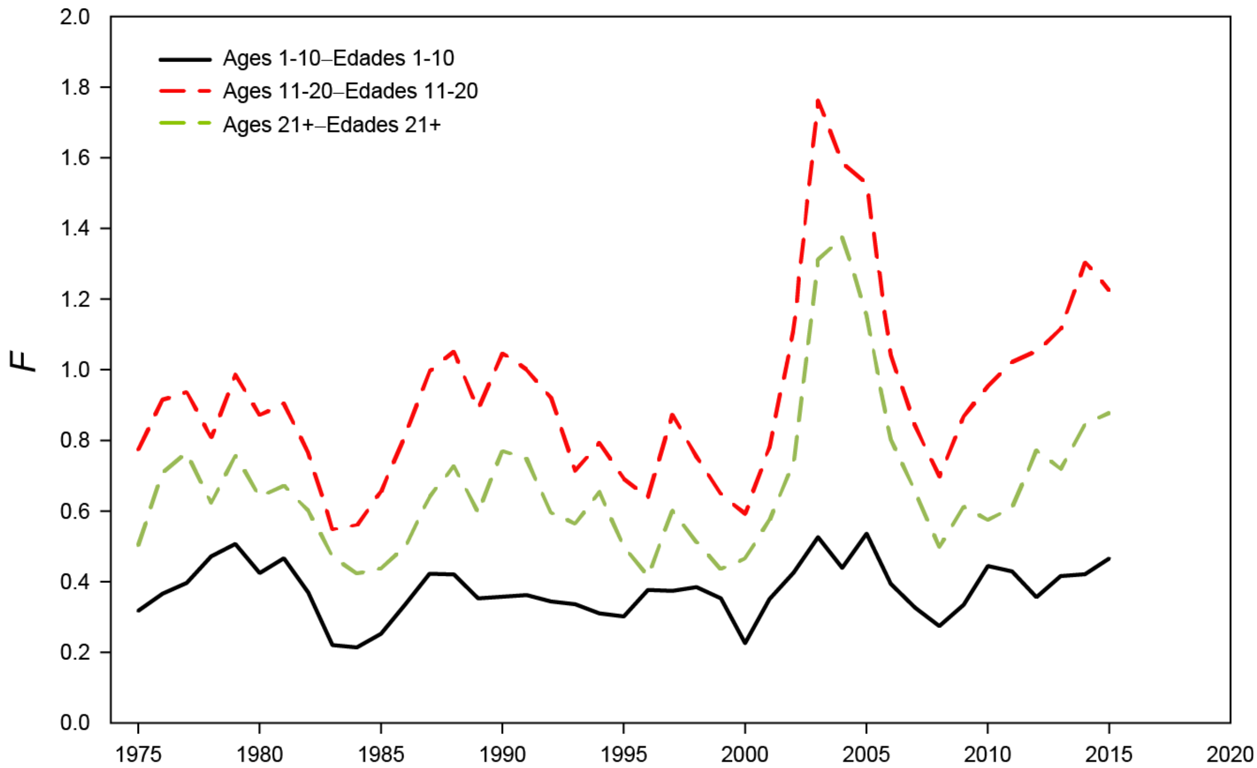

FIGURE B-3. Average annual fishing mortality (*F*) by age groups, by all gears, of yellowfin tuna recruited to the fisheries of the EPO. The age groups are defined by age in quarters.

FIGURA B-3. Mortalidad por pesca (*F*) anual media, por grupo de edad, por todas las artes, de atún aleta amarilla reclutado a las pesquerías del OPO. Se definen los grupos de edad por edad en trimestres.

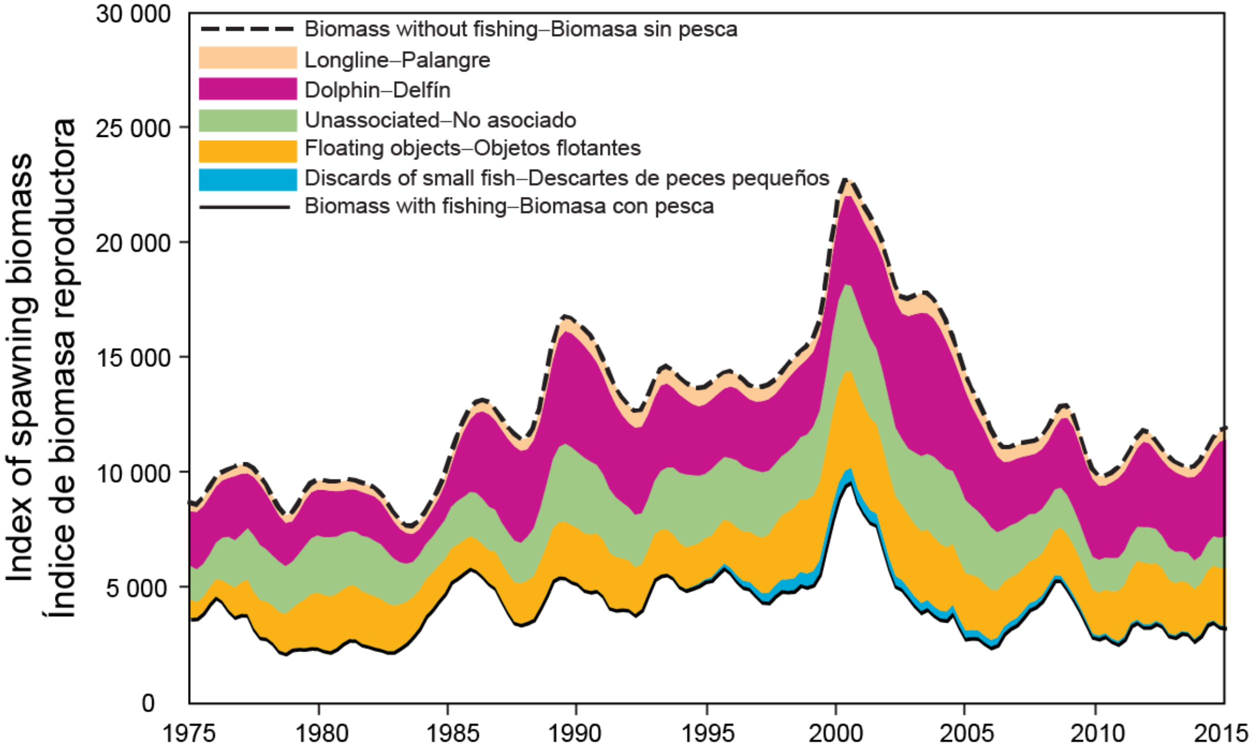

FIGURE B-4. Biomass trajectory of a simulated population of yellowfin tuna that was never exploited (dashed line) and that predicted by the stock assessment model (solid line). The shaded areas between the two lines show the portions of the fishery impact attributed to each fishing method.

FIGURA B-4. Trayectoria de la biomasa de una población simulada de atún aleta amarilla que nunca fue explotada (línea de trazos) y aquella predicha por el modelo de evaluación de la población (línea sólida). Las áreas sombreadas entre las dos líneas representan la porción del impacto de la pesca atribuida a cada método de pesca.

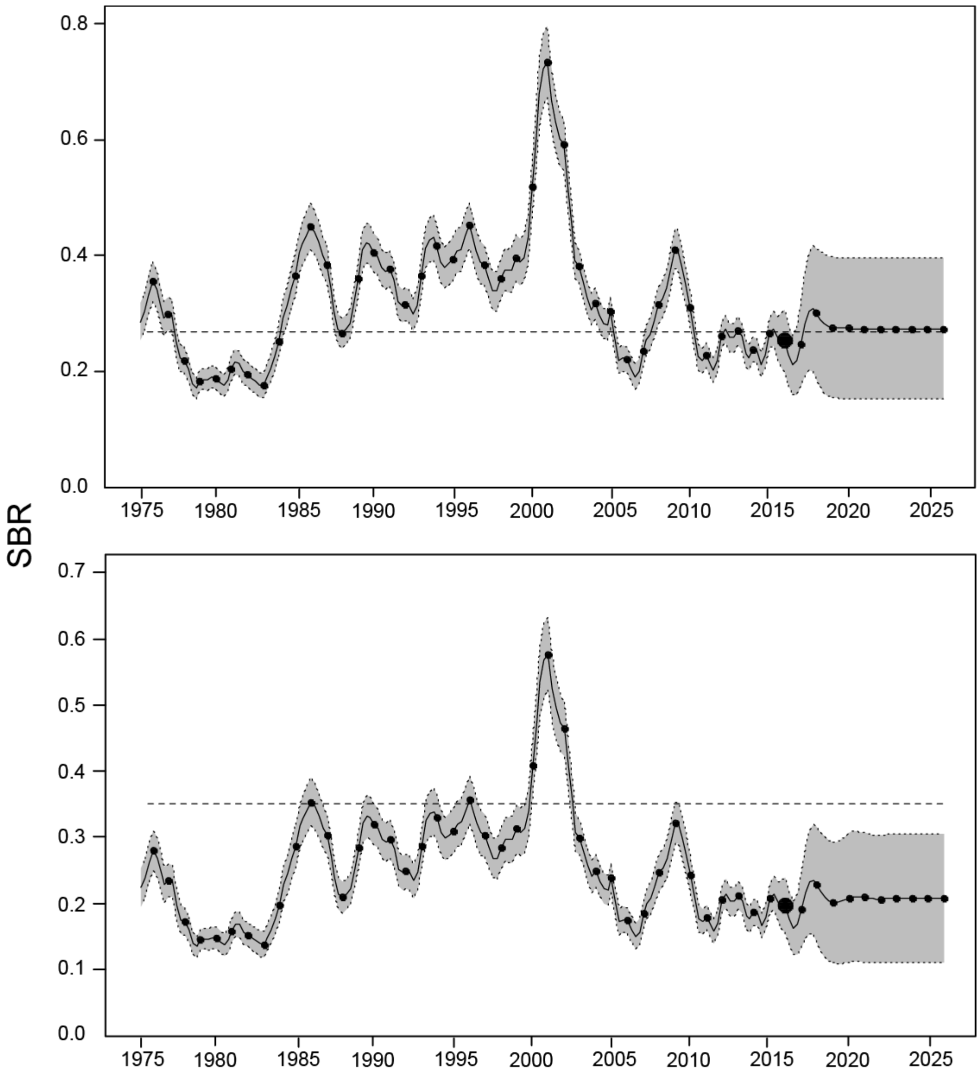

FIGURE B-5. Spawning biomass ratios (SBRs) for yellowfin tuna in the EPO, including projections for 2016-2026 based on average fishing mortality rates during 2013-2015, from the base case (top) and the sensitivity analysis that assumes a stock-recruitment relationship (h = 0.75, bottom). The dashed horizontal line (at 0.21 and 0.30, respectively) identifies the SBR at MSY. The solid curve illustrates the maximum likelihood estimates, and the estimates after 2016 (the large dot) indicate the SBR predicted to occur if fishing mortality rates continue at the average of that observed during 2013-2015, and average recruitment occur during the next 10 years. The shaded area indicates the approximate 95% confidence intervals around those estimates.

FIGURA B-5. Cocientes de biomasa reproductora (SBR) de atún aleta amarilla en el OPO, con proyecciones para 2016-2026 basadas en las tasas de mortalidad por pesca medias durante 2013-2015, del caso base (recuadro superior) y el análisis de sensibilidad que supone una relación población-reclutamiento (h = 0.75, recuadro inferior). La línea de trazos horizontal (en 0.27 y 0.35, respectivamente) identifica el SBR correspondiente al RMS. La curva sólida ilustra las estimaciones de verosimilitud máxima, y las estimaciones a partir de 2016 (punto grande) indican el SBR que se predice ocurrirá con tasas de mortalidad por pesca en el promedio de aquellas observadas durante 2013-2015, y con reclutamiento medio durante los 10 años próximos. El área sombreada indica los intervalos de confianza de 95% aproximados alrededor de esas estimaciones.

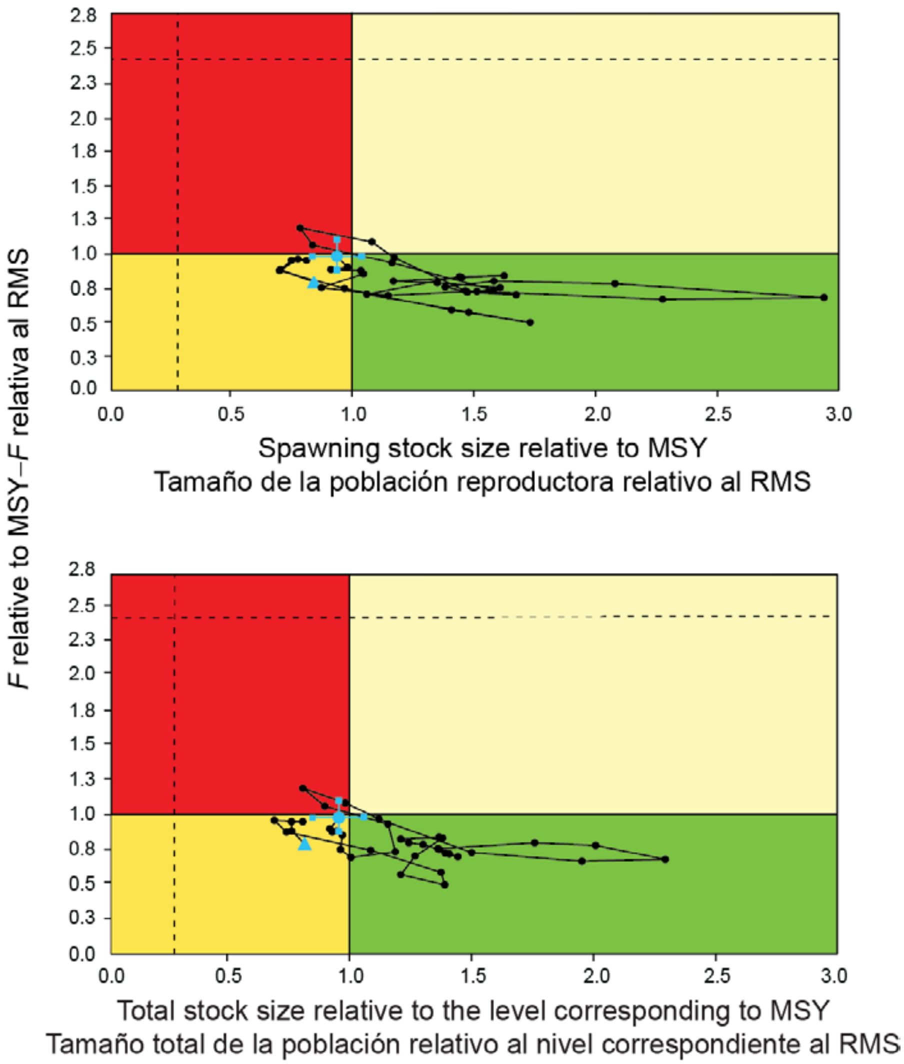

FIGURE B-6. Kobe (phase) plot of the time series of estimates of stock size (top panel: spawning biomass; bottom panel: total biomass of fish aged 3+ quarters) and fishing mortality relative to their MSY reference points. The panels represent interim target reference points (S_{MSY} and F_{MSY}). The dashed lines represent the interim limit reference points of 0.28 *S_{MSY} and 2.42*F_{MSY}, which correspond to a 50% reduction in recruitment from its average unexploited level based on a conservative steepness value (h = 0.75) for the Beverton-Holt stock-recruitment relationship. Each dot is based on the average exploitation rate over three years; the large blue dot indicates the most recent estimate. The squares around the most recent estimate represent its approximate 95% confidence interval. The triangle represents the first estimate (1975).

FIGURA B-6. Gráfica de Kobe (fase) de la serie de tiempo de las estimaciones del tamaño de la población (panel superior: biomasa reproductora; panel inferior: biomasa total de peces de 3+ trimestres de edad) y la mortalidad por pesca en relación con sus puntos de referencia de RMS. Las líneas de trazos representan los puntos de referencia límite provisionales de 0.28*S_{RMS} y 2.42*F_{RMS}, que corresponden a una reducción de 50% del reclutamiento de su nivel medio no explotado basada en un valor cauteloso de la inclinación de la relación población-reclutamiento de Beverton-Holt (h = 0.75). Cada punto se basa en la tasa de explotación media por trienio; el punto azul grande indica la estimación más reciente. Los cuadrados alrededor de la estimación más reciente representan su intervalo de confianza de 95% aproximado. El triángulo representa la primera estimación (1975).

TABLE B-1. MSY and related quantities for the base case and the stock-recruitment relationship sensitivity analysis, based on average fishing mortality (F) for 2013-2015. B_{recent} and B_{MSY} are defined as the biomass, in metric tons, of fish 3+ quarters old at the start of the first quarter of 2016 and at MSY, respectively, and S_{recent} and S_{MSY} are defined as indices of spawning biomass (therefore, they are not in metric tons). C_{recent} is the estimated total catch for 2015.
TABLA B-1. RMS y cantidades relacionadas para el caso base y el análisis de sensibilidad a la relación población-reclutamiento, basados en la mortalidad por pesca (F) media de 2012-2014. Se definen B_{recent} y B_{RMS} como la biomasa, en toneladas, de peces de 3+ trimestres de edad al principio del primer trimestre de 2015 y en RMS, respectivamente, y S_{recent} y S_{RMS} como índices de biomasa reproductora (por lo tanto, no se expresan en toneladas). C_{recent} es la captura total estimada de 2015.

YFT	**Base case Caso base**	$\boldsymbol{h}$ **= 0.75**
MSY-RMS	272,841	287,476
B_{MSY}- B_{RMS}	372,010	547,238
S_{MSY}- S_{RMS}	3,528	5,897
B_{MSY}/B_0- B_{RMS}/B_0	0.32	0.37
S_{MSY}/S_0- S_{RMS}/S_0	0.27	0.35
C_{recent}/MSY- C_{recent}/RMS	0.94	0.89
$B_{\text{recent}}/B_{\text{MSY}}$- $B_{\text{recent}}/B_{\text{RMS}}$	0.96	0.64
$S_{\text{recent}}/S_{\text{MSY}}$-$S_{\text{recent}}/S_{\text{RMS}}$	0.95	0.56
F multiplier-Multiplicador de F	1.02	0.65

C. SKIPJACK TUNA

Skipjack are distributed across the Pacific Ocean, and it is likely that there is a continuous stock throughout the Pacific Ocean, with exchange of individuals at a local level, although large-scale movements are thought to be rare. The bulk of the catches of skipjack are made in the eastern and western regions; the purse-seine catches are relatively low in the vicinity of the western boundary of the EPO at 150°W. The movements of tagged skipjack generally cover hundreds, rather than thousands, of kilometers, and exchange of fish between the eastern and western Pacific Ocean appears to be limited. Movement rates between the EPO and the western Pacific cannot be estimated with currently-available tagging data. In some analyses the EPO was divided into six independent sub-regions to accommodate spatial structure of the population and fishery dynamics.

Stock assessment requires substantial amounts of information and the information varies depending on the method used. The methods applied to skipjack require a variety of information, including data on retained catches, discards, indices of abundance, the size compositions of the catches of the various fisheries, tagging data, and oceanographic data. In addition, assumptions have to be made about processes such as growth, recruitment, movement, natural mortality, selectivity, and stock structure.

Biomass, recruitment, and fishing mortality are estimated to be highly variable over time. The estimates are uncertain and differ among the alternative assessment methods. A large recruitment appears to have entered the population in 1999, and led to increased biomass in that year, but the increase was temporary, due to the short-lived nature of skipjack. Biomass appears to have been above average in recent years, but this may differ among regions. SEAPODYM estimates annual biomass of skipjack 30cm or larger cycling between 1,800,000 t and 2,350,000 t from 1998 to 2008, but the quality of these estimates has yet to be determined. The average weight of skipjack started declining in 2000, but has stabilized in recent years (Figure C-1). Previous assessments using a catch-at-length analysis (A-SCALA) to assess skipjack tuna in the EPO were considered preliminary because: 1) it was unknown if catch-per-day-fished for purse-seine fisheries is proportional to abundance; 2) it is possible that there is a population of large skipjack that is invulnerable to the fisheries; and 3) the structure of the EPO stock in relation to the western and central Pacific stocks is uncertain. These issues are also relevant to the other assessments.

Previous assessments estimated that maximum yields are achieved with infinite fishing mortality because the critical weight is less than the average weight at recruitment to the fishery. However, this is uncertain because of uncertainties in the estimates of natural mortality and growth. For this reason, no traditional reference points are available for skipjack tuna in the EPO. Consequently, indicators and reference levels have been used to evaluate the status of the stock. The main concern with the skipjack stock is the constantly increasing exploitation rate. However, exploitation rate appears to have leveled off in recent years. The data- and model-based indicators have yet to detect any adverse consequence of this increase. The average weight has declined to levels seen in the early 1980s and was below its lower reference level in 2015 (Figure C-1), which can be a consequence of overexploitation, but it can also be caused by recent recruitments being greater than past recruitments or expansion of the fishery into areas occupied by smaller skipjack. The low 2015 level is likely due to the large recruitment in 2015. However, average weight has stabilized in recent years. The tagging analyses, length-structured model, A-SCALA, and the SEAPODYM analyses do not provide any information that indicates a credible risk to the skipjack stock(s).

Susceptibility and productivity analysis (PSA; see IATTC Fishery Status Report 12, p 149) shows that skipjack has substantially higher productivity than bigeye tuna. Biomass and fishing mortality corresponding to MSY are, respectively, negatively and positively related to productivity. Therefore, since skipjack and bigeye have about the same susceptibility, which is related to fishing mortality, the status of skipjack can be inferred from the status of bigeye. The current assessment of bigeye tuna estimates that the fishing mortality is less than FMSY; therefore, the fishing mortality for skipjack should also be less than FMSY. Since effort and skipjack biomass have been relatively constant over the past 10 years, this also implies that skipjack biomass is above BMSY.

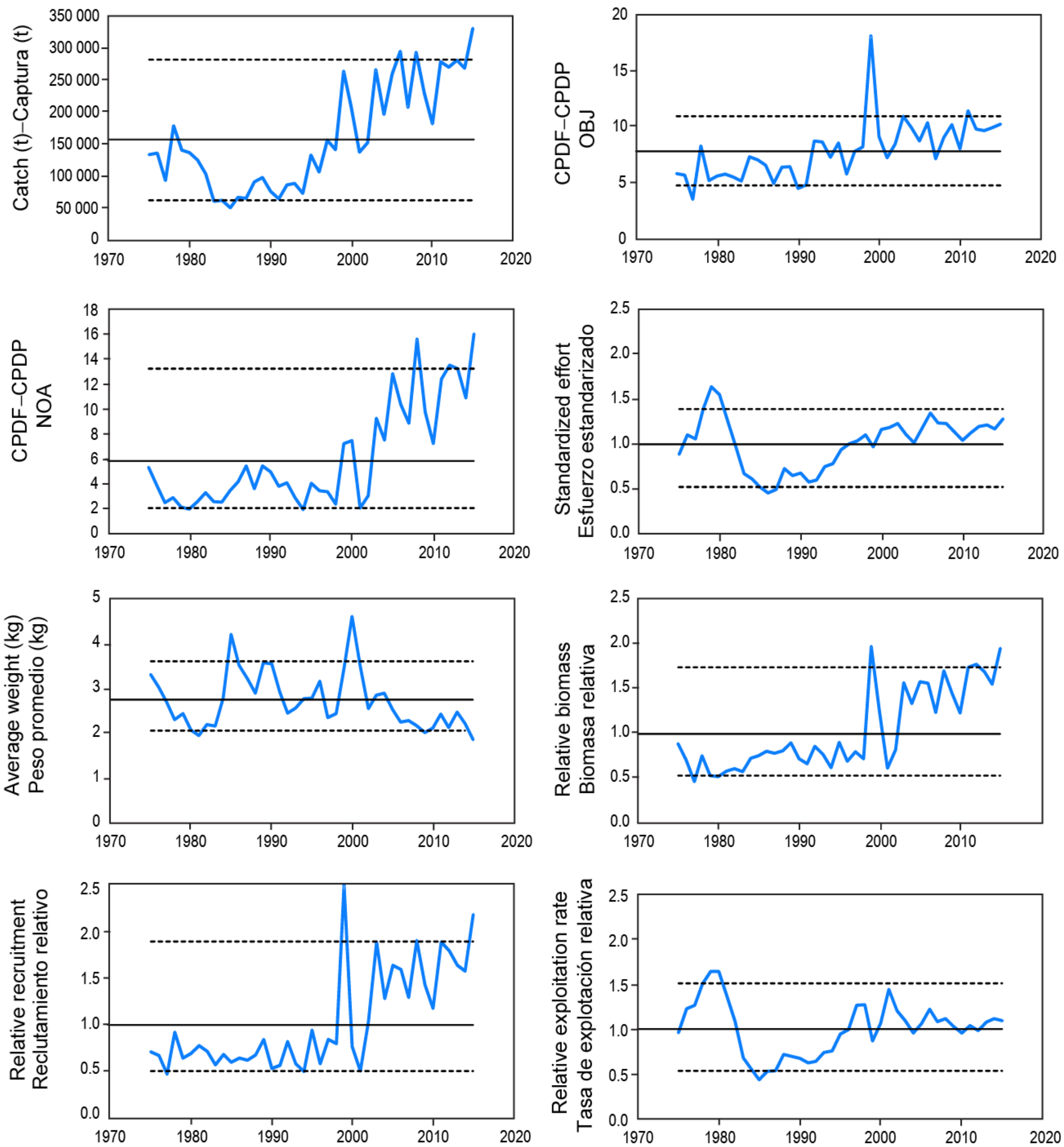

FIGURE C-1. Indicators of stock status for skipjack tuna in the eastern Pacific Ocean. OBJ: floating-object fishery; NOA: unassociated fishery; CPDF: catch per day fished. All indicators are scaled so that their average equals one.

FIGURA C-1. Indicadores del estatus 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 escalan todos los indicadores para que su promedio equivalga a uno.

D. BIGEYE TUNA

This report presents the most current stock assessment of bigeye tuna (Thunnus obesus) in the eastern Pacific Ocean (EPO). An integrated statistical age-structured stock assessment model (Stock Synthesis 3.23b) was used in the assessment.

There have been substantial changes in the bigeye tuna fishery in the EPO over recent decades (Figure D-1). Initially, the majority of the bigeye catch was taken by longline vessels. With the expansion of the fishery on fish-aggregating devices (FADs) since 1993, the purse-seine fishery has taken an increasing component of the bigeye catch. In recent years, purse-seine catches of bigeye were taken primarily between 5°N and 5°S across the equatorial Pacific as far west as the western boundary (150°W) of the EPO (Figure D-3). The longline catches of bigeye in the EPO are predominantly taken below 5°S, but a substantial portion is also taken north of 10°N (Figure D-4). The assessment is conducted as if there were a single stock of bigeye in the EPO, with minimal net movement of fish between the EPO and the western and central Pacific Ocean (WCPO). Its results are consistent with the results of other analyses of bigeye tuna on a Pacific-wide basis. However, the distribution of the bigeye catches extends across the equatorial Pacific Ocean. In addition, a large amount of conventional and electronic tagging data has recently accumulated from the Pacific Tuna Tagging Programme, which has focused its bigeye tagging efforts between 180° and 140°W since 2008. The tag recoveries clearly show that there is extensive longitudinal movement of bigeye across the IATTC's management boundary at 150°W, in particular from west to east. The IATTC staff is collaborating with Secretariat of the Pacific Community (SPC) on an updated Pacific-wide bigeye stock assessment. This research will incorporate the new tagging data in a spatially-structured population dynamics model, which will help to evaluate potential biases resulting from the current approach of conducting separate assessments for the EPO and WCPO.

The assessment of bigeye tuna in the eastern Pacific Ocean in 2015 is similar to the previous assessment, except that separate series of length-frequency data for Japanese longline commercial and training vessels are now available, and both were used in the assessment. The results of this assessment indicate a recovering trend for bigeye in the EPO during 2005-2009, subsequent to IATTC tuna conservation resolutions initiated in 2004 (Figure D-5). However, although the resolutions have continued since 2009, the rebuilding trend was not sustained during 2010-2012, and the spawning biomass ratio (SBR) gradually declined to a historically low level of 0.16 at the start of 2013. This decline may be related to a series of recent below-average recruitments which coincided with a series of strong La Niña events (Figure D-2). More recently, the SBR is estimated to have increased slightly, from 0.16 in 2013 to 0.20 at the start of 2016; in the model, this increase is driven mainly by the recent increase in the catch per unit of effort (CPUE) of the longline fisheries that catch adult bigeye. There is uncertainty about recent and future levels of recruitment and biomass.

There have been important changes in the amount of fishing mortality caused by the fisheries that catch bigeye tuna in the EPO. On average, since 1993 the fishing mortality of bigeye less than about 15 quarters old has increased substantially, and that of fish more than about 15 quarters old has also increased, but to a lesser extent) (Figure D-3). The increase in the fishing mortality of the younger fish was caused by the expansion of the purse-seine fisheries that catch tuna in association with floating objects. It is clear that the longline fishery had the greatest impact on the stock prior to 1995, but with the decrease in longline effort and the expansion of the floating-object fishery, at present the impact of the purse-seine fishery on the bigeye stock is far greater than that of the longline fishery (Figure D-4). The discarding of small bigeye has a small, but detectable, impact on the depletion of the stock.

At current levels of fishing mortality (*F*), and if recent levels of effort and catchability continue and recruitment remains average, the spawning biomass (*S*) is predicted to continue rebuilding and stabilize at about 0.22 (Figure D-5), above the level corresponding to the maximum sustainable yield (MSY) (0.21). The recent fishing mortality rates are estimated to be below the level corresponding to MSY, whereas recent spawning biomasses are estimated to be slightly below that level (Table D-1 and Figure D-6).

These interpretations are uncertain and highly sensitive to the assumptions made about the steepness parameter (*h*) of the stock-recruitment relationship, the weighting assigned to the size-composition data (in particular to the longline size-composition data), the growth curve, and the assumed rates of natural mortality (*M*) for bigeye.

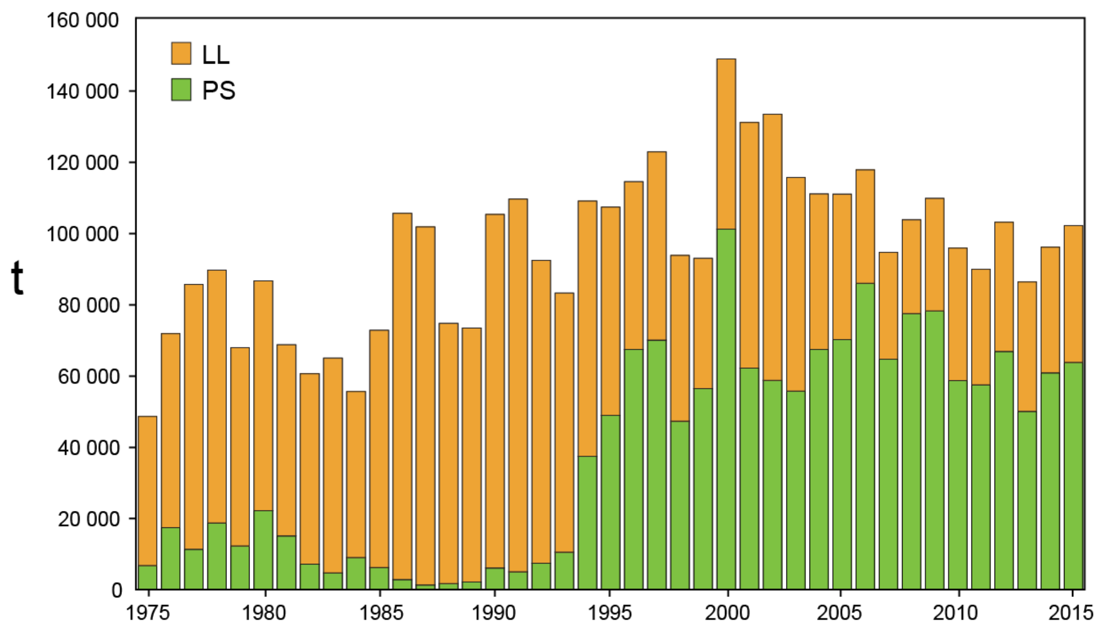

FIGURE D-1. Total catches (retained catches plus discards) of bigeye tuna by the purse-seine fisheries, and retained catches for the longline fisheries, in the eastern Pacific Ocean, 1975-2015. The purse-seine catches are adjusted to the species composition estimate obtained from sampling the catches. The 2015 catch data are preliminary.

FIGURA D-1. Capturas totales (capturas retenidas más descartes) de atún patudo por las pesquerías de cerco y capturas retenidas de las pesquerías palangreras en el Océano Pacífico oriental, 1975-2015. Las capturas cerqueras se basan en datos de descargas, ajustados a la estimación de la composición por especie.

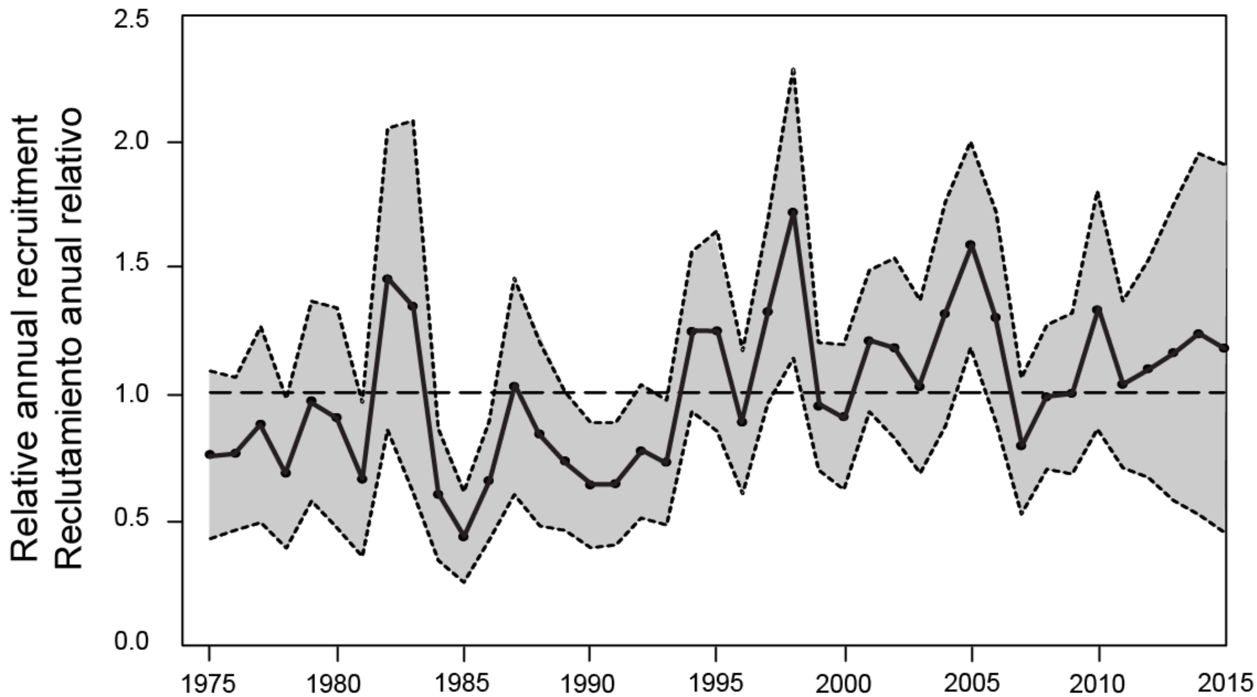

FIGURE D-2. Estimated annual recruitment of bigeye tuna to the fisheries of the EPO. The estimates are scaled so that the estimate of virgin recruitment is equal to 1.0 (dashed horizontal line). The solid line shows the maximum likelihood estimates of recruitment, and the shaded area indicates the approximate 95% intervals around those estimates.

FIGURA D-2. Reclutamiento estimado de atún patudo a las pesquerías del OPO. Se escalan las estimaciones para que la estimación de reclutamiento virgen equivalga a 1,0 (línea de trazos horizontal). La línea sólida indica las estimaciones de reclutamiento de verosimilitud máxima, y el área sombreada indica los intervalos de confianza de 95% aproximados de esas estimaciones.

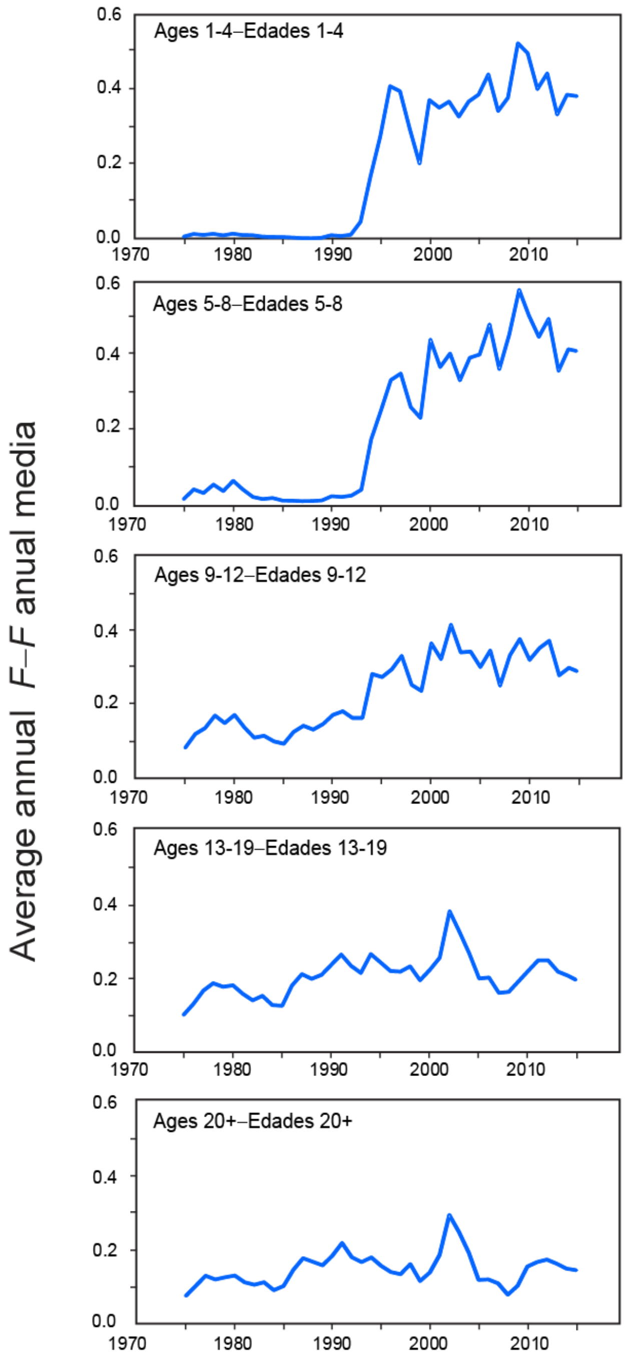

FIGURE D-3. Average annual fishing mortality, by all gears, of bigeye tuna recruited to the fisheries of the EPO. Each panel illustrates the average fishing mortality rates that affected the fish within the range of ages indicated in the title of each panel. For example, the trend illustrated in the top panel is an average of the fishing mortalities that affected the fish that were 1-4 quarters old.

FIGURA D-3. Mortalidad por pesca anual media, por todas las artes, de atún patudo reclutado a las pesquerías del OPO. Cada recuadro ilustra las tasas medias de mortalidad por pesca que afectaron a los peces de la edad indicada en el título de cada recuadro. Por ejemplo, la tendencia ilustrada en el recuadro superior es un promedio de las mortalidades por pesca que afectaron a los peces de entre 1 y 4 trimestres de edad.

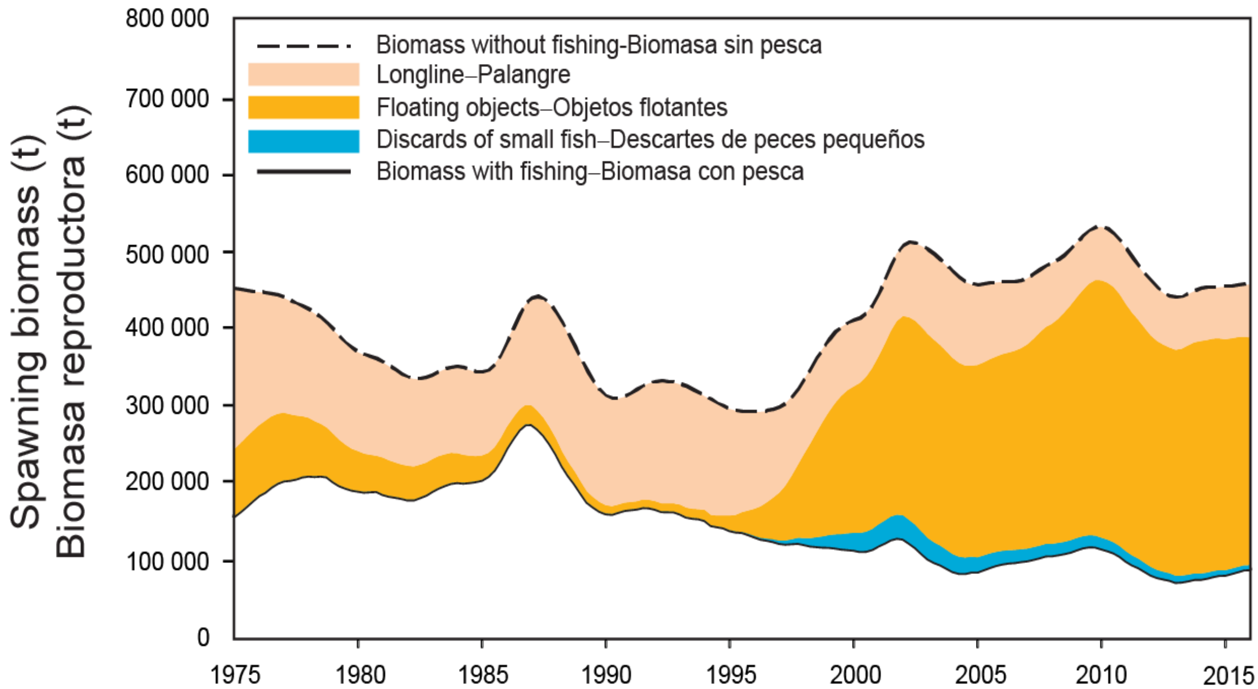

FIGURE D-4. Trajectory of the spawning biomass of a simulated population of bigeye tuna that was not exploited (top line) and that predicted by the stock assessment model (bottom line). The shaded areas between the two lines show the portions of the impact attributed to each fishing method. t = metric tons.

FIGURA D-4. Trayectoria de la biomasa reproductora de una población simulada de atún patudo no explotada (línea superior) y la que predice el modelo de evaluación (línea inferior). Las áreas sombreadas entre las dos líneas señalan la porción del efecto atribuida a cada método de pesca. t = toneladas métricas.

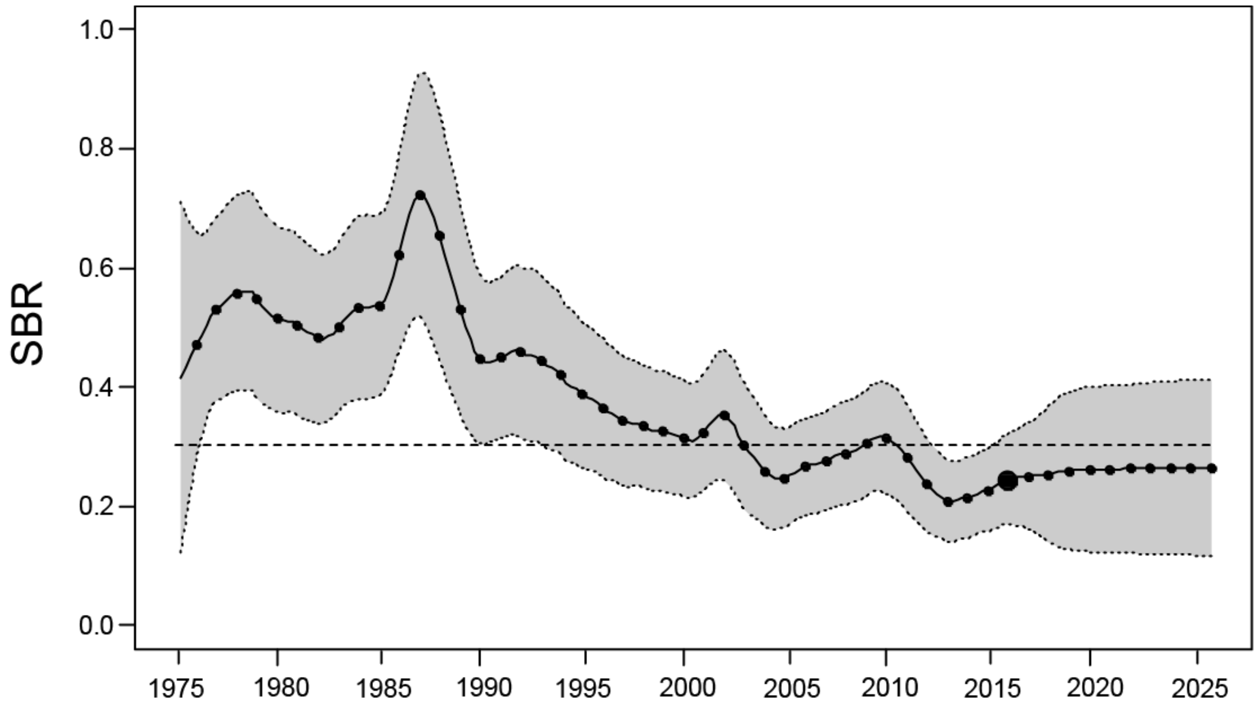

FIGURE D-5. Estimated spawning biomass ratios (SBRs) of bigeye tuna in the EPO, including projections for 2016-2026 based on average fishing mortality rates during 2013-2015. The dashed horizontal line (at 0.21) identifies the SBR at MSY. The solid line illustrates the maximum likelihood estimates, and the estimates after 2016 (the large dot) indicate the SBR predicted to occur if fishing mortality rates continue at the average of that observed during 2013-2015. The dashed lines are the 95-percent confidence intervals around these estimates.

FIGURA D-5. Cocientes de biomasa reproductora (SBR) del atún patudo en el OPO, incluyendo proyecciones para 2016-2026 basadas en las tasas medias de mortalidad por pesca durante 2013-2015. La línea de trazos horizontal identifica el SBR en RMS. La línea sólida ilustra las estimaciones de verosimilitud máxima, y las estimaciones a partir de 2016 (el punto grande) señalan el SBR predicho si las tasas de mortalidad por pesca continúan en el promedio observado durante 2013-2015. Las líneas de trazos representan los intervalos de confianza de 95% alrededor de esas estimaciones.

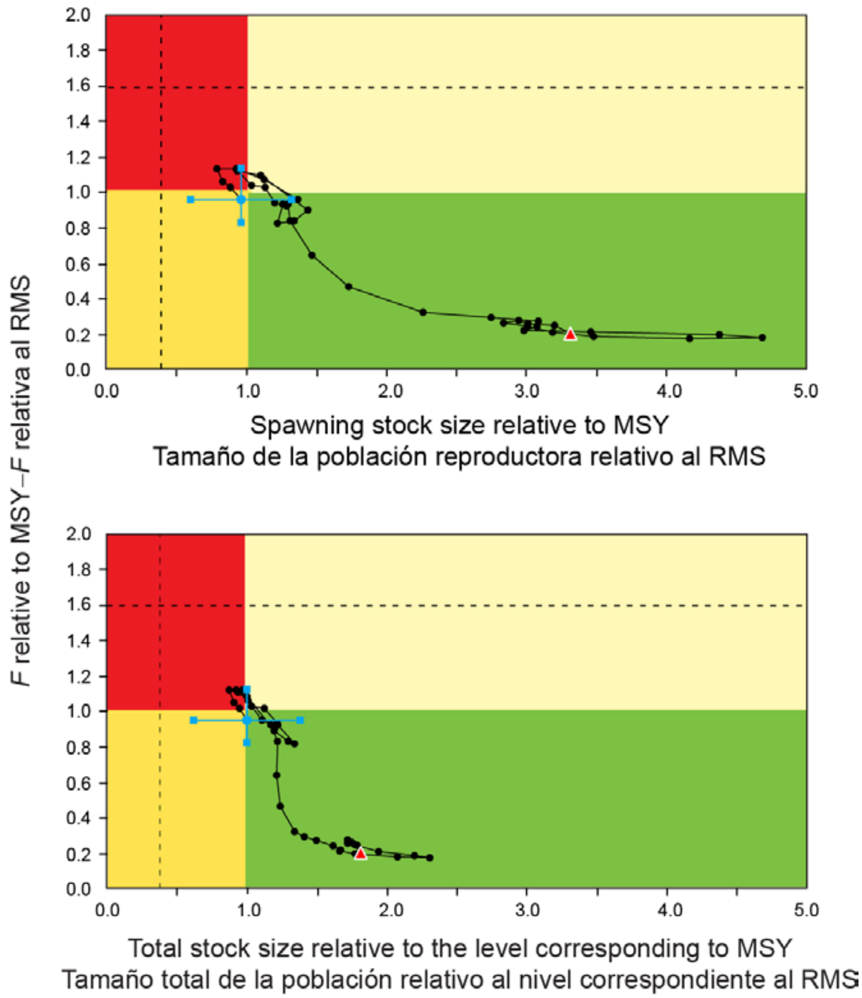

FIGURE D.6. Kobe (phase) plot of the time series of estimates of spawning stock size (top panel: spawning biomass; bottom panel: total biomass aged 3+ quarters) and fishing mortality relative to their MSY reference points. The colored panels represent interim target reference points (S_{MSY} and $F_{MSY;}$ solid lines) and limit reference points (dashed lines) of 0.38 S_{MSY} and 1.6 F_{MSY}, which correspond to a 50% reduction in recruitment from its average unexploited level based on a conservative steepness value (h = 0.75) for the Beverton-Holt stock-recruitment relationship. Each dot is based on the average fishing mortality rate over three years; the large dot indicates the most recent estimate. The squares around the most recent estimate represent its approximate 95% confidence interval. The triangle represents the first estimate (1975).

FIGURA D.6. Gráfica de Kobe (fase) de la serie de tiempo de las estimaciones del tamaño de la población reproductora (panel superior: biomasa reproductora; panel inferior: biomasa total de edad 3+ trimestres) y la mortalidad por pesca relativas a sus puntos de referencia de RMS. Los recuadros colorados representan los puntos de referencia objetivo provisionales (S_{RMS} y $1F_{\mathrm{RMS};}$ líneas sólidas) y los puntos de referencia límite (líneas de trazos) de 0,38 S_{RMS} y 1,6 F_{RMS}, que corresponden a una reducción de 50% del reclutamiento de su nivel medio no explotado basada en un valor cauteloso (h = 0.75) de la inclinación de la relación población-reclutamiento de Beverton-Holt. Cada punto se basa en la tasa de explotación media de un trienio; el punto grande indica la estimación más reciente. Los cuadros alrededor de la estimación más reciente representan su intervalo de confianza de 95% aproximado. El triángulo representa la primera estimación (1975).

TABLE D.1. Estimates of the MSY and its associated quantities for bigeye tuna for the base case assessment and the sensitivity analyses. All analyses are based on average fishing mortality during 2013-2015. B_{recent} and B_{MSY} are defined as the biomass of fish 3+ quarters old (in metric tons) at the beginning of 2016 and at MSY, respectively. S_{recent} and S_{MSY} are in metric tons. C_{recent} is the estimated total catch in 2015. The F multiplier indicates how many times effort would have to be effectively increased to achieve the MSY in relation to the average fishing mortality during 2013-2015.
TABLA D.1. Estimaciones del RMS y sus cantidades asociadas para el atún patudo para la evaluación del caso base y los análisis de sensibilidad. Todos los análisis se basan en la mortalidad por pesca promedio de 2013-2015. Se definen B_{recent} y B_{RMS} como la biomasa de peces de 3+ trimestres de edad (en toneladas) al principio de 2016 y en RMS, respectivamente. Se expresan S_{recent} y S_{MSY} en toneladas métricas. C_{recent} es la captura total estimada en 2015. El multiplicador de F indica cuántas veces se tendría que incrementar el esfuerzo para lograr el RMS en relación con la mortalidad por pesca media durante 2013-2015.

	Base case-Caso base	***h* = 0.75**
MSY-RMS	107,864	107,595
B_{MSY}- B_{RMS}	389,211	726,606
S_{MSY}- S_{RMS}	95,101	200,215
B_{MSY}/B_0- B_{RMS}/B_0	0.26	0.34
S_{MSY}/S_0- S_{RMS}/S_0	0.21	0.30
C_{recent}/MSY- C_{recent}/RMS	0.97	0.97
B_{recent}/B_{MSY}- B_{recent}/B_{RMS}	1.00	0.83
S_{recent}/S_{MSY}-S_{recent}/S_{RMS}	0.96	0.81
F multiplier-Multiplicador de F	1.05	0.91

E. PACIFIC BLUEFIN TUNA

Tagging studies have shown that there is exchange of Pacific bluefin between the eastern and western Pacific Ocean. Larval, postlarval, 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 recruitement, 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.

A full 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 2016. The assessment was conducted with Stock Synthesis 3, an integrated statistical age-structured stock assessment model. The assessment was a substantial improvement over the previous assessments. Long-term fluctuations in spawning stock biomass (SSB) occurred throughout the assessment period (1952-2014), and the SSB has been declining for more than a decade with a leveling off in recent years; however, there is no evidence of reduced recruitment. Age-specific fishing mortality has increasedup to

96% (age 2) in the recent period (2011-2013) relative to the baseline period (2002-2004) used in recent WCPFC and IATTC conservation measures.

Estimated age-specific fishing mortalities for the stock in the recent period (2011-2013) relative to 2002-2004 (the base period for the current WCPFC conservation measures) show increases of 96, 4, 86, and 43% for ages 2, 3, 4 and 5, respectively, and decreases of 28 and 1% for ages 0 and 1. Although no target or limit reference points have been established for the Pacific bluefin stock, the current *F* (2011-2013 average) is above all target and limit biological reference points commonly used for management. The current (2014) Pacific bluefin SSB level is near historic low levels, and the ratio of SSB in 2014 relative to unfished SSB is low.

Stock projections of spawning biomass and catches of Pacific bluefin tuna from 2015 to 2034 were conducted assuming alternative harvest scenarios. Recent WCPFC and IATTC conservation and management measures, combined with additional Japanese domestic regulations aimed at reducing mortality, if properly implemented and enforced, are expected to contribute to improvements in the stock status of Pacific bluefin tuna.

The IATTC staff conducted an alternative analysis to investigate the robsustness of the assssment (document SAC-07-05d). This analysis confirmed the results of the ISC update assessment.

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 finding that the north Pacific bluefin stock is at very low levels and the fishing mortality is higher than any reasonable reference point is robust to model assumptions, and support previous findings. The stock is projected to rebuild under current management actions (ISC 2016, Executive summary). However, due to uncertainty in how recruitment is related to the spawning stock size and when recruitment might be impacted by the low spawning abundance level, there is concern over the low abundance of spawners. This is exacerbated by the limited number of cohorts that comprise the spawning biomass.

The IATTC has adopted resolutions to restrict the catch of bluefin tuna in the EPO. Resolutions C-12-09, C-13-02, and C-14-06 limit the commercial catches in the IATTC Convention Area by all CPCs to a total 10,000 metric tons during 2012-2013 fishing years , 5,000 metric tons in 2014, and a combined total of 6,600 metric tons during 2015-2016, respectively.

Reference points

Developing management reference points for bluefin is problematic, due to sensitivity to the stock assessment model’s assumptions. In particular, absolute levels of biomass and fishing mortality, and reference points based on maximum sustainable yield (MSY), are hypersensitive to the value of natural mortality. Relative trends in biomass and fishing mortality levels are more robust to model assumptions. Therefore, management reference points based on relative biomass or fishing mortality should be considered for managing bluefin . It is unlikely that these management measures can be designed to optimize yield, and management should be designed to provide reasonable yields while ensuring sustainability until the uncertainty in the assessment is reduced.

A management “indicator” was developed that is based on integrating multiple years of fishing mortality and takes into consideration the age structure of the fishing mortality. The indicator is based on estimating the impact of fisheries on the stock of fish. The fishery impact over time is used as an indicator for developing reference points based on historic performance. The assumption is that if the fishery impact is less than that seen in the past, then the population is likely to be sustainable at current levels of fishing mortality.

The fishery impact indicator is estimated for bluefin based on spawning biomass. The fisheries are grouped into those in the eastern Pacific Ocean (EPO) and those of the WPO because setting management guidelines for the EPO is the goal of this analysis. The base case assessment developed by the ISC in 2008 is used as the stock assessment model. The sensitivity of the fishery impact and its use as a management indicator to the different natural mortality assumptions are evaluated.

The index of impact proposed for management is calculated as the estimate of actual spawning biomass divided by the hypothetical spawning biomass in the absence of a fishery. This assumes that the impact is measured under the assumption that the impact of other fisheries is not controlled.

The estimated impact of the fisheries on the bluefin population for the entire time period modeled (1952-2006) is substantial (Figure E-2). The impact is highly sensitive to the assumed values for natural mortality. The WPO fisheries have had a greater impact than the EPO fisheries, and their rate of increase in recent years is greater. The temporal trend in the impact is robust to the assumed level of natural mortality.

The temporal trend in the estimated fisheries impact is robust to the assumption about natural mortality. Therefore, using the relative fishery impact as an indicator for management advice based on estimated historical performance may be useful. The impact of the EPO fisheries was substantially less during 1994-2007 than it was during 1970-1993, when bluefin was reduced to a much lower level; however, the impact has been increasing recently. The estimated status of bluefin is uncertain, and is sensitive to model assumptions. Catch levels should be set based on the years in which the impact was low until the uncertainty in the assessment is reduced. This management measure should ensure that the fishery is sustainable, provided equivalent measures are taken in the WPO.

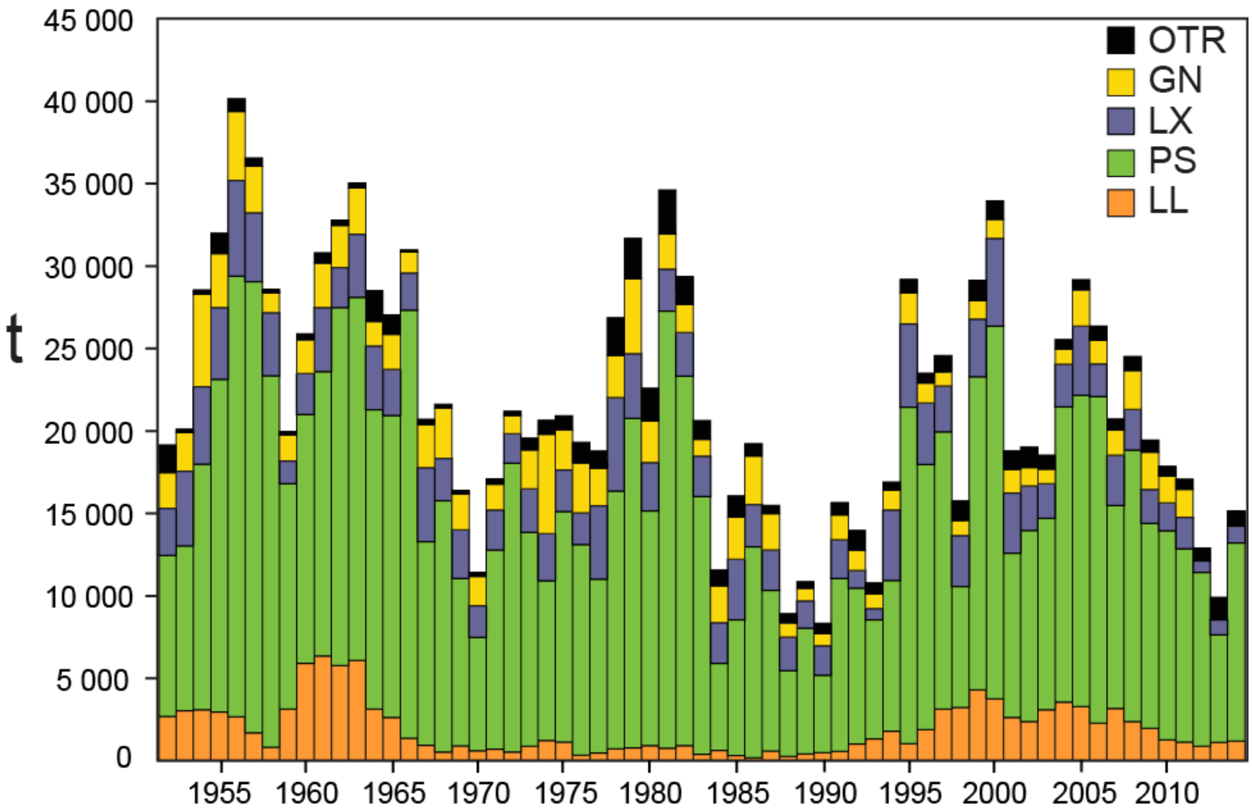

FIGURE E-1. Retained catches of Pacific bluefin tuna.
FIGURA E-1. Capturas retenidas de atún aleta azul del Pacífico.

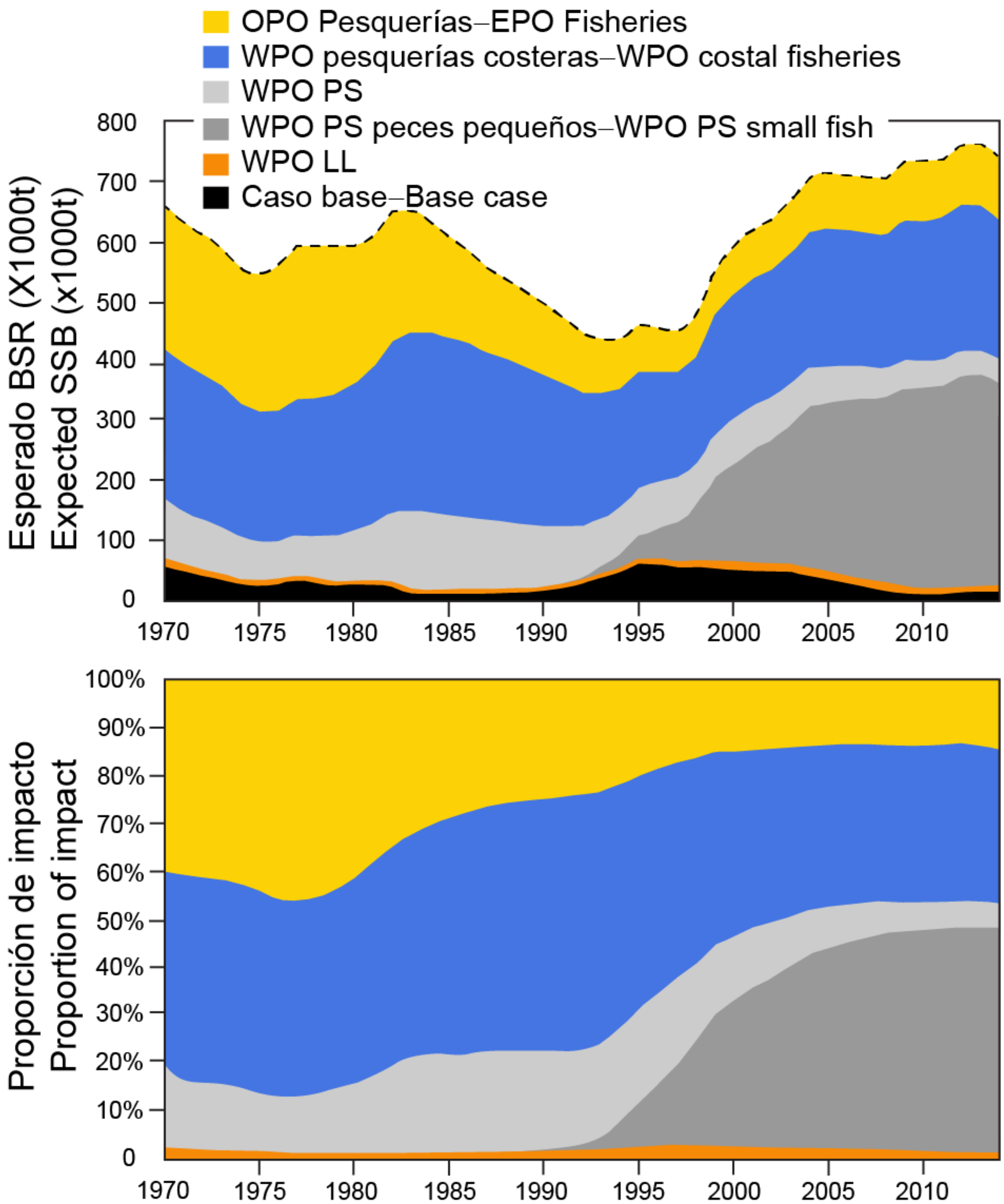

FIGURE E-2. Estimates of the impact on the Pacific bluefin tuna population of fisheries in the EPO and in the WPO (upper panel). The dashed line represents the estimated hypothetical unfished spawning biomass, and the solid line the estimated actual spawning biomass. The shaded areas indicate the impact attributed to each fishery. The lower panel presents the proportion of impact attributed to the EPO and WPO.

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.

F. ALBACORE TUNA

There are two stocks of albacore in the Pacific Ocean, one occurring 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 about 57% of the fish are taken in pole-and-line and troll fisheries that catch smaller, younger albacore, whereas about 95% of the albacore caught in the South Pacific are taken by longline. 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-1a). Following a second decline in the early 2000s, catches have recovered slightly, and have fluctuated between about 69,000 and 95,000 t in recent years (2006-2013). During 2010-2014 the average annual catch was about 84,000 t. 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, ranging from about 59,000 to 88,000 t during 2003-2013 (Figure F-1b). During 2010-2014 the average annual catch was about 82,000 t.

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 20ºN and 20ºS 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 15º and 19.5ºC. 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 stock assessments for the South and North Pacific stocks of albacore were presented in 2012 and 2014, respectively.

The assessment of South Pacific albacore, which was carried out in 2012 with MULTIFAN-CL by scientists of the Secretariat of the Pacific Community, incorporated catch and effort data, length-frequency data, tagging data, and information on biological parameters. Although there were sources of structural uncertainty, in particular growth, it was concluded that the stock was above the level corresponding to the maximum sustainable yield (MSY). Specifically, the current abundance relative to biomass-based reference points $B_{current}/B_{MSY}$ and $SB_{current}/SB_{MSY}$ is estimated to be above 1.0, and therefore the stock was not in an overfished state. In addition, it was concluded that the risk of overfishing occuring was low (the median of the most recent fishing mortality estimate relative to the fishing mortality reference point $F_{current}/F_{MSY}$ was 0.21). There appeared to be no need to restrict the fisheries for albacore in the South Pacific Ocean, but additional research to attempt to resolve the uncertainties in the data was recommended. A new stock assessment of South Pacific albacore is currently being carried out by scientists of the Secretariat of the Pacific Community (SPC), and will be presented to the Scientific Committee of the Western and Central Pacific Fisheries Commission (WCPFC) in August 2015.

An assessment of North Pacific albacore using fisheries data through 2012 was conducted at a workshop of the Albacore Working Group of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC), held in April 2014. The stock was assessed using an age- and sex-structured Stock Synthesis (SS Version 3.24f) model fitted to time series of standardized CPUE and size-composition data over a 1966 to 2012 time frame. The base-case model was fitted to the Japanese pole-and-line (PL) and longline (LL) indices, which were considered by the Working Group to be the most representative indices of abundance trends for juveniles and adults, respectively. All available fishery data from the Pacific Ocean north of the equator were used for the stock assessment, which assumed a single well-mixed stock. Sex-specific growth curves were used because there is evidence of sexually dimorphic growth, with male albacore attaining greater sizes and ages than females. The assumed value of the steepness parameter (h) in the Beverton-Holt stock-recruitment relationship was 0.9, based on two separate external estimates of this parameter. The assessment model was fitted to the abundance indices and size-composition data in a likelihood-based statistical framework. Maximum likelihood estimates of model parameters, derived outputs, and their variances were used to characterize stock status. Several sensitivity analyses were conducted to evaluate both changes in model performance and the range of uncertainty resulting from changes in model parameters, including some of the data series used in the analyses, growth curve parameters, natural mortality, stock-recruitment steepness, initial year, selectivity estimation, and weighting of size-composition data. The conclusions reached at that workshop were presented to the eleventh plenary meeting of the ISC, held in August 2014. Among these were the following:

1. The base-case model estimates that the spawning stock biomass (SSB) has likely fluctuated between 98,000 and 204,000 t between 1966 and 2012 (Figure F-2), and that recruitment has averaged about 43 million fish annually during this period. There are periods of above- and below-average recruitment at the beginning of the assessment time frame, followed by fluctuations around the average since the 1990s. Female SSB was estimated to be approximately 110,101 t in the terminal year of the assessment (2012), and stock depletion is estimated to be 35.8% of unfished SSB.
2. The estimated spawners per recruit (SPR) relative to the unfished population in the terminal year of the assessment is 0.41, which corresponds to a relatively low exploitation level (*i.e.*, 1-SPR = 0.59). While the base case model's estimate of current F-at-age on juvenile fish is lower than in 2002-2004, and current F on adult fish (50% of age-5 fish, and all fish age 6 and older) is higher, on average, than during 2002-2004.
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 in an overfished condition at present, as there is little evidence from the assessment that fishing has reduced SSB below reasonable candidate biomass-based reference points.
4. Under the base-case model, the point estimate (± SD) of maximum sustainable yield (MSY) is 105,571 ± 14,759 t, and the point estimate of spawning biomass to produce MSY (SSB_{MSY}, adult female biomass) is 49,680 ± 6,739 t. The ratio of $F_{2010\text{-}2012}/F_{MSY}$ is estimated to be 0.52, and the ratio of $F_{2002\text{-}2004}/F_{MSY}$ (2002-2004 are the reference years for IATTC conservation and management measures for north Pacific albacore) is estimated to be 0.76.
5. Stochastic stock projections were conducted externally to the base case model to evaluate the impact of various levels of fishing intensity on future female SSB for north Pacific albacore. Future recruitment was based on random resampling of historical recruitment for three periods: (1) low recruitment (about 29 million recruits), 1983-1989, (2) average recruitment (about 43 million), 1966-2010, and high recruitment (about 55 million recruits), 1966-1975. These calculations incorporate the structure of the assessment model (*e.g.*, multi-fleet, multi-season,

size- and age-selectivity) to produce results consistent with the assessment model. Projections started in 2011 and continued through 2041 under two levels of fishing mortality (constant $F_{2010\text{-}2012}$, constant $F_{2002\text{-}2004}$) and constant catch averaged for 2010-2012, and three levels of recruitment (low, average, and high, as defined above). Based on these projections, the stock performs better under the constant $F_{2010\text{-}2012}$ harvest scenario than the constant $F_{2002\text{-}2004}$ harvest scenario. Assuming average historical recruitment and fishing at a constant current F, median female SSB is expected to remain relatively stable between the 25th and median historical percentiles over both the short and long term. In contrast, if a low-recruitment scenario is assumed, then median female SSB declines under both harvest scenarios. The high-recruitment scenario is more optimistic, with median SSB increasing above the historical median SSB.

6. The Working Group concluded that the north Pacific albacore stock is not experiencing overfishing and is probably not in an overfished condition. The current exploitation level ($F_{2010\text{-}2012}$) is estimated to be below that of $F_{2002\text{-}2004}$, which had led previously to the implementation of conservation and management measures for the stock in the eastern Pacific (IATTC Resolution C-05-02, supplemented by Resolution C-13-03) and the western and central Pacific Ocean (WCPFC CMM 2005-03). The Working Group noted that there is no evidence that fishing has reduced SSB below thresholds associated with the majority of biomass-based reference points that might be chosen and that 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 exploitation levels, assuming average historical recruitment in both the short and long term.
7. The Working Group noted that the lack of sex-specific size data, the absence of updated estimates of important life history parameters (natural mortality, maturity), and the simplified treatment of the spatial structure of north Pacific albacore population dynamics are important sources of uncertainty in the assessment.

In 2013 the IATTC adopted resolution C-13-03 on North Pacific albacore, which supplemented C-05-02 . By 1 December 2013, all CPCs were required to report catch, by gear and effort directed at northern albacore, in the Convention Area during 2007-2012, as well as the average effort for 2002-2004. The effort in vessel-days during 2007-2012 was only 2% higher than during 2002-2004, and the average number of vessels operating during 2007-2012 was about 7% lower than during 2002-2004.

Currently the Working Group is developing a work plan to implement a Management Strategy Evaluation for the North Pacific albacore stock.

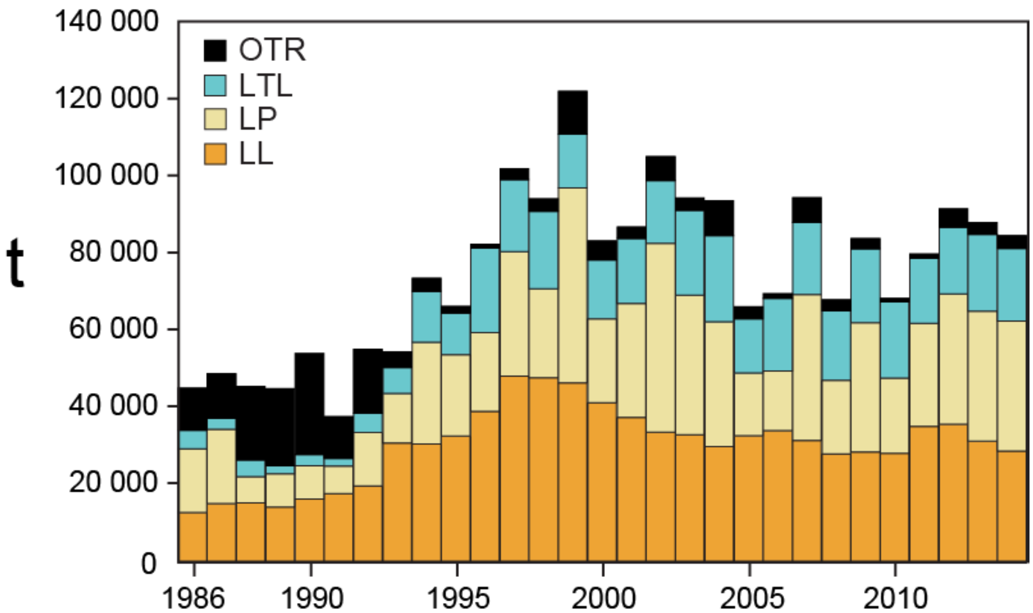

FIGURE F-1a. Retained catches of North Pacific albacore.
FIGURA F-1a. Capturas retenidas de albacora del Pacífico norte.

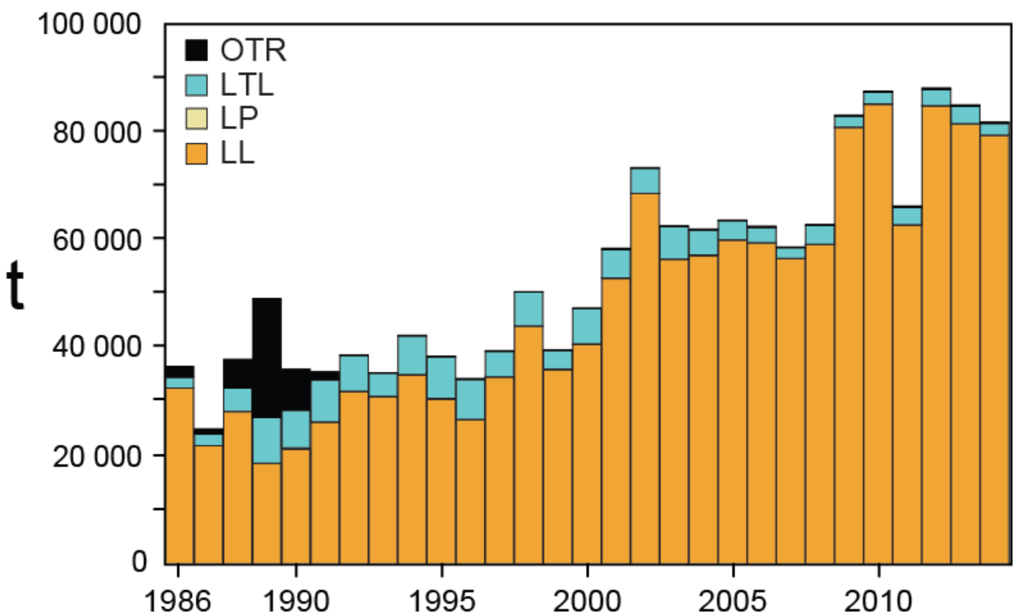

FIGURE F-1b. Retained catches of South Pacific albacore.
FIGURA F-1b. Capturas retenidas de albacora del Pacífico sur.

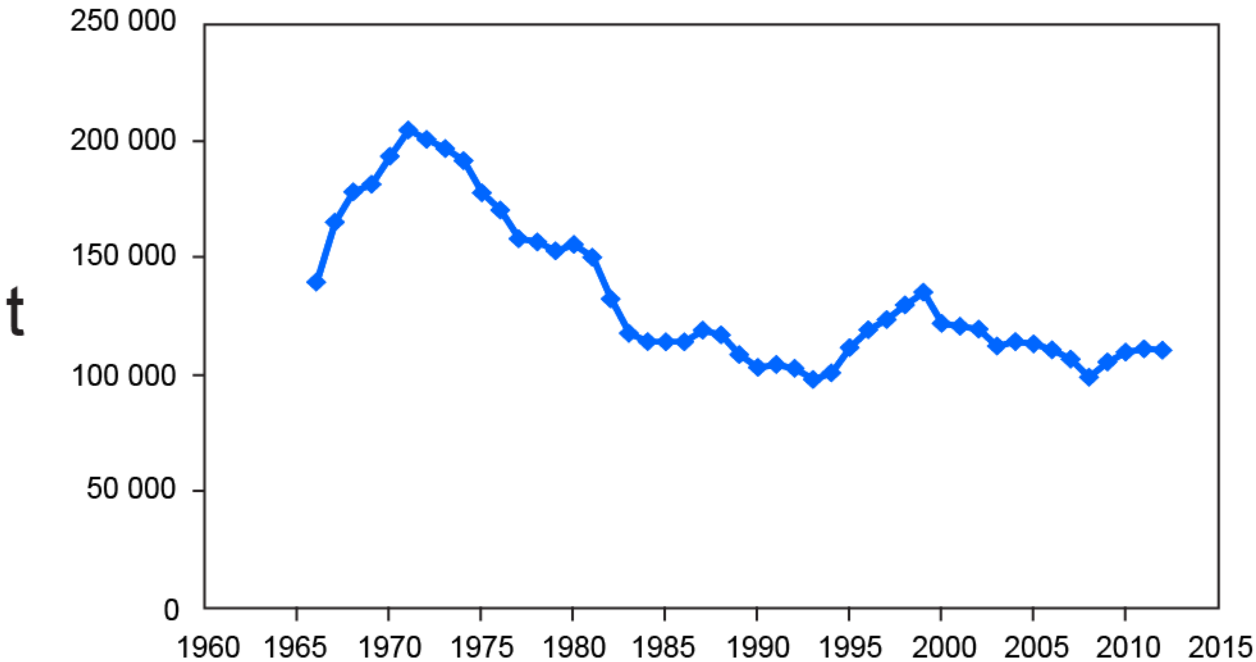

FIGURE F-2. Spawning stock biomass of North Pacific albacore tuna, from the North Pacific Albacore Workshop analysis of 2012.
FIGURA F-2. Biomasa de la población reproductora del atún albacora del Pacífico norte, de los análisis de la Reunión Técnica sobre el albacora del Pacífico norte de 2012.

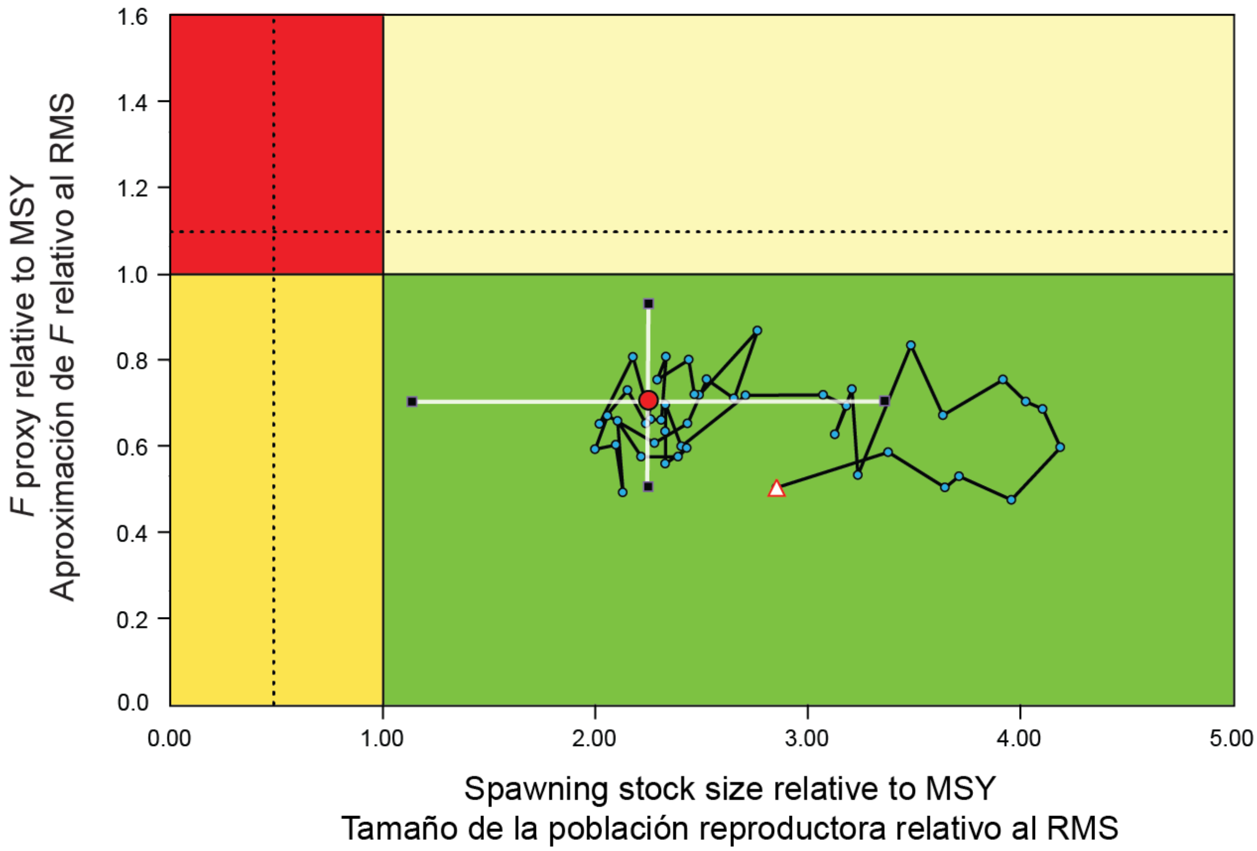

FIGURE F-3. Kobe (phase) plot for the North Pacific albacore stock from the base-case assessment model (which assumes a steepness value of 0.9). The *F* proxy is computed as (1-(Spawning biomass per recruit [year] / Spawning biomass per recruit [virgin])). The limit and target reference points are those proposed by the IATTC staff and are included here for illustrative purposes. The 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 (1966).

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-(Biomasa reproductora por recluta [año] / 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. 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 (1966).

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 by recreational fishermen.

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 regions of spawning are known, and analyses of fisheries and genetic data indicate 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. Though assessments of eastern Pacific stocks did not include parameters for movements among these or other stocks, there may be limited exchange of fish among them.

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.

The standardized catches per unit of effort of the longline fisheries in the northern region of the 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 northern EPO.

The most recent assessment of the stock of swordfish in the southwestern EPO was conducted with Stock Synthesis, using data that were updated as of 22 April 2011. Key results from that assessment were (1) that the swordfish stock in the southeast Pacific Ocean is not experiencing overfishing and is not overfished; (2) that the spawning biomass ratio is about 1.45, indicating that the spawning biomass is about 50 percent above the carrying capacity, and substantially above the level which is expected to produce catch at the MSY level; (3) that the recent catch levels (Figure G-2) were at levels at about MSY (~25,000 t); and (4) that there has been a recent series of high recruitments to the swordfish stock. There is no indication of a significant impact of fishing on this stock. The results of the assessment did suggest an expansion of the fishery onto components of the stock that were previously not, or were only lightly, exploited.

In the northern EPO the annual longline fishing effort, though recently increasing 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.

In the southern EPO catches have been steadily increasing since about 2005, and recent annual catches are nearing the estimated MSY.

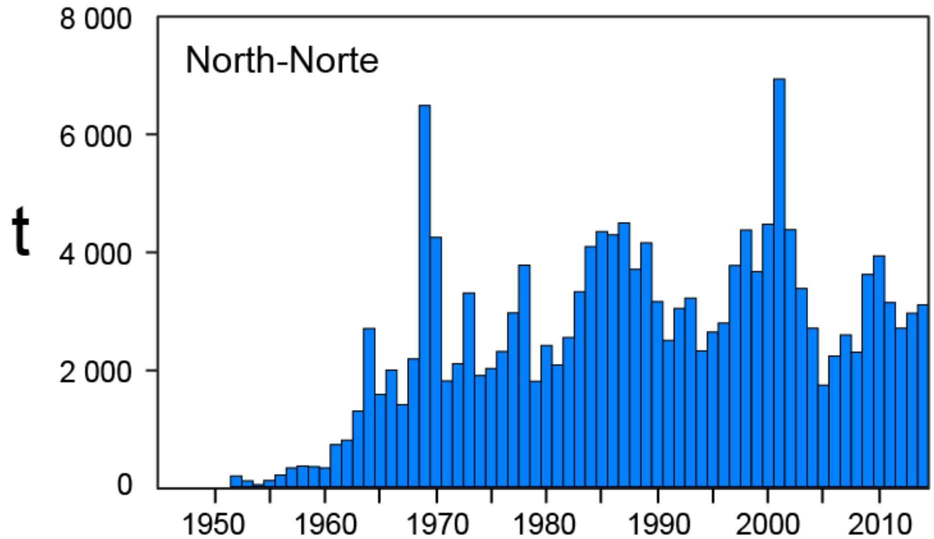

FIGURE G-1. Retained catches of swordfish in the northeastern Pacific Ocean.
FIGURA G-1. Capturas retenidas de pez espada en el Océano Pacífico noreste.

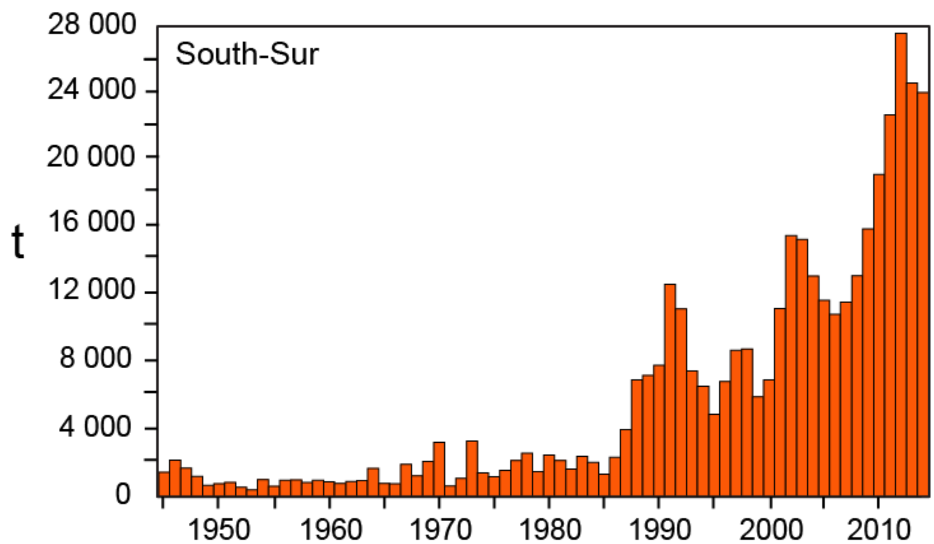

FIGURE G-2. Retained catches of swordfish in the southeastern Pacific Ocean
FIGURA G-2. Capturas retenidas de pez espada en el Océano Pacífico sudeste.

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 fishermen. A few of these fish have been recaptured long distances from the locations of release. Blue marlin have been tagged with electronic pop-off satellite tags (PSATs) which collected data over periods of about 30-180 days, mostly in the Gulf of Mexico and the Atlantic Ocean, in studies of post-release survival and movement. More recently such studies have been undertaken in the Pacific Ocean.

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

The most recent 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.

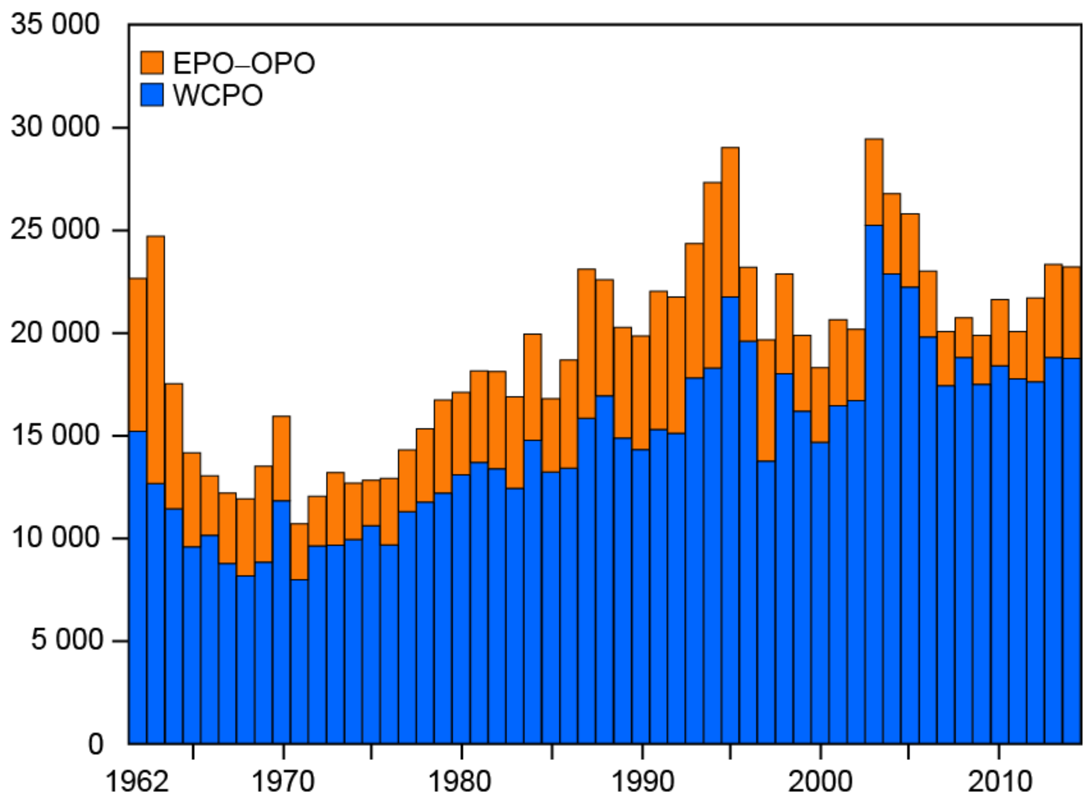

FIGURE H-1. Retained catches of blue marlin in Pacific Ocean by region.
FIGURA H-1. Capturas retenidas de marlín azul en el Océano Pacífico, por región.

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) region lying 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 now moderately well known. It has been clear for some years that there are a number of stocks. Information on the movements of striped marlin is limited. Fish tagged with conventional dart tags and released off the tip of the Baja California peninsula have generally been recaptured near where they were tagged, but some have been recaptured around the Revillagigedo Islands, a few around Hawaii, and one near Norfolk Island. Tagging studies of striped marlin in the Pacific conducted using pop-off satellite tags indicated that there is essentially no mixing of tagged fish among tagging areas and that striped marlin maintain site fidelity. Recent results of 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; however, removals by recreational fisheries have become more important in recent years (Figure I-1). Longline fisheries expanded into the EPO beginning in the mid-1950s, and they 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.

Fishing by smaller longline vessels targeting tuna and other species off Central America, for which catch data are not available, appears to have increased recently. 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 assessment of this stock was conducted using Stock Synthesis, with data updated as of 30 October 2010. Key results of the assessment were that (1) the stock is not overfished; (2) overfishing is not occurring; (3) the spawning stock biomass has been increasing and is above that expected to support MSY catch; and (4) catches in recent years have remained at about half the MSY catch level. If fishing effort and harvests had continued at levels near 2010 levels, it was expected that the biomass of the stock would continue to increase over the near term.

The fishing effort by large longline vessels in the northern EPO has increased by about 20%, and the catch of striped marlin by longlines by about 70%, since 2010. This differential may be due to increasing striped marlin biomass or such as spatial/temporal shifts in fisheries resulting in increased availability of striped marlin to the longline fishery.

The most recent report of catch by the recreational fishery was for 1990-2007 and included preliminary data for 2008. It is estimated that this fishery makes the majority of the catch of striped marlin in the northern EPO. Based on recent analyses of other billfish species, it appears that catches of billfish, including striped marlin, by components of the smaller-vessel longline fishery operating off Central America have not been reported. Therefore the total catch of striped marlin in the EPO, and thus the total impact of fishing on the stock since about 2008-2009, is not known.

Since catches of striped marlin and fishing effort have increased in the large-vessel longline fishery, and because there is uncertainty in the estimated total catch of striped marlin in the EPO since at least 2008, the trends in spawning and total biomass of striped marlin in the EPO are unknown. Efforts have and are being made 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 a precautionary approach be adopted, and that fishing effort directed at striped marlin in the EPO not be increased.

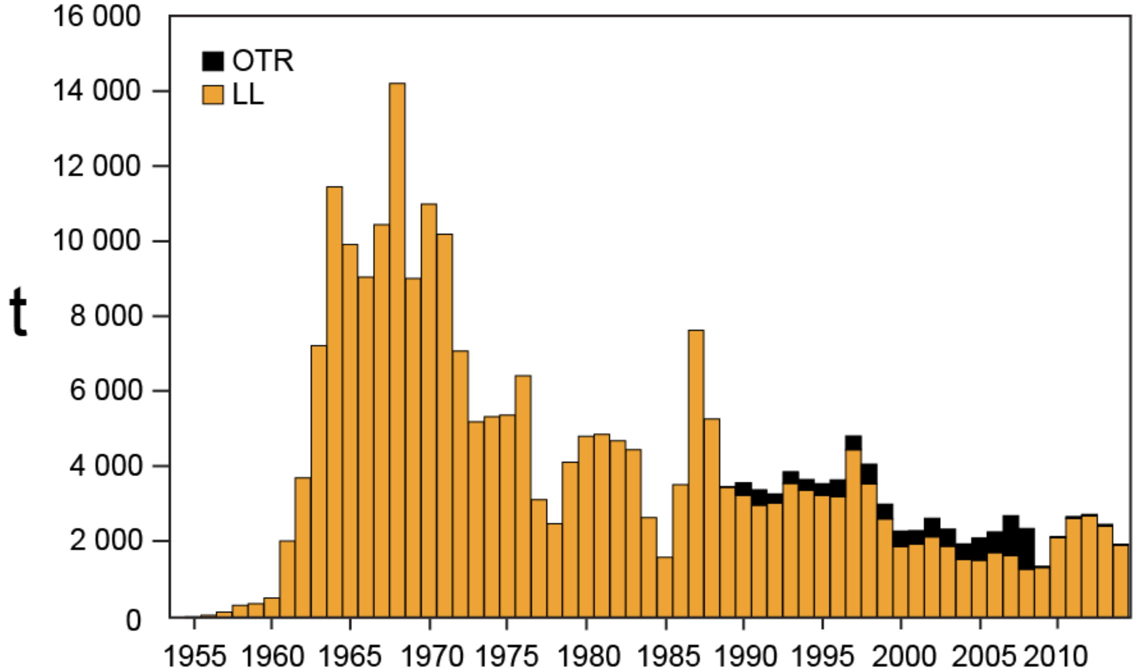

FIGURE I-1. Landings of striped marlin from the northern EPO by longline and recreational fisheries, 1954-2012. Due to unreported catches by recreational fisheries, estimates for 2009-2014 are minimums.
FIGURA I-1. Descargas de marlín rayado del OPO norte por las pesquerías palangreras y recreativas, 1954-2012. Debido a capturas no reportadas por pesquerías recreativas, las estimaciones de 2009-2014 son mínimos.

J. SAILFISH

The stock structure of sailfish (*Istiophorus platypterus*) in the Pacific Ocean is well known. They are found in highest abundance in waters relatively near the continents and the Indo-Pacific land masses bordering the Pacific, and only infrequently in the high seas separating them. This separation by its very nature suggests that the regions of abundance in the EPO and in the western Pacific should be managed separately, and in this case, the separation has over time resulted in genetically distinct populations in the east and the west.

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-vessel, tuna-targeting longline fisheries of Chinese Taipei, Costa Rica, Japan, and Korea; the smaller-vessel longline fisheries targeting tuna and other species, particularly those operating in waters 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.

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 – much more probably – that there was a large amount of catch 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, which is generally 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. Sailfish abundance trended downward over 1994-2009, since when it has been relatively constant or slightly increasing (Figure J-1).
3. Recent reported annual catches are on the order of 500 t (Figure J-2), significantly less than the 1993-2007 average of about 2,100 t.
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 and artisanal fisheries, be compiled and that, where necessary, catch monitoring programs to identify catches by species be implemented.

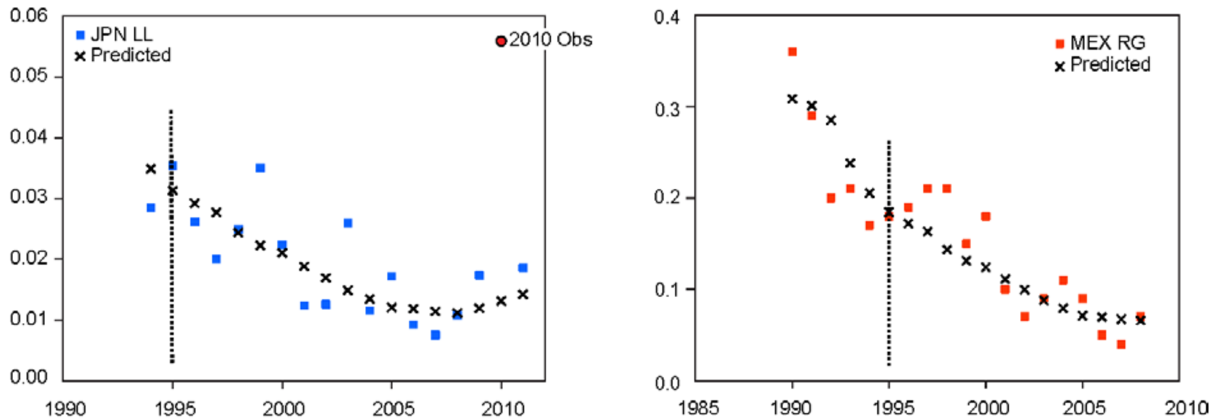

FIGURE J-1. Observed and predicted indices of relative abundance of sailfish in the EPO from Japanese longline (JPN LL) and Mexican recreational (MEX RG) fisheries. The 2010 observation in the JPN LL series was not included in the analyses.
FIGURA J-1. Indices observados y predichos de abundancia relativa 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.

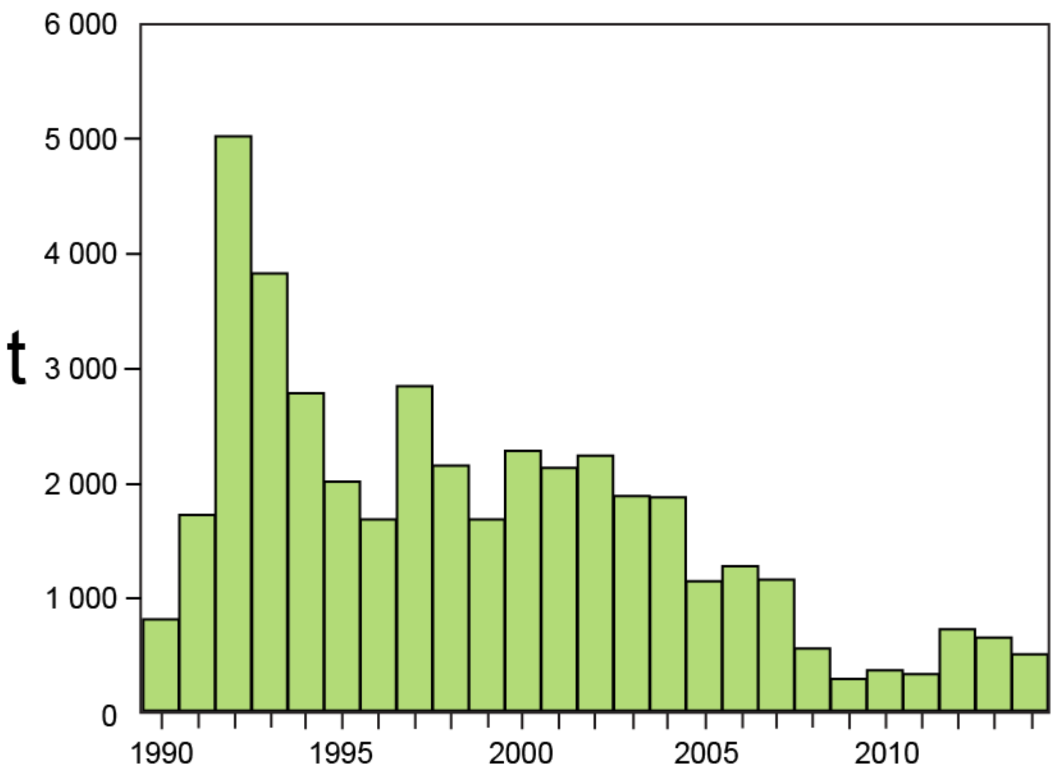

FIGURE J-2. Total reported catches of sailfish in the EPO, 1990-2014. The actual catches were probably greater.
FIGURA J-2. Capturas totales reportadas de pez vela en el OPO, 1990-2014. (Las capturas reales son probablemente mayores).

K. UPDATED STOCK STATUS INDICATORS FOR SILKY SHARKS IN THE EASTERN PACIFIC OCEAN (1994-2015)

An attempt by the IATTC staff in 2013 to assess the status of the silky shark (*Carcharhinus falciformis*) in the eastern Pacific Ocean (EPO), using conventional stock assessment models, was severely handicapped by major uncertainties in the fishery data, mainly regarding total catch levels in the early years for all fisheries operating in the EPO that caught silky sharks (SAC-05 INF-F). Although this stock assessment attempt produced a substantial amount of new information about the silky shark in the EPO (*e.g*., absolute and relative magnitude of the catch by different fisheries, and their selectivities), the absolute scale of population trends and the derived management quantities were compromised. Since a conventional stock assessment was not possible, in 2014 the staff proposed a suite of possible stock status (or stability) indicators (SSIs) which could be considered for managing the silky sharks in the EPO (SAC-05-11a), including standardized catch-per-unit-effort type indices from the purse-seine fishery. Document SAC-07-06b.i presents an update of the purse-seine indices through 2015.

Following previous methodology, indices for the silky shark were computed for the northern and southern EPO (north and south of the equator, respectively). For the northern EPO, the floating-object set index shows an initial sharp decline during 1994-1998, followed by a period of relative stability at a low level (1999-2009), then a sharp increase from 2009 to 2010, a sharp decrease from 2010 through 2012, and again a sharp increase from 2012 through 2015 (Figure K-1). The floating-object set index trend in the shows agreement with standardized presence/absence indices for the silky shark computed for dolphin sets and unassociated sets (Figure K-2). A comparison of differences among floating-object set trends computed by sub-area in the north suggest that the overall recent increasing trend may reflect an integration of spatially-distinct processes, including the effect of fishing pressure closer to the coast, and environmentally-mediated movement of individuals into the tropical EPO from the west. For the southern area, the floating-object set indicator shows a sharp decline during 1994-2004, followed by a period of stability at much lower levels until 2013, and then a small increase in 2014, with little change in 2015 (Figure K-1). Due to the very low levels of silky shark bycatch in the southern area in dolphin and unassociated sets, no indices were computed for these sets types in the southern area.

The IATTC staff does not consider the more optimistic recent trends in the indices to be strong enough to offset the urgent need for precautionary management actions, and reiterates its previous recommendations. In addition, it is critical that improvements are made in shark fishery data collection in the EPO so that conventional stock assessments and/or other indicators of stock status can be developed and the results made available to better inform the management of silky and other shark species.

With respect to future research on SSIs for the silky shark in the EPO, priority should be given to improving the collection of shark fishery data in the EPO. As part of this effort, it is essential that data from other sources be collected to develop additional indicators. The purse-seine indicators alone are not sufficient to determine stock status for a species that may be impacted by different factors in different regions within the EPO. Obtaining reliable catch data for all fisheries catching silky sharks in the EPO, indices of abundance for other fisheries (*e.g*., longline fisheries, which take the majority of the catch), and composition data, is vital. To date, no target or limit reference points or harvest control rules have been developed for the silky shark. While the current data shortcomings persist, management strategy evaluation (MSE) work to simulation-test and identify the reference points and harvest control rules that will achieve the conservation goals for the EPO should be conducted.

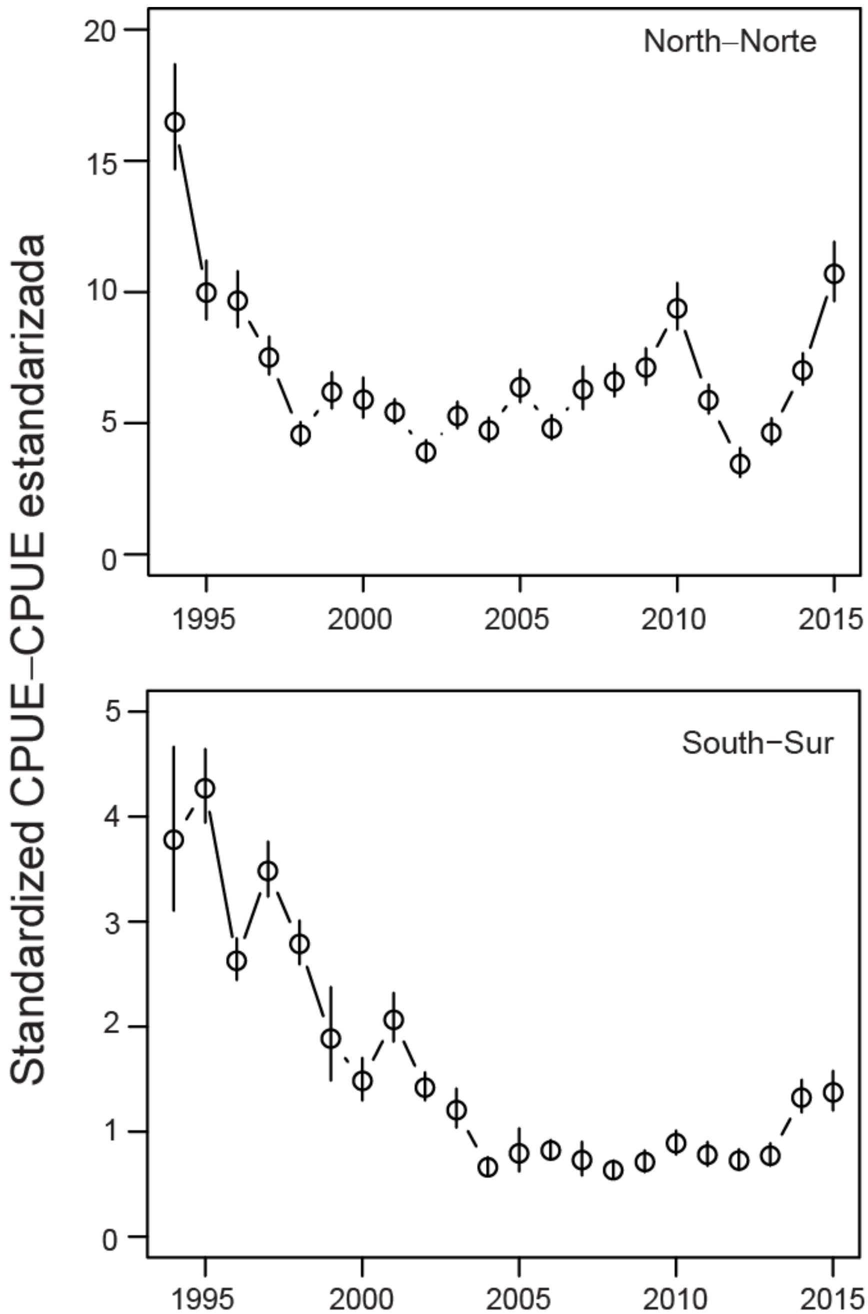

FIGURE K-1. Standardized catch-per-unit-effort (CPUE, in number of sharks per set) of all silky sharks in floating-object sets for northern (top) and southern (bottom) EPO stocks.

FIGURA K-1. Captura por unidad de esfuerzo (CPUE, en número de tiburones por lance) estandarizada de todos los tiburones en lances sobre objetos flotantes de las poblaciones del OPO del norte (arriba) y sur (abajo).

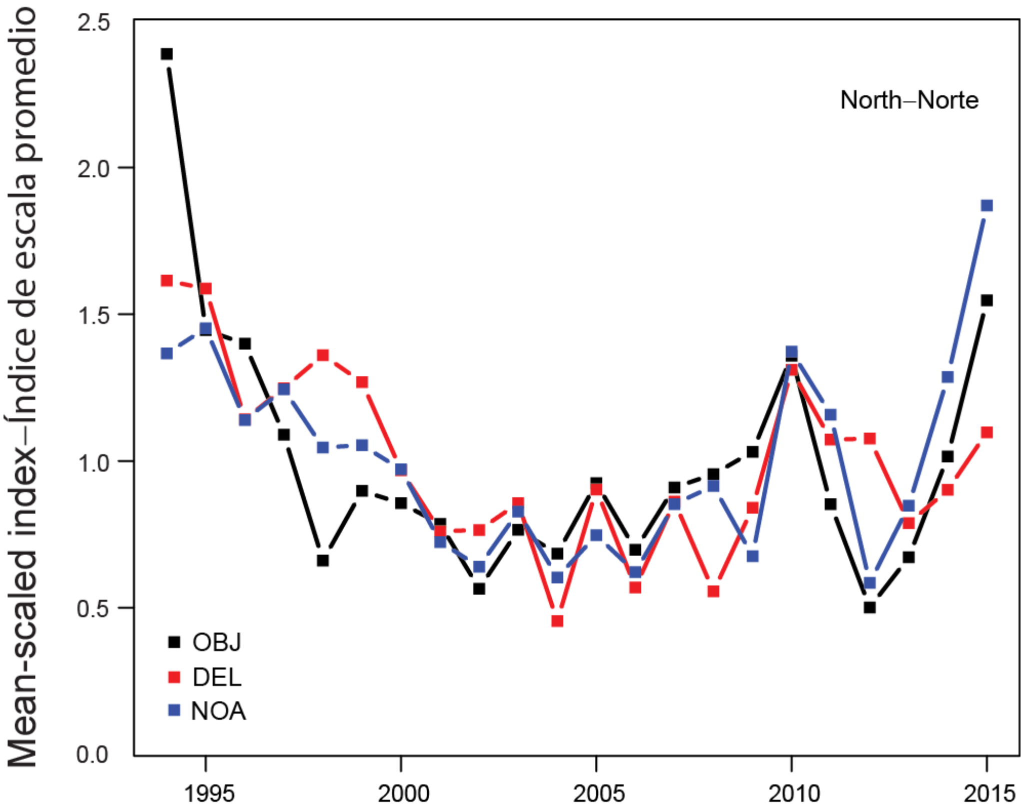

FIGURE K-2. Comparison of stock status indicators (SSIs) for the northern silky shark produced for different purse-seine set types (floating-object (OBJ), dolphin (DEL), unassociated (NOA)).
FIGURA K-2. Comparación de indicadores de condición de población (SSI) para el tiburón sedoso del norte producidos para distintos tipos de lance cerquero (objeto flotante (OBJ), delfín (DEL), no asociado (NOA)).

L. ECOSYSTEM CONSIDERATIONS

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 it provides that management of fisheries should ensure the conservation not only of target species, but also of species belonging to the same ecosystem or associated with or dependent upon the target species.[3] 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 taken account of ecosystem issues in many of its decisions, and this report on the offshore pelagic ecosystem of the tropical and subtropical Pacific Ocean, which is the habitat of tunas and billfishes, has been available since 2003 to assist in making its management decisions. This section provides a coherent view, summarizing what is known about the direct impact of the fisheries upon various species and species groups of the ecosystem, and reviews what is known about the environment and about other species that are not directly impacted by the fisheries but may be indirectly impacted by means of predator-prey interactions in the food web.

This review does not suggest objectives for the incorporation of ecosystem considerations into the management of tuna or billfish fisheries, nor any new management measures. Rather, its prime purpose is to offer the Commission the opportunity to ensure that ecosystem considerations are part of its agenda.

It is important to remember that the view that we have of the ecosystem is based on the recent past; we have almost no information 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 fluctuations and more recently recognized longer-term changes, such as the Pacific Decadal Oscillation and other climate changes.

In addition to reporting the catches of the principal species of tunas and billfishes, the staff has reported the bycatches of non-target species that are either retained or discarded. In this section, data on these bycatches are presented in the context of the effect of the fishery on the ecosystem. Unfortunately, while

[3] 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.

relatively good information is available for the tunas and billfishes, information for the entire fishery is not available. The information is comprehensive for large (carrying capacity greater than 363 metric tons) purse seiners that carry observers under the Agreement on the International Dolphin Conservation Program (AIDCP), and information on retained catches is also reported for other purse seiners, pole-and-line vessels, and much of the longline fleet. Some information is available on sharks that are retained by parts of the longline fleet. Information on retained and discarded non-target species is reported for large purse-seiners, and is available for very few trips of smaller ones. There is little information available on the bycatches and discards for other fishing vessels.

2. IMPACT OF CATCHES

2.1. Single-species assessments

Current information on the effects of the tuna fisheries on the stocks of individual species in the eastern Pacific Ocean (EPO) and the detailed assessments are found in this document. An ecosystem perspective requires a focus on how the fishery may have altered various components of the ecosystem. Sections 2.2 and 2.3 of this report refer to information on the current biomass of each stock considered, compared to estimates of what it might have been in the absence of a fishery. Furthermore, section 2.2 includes a summary of some recent research conducted on drifting fish aggregating device- (FAD) associated aggregations, including methods which may lead to solutions on how to reduce the fishing mortality on undesirable-sizes of bigeye and yellowfin tunas. There are no direct measurements of the stock size before the fishery began, and, in any case, the stocks would have varied from year to year. In addition, the unexploited stock size may be influenced by predator and prey abundance, which is not included in the single-species analyses.

2.2. Tunas

Information on the effects of the fisheries on yellowfin, bigeye, and skipjack tunas is found in Documents SAC-07-05b, 05a, and 05c, respectively, and an executive summary of Pacific bluefin tuna will be available at this meeting. The ISC Northern Albacore Working Group completed its stock assessment in 2014 and the next assessment is scheduled for 2017.

IATTC staff recently published two studies that focused on the potential reduction of fishing mortality by purse seine on undesirable sizes of bigeye and yellowfin tunas and other species of concern, while still capturing associated schools of skipjack tuna. The first of these studies evaluated the simultaneous behaviors of skipjack, bigeye, and yellowfin tunas within large multi-species aggregations associated with FADs. The researchers documented spatial and temporal differences in the schooling behavior of the three species of tunas, including depth distributions, and found that the differences did not appear sufficient such that modifications in purse seine fishing practices could effectively avoid the capture of small bigeye and yellowfin, while optimizing the capture of skipjack. The second study assessed a fishing captain's ability to predict species composition, sizes, and quantities of tunas associated with drifting FADs, before encirclement with a purse-seine. The captain's predictions were significantly related to the actual total catch and catch by species, but not to size categories by species. Predictions of species composition were most accurate when estimates of bigeye and yellowfin tuna were combined, indicating the captain was overestimating one species while underestimating the other.

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 13. Stock assessments and/or stock structure analyses for swordfish (2007, structure), eastern Pacific striped marlin (2010, assessment and structure), northeast Pacific striped marlin (2011, assessment), southeast Pacific swordfish (2012, assessment), and eastern Pacific sailfish (2013, assessment) were completed by the IATTC staff. Stock assessments for Pacific blue marlin (2013) and for north Pacific swordfish (2014) and striped marlin (2015) were completed by the billfish working group of the International Scientific Committee (ISC) for Tuna and

Tuna-like Species in the North Pacific Ocean.

2.3.1. Black marlin and shortbill spearfish

No stock assessments have been made for these species, although there are some data published jointly by scientists of the National Research Institute of Far Seas Fisheries (NRIFSF) of Japan and the IATTC in the IATTC Bulletin series that show trends in catches, effort, and catches per unit of effort (CPUEs).

2.4. Summary

Preliminary estimates of the catches (including purse-seine discards), in metric tons, of tunas, bonitos, and billfishes during 2015 in the EPO are found in Tables A-2a and A-2b of Document SAC-07-03a.

2.5. 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 size range of about 10 to 40 kg in the EPO. Purse-seine fishermen have found that their catches of yellowfin in the EPO can be maximized by setting their nets around herds of dolphins and the associated schools of tunas, and then releasing the dolphins while retaining the tunas. The estimated incidental mortality of dolphins in this operation was high during the early years of the fishery, and the populations of dolphins were reduced from their unexploited levels during the 1960s and 1970s. After the late 1980s the incidental mortality decreased precipitously, and there is now evidence that the populations are recovering. Preliminary mortality estimates of dolphins in the fishery in 2015 are shown in Table 1. The IATTC staff is responsible for the assessment of dolphin populations associated with the purse-seine fishery for tunas, as a basis for the dolphin mortality limits established by the Agreement on the International Dolphin Conservation Program (AIDCP).

Studies of the association of tunas with dolphins have been an important component of the staff's long-term approach to understanding key interactions in the ecosystem. The extent to which yellowfin tuna and dolphins compete for resources, whether either or both of them benefits from the interaction, why the tuna are most often found with spotted dolphins versus other dolphins, and why the species associate most strongly in the eastern tropical Pacific, remain critical pieces of information, given the large biomasses of both groups and their high rates of prey consumption. Three studies were conducted to address these hypotheses: a simultaneous tracking study of spotted dolphins and yellowfin tuna, a trophic interactions study comparing their prey and daily foraging patterns, and a spatial study of oceanographic features correlated with the tuna dolphin association. These studies demonstrated that the association is neither permanent nor obligatory, and that the benefits of the association are not based on feeding advantages. The studies support the hypothesis that one or both species reduce the risk of predation by forming large, mixed-species groups. The association is most prevalent where the habitat of the tuna is compressed to the warm, shallow, surface waters of the mixed layer by the oxygen minimum zone, a thick layer of oxygen-poor waters underlying the mixed layer. The association has been observed in areas with similar oceanographic conditions in other oceans, but it is most prevalent and consistent in the eastern tropical Pacific, where the oxygen minimum zone is the most hypoxic and extensive in the world.

During August-December 2006, scientists of the U.S. National Marine Fisheries Service (NMFS) conducted the latest in a series of research cruises under the *Stenella* Abundance Research (STAR) project. The primary objective of the multi-year study is to investigate trends in population size of the dolphins that have been taken as incidental catch by the purse-seine fishery in the EPO. Data on cetacean distribution, herd size, and herd composition were collected from the large-scale line-transect surveys to estimate dolphin abundance. Oceanographic data are collected to characterize habitat and its variation over time. Data on distribution and abundance of prey fishes and squids, seabirds, and sea turtles further characterize the ecosystem in which these dolphins live. The 2006 survey covered the same areas and used the same methods as past surveys. Data from the 2006 survey produced new abundance estimates, and previous data were re-analyzed to produce revised estimates for 10 dolphin species and/or stocks in the EPO between 1986 and 2006. The 2006 estimates for northeastern offshore spotted dolphins were somewhat greater, and for eastern spinner dolphins substantially greater, than the estimates for 1998-2000. Estimates of population growth for these two depleted stocks and the depleted coastal spotted dolphin stock may indicate they are recovering, but the western-southern offshore spotted dolphin stock may be declining. The 1998-2006 abundance estimates for coastal spotted, whitebelly spinner, and rough-toothed (*Steno bredanensis*) dolphins showed an increasing trend, while those for the striped (*S. coeruleoalba*), short-beaked common (*Delphinus delphis*), bottlenose (*Tursiops truncatus*), and Risso's (*Grampus griseus*) dolphins were generally similar to previous estimates obtained with the same methods. Because there have been no NMFS surveys since 2006, new modelling was conducted during 2014 and 2015 on trends in dolphin relative abundance using purse-seine observer data. That research concluded that indices of relative abundance from purse-seine observer data for species such as dolphins in the EPO that are directly associated with the fishing process are unlikely to be reliable indicators. Not only are such indices susceptible to the usual problems of changes in fishing behavior, but there is not a clear distinction between indexing the dolphin-tuna association and indexing dolphin abundance. This research, as well as alternative means of monitoring dolphin stocks, was published in 2015.

Scientists of the NMFS have made estimates of the abundances of several other species of marine mammals based on data from research cruises made between 1986 and 2000 in the EPO. Of the species not significantly affected by the tuna fishery, short-finned pilot whales (*Globicephala macrorhynchus*) and three stocks of common dolphins showed increasing trends in abundance during that 15-year period. The apparent increased abundance of these mammals may have caused a decrease in the carrying capacity of the EPO for other predators that overlap in diet, including spotted dolphins. Bryde's whales (*Balaenoptera edeni*) also increased in estimated abundance, but there is very little diet overlap between these baleen whales and the upper-level predators impacted by the fisheries. The abundance estimates for sperm whales (*Physeter macrocephalus*) tended to decrease during 1986-2000.

Some marine mammals are adversely affected by reduced food availability during El Niño events, especially in coastal ecosystems. Examples that have been documented include dolphins, pinnipeds, and Bryde's whales off Peru, and pinnipeds around the Galapagos Islands. Large whales are able to move in response to changes in prey productivity and distribution.

TABLE 1. Mortality of dolphins and other marine mammals caused by the fishery in the EPO during 2015

Species and stock	Incidental mortality	
	Number	Metric tons
Offshore spotted dolphin		
Northeastern	191	12.5
Western-southern	158	10.3
Spinner dolphin		
Eastern	196	8.7
Whitebelly	139	8.4
Common dolphin		
Northern	43	3.0
Central	21	1.5
Southern	12	0.8
Other mammals*	5	0.3
Total	**765**	**45.5**

*"Other mammals" includes the following species and stocks, whose observed mortalities were as follows: unidentified dolphins 5 (0.3 t).

2.6. 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. At the 4th meeting of the IATTC Working Group on Bycatch in January 2004, it was reported that 166 leatherback (*Dermochelys coriacea*) and 6,000 other turtle species, mostly olive Ridley (*Lepidochelys olivacea*), were incidentally caught by Japan's longline fishery in the EPO during 2000, and that, of these, 25 and 3,000, respectively, were dead. At the 6th meeting of the Working Group in February 2007, it was reported that the Spanish longline fleet targeting swordfish in the EPO averaged 65 interactions and 8 mortalities per million hooks during 1990-2005. The mortality rates due to longlining in the EPO are likely to be similar for other fleets targeting bigeye tuna, and possibly greater for those that set their lines at shallower depths for albacore and swordfish. About 23 million of the 200 million hooks set each year in the EPO by distant-water longline vessels target swordfish with shallow longlines.

In addition, there is a sizeable fleet of artisanal longline vessels that fish for tunas, billfishes, sharks, and dorado (*Coryphaena* spp.) in the EPO. Since 2005, staff members of the IATTC and some other organizations, together with the governments of several coastal Latin American nations, have been engaged in a program to reduce the hooking rates and mortalities of sea turtles in these fisheries. Additional information on this program can be found in Section 9.2.

Sea turtles are occasionally caught in purse seines in the EPO tuna fishery. Most interactions occur when the turtles associate with floating objects, and are captured when the object is encircled. In other cases, nets set around unassociated schools of tunas or schools associated with dolphins may capture sea turtles that happen to be at those locations. The olive Ridley turtle 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. From 1990, when IATTC observers began recording this information, through 2015, 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. Sea turtles, at times, become entangled in the webbing under fish-aggregating devices (FADs) and drown. In some cases, they are entangled by the fishing gear and may be injured or killed. Preliminary estimates of the mortalities (in numbers) of turtles caused by large purse-seine vessels during 2015, by set type (on floating objects (OBJ), unassociated schools (NOA), and dolphins (DEL)), are shown in Table 2.

TABLE 2. Numbers of turtle mortalities caused by large purse-seine vessels in the EPO during 2015

	Set type			Total
	OBJ	NOA	DEL	
Olive Ridley	2	-	1	3
Eastern Pacific green	-	-	-	-
Loggerhead	-	-	-	-
Hawksbill	-	-	-	-
Leatherback	-	-	-	-
Unidentified	-	4	-	4
Total	**2**	**4**	**1**	**7**

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

The populations of olive Ridley and loggerhead turtles are designated as vulnerable, those of green and loggerhead turtles are designated as endangered, and those of hawksbill and leatherback turtles as critically endangered, by the International Union for the Conservation of Nature (IUCN).

2.7. Sharks and other large fishes

Sharks and other large fishes are taken by both purse-seine and longline vessels. Silky sharks (*Carcharhinus falciformis*) are the most commonly-caught species of shark in the purse-seine fishery. The longline fisheries also take silky sharks. An analysis of longline and purse-seine fishing is necessary to estimate the impact of fishing on the stock(s).

A project was conducted during May 2007-June 2008 by scientists of the IATTC and the NMFS to collect and archive tissue samples of sharks, rays, and other large fishes for genetics analysis. Data from the archived samples are being used in studies of large-scale stock structure of these taxa in the EPO, information that is vital for stock assessments and is generally lacking throughout the Pacific Ocean. The preliminary results of an analysis for silky sharks showed that for management purposes, silky sharks in the EPO should be divided into two stocks, one north and one south of the equator. In addition, the results of a mitochondrial-DNA study from 2013 show a slight genetic divergence between silky sharks in the western and eastern Pacific, which supports assessing and managing these two populations separately.

Stock assessments are available for only four shark species in the EPO: silky, blue (*Prionace glauca*), mako (*Isurus oxyrinchus*) and common thresher sharks (*Alopias vulpinus*). The impacts of the bycatches on the stocks of other shark species in the EPO are unknown.

A stock assessment for silky sharks covering the 1993-2010 period was attempted using the Stock Synthesis model. Unfortunately, the model was unable to fit the main index of abundance adequately, and therefore the results were not reliable since relative trends and absolute scale are compromised in the assessment. Results are presented in Document SAC-05 INF-F. The majority of the catches of silky sharks in the EPO is estimated to be taken by longliners, some of them targeting sharks. As an alternative to conventional stock assessment models, a suite of possible stock status (or stability) indicators (SSIs), which could be considered for managing the northern and southern stocks of silky sharks in the EPO, are provided in Document SAC-05-11a. Updated SSIs, based on standardized catch-per-unit effort (CPUE) in purse-seine sets on floating objects (CPUE-OBJ), for silky sharks from 1994-2014 are presented in Document SAC-06-08b. Results therein indicate an apparent reduction in bycatch rates for all size classes north of the equator. For the southern stock, there is a major decline in bycatch rates. No stock status target and limit reference points have been developed for silky sharks based on these indicators. No harvest control rules have been developed and tested. At this point, the indicators cannot be used directly for determining the status of the stock or for establishing catch limits.

A stock assessment for blue sharks in the North Pacific Ocean was conducted by scientists of the ISC Shark Working Group in 2014. The report states, “Results of the reference case model showed that the stock biomass was near a time-series high in 1971, fell to its lowest level between the late 1980s and early 1990s, and subsequently increased gradually and has leveled off at a biomass similar to that at the beginning of the time-series.”

The ISC Shark Working Group conducted a new stock assessment of mako sharks in 2015. The report acknowledged the limited data available for this species and the lack of information on important fisheries. Thus, the stock status (overfishing and overfished) of mako sharks in the North Pacific Ocean is undetermined.

Scientists at the NMFS conducted a stock assessment for common thresher sharks along the west coast of North America. Their results indicate, “this stock of common thresher sharks is unlikely to be in an overfished condition nor experiencing overfishing. The stock experienced a relatively large and quick decline in the late 1970s and early 1980s, soon after the onset of the USA swordfish/shark drift gillnet fishery, with spawning depletion dropping to 0.4 in 1985. The population appeared to have stabilized in the mid-1980s after substantial regulations were imposed. Over the past 15 years, the stock began recovering relatively quickly and is currently close to an unexploited level.”

Preliminary estimates of the catches (including purse-seine discards), in metric tons, of sharks and other large fishes in the EPO during 2015, other than those mentioned above, by large purse-seine vessels are shown in Table 3. Complete data are not available for small purse-seine, longline, and other types of vessels.

The catch rates of species other than tunas in the purse-seine fishery are different for each type of set. With a few exceptions, the bycatch rates are greatest in sets on floating objects, followed by unassociated sets and, at a much lower level, dolphin sets. Dolphin bycatch rates are greatest for dolphin sets, followed by unassociated sets and, at a much lower level, floating-object sets. In general, the bycatch rates of manta rays (Mobulidae), and stingrays (Dasyatidae) are greatest in unassociated sets, followed by dolphin sets, and lowest in floating-object sets, although in 2015 the bycatch rate was greater in dolphin sets than unassociated sets. Because of these differences, it is necessary to follow the changes in frequency of the different types of sets to interpret the changes in bycatch data. The estimated numbers of purse-seine sets of each type in the EPO during 1999-2015 are shown in Table A-7 of Document SAC-07-03a.

The reduction of bycatches is a goal of ecosystem-based fisheries management. A recently-published study analyzed the ratio of bycatch to target catch across a range of set size-classes (in tons). The study demonstrated that the ratios of total bycatch to tuna catch and silky shark bycatch to tuna catch decreased as set size increased. The greatest bycatch ratios occurred in sets catching <20 t.

In October 2006, the NMFS hosted a workshop on bycatch reduction in the EPO purse-seine fishery. The attendees supported a proposal for research on methods to reduce bycatches of sharks by attracting them away from floating objects prior to setting the purse seine. They also supported a suite of field experiments on bycatch reduction devices and techniques; these would include FAD modifications and manipulations, assessing behavioral and physiological indicators of stress, and removing living animals from the seine and deck (e.g. sorting grids, bubble gates, and vacuum pumps). A third idea was to use IATTC data to determine if spatial, temporal, and environmental factors can be used to predict bycatches in FAD sets and to determine to what extent time/area closures would be effective in reducing bycatches.

A recent review of bycatch in the tropical tuna purse-seine fisheries of the world addressed available actions and concepts to reduce shark bycatch. These included spatial and seasonal closures, effort controls, and prohibition of shark landings, shark size limits, shark bycatch quotas per vessel, a mandate to release immediately any shark brought onboard, setting best procedures for shark handling during release, and training of crews in these procedures.

Dorado (*Coryphaena hippurus*) is one of the most important species caught in the artisanal fisheries of the coastal nations in the EPO. Dorado are also caught incidentally in the purse-seine tuna fishery in the EPO. Under the Antigua Convention and its ecosystem approach to fisheries, it is therefore appropriate that the IATTC staff study the species, with a view to determining the impact of fishing, and to recommend appropriate conservation measures of this important resource if required. In this context, some Members of the IATTC with coastlines in the region have requested that collaborative research on dorado be carried out with

TABLE 3. Catches, in tons, of sharks and other large fishes by large purse-seine vessels with observers aboard in the EPO, 2015

	Set type			Total
	OBJ	**NOA**	**DEL**	
Silky shark (*Carcharhinus falciformis)*	541	133	48	722
Oceanic whitetip shark (*C. longimanus)*	3	<1	<1	4
Hammerhead sharks (*Sphyrna* spp.)	54	4	1	59
Thresher sharks (*Alopias* spp.)	1	4	3	9
Other sharks	46	10	105	160
Manta rays (Mobulidae)	6	20	45	71
Pelagic sting rays (Dasyatidae)	<1	<1	<1	<1
Dorado (*Coryphaena* spp.)	1206	8	<1	1215
Wahoo (*Acanthocybium solandri)*	366	1	<1	368
Rainbow runner (*Elagatis bipinnulata*) and yellowtail (*Seriola lalandi*)	33	9	<1	42
Other large fishes	367	12	1	379

the IATTC staff so that solid scientific information is available for this purpose.

The IATTC held its [first technical meeting on dorado] in 2014. That meeting had three objectives: 1) to promote synergy among the Members of the IATTC for a regional investigation of dorado in the EPO; 2) to review the current state of knowledge of dorado and identify available data sets across fisheries/regions in the EPO); and 3) to plan a future collaborative research plan. This collaborative effort thus far includes: analysis of available catch statistics and trade records, improvement of field data collection programs, investigation of seasonal trends, and identification of fishery units. In addition, available fishery data on dorado from IATTC Members and other nations are being analyzed to develop stock status indicators (SSIs) which could potentially provide a basis for advice for managing the species in the EPO (see SAC-05-11b). The work was continued in 2015 and a second technical meeting was held with the aim to address two important questions: 1) What are reasonable stock structure assumptions to consider for regional management of dorado in the EPO? and 2) Which indicators of stock status should be monitored to provide scientific advice for regional management?

3. OTHER FAUNA

3.1. Seabirds

There are approximately 100 species of seabirds in the tropical EPO. Some seabirds associate with epipelagic predators near the sea surface, such as fishes (especially tunas) and marine mammals. Subsurface predators often drive prey to the surface to trap them against the air-water interface, where the prey becomes available to the birds. Most species of seabirds take prey within a half meter of the sea surface or in the air (flyingfishes (Exocoetidae) and squids (primarily Ommastrephidae)). In addition to driving the prey to the surface, subsurface predators make prey available to the birds by injuring or disorienting the prey, and by leaving scraps after feeding on large prey. Feeding opportunities for some seabird species are dependent on the presence of tuna schools feeding near the surface.

Seabirds are affected by the variability of the ocean environment. During the 1982-1983 El Niño event, seabird populations throughout the tropical and northeastern Pacific Ocean experienced breeding failures and mass mortalities, or migrated elsewhere in search of food. Some species, however, are apparently not affected by El Niño episodes. In general, seabirds that forage in upwelling areas of the tropical EPO and Peru Current suffer reproductive failures and mortalities due to food shortage during El Niño events, while seabirds that forage in areas less affected by El Niño episodes may be relatively unaffected.

According to the *Report of the Scientific Research Program under the U.S. International Dolphin Conservation Program Act*, prepared by the NMFS in September 2002, there were no significant temporal trends in abundance estimates over the 1986-2000 period for any species of seabird, except for a downward trend for the Tahiti petrel (*Pseudobulweria rostrata*), in the tropical EPO. Population status and trends are currently under review for waved (*Phoebastria irrorata*), black-footed (*P. nigripes*), and Laysan (*P. immutabilis*) albatrosses.

Some seabirds, especially albatrosses and petrels, are susceptible to being caught on baited hooks in pelagic longline fisheries. Satellite tracking and at-sea observation data have identified the importance of the IATTC area for waved, black-footed, Laysan, and black-browed (*Thalassarche melanophrys*) albatrosses, plus several other species that breed in New Zealand, yet forage off the coast of South America. 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 show no interactions with waved albatross during these vessels' fishing operations. Data from the US pelagic longline fishery in the northeastern Pacific Ocean indicate that bycatches of black-footed and Laysan albatrosses occur. Few comparable data for the longline fisheries in the central and southeastern Pacific Ocean are available. At the 6th meeting of the IATTC Working Group on Bycatch in February 2007, it was reported that the Spanish surface longline fleet targeting swordfish in the EPO averaged 40 seabird interactions per million hooks, virtually all resulting in mortality, during 1990-2005. In 2007, the IATTC Stock Assessment

Working Group identified areas of vulnerability to industrial longline fishing for several species of albatross and proposed mitigation measures. See also section 9.3.

3.2. Forage

The forage taxa occupying the middle trophic levels in the EPO are obviously important components of the ecosystem, providing a link between primary producers at the base of the food web and the upper-trophic-level predators, such as tunas and billfishes. Indirect effects on those predators caused by environmental variability are transmitted to the upper trophic levels through the forage taxa. Little is known, however, about fluctuations in abundance of the large variety of prey species in the EPO. Scientists from the NMFS have recorded data on the distributions and abundances of common prey groups, including lantern fishes (Myctophidae), flyingfishes, and some squids, in the tropical EPO during 1986-1990 and 1998-2000. Mean abundance estimates for all fish taxa and, to a lesser extent, for squids increased from 1986 through 1990. The estimates were low again in 1998, and then increased through 2000. Their interpretation of this pattern was that El Niño events in 1986-1987 and 1997-1998 had negative effects on these prey populations. More data on these taxa were collected during the NMFS STAR 2003 and 2006 cruises.

Recent research by a scientist at NMFS focused on assessing the habitat use of several mesopelagic fish families throughout various life stages in the EPO to aid in understanding their role in the ecosystem. The work also included describing ontogenetic changes in abundance and horizontal distribution of common species of mesopelagic fish larvae impacted by the El Niño event in 1997-1998 followed by the La Niña in the California Cooperative Oceanic Fisheries Investigations (CalCOFI) study area. Within the CalCOFI sampling region, mesopelagic fishes (2 species of Myctophidae and 1 species of Phosichthyidae) with an affinity for warm water conditions had a higher larval abundance, were closer to shore during the El Niño, and were less abundant and farther offshore during the La Niña. The opposite pattern was generally observed for mesopelagic fishes (3 species of Bathylagidae and 4 species of Myctophidae) with an affinity for cold water conditions.

Cephalopods, especially squids, play a central role in many, if not most, marine pelagic food webs by linking the massive biomasses of micronekton, particularly myctophid fishes, to many oceanic predators. Given the high trophic flux passing through the squid community, a concerted research effort on squids is thought to be important for understanding their role as key prey and predators. In 2013, a special volume of the journal Deep Sea Research II, Topical Studies in Oceanography (Vol. 5) was focused on The Role of Squids in Pelagic Ecosystems. The volume covers six main research areas: squids as prey, squids as predators, the role of squids in marine ecosystems, physiology, climate change, and the Humboldt or jumbo squid (*Dosidicus gigas*) as a recent example of ecological plasticity in a cephalopod species.

Humboldt squid populations in the EPO have increased in size and geographic range in recent years. For example, the Humboldt squid expanded its range to the north into waters off central California, USA from 2002 to mid-2010. In addition, in 2002 observers on tuna purse-seine vessels reported increased incidental catches of Humboldt squid taken with tunas, primarily skipjack, off Peru. Juvenile stages of these squid are common prey for yellowfin and bigeye tunas, and other predatory fishes, and Humboldt squid are also voracious predators of small fishes and cephalopods throughout their range. Large Humboldt squid have been observed attacking skipjack and yellowfin inside a purse seine. Not only have these squid impacted the ecosystems that they have expanded into, but they are also thought to have the capacity to affect the trophic structure in pelagic regions. Changes in the abundance and geographic range of Humboldt squid could affect the foraging behavior of the tunas and other predators, perhaps changing their vulnerability to capture.

Some small fishes, many of which are forage for the larger predators, are incidentally caught by purse-seine vessels in the EPO. Frigate and bullet tunas (*Auxis* spp.), for example, are a common prey of many of the animals that occupy the upper trophic levels in the tropical EPO. In the tropical EPO ecosystem model (Section 8), frigate and bullet tunas comprise 10% or more of the diet of eight predator species or

TABLE 4. Catches of small fishes, in tons, by large purse-seine vessels with observers aboard in the EPO, 2015

	Set type			Total
	OBJ	NOA	DEL	
Triggerfishes (Balistidae) and filefishes (Monacanthidae)	141	4	<1	145
Other small fishes	16	<1	<1	16
Frigate and bullet tunas (*Auxis* spp.)	177	65	0	242

groups. Small quantities of frigate and bullet tunas are captured by purse-seine vessels on the high seas and by artisanal fisheries in some coastal regions of Central and South America. The vast majority of frigate and bullet tunas captured by tuna purse-seine vessels is discarded at sea. Preliminary estimates of the catches (including purse-seine discards), in metric tons, of small fishes by large purse-seine vessels with observers aboard in the EPO during 2015 are shown in Table 4

3.3. Larval fishes and plankton

Larval fishes have been collected by manta (surface) net tows in the EPO for many years by personnel of the NMFS Southwest Fisheries Science Center. Of the 314 taxonomic categories identified, 17 were found to be most likely to show the effects of environmental change. The occurrence, abundance, and distribution of these key taxa revealed no consistent temporal trends. Recent research 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 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 availability.

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 Nino event, while the zooplankton biomass did not change.

Copepods often comprise the dominant component of secondary production in marine ecosystems. An analysis of the trophic structure among the community of pelagic copepods in the EPO was conducted by a student of the Centro Interdisciplinario de Ciencias Marinas, Instituto Politécnico Nacional, La Paz, Mexico, using samples collected by scientists of the NMFS STAR project. The stable nitrogen isotope values of omnivorous copepods were used in a separate analysis of the trophic position of yellowfin tuna, by treating the copepods as a proxy for the isotopic variability at the base of the food web (see next section).

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. Given the need to evaluate the implications of fishing activities on the underlying ecosystems, it is essential to acquire accurate information on the trophic links and biomass flows through the food web in open-ocean ecosystems, and a basic understanding of the natural variability forced by the environment.

Knowledge of the trophic ecology of predatory fishes has historically been derived from stomach contents analysis, and more recently from chemical indicators. Large pelagic predators are considered efficient biological samplers of micronekton organisms, which are poorly sampled by nets and trawls. Diet studies have revealed many of the key trophic connections in the pelagic EPO, and have formed the basis for representing food-web interactions in an ecosystem model (IATTC Bulletin, Vol. 22, No. 3) to explore indirect ecosystem effects of fishing. For example, studies in the 1990s and 2000s revealed that the most common prey items of yellowfin tuna caught by purse seines offshore were frigate and bullet tunas, red crabs (*Pleuroncodes planipes*), Humboldt squid, a mesopelagic fish (*Vinciguerria lucetia*), and several epipelagic fishes. Bigeye tuna feed at greater depths than do yellowfin and skipjack, and consume primarily cephalopods and mesopelagic fishes. The most important prey of skipjack overall were reported to be euphausiid crustaceans during the late 1950s, whereas the small mesopelagic fish *V. lucetia* appeared dominant in the diet during the early 1990s. Tunas that feed inshore often utilize different prey than those caught offshore.

Historical studies of tuna diets in the EPO were based on qualitative data from few samples, with little or no indication of relative prey importance. Contemporary studies, however, have used diet indices, typically volume or weight importance, numeric importance, and frequency of occurrence of prey items to quantify diet composition, often in conjunction with chemical indicators, such as stable-isotope and fatty-acid analyses. A chapter entitled “Bioenergetics, trophic ecology, and niche separation of tunas” will be published in 2016 in the serial *Advances in Marine Biology*. It reviews current understanding of the bioenergetics and feeding dynamics of tunas on a global scale, with emphasis on yellowfin, bigeye, skipjack, albacore, and Atlantic bluefin tunas in seven oceans or ocean regions. Food consumption balances bioenergetics expenditures for respiration, growth (including gonad production), specific dynamic action, egestion, and excretion. Each species of tuna appears to have a generalized feeding strategy, in the sense that their diets were characterized by high prey diversity and overall low abundance of individual prey types. Ontogenetic and spatial diet differences are substantial, and significant inter-decadal changes in prey composition have been observed. Diet shifts from larger to smaller prey taxa highlight ecosystem-wide changes in prey availability and diversity, and provide implications for changing bioenergetics requirements into the future. The lack of long-term data limits the ability to predict the impacts of climate change on tuna feeding behavior, and thus there is a need for systematic collection of feeding data as part of routine monitoring of these species.

New statistical methods for analyzing complex, multivariate stomach-contents data have been developed through an international collaboration, Climate Impacts on Oceanic Top Predators-Integrated Marine Biogeochemistry and Ecosystem Research (CLIOTOP-IMBER), Working Group 3 (WG3: Trophic pathways in open-ocean ecosystems), to assess the trophodynamics of marine top predators. This methodology shows promise for analyzing broad-scale spatial, temporal, environmental, and biological relationships in a classification-tree modeling framework that predicts the prey compositions of predators. Two recent studies of yellowfin tuna and silky sharks in the EPO, discussed below, used the approach to infer changes in prey populations over space (yellowfin and silky sharks) and time (yellowfin) based on stomach contents data. In 2015, progress was made by WG3 on a global analysis of the diets of yellowfin, bigeye and albacore tunas, using the classification tree approach to assess whether spatial analyses can be used to hypothesize predation changes in a warming ocean. Diet data of yellowfin and bigeye tuna caught in the purse-seine fishery in the EPO was included in this global analysis.

Stomach samples of ubiquitous generalist predators, such as the tunas, can be used to infer changes in prey populations by identifying changes in foraging habits over time. Prey populations that support upper-level predators vary over time (see 3.2 Forage), and some prey impart considerable predation pressure on animals that occupy the lower trophic levels (including the early life stages of large fishes). A comprehensive analysis of predation by yellowfin tuna on a decadal scale in the EPO was completed in

2013. Samples from 6,810 fish were taken from 433 purse-seine sets during two 2-year periods separated by a decade. Simultaneously, widespread reductions in biological production, changes in phytoplankton community composition, and a vertical expansion and intensification of the oxygen minimum zone appeared to alter the food webs in tropical and subtropical oceans (see 5. Physical environment). A modified classification tree approach, mentioned above, was used to analyze spatial, temporal, environmental, and biological covariates explaining the predation patterns of the yellowfin during 1992-1994 and 2003-2005. For the majority of the yellowfin stock in the EPO, a major diet shift was apparent during the decade. Fishes were more abundant (by weight) during the early 1990s, while cephalopods and crustaceans predominated a decade later. As a group, epipelagic fishes declined from 82% to 31% of the diet, while mesopelagic species increased from 9% to 29% over the decade. Spatial partial dependence plots revealed range expansions by *Vinciguerria lucetia*, Humboldt squid (*Dosidicus gigas*), and *Pleuroncodes planipes*, range contractions by *Auxis* spp. and a boxfish (*Lactoria diaphana*), and a near disappearance of driftfish (*Cubiceps* spp.) from the diet. Evidence from predation rates suggests that biomasses of *V. lucetia* and *D. gigas* have increased in the first half of the 2000s and that the distribution of *D. gigas* apparently expanded offshore as well as poleward (see 3.2 Forage).

The food-web representations that form the basis of ecosystem models are usually highly generalized, and do not account for variability in space and time. To gain insight into the role of the silky shark in the ecosystem, in 2014 an analysis of spatial variability was carried out, based on the stomach contents of 289 silky sharks captured as bycatch in sets on floating objects, primarily drifting fish-aggregating devices (FADs), by the tuna purse-seine fishery of the EPO. The dataset is novel because biological data for open-ocean carcharhinid sharks are difficult to collect, and it includes data for silky sharks caught over a broad region of the tropical EPO. Results from classification tree and quantile regression methodologies suggest that the silky shark is an opportunistic predator that forages on a variety of prey. Broad-scale spatial and shark size covariates explained the feeding habits of the silky sharks. A strong spatial shift in diet was revealed, with different foraging patterns in the eastern (inshore) and western (offshore) regions. Greater proportions of FAD-associated prey than non-FAD-associated prey were observed in the diet throughout the EPO, but especially in the offshore region. Yellowfin tuna and silky sharks shared some of the same prey resources during these same two 2-year periods separated by a decade, e.g., Humboldt squid, flyingfishes, jacks and pompanos, and Tetraodontiformes. As was the case for yellowfin tuna, spatial and temporal factors likely both have a role in determining silky shark predation habits, but the samples were inadequate to test whether the diet of the sharks had changed over time. The analysis provided a comprehensive description of silky shark predation in the EPO, while demonstrating the need for increased sampling coverage over space and time, and presents important information on the dynamic component of trophic interactions of silky sharks. This information can be used to improve future ecosystem models.

Predator-prey interactions for yellowfin, bigeye and albacore tunas, collected over a 40-year period from the Pacific, Indian and Atlantic Oceans, were used to quantitatively assess broad, macro-scale trophic patterns in pelagic ecosystems. Collation of these data, representing more than 10,000 predators, in a global database, was a critical first step, and underpinned analyses. A modified classification tree approach showed significant spatial differences and partitioning in the principal prey items consumed by all three tuna species, reflecting regional distributions of micronekton. Ommastrephid squids were one of the most important prey groups in all oceans across tuna species. Generalized additive models revealed that diet diversity was mainly driven by regional-scale processes and tuna length (59-81% Deviance Explained). In regions of low primary productivity the diet diversity of yellowfin tuna was more than double the diversity values in regions of high productivity. Ontogenetic and spatial patterns in diet diversity were found for bigeye tuna, with diet diversity of larger fish less related to primary production levels. Diet diversity of albacore tuna was globally higher than that of the other tunas and was uniformly high in all oceans except in the oligotrophic Mediterranean Sea. These results suggest that the current expansion of warmer, less productive waters in the world's oceans may alter foraging opportunities of yellowfin tuna due to changes in the regional abundance of prey resources. Due to the larger depth range across which bigeye and albacore tunas forage, these species are less likely to be affected by changes in temperature and other environmental processes at the surface and within the mixed layer. Well-planned, long-term diet studies for large pelagic ecosystems are needed to test these preliminary hypotheses.

Trophic-ecology studies have become focused on understanding entire food webs, initially by describing the inter-specific connections among the predator communities, comprising tunas, sharks, billfishes, dorado, wahoo, rainbow runner, and others. In general, considerable resource partitioning is evident among the components of these communities, and researchers seek to understand the spatial scale of the observable trophic patterns, and also the role of climate variability in influencing the patterns. In 2012, an analysis of predation by a suite of apex predators (including sharks, billfishes, tunas, and other fishes and mammals) on yellowfin and skipjack tunas in the EPO was published. Predation rates on yellowfin and skipjack were high for sharks and billfishes, and those animals consumed a wide size range of tunas, including subadults capable of making a notable contribution to the reproductive output of tuna populations. The tropical tunas in the EPO act as mesopredators more than apex predators.

While diet studies have yielded many insights, stable isotope analysis is a useful complement to stomach contents for delineating the complex structure of marine food webs. Stomach contents represent a sample of only the most-recent several hours of feeding at the time of day an animal is captured, and under the conditions required for its capture. Stable carbon and nitrogen isotopes, however, integrate information on all components of the entire diet into the animal's tissues, providing a recent history of trophic interactions and information on the structure and dynamics of ecological communities. More insight is provided by compound-specific isotope analysis of amino acids (AA-CSIA). In samples of consumer tissues, "source" amino acids (*e.g.* phenylalanine, glycine) retained the isotopic values at the base of the food web, and "trophic" amino acids (*e.g.* glutamic acid) became enriched in ^{15}N by about 7.6‰ relative to the baseline. In AA-CSIA, predator tissues alone are adequate for trophic-position estimates, and separate analysis of the isotopic composition of organisms at the base of the food web is not necessary. An analysis of the spatial distribution of stable isotope values of yellowfin tuna in relation to those of copepods showed that the trophic position of yellowfin tuna increased from inshore to offshore in the EPO, a characteristic of the food web never detected in diet data. This is likely a result of differences in food-chain length due to phytoplankton species composition (species with small cell size) in offshore oligotrophic waters versus larger diatom species in the more productive eastern waters.

CSIA was recently utilized in the EPO and other regions through a research grant from the Comparative Analysis of Marine Ecosystem Organization (CAMEO) program, which is implemented as a partnership between the NMFS and the U.S. National Science Foundation, Division of Ocean Sciences. The research collaboration among the IATTC, the University of Hawaii, Scripps Institution of Oceanography, and the Oceanic Institute, Hawaii, seeks to develop amino acid compound-specific isotopic analysis as a tool that can provide an unbiased evaluation of trophic position for a wide variety of marine organisms and to use this information to validate output from trophic mass-balance ecosystem models. To accomplish this goal, the research combines laboratory experiments and field collections in contrasting ecosystems that have important fisheries. The field component was undertaken in varying biogeochemical environments, including the equatorial EPO, to examine trophic position of a range of individual species, from macrozooplankton to large fishes, and to compare trophic position estimates derived from AA-CSIA for these species with ecosystem model output. The project began in 2010 and was extended into 2014.

Most of the samples for the EPO portion of the study were collected and stored frozen by personnel of the NMFS, Protected Resources Division, Southwest Fisheries Science Center (SWFSC), aboard the research vessels *David Starr Jordan* and *McArthur II* during the *Stenella* Abundance Research Project (STAR) in 2006. The samples for the study nearly span the food web in the EPO, and all were taken along an east-to-southwest transect that appeared to span a productivity gradient. The components include macroplankton (two euphausiid crustaceans, *Euphausia distinguenda* and *E. tenera*), mesopelagic-micronekton (two myctophid fishes, *Myctophum nitidulum* and *Symbolophorus reversus*), cephalopods (two species of pelagic squids, *Dosidicus gigas* and *Sthenoteuthis oualaniensis*), and small and large micronektonivores and nektonivores (skipjack, yellowfin, and bigeye tunas collected aboard commercial purse-seine vessels fishing in the EPO during 2003-2005).

Stable isotope analyses of bulk tissues and amino acids were conducted on several specimens each of the species listed above. Bulk $\delta^{15}N$ values varied markedly across the longitude and latitude gradients. There were no distinct longitudinal trends, but the $\delta^{15}N$ values increased consistently with increasing latitude. Trophic position estimates based on the amino-acid $\delta^{15}N$ values, however, varied little intra-specifically across the sample transect. These two results suggest that the isotopic variability in the food web was likely due to biogeochemical variability at the base of the food web rather than differences in diets within the food web. Increasing $\delta^{15}N$ values with latitude correspond to high rates of denitrification associated with the large oxygen minimum zone in the ETP. Among-species comparisons of absolute trophic positions based on AA-CSIA estimates with estimates based on diet from the EPO ecosystem model (IATTC Bulletin, Vol. 22, No. 3) showed underestimates for the predators occupying higher trophic levels, *i.e.* the three tunas and two squids. These underestimates are likely because the previously-accepted trophic enrichment factor of 7.6 ‰ for phenylalanine and glutamic acid, which was derived from laboratory experiments with primary producers and invertebrate consumers, is inadequate for higher-level predators. A Master of Science thesis was developed from this work, and a manuscript has been provisionally accepted for publication in 2016[4].

Previous studies suggest that differences in $\delta^{15}N$ values of source and trophic amino acids can be used to examine historical changes in the trophic positions of archived samples, to investigate, for example, the potential effects of fisheries removals on system trophic dynamics. Where historical diet data are lacking or absent, AA-CSIA of archived specimens may be the only way to determine the past trophic status of key predator and prey species. Given the importance of retrospective ecosystem analyses, capabilities are being developed for conducting these analyses by thoroughly examining the possible artifacts of sample preservation methods on subsamples of key species. In this two-year study, muscle samples from 3 yellowfin tuna and 3 Humboldt squid were collected, fixed in formalin, and stored long-term in ethanol. Paired samples were frozen for two years to compare with the preserved samples. The duration of preservation and freezing ranged from 1 week to 2 years, and all preserved samples showed a uniform increase in bulk $\delta^{15}N$ values. $\delta^{15}N$ values of several amino acids (threonine, phenylalanine, and valine) were significantly different between preserved and frozen samples. A follow-up experiment is underway to evaluate whether alteration of $\delta^{15}N$ values was caused by formalin fixation or ethanol preservation. These data suggest that caution and further investigation be used for future studies that aim to conduct AA-CSIA on formalin-ethanol preserved tissues.

In early 2016, a proposal by a task team of CLIOTOP WG3 members was accepted by the CLIOTOP Scientific Steering Committee. This work will be a companion paper to the global tuna diet analysis described above. The task team represents an international collaborative effort to move from regional trophic studies of top marine predators to a global comparative study of oceanic food webs using stable isotope compositions of the same three tuna species featured in the diet paper: yellowfin, bigeye, and albacore tunas. The team will assess isotopic differences among oceans, regions, and tuna species. Predictive models will be used to undertake an inter-ocean comparison of a proxy for trophic position based on stable isotope values. The proxy is based on $\delta^{15}N$ values of the tunas minus known regional differences in baseline $\delta^{15}N$ values derived from a coupled ocean circulation-biogeochemical-isotope model. A similar approach will be taken with lipid-corrected $\delta^{13}C$ values to examine regional differences in carbon-based primary production origins. Environmental variables (SST, Chl-*a*, net primary productivity, and mixed layer depth) will be included to explore the influence of global oceanographic

[4] Hetherington, E.D., R.J. Olson, J.C. Drazen, C.E. Lennert-Cody, L.T. Ballance, R.S. Kaufmann, and B.N. Popp. In revision. Spatial variability in food web structure in the eastern tropical Pacific Ocean using compound-specific nitrogen isotope analysis of amino acids. Limnology and Oceanography.

processes on the isotopic compositions of the tuna species and food-chain length.

5. PHYSICAL ENVIRONMENT[5]

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. Environmental conditions are thought to cause considerable variability in the recruitment of tunas and billfishes. Stock assessments by the IATTC have often incorporated the assumption that oceanographic conditions might influence recruitment in the EPO.

Different types of climate perturbations may impact fisheries differently. It is thought that a shallow thermocline in the EPO contributes to the success of purse-seine fishing for tunas, perhaps by acting as a thermal barrier to schools of small tunas, keeping them near the sea surface. When the thermocline is deep, as during an El Niño event, tunas seem to be less vulnerable to capture, and the catch rates have declined. Warmer- or cooler-than-average sea-surface temperatures (SSTs) can also cause these mobile fishes to move to more favorable habitats.

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). The ENSO is an irregular fluctuation involving the entire tropical Pacific Ocean and global atmosphere. It results in variations of the winds, rainfall, thermocline depth, circulation, biological productivity, and the feeding and reproduction of fishes, birds, and marine mammals. El Niño events occur at 2- to 7-year intervals, and are characterized by weaker trade winds, deeper thermoclines, and abnormally-high SSTs in the equatorial EPO. El Niño's opposite phase, often called La Niña (or anti-El Niño), is characterized by stronger trade winds, shallower thermoclines, and lower SSTs. Research has documented a connection between the ENSO and the rate of primary production, phytoplankton biomass, and phytoplankton species composition. Upwelling of nutrient-rich subsurface water is reduced during El Niño episodes, leading to a marked reduction in primary and secondary production. ENSO also directly affects animals at middle and upper trophic levels. Researchers have concluded that the 1982-1983 El Niño event, for example, deepened the thermocline and nutricline, decreased primary production, reduced zooplankton abundance, and ultimately reduced the growth rates, reproductive successes, and survival of various birds, mammals, and fishes in the EPO. In general, however, the ocean inhabitants recover within short periods because their life histories are adapted to respond to a variable habitat.

The IATTC staff issues quarterly reports of the monthly average oceanographic and meteorological data for the EPO, including a summary of current ENSO conditions. The SSTs had been mostly below normal from October 2013 through March 2014, but during April 2014 through September 2015 they were virtually all above normal. By January 2015 the area of warm water off Mexico had expanded to the southwest, combining with an area of warm water along the equator that persisted through June. During the third quarter, the areas of warm water off Baja California and along the equator grew larger and warmer. During the fourth quarter, the SSTs were above normal over much of the area north of 10°S, and off Peru, but nearly normal over most of the rest of the area south of the equator. According to the Climate Diagnostics Bulletin of the U.S. National Weather Service for December 2015, "Most models indicate that a strong El Niño will weaken with a transition to…neutral [conditions] during the late spring or early summer…The forecasters are in agreement with the model consensus, though the exact timing of the transition is difficult to predict."

Variability on a decadal scale (*i.e.* 10 to 30 years) also affects the EPO. During the late 1970s there was a major shift in physical and biological states in the North Pacific Ocean. This climate shift was also

[5] 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.

detected in the tropical EPO by small increases in SSTs, weakening of the trade winds, and a moderate change in surface chlorophyll levels. Some researchers have reported another major shift in the North Pacific in 1989. Climate-induced variability in the ocean has often been described in terms of "regimes," characterized by relatively stable means and patterns in the physical and biological variables. Analyses by the IATTC staff have indicated that yellowfin tuna in the EPO have experienced regimes of lower (1975-1982) and higher (1983-2001) recruitment, and possibly intermediate (2002-2012) recruitment. The recruitments for 2013 and 2014 have been estimated to be above average, but there is high uncertainty in the estimated values.The increased recruitment during 1983-2001 is thought to be due to a shift to a higher productivity regime in the Pacific Ocean. Decadal fluctuations in upwelling and water transport are simultaneous to the higher-frequency ENSO pattern, and have basin-wide effects on the SSTs and thermocline slope that are similar to those caused by ENSO, but on longer time scales.

Recent peer-reviewed literature provides strong evidence that large-scale changes in biological production and habitat have resulted from physical forcing in the subtropical and tropical Pacific Ocean. These changes are thought to be capable of affecting prey communities. Primary production has declined over vast oceanic regions in the recent decade(s). A study published in 2008, using "Sea-viewing Wide Field-of-view Sensor" (SeaWiFS) remote-sensed ocean color data, showed that, in the North and South Pacific, the most oligotrophic surface waters have increased in area by 2.2 and 1.4 % per year, respectively, between 1998 and 2006. These statistically-significant increases in the oligotrophic gyres occurred concurrently with significant increases in mean SSTs. In the North Pacific, the direction of expansion was northeast, reaching well into the eastern Pacific to about 120°W and as far south as about 15°N. Net primary productivity also has declined in the tropical and subtropical oceans since 1999. The mechanism is recognized as increased upper-ocean temperature and vertical stratification, influencing the availability of nutrients for phytoplankton growth. Evidence is also strong that primary producers have changed in community composition and size structure in recent decades. Phytoplankton cell size is relevant to predation dynamics of tunas because food webs that have small picophytoplankton at their base require more trophic steps to reach predators of a given size than do food webs that begin with larger nanophytoplankton (*e.g.* diatoms). Energy transfer efficiency is lower for picophytoplankton-based food webs than for nanophytoplankton-based food webs, *i.e.* for a given amount of primary production less energy will reach a yellowfin of a given size in the former than in the latter because mean annual trophic transfer efficiency at each step is relatively constant. A study published in 2012 used satellite remotely-sensed SSTs and chlorophyll-a concentrations to estimate the monthly size composition of phytoplankton communities during 1998-2007. With the seasonal component removed, the median phytoplankton cell size estimated for the subtropical 10°-30°N and 10°-30°S Pacific declined by 2.2% and 2.3%, respectively, over the 9-year period. Expansion of the oxygen minimum zone (OMZ) is a third factor that demonstrates ecosystem change on a scale capable of affecting prey communities. The OMZ is a thick low-oxygen layer at intermediate depths, which is largely suboxic ($<\sim 10\ \mu mol\ kg^{-1}$) in the tropical EPO. Time series of dissolved oxygen concentration at depth from 1960 to 2008 revealed a vertical expansion and intensification of the OMZ in the central and eastern tropical Pacific and Atlantic Oceans, and in other regions of the world's oceans. Potential biological consequences of an expanding OMZ are numerous, but for the epipelagic tunas habitat compression can have profound implications. Shoaling of the OMZ restricts the depth distribution of tunas and other pelagic fishes into a narrower surface layer, compressing their foraging habitat and altering forage communities. Enhanced foraging opportunities for all epipelagic predators could alter trophic pathways and affect prey species composition. In addition, with a shoaled OMZ, mesopelagic vertically-migrating prey, such as the phosichthyid fish *Vinciguerria lucetia*, myctophid fishes, and ommastrephid squids, would likely occur at shallower daytime depths and become more vulnerable to epipelagic predators. These are some of the taxa that increased most in the yellowfin diet in the tropical EPO between 1992-1994 and 2003-2005 (see 4, Trophic interactions).

6. AGGREGATE INDICATORS

Recognition of the consequences of fishing for marine ecosystems has stimulated considerable research in recent years. Numerous objectives have been proposed to evaluate fishery impacts on ecosystems and to define over-fishing from an ecosystem perspective. Whereas reference points have been used primarily for single-species management of target species, applying performance measures and reference points to non-target species is believed to be a tractable first step. Current examples include incidental mortality limits for dolphins in the EPO purse-seine fishery under the AIDCP. Another area of interest is whether useful performance indicators based on ecosystem-level properties might be developed. Several ecosystem metrics or indicators, including 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, have been proposed. Whereas there is general agreement that multiple system-level indicators should be used, there is concern over whether there is sufficient practical knowledge of the dynamics of such metrics and whether a theoretical basis for identifying precautionary or limit reference points based on ecosystem properties exists. Ecosystem-level metrics are not yet commonly used for managing fisheries.

Ecological Metrics. Relationships between indices of species associations in the catch and environmental characteristics are viewed as potentially valuable information for bycatch mitigation. Preliminary work in 2007-2008, based on novel methods of ordination developed by scientists at the Institute of Statistical Mathematics in Tokyo, Japan, showed clear large-scale spatial patterns in different groupings of target and bycatch species for floating-object sets in the EPO purse-seine fishery and relationships to environmental variables, such as SST, chlorophyll-a density, and mixed layer depth. More work is needed on this or similar approaches.

A variety of ecological metrics were employed in a study published in 2012[6] to evaluate the ecological effects of purse-seine fishing in the EPO during 1993-2008. Comparisons of the catch of target and non-target (bycatch) species, both retained and discarded, by types of purse-seine sets (on dolphins, floating objects, and unassociated tunas) were made on the basis of replacement time, diversity, biomass (weight), number of individuals, and trophic level. Previous comparisons considered only numbers of individuals and only discarded animals, without regard to body size, life-history characteristics, or position in the food web. During 1993-2008, the mean biomass removed was 17.0, 41.1 and 12.8 t/set for dolphin sets, floating-object sets, and unassociated sets, respectively. Of these amounts, bycatch was 0.3% for dolphin sets, 3.8% for floating-object sets, 1.4% for unassociated sets, and 2.1% for all methods combined. The discard rate was 0.7% for dolphin sets, 10.5% for floating-object sets, 2.2% for unassociated sets, and 5.4% for all methods combined. With the addition of 0.7% estimated for smaller vessels, the overall discard rate was 4.8%. This rate is low compared with global estimates of 7.5% for tuna longlines, 30.0% for tuna mid-water trawls, and 8.0% for all fisheries combined.

Replacement time is a measure of the length of time required for replacement of biomass removed by the fishery. Unsustainable levels of harvest may lead to greater decreases in probabilities of persistence of long-lived animals with low fecundity and late age of maturity than of fast-growing, highly fecund species. In contrast to trophic-level metrics, replacement-time metrics were sensitive to categories of animals with relatively high biomass to production-of-biomass (B/P) ratios, such as bigeye tunas, sharks, and cetaceans. Mean replacement time for total removals averaged over years was lowest for dolphin sets (mean 0.48 years), intermediate for unassociated sets (0.57 years), and highest for floating-object sets (0.74 years). There were no temporal trends in mean replacement time for landings, and mean replacement times for discards were more variable than those for landings. Mean replacement times for dolphin-set discards were approximately 7 times the mean replacement times for floating-object or unassociated-set discards because dolphins have a low reproductive rate.

Diversity. Fishing alters diversity by selectively removing target species. The relationship between

[6] Gerrodette, T., R. Olson, S. Reilly, G. Watters, and W. Perrin. 2012. Ecological metrics of biomass removed by three methods of purse-seine fishing for tunas in the eastern tropical Pacific Ocean. Conservation Biology. 26 (2): 248-256

diversity of species removed and effects on the diversity and stability of the ecosystem from which they were removed may be complex. Higher diversity of catch may be associated with fewer undesirable effects on the ecosystem, although the complexity of competitive and trophic interactions among species makes the relationship between diversity of catch and diversity and stability of the ecosystem difficult to determine. The Shannon diversity index for total removals was lowest for dolphin sets (mean 0.62), intermediate for unassociated sets (1.22), and highest for floating-object sets (1.38). The diversity of dolphin-set landings increased by 0.023/year, on average, from 0.45 to 0.79, due primarily to an increase of the percentage of skipjack tuna in the catch from <1% to >7% and a concurrent decrease in the percentage of yellowfin tuna. The diversity of unassociated-set landings and discards both decreased, and diversity of total removals decreased by a mean of 0.024/year, from 1.40 to 1.04.

Biomass. The relative amounts and characteristics of the biomass removed by each of the fishing methods varied as a function of how removal was measured. Landings from floating-object sets were greatest by all four measures of removal, but were particularly high when removal was measured on the basis of number of individuals or replacement time. The amount and composition of discards varied among the fishing methods. Discards of the target tuna species were the greatest proportion of removed animals whether measured in biomass, number of individuals, or trophic-level units. Discards of cetaceans in dolphin sets and sharks in floating-object and unassociated sets were greater when measured in replacement-time units than when measured in other units because of the low reproductive rates of these animals.

Trophic structure and trophic levels of catches. Ecologically-based approaches to fisheries management place renewed emphasis on achieving accurate depictions of trophic links and biomass flows through the food web in exploited systems. The structure of the food web and the interactions among its components have a demonstrable role in determining the dynamics and productivity of ecosystems. Trophic levels (TLs) are used in food-web ecology to characterize the functional role of organisms, to facilitate estimates of energy or mass flow through communities, and for elucidating trophodynamics aspects of ecosystem functioning. A simplified food-web diagram, with approximate TLs, of the pelagic tropical EPO, is shown in Figure L-1. 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).

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 TL of the organisms taken by a fishery is a useful metric of ecosystem change and sustainability because it integrates an array of biological information about the components of the system. There has been increasing attention to analyzing the mean TL of fisheries catches since a study demonstrated that, according to FAO landings statistics, the mean TL of the fishes and invertebrates landed globally had declined between 1950 and 1994, which was hypothesized by the authors of that study to be detrimental to the ecosystems. Some ecosystems, however, have changed in the other direction, from lower to higher TL communities. Given the potential utility of this approach, mean TLs were estimated for a time series of annual catches and discards by species from 1993 to 2014 for three purse-seine fishing modes and the pole-and-line fishery in the EPO. The estimates were made by applying the TL values from the EPO ecosystem model (see Section 8), weighted by the catch data by fishery and year for all model groups from the IATTC tuna, bycatch, and discard data bases. The TLs from the ecosystem model were based on diet data for all species groups and mass balance among groups. The weighted mean TLs of the summed catches of all purse-seine and pole-and-line fisheries were similar and fairly constant from year to year

(Figure L-2: Average PS+LP). A slight downward trend for the unassociated sets, amounting to 0.05 TL over the 21-year period, resulted from increasing proportions of skipjack and decreasing proportions of yellowfin tuna in the catch, not from increasing catches of low trophic-level species. It is not, therefore, considered an ecologically-detrimental decline. In general, the TLs of the unassociated sets and the pole-and-line fishery were below average and those of the dolphin sets were above average for most years (Figure L-2). The TLs of the floating-object sets varied more than those of the other set types and fisheries, primarily due to the inter-annual variability in the amounts of bigeye and skipjack caught in those sets. The TLs of floating-object sets were positively related to the percentage of the total catch comprised of large bigeye and negatively related to the percentage of the catch comprised of skipjack.

Mean TLs were also estimated separately for the time series of retained and discarded catches of the purse-seine fishery each year from 1993 to 2014 (Figure L-3). The discarded catches were much less than the retained catches, and thus the TL patterns of the total (retained plus discarded) catches (Figure L-2) were determined primarily by the TLs of the retained catches (Figure L-3). The TLs of the discarded catches varied more year-to-year than those of the retained catches, due to the species diversity of the incidental catches. The considerable reduction in the mean TLs of the dolphin-set discards over the 21-year period (Figure L-3) was largely due to an increase in the proportions of discarded prey fishes (bullet and frigate tunas (*Auxis* spp.) and miscellaneous epipelagic fishes) and rays (Rajiformes, mostly manta rays, Mobulidae) with lower trophic levels. In 2014, the mean TLs of dolphin-set discards increased by about 0.2 TLs from those in 2013 primarily due to an increase in the proportions of discarded mesopelagic (TL 4.65) and spotted (TL 5.03) dolphins and a decrease in the proportions of discarded rays. For unassociated sets, marked inter-annual reductions in TL were due to increased bycatches of rays (TL 3.68), which feed on plankton and other small animals that occupy low TLs, a reduction in the catches of large sharks (TL 4.93-5.23), and an increase in prey fishes such as *Auxis* spp. (TL 3.86) in the bycatch. In 2014, the mean TLs of unassociated-set discards also increased by about 0.2 TLs from those in 2013, mostly due to an incease in the proportion of skipjack and a decrease in the proportion of discarded bullet and frigate tunas. For floating-object sets, the discards of bigeye were related to higher mean TLs of the discarded catches.

7. ECOLOGICAL RISK ASSESSMENT

Long-term ecological sustainability is a requirement of ecosystem-based fisheries management. Fishing directly impacts the populations of not only target species, but also the species incidentally caught as bycatch. The vulnerability to overfishing of many of the stocks incidentally caught in the EPO tuna fisheries is unknown, and biological and fisheries data are severely limited for most of those stocks. Many fisheries managers and scientists are turning to risk assessments to evaluate vulnerability to fishing. 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 a version of productivity and susceptibility analysis (PSA[7]), used to evaluate fisheries in other ocean regions in recent years, to estimate the vulnerability of data-poor, non-target species caught by the purse-seine fishery in the EPO. PSA considers a stock's vulnerability as a combination of its productivity and its susceptibility to the fishery. Stock productivity is the capacity of a stock to recover if it is depleted, and is a function of the species' life history traits. Stock susceptibility is the degree to which a fishery can negatively impact a stock, i.e. the propensity of a species to be captured by, and incur mortality from, a fishery. Productivity and susceptibility indices of a stock are determined by deriving a score ranging from 1 (low) to 3 (high) for a standardized set of attributes related to each index. The individual attribute scores are then averaged for each factor and graphically displayed on an x-y scatter plot. The scale of the x-axis on the scatter plot is reversed because species/stocks with a high productivity score and a low susceptibility score (i.e. at the

[7] Patrick, W.S., P. Spencer, J. Link, J. Cope, J. Field, D. Kobayashi, P. Lawson, T. Gedamke, E. Cortés, O. Ormseth, K. Bigelow, and W. Overholtz. 2010. Using productivity and susceptibility indices to assess the vulnerability of United States fish stocks to overfishing. Fish. Bull. U.S. 108: 305-322.

origin of the plots) are considered to be the least vulnerable. When scoring the attributes, the data quality associated with each attribute score is assessed, and the attributes are weighted by the data-quality score. Stocks that receive a low productivity score (p) and high susceptibility score (s) are considered to be at a high risk of becoming depleted, while stocks with a high productivity score and low susceptibility score are considered to be at low risk. Vulnerability scores (v) are calculated from the p and s scores as the Euclidean distance from the origin of the x-y scatter plot and the datum point:

$$v = \sqrt{(p-3)^2 + (s-1)^2}$$

To examine the utility of productivity and susceptibility indices for assessing the vulnerability of incidentally-caught fishes, mammals, and turtles to overfishing in the EPO, a preliminary evaluation of three purse-seine "fisheries" in the EPO was made in 2010, using 26 species that comprise the majority of the biomass removed by Class-6 purse-seine vessels (carrying capacity greater than 363 metric tons) during 2005-2009. Nine productivity and eight susceptibility attributes, based on established PSA methodology[4], were used in the preliminary PSA, and some were modified for greater consistency with data from the tuna fisheries in the EPO. Information corresponding to the productivity attributes for each species was compiled from a variety of published and unpublished sources and EPO fisheries data (*i.e.* not adopted from previous PSAs) to better approximate the distribution of life history characteristics observed in the species found in the EPO. Scoring thresholds for productivity attributes were derived by dividing the compiled data into equal thirds. Scoring criteria for the susceptibility attributes were taken from the example PSA[4] and modified where appropriate to better fit the EPO fisheries. However, problems arose when trying to compare susceptibility estimates for species across the different fisheries (Fishery Status Report 8). In 2012, the PSA was revised to include seven additional species, based on data from 2005-2011 (Fishery Status Report 10).

The staff of the Biology and Ecosystem Program had planned to finalize and publish the PSA analysis during 2014, but the retirement of one staff member and budget constraints have prevented the work from being finished. In 2015 a vacancy announcement for an Ecosystem Specialist was posted. The selected appointee, a senior scientist and recognized expert in developing ERAs, will join the IATTC staff in August of 2016. He will lead the ERA effort for the EPO. Substantial progress on this work will be made during the latter half of 2016 and a report on the advancement will be available at the 2017 SAC meeting. Meanwhile, in response to requests made by SAC participants at the 2015 meeting, an effort was made by the IATTC staff to describe available catch data for the purposes of including gear types in addition to large purse seiners, in an ERA (described in SAC-07-INF C(d)). This effort will assist the new appointee in choosing the appropriate type of ERA for the EPO fisheries. Here we review the modifications made to the PSA presented at the 2015 SAC meeting.

Three modifications of the analysis were made to the PSA for the SAC meeting in May 2015: 1) the procedures for determining which species to include in the analysis were modified; 2) the susceptibility values for each fishery were combined to produce one overall susceptibility value for each species; and 3) the use of bycatch and catch information in the formulation of s was modified. The list of productivity attributes remains unchanged (Table L-1) while the list of susceptibility attributes has been revised due to this 3rd modification (Table L-2). These three modifications are described briefly below. For the remainder of this section, the term "catch" will be used to refer to bycatch for non-tuna species and catch for tuna species.

The first modification was to establish a two-step procedure to identify and exclude rare species, based on the biomass caught per fishery. However, as a precautionary measure, rare species classified as "vulnerable," "endangered," or "near threatened" on the IUCN Red List were retained, or are now included, in the analysis. Currently, the PSA includes 32 species (Table L-3a); an additional eight sensitive species, two rays and six sharks, will be included in the future.

The second modification was to combine the susceptibility values for each species across fisheries to produce one overall species-specific purse-seine susceptibility. A preliminary combined susceptibility score for a species, s_j^1, was calculated as the weighted sum of the individual fishery susceptibility values for that species (Table L-3a), with weights equal to the proportion of sets in each fishery:

$$s_j^1 = \sum_k s_{jk} p_k$$

where

s_j^1 is the combined susceptibility for species j

s_{jk} is the susceptibility for species j in set type k, computed using only the attributes in Table L-2. s_{jk} ranges from 1 (lowest) to 3 (highest). For a species with catches < 5% in set type k, $s_{jk} \equiv 1$, unless a s_{jk} was computed for one of the previous PSAs (Fishery Status Reports 8 and 10), in which case this s_{jk} was used; otherwise it was assumed that if catches were less than 5% in a fishery, the species was only minimally susceptible to that fishery. A previous PSA (Fishery Status Report 10) used catch trend information as an additional attribute to calculate the s_{jk}, however, the catch trend information was removed from the s_{jk} here because, following the established PSA[4] methodology, the other susceptibility attributes are time-invariant (but see below).

$p_k = \left(\frac{N_k}{\sum_k N_k}\right)$ and N_k is the total number of sets (class-6) of set type k in 2013

s_j^1 takes into account fishing effort by set type, even for set types with little or no catch of a species. A preliminary PSA plot using s_j^1 is shown in Figure L-4a, and the values of s_{jk}, s_j^1 and v_1 are shown in Table L-3a. A concern with regard to s_j^1 for some species is that the variation in the s_{jk} computed from the attributes in Table L-2 does not correlate well with differences observed among catch rates by set type, suggesting the attributes in Table L-2 do not capture the full susceptibility of species j; in general it is assumed that higher catch rates should reflect higher overall susceptibility. In addition, the s_{jk} do not account for long-term trends.

The third modification, the use of catch information in the formulation of s, was made to try to account for differences in observed catch rates among set types, by species, and to account for long-term trends in abundance. Two preliminary alternate susceptibility formulations were computed as "proof of concept" for these ideas. The first, s_j^2, modifies s_j^1 to take into consideration current catch rates, which are assumed to be an alternate proxy for susceptibility and to reflect the actual integrated effects of the susceptibility attributes in Table L-2:

$$s_j^2 = \sum_k s_{jk}^* p_k$$

where

s_j^2 is the combined susceptibility for species j, adjusted for recent catch rates

s_{jk}^* is the average of s_{jk} and of the catch rate susceptibility: $s_{jk}^* = \frac{1}{2}\left(s_{jk} + s_{cps\_jk}\right)$

s_{jk} is as defined for s_j^1

s_{cps_jk} is the catch rate susceptibility and takes a value of 1, 2 or 3, assigned as follows. If the species is not a target tuna species, catch-per set, in number of animals per set, is used to assign a value to s_{cps_jk}:

$$\begin{cases} 1 & \text{for} \quad \mathrm{cps}_{jk} = 0 \\ 2 & \text{for } 0 < \mathrm{cps}_{jk} < 1.0 \\ 3 & \text{for } \mathrm{cps}_{jk} \geq 1.0 \end{cases}$$

If the species is a target tuna species, then the following values are assigned to s_{cps_jk}:

	Dolphin sets	Unassociated sets	Floating-object sets
Bigeye	1	2	3
Yellowfin	3	3	3
Skipjack	2	3	3

$cps_{\_jk}$ is the catch-per-set for species *j* in set type *k* (= class-6 catch (in numbers of animals) divided by number of class-6 sets), for the most recent year (2013). Catch-per-set was used instead of total catch in order to control for differences in effort among set types.

p_k is as defined for s_j^1

A preliminary PSA plot using s_j^2 is shown in Figure L-4b and the values of s_{jk}^*, s_j^2 and v_2 are shown in Table L-3b. s_j^2 could be affected by differences in abundance among species because catch-per-set is affected by abundance. Ranking cps_{jk} may help to minimize this problem. The present rules for ranking cps_{jk} for non-target tuna species were based on the idea that no catch equates to minimal susceptibility, catch that increases at a rate of less than one animal per set equates to moderate susceptibility, and catch that increases at an effort rate of one or more animals per set equates to high susceptibility. However, these rules are a "proof of concept" and could be modified.

The second alternate susceptibility formulation, computed for species other than target tunas and dolphins, s_j^3, adjusts for long-term trends:

$$s_j^3 = \sum_k s_{jk}^{**} p_k$$

where

s_j^3 is the combined susceptibility for species *j*, adjusted for long-term trends

s_{jk}^{**} is the average of s_{jk} and the trend susceptibility: $s_{jk}^{**} = \frac{1}{2}\left(s_{jk} + s_{trend\_jk}\right)$;

s_{jk} is as defined for s_j^1

S_{trend_jk} is the trend susceptibility for species *j* in set type *k*, obtained as follows:

$$\begin{cases} 1.0 & \text{if species } j \text{ does not occur in set type } k \\ 1.5 & \text{if } trend_{jk} \text{ is not significant or is significant but increasing} \\ 3.0 & \text{if } trend_{jk} \text{ is significant and decreasing} \end{cases}$$

$trend_{jk}$ is the slope of the regression of $cps_{jk,y}$ and year *y*, from the start of the data collection (which may vary by species). $trend_{jk}$ was computed for species for which full assessments (or management indicators) do not exist and for which the fishery data have not been determined to be unsuitable for trend estimation; *i.e.*, for species other than the three target tuna species and the dolphin species (but see below) . A significant trend was any slope with a *p*-value < 0.05.

$cps_{,jk,y}$ is the catch-per-set of species *j* of set type *k* in year *y*

A preliminary PSA plot using s_j^3 for species other than the three target tuna species and dolphin species is shown in Figure L-4c, and the values of s_{jk}^{**} , s_j^3 and v_3 are shown in Table L-3c. For the future, s_j^3 could be expanded to include the three target tuna species by estimating trends from spawning biomass, and could be expanded to dolphin species by using trends estimated from historical line-transect abundance estimates. A concern with regards to s_j^3 is that trends estimated from catch-per-set may not reliably track changes in abundance (as was shown for dolphins in Document SAC-05-11d).

The three susceptibility measures, s_j^1, s_j^2, and s_j^3, are considered preliminary and represent "proof of concept" ideas to illustrate several options for computing susceptibility tailored to the EPO purse-seine fishery. These measures along with the available catch data for non-target species by gear type will be reviewed with the new Ecosystem Specialist in August 2016. This work will help to facilitate future improvements to the existing PSA in the EPO and/or assist in the development of a new ERA.

8. ECOSYSTEM MODELING

It is clear that the different components of an ecosystem interact. Ecosystem-based fisheries management is facilitated through the development of multi-species ecosystem models that represent ecological interactions among species or guilds. Our understanding of the complex maze of connections in open-ocean ecosystems is at an early stage, and, consequently, the current ecosystem models are most useful as descriptive devices for exploring the effects of a mix of hypotheses and established connections among the ecosystem components. Ecosystem models must be compromises between simplistic representations on the one hand and unmanageable complexity on the other.

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 sensitive species (*e.g.* sea turtles). Some taxa are further separated into size categories (*e.g.* large and small marlins). The model has finer taxonomic resolution at the upper trophic levels, but most of the system's biomass is contained in the middle and lower trophic levels. Fisheries landings and discards were estimated for 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 adequately described by the model.

Most of the information describing inter-specific interactions in the model came from a joint IATTC-NMFS project, which included studies of the food habits of co-occurring yellowfin, skipjack, and bigeye tuna, dolphins, pelagic sharks, billfishes, dorado, wahoo, rainbow runner, and others. The impetus of the project was to contribute to the understanding of the tuna-dolphin association, and a community-level sampling design was adopted.

The ecosystem model has been used to evaluate the possible effects of variability in bottom-up forcing by the environment on the middle and upper trophic levels of the pelagic ecosystem. Predetermined time series of producer biomasses were put into the model as proxies for changes in primary production that have been documented during El Niño and La Niña events, and the dynamics of the remaining components of the ecosystem were simulated. The model was also used to evaluate the relative contributions of fishing and the environment in shaping ecosystem structure in the tropical pelagic EPO. This was done by using the model to predict which components of the ecosystem might be susceptible to top-down effects of fishing, given the apparent importance of environmental variability in structuring the ecosystem. In general, animals with relatively low turnover rates were influenced more by fishing than by the environment, and animals with relatively high turnover rates more by the environment than by fishing.

The structure of marine ecosystems is generally thought to be controlled by one of two mechanisms: 'bottom-up' control (resource-driven) where the dynamics of primary producers (e.g. phytoplankton) controls the production and biomass at higher trophic levels, or 'top-down' control (consumer-driven) where predation by high trophic-level predators controls the abundance and composition of prey at lower trophic levels. In relatively recent years, 'wasp-waist' control of marine ecosystems has also been recognized. 'Wasp-waist' control is a combination of bottom-up and top-down forcing by a small number of abundant, highly productive, and short-lived species at intermediate trophic levels (*e.g.* sardines and anchovies) that form a narrow 'waist' through which energy flow in the system is regulated. These species exert top-down predatory control of energy flows from zooplankton, but also have bottom-up control by providing energy for high trophic-level predators. It has been assumed that wasp-waist control occurs primarily in highly productive and species-poor coastal systems (e.g. upwelling regions), which can be highly unstable and undergo rapid natural regime shifts in short periods of time. The ecosystem model for the tropical EPO was used in conjunction with a model for a region off the east coast of

Australia where tunas and billfishes are caught to examine possible forcing dynamics of these systems. These two large species-rich pelagic ecosystems also showed wasp-waist-like structure, in that short-lived and fast-growing cephalopods and fishes in intermediate trophic levels comprise the vast majority of the biomass. The largest forcing effects were seen when altering the biomasses of mid trophic-level epipelagic and mesopelagic fishes in the models, whereby dramatic trophic cascades occurred both upward and downward in the system. These tropical pelagic ecosystems appear to possess a complex structure whereby several waist groups and alternate trophic pathways from primary producers to apex predators can cause unpredictable effects when the biomasses of particular functional groups are altered. Such models highlight the possible structuring mechanisms in pelagic systems, which have implications for fisheries that exploit these groups, such as squid fisheries, as well as for fisheries of top predators such as tunas and billfishes that prey upon wasp-waist species.

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

Both the IATTC convention and the AIDCP have objectives that address the incorporation of ecosystem considerations into the management of the tuna fisheries in the EPO. Actions taken in the past include:

9.1. Dolphins

a. For many years, the impact of the fishery on the dolphin populations has been assessed, and programs to reduce or eliminate that impact have met with considerable success.

b. The incidental mortalities of all stocks of dolphins have been limited to levels that are insignificant relative to stock sizes.

9.2. Sea turtles

a. A data base on all sea turtle sightings, captures, and mortalities reported by observers has been compiled.

b. In June 2003 the IATTC adopted a Recommendation on Sea Turtles, which contemplates "the development of a three-year program that could include mitigation of sea turtle bycatch, biological research on sea turtles, improvement of fishing gears, industry education and other techniques to improve sea turtle conservation." In January 2004, the Working Group on Bycatch drew up a detailed program that includes all these elements, and urges all nations with vessels fishing for tunas in the EPO to provide the IATTC with information on interactions with sea turtles in the EPO, including both incidental and direct catches and other impacts on sea turtle populations. Resolution C-04-07 on a three-year program to mitigate the impact of tuna fishing on sea turtles was adopted by the IATTC in June 2004; it includes requirements for data collection, mitigation measures, industry education, capacity building, and reporting.

c. Resolution C-04-05 REV 2, adopted by the IATTC in June 2006, contains provisions on releasing and handling of sea turtles captured in purse seines. The resolution also prohibits vessels from disposing of plastic containers and other debris at sea, and instructs the Director to study and formulate recommendations regarding the design of FADs, particularly the use of netting attached underwater to FADs.

d. Resolution C-07-03, adopted by the IATTC in June 2007, contains provisions on implementing observer programs for fisheries under the purview of the Commission that may have impacts on sea turtles and are not currently being observed. The resolution requires fishermen to foster recovery and resuscitation of comatose or inactive hard-shell sea turtles before returning them to the water. CPCs with purse-seine and longline vessels fishing for species covered by the IATTC Convention in the EPO are directed to avoid encounters with sea turtles, to reduce mortalities using a variety of techniques, and to conduct research on modifications of FAD designs and longline gear and fishing practices.

e. In response to a request made by the Subsecretaría de Recursos Pesqueros of Ecuador, a program was established by the World Wildlife Fund, the IATTC, and the government of the United States to mitigate the incidental capture and reduce the mortality of sea turtles due to longline fishing. A key element of this program is the comparison of catch rates of tunas, billfishes, sharks, and dorado caught with J hooks to the catch rates using circle hooks. Circle hooks do not hook as many turtles as the J hooks, which are traditionally used in the longline fishery, and the chance of serious injury to the sea turtles that bite the circle hooks is reduced because the hooks are wider and they tend to hook the lower jaw, rather than the more dangerous deep hookings in the esophagus and other areas, which are more common with the J hooks. Improved procedures and instruments to release hooked and entangled sea turtles have also been disseminated to the longline fleets of the region.

By the end of 2008 the hook-exchange and observer program, which began in Ecuador in 2003, was active in Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Mexico, Nicaragua, Panama, and Peru and under development in Chile, with workshops taking place in many ports. The program in Ecuador is being carried out in partnership with the government and the Overseas Fishery Cooperation Foundation of Japan, while those in other countries are currently funded by U.S. agencies. Initial results show that, in the fisheries that target tunas, billfishes, and sharks, there was a significant reduction in the hooking rates of sea turtles with the circle hooks, and fewer hooks lodged in the esophagus or other areas detrimental to the turtles. The catch rates of the target species are, in general, similar to the catch rates with the J-hooks. An experiment was also carried out in the dorado fishery using smaller circle hooks. There were reductions in turtle hooking rates, but the reductions were not as great as for the fisheries that target tunas, billfishes, and sharks. In addition, workshops and presentations were conducted by IATTC staff members and others in all of the countries participating in the program.

9.3. Seabirds

a. Recommendation C-10-02 adopted by the IATTC in October 2010, reaffirmed the importance that IATTC Parties and cooperating non-Parties, fishing entities, and regional economic integration organizations implement, if appropriate, the FAO International Plan of Action for Reducing the Incidental Catch of Seabirds in Longline Fisheries ("IPOA-Seabirds"). The governments listed on the Recommendation agreed to report to the IATTC on their implementation of the IPOA-Seabirds, including, as appropriate, the status of their National Plans of Action for reducing incidental catches of seabirds in longline fisheries. It was also agreed that the governments would require their longline vessels that fish for species covered by the IATTC in specific areas (specified in Annex 1 of the Recommendation) to use at least two of a set of eight mitigation measures listed. In addition, members and cooperating non-members of the IATTC were encouraged to establish national programs to place observers aboard longline vessels flying their flags or fishing in their waters, and to adopt measures aimed at ensuring that seabirds captured alive during longline fishing operations are released alive and in the best condition possible.

b. Resolution C-11-02, adopted by the IATTC in July 2011, reaffirmed the importance of implementing the IPOA-Seabirds (see 9.3.a) and provides that Members and cooperating non-Members (CPCs) shall require their longline vessels of more than 20 meters length overall and that fish for species covered by the IATTC in the EPO to use at least two of the specified mitigation measures, and establishes minimum technical standards for the measures. CPCs are encouraged to work, jointly and individually, to undertake research to further develop and refine methods for mitigating seabird bycatch, and to submit to the IATTC any information derived from such efforts. Also, CPCs are encouraged to establish national programs to place observers aboard longline vessels flying their flags or fishing in their waters, for the purpose of, *inter alia*, gathering information on the interactions of seabirds with the longline fisheries.

9.4. Other species

a. In June 2000, the IATTC adopted a resolution on live release of sharks, rays, billfishes, dorado, wahoo, and other non-target species.

b. Resolution C-04-05, adopted by the IATTC in June 2006, instructs the Director to seek funds for reduction of incidental mortality of juvenile tunas, for developing techniques and equipment to facilitate release of billfishes, sharks, and rays from the deck or the net, and to carry out experiments to estimate the survival rates of released billfishes, sharks, and rays.

c. Resolution C-11-10, adopted by the IATTC in July 2011, prohibits retaining onboard, transhipping, landing, storing, selling, or offering for sale any part or whole carcass of oceanic whitetip sharks in the fisheries covered by the Antigua Convention, and to promptly release unharmed, to the extent practicable, oceanic whitetip sharks when brought alongside the vessel.

d. Resolution C-15-04, adopted by the IATTC in July 2015, prohibits retaining onboard, transhipping, landing, storing, selling, or offering for sale any part or whole carcass of manta rays (Mobulidae) (which includes *Manta birostris* and *Mobula* spp.) and requires vessels to release all mobulid rays alive wherever possible. The requirements set forth in the resolution do not apply to small-scale and artisanal fisheries exclusively for domestic consumption. The number of discards and releases of mobulid rays and the status (dead or alive) will be reported to the IATTC via the observer programs.

9.5. Fish-aggregating devices (FADs)

a. Resolution C-15-03, adopted by the IATTC in July 2015, requires all purse-seine vessels, when fishing on FADs in the IATTC Convention Area, to collect and report FAD information including an inventory of the FADs present on the vessel, specifying, for each FAD, identification, type, and design characteristics. In addition to this information, for each FAD activity, the position, date, hour, type of activity, and results of any set in terms of catch and by-catch must be reported. Data may be collected through a dedicated logbook, modifications to regional logsheets, or other domestic reporting procedures. The IATTC staff will analyze the data collected to identify any additional elements for data collection and reporting formats necessary to evaluate the effects of FAD use on the ecosystem, and provide initial recommendations for the management of FADs in the EPO. Recommendations shall include methods for limiting the capture of small bigeye and yellowfin tuna associated with fishing on FADs. CPCs shall require owners and operators of their applicable flagged purse-seine fishing vessels to identify all FADs deployed or modified by such vessels in accordance with a Commission identification scheme. To reduce entanglement of sharks, sea turtles, or any other species, principles for the design and deployment of FADs are specified. Setting a purse seine on tuna associated with a live whale shark is prohibited, if the animal is sighted prior to the set. A working group on FADs is established and its objectives are to collect and compile information on FADs, review data collection requirements, compile information regarding developments in other tuna-RFMOs on FADs, compile information regarding developments on the latest scientific information on FADs, including information on non-entangling FADs, and prepare a preliminary report for the SAC.

9.6. All species

a. Data on the bycatches of large purse-seine vessels are being collected, and governments are urged to provide bycatch information for other vessels.

b. Data on the spatial distributions of the bycatches and the bycatch/catch ratios have been collected for analyses of policy options to reduce bycatches.

c. Information to evaluate measures to reduce the bycatches, such as closures, effort limits, *etc*., has been collected.

d. Assessments of habitat preferences and the effect of environmental changes have been made.

e. Requirements have been adopted for the CPCs to ensure that, from 1 January 2013, at least 5% of the fishing effort made by its longline vessels greater than 20 m length overall carry a scientific observer.

10. FUTURE DEVELOPMENTS

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

An array of measures has been proposed to study changes in ecosystem properties. This could include studies of average trophic level, size spectra, dominance, diversity, *etc*., to describe the ecosystem in an aggregate way.

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 our 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.

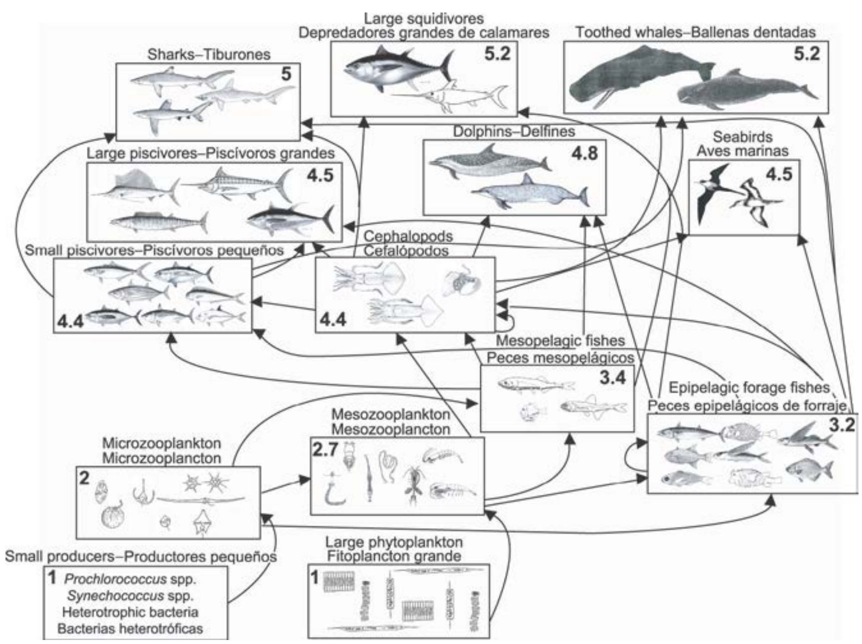

FIGURE L-1. Simplified food-web diagram of the pelagic ecosystem in the tropical EPO. The numbers inside the boxes indicate the approximate trophic level of each group.
FIGURA L-1. Diagrama simplificado de la red trófica del ecosistema pelágico en el OPO tropical. Los números en los recuadros indican el nivel trófico aproximado de cada grupo.

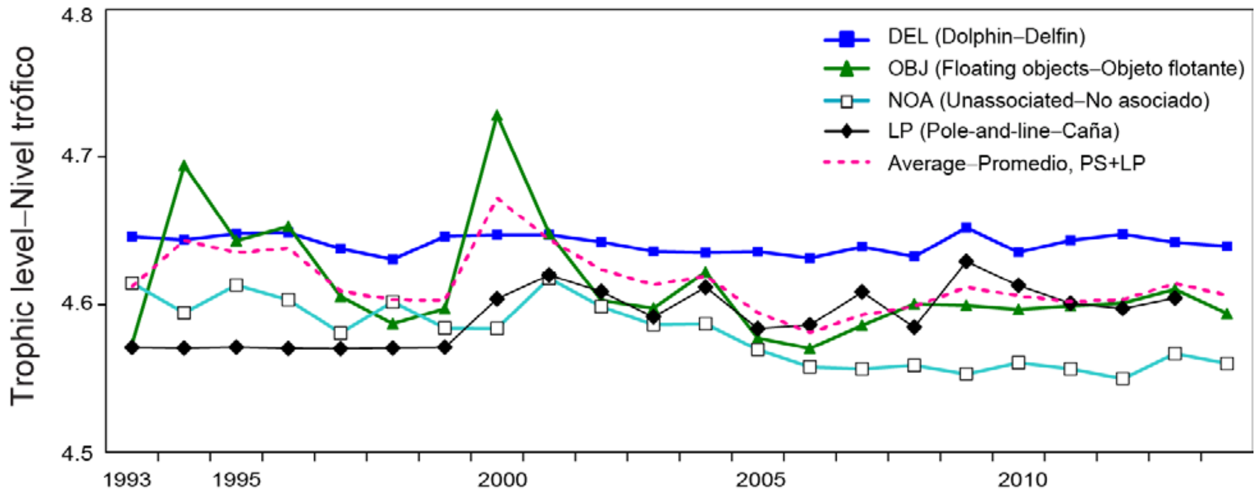

FIGURE L-2. Yearly mean trophic level estimates of the catches (retained and discarded) by the purse-seine and pole-and-line fisheries in the tropical EPO, 1993-2014. Pole-and-line catches were not reported separately in 2014, instead they were combined with other gears.

FIGURA L-2. Estimaciones anuales del nivel trófico de las capturas (retenidas y descartadas) de las pesquerías cerquera y cañera en el OPO tropical, 1993-2014. Las capturas cañeras no fueron reportadas por separado en 2014, sino que fueron combinadas con otras artes.

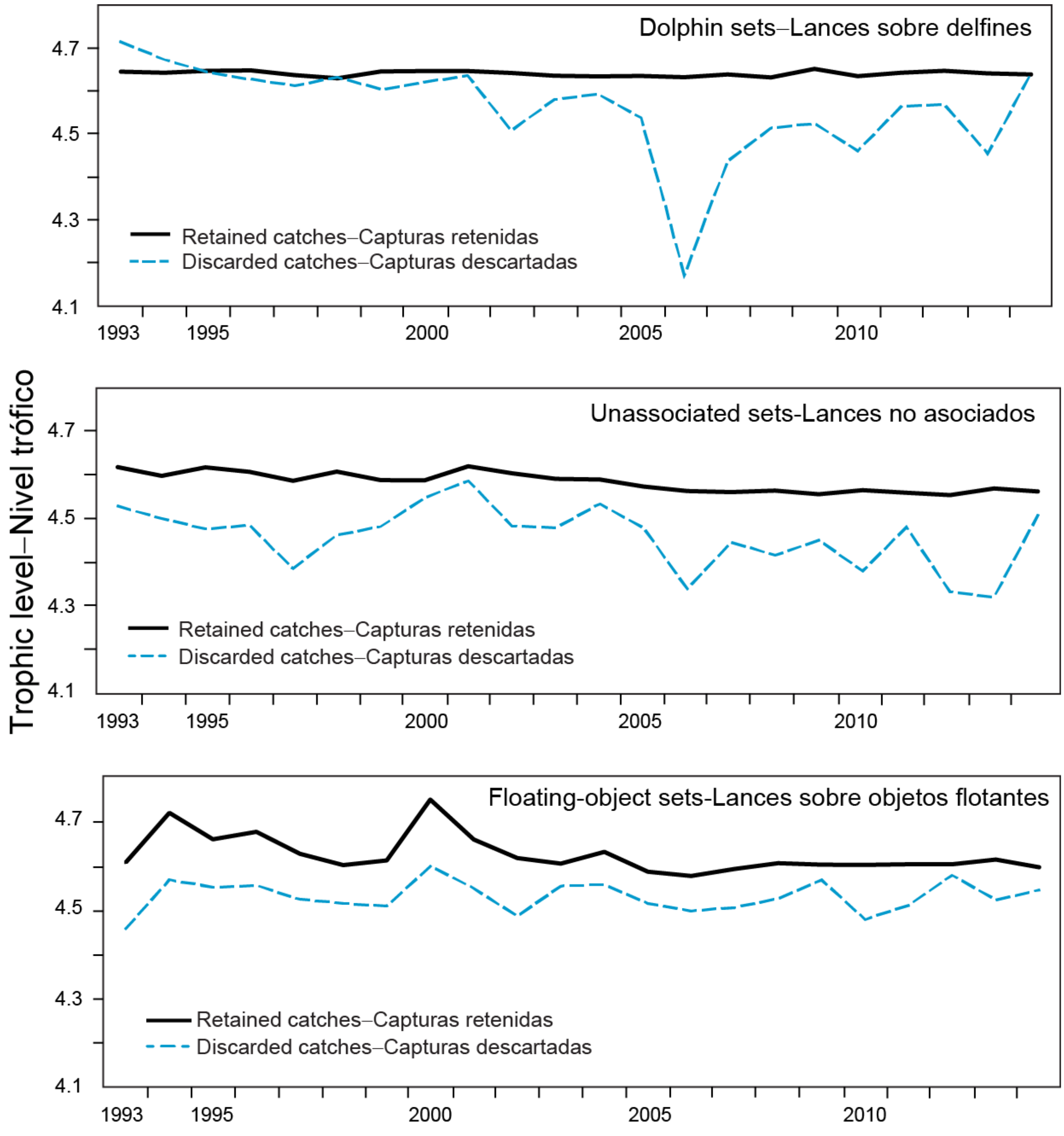

FIGURE L-3. Trophic level estimates of the retained catches and discarded catches by purse-seine fisheries in the tropical EPO, 1993-2014.

FIGURA L-3. Estimaciones del nivel trófico de las capturas retenidas y descartadas por las pesquerías cerqueras en el OPO tropical, 1993-2014.

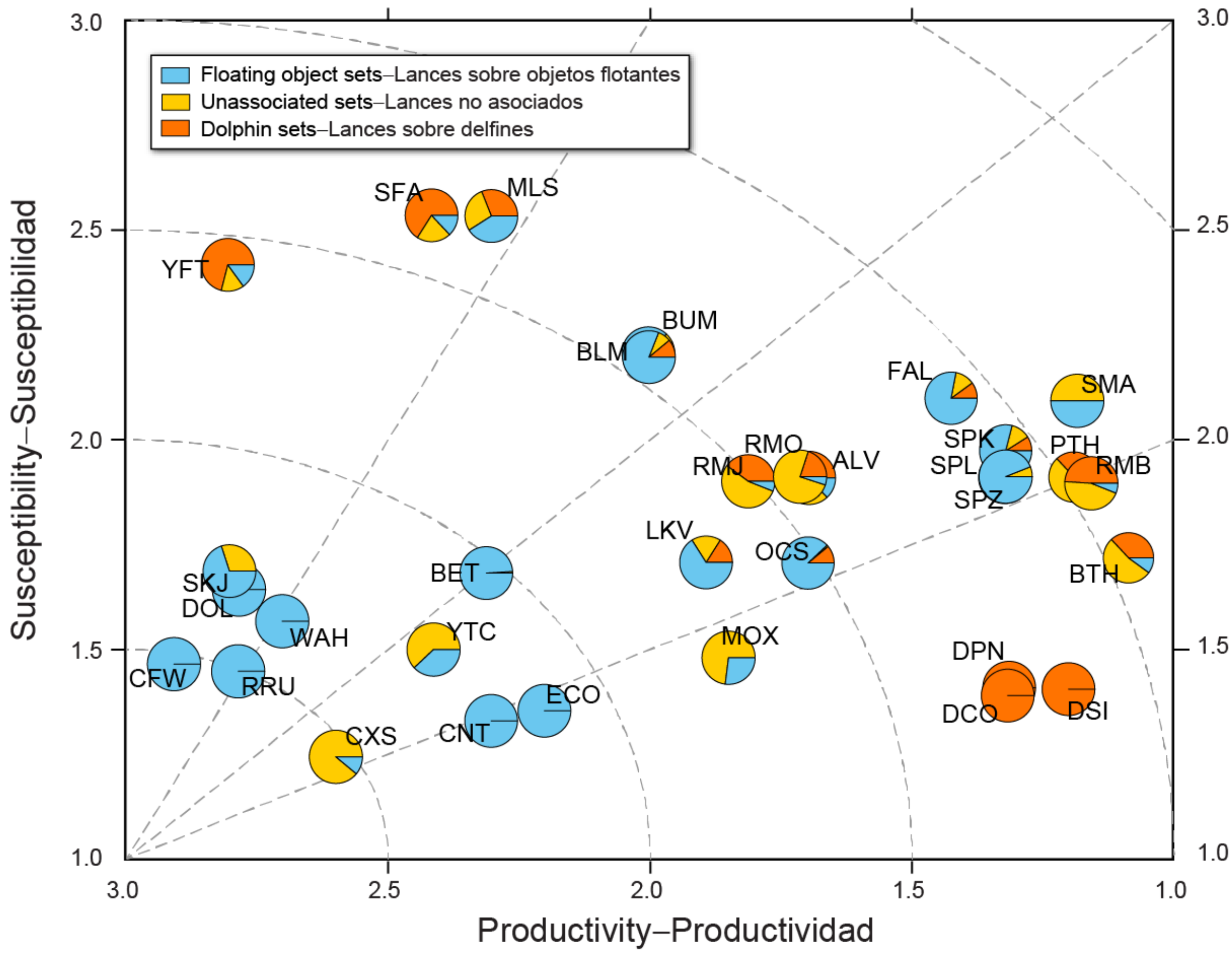

FIGURE L-4a. Productivity and susceptibility x-y plot for target and bycatch species caught by the purse-seine fishery of the EPO during 2005-2013, based on s_j^1. The pie charts show the proportion of bycatch (non-tuna species) or proportion of catch (tuna species), by set type, for those set types with bycatch or catch ≥ 5% for the species. The 3-alpha species codes next to each pie chart are defined in Table L-3a.

FIGURA L-4a. Gráfica x-y de productividad y susceptibilidad de especies objetivo y de captura incidental capturadas por la pesquería de cerco del OPO durante 2005-2013, basada en s_j^1. Las gráficas de sectores ilustran la proporción de captura incidental (especies aparte de los atunes) o proporción de la captura (especies de atunes), por tipo de lance, en aquellos tipos de lance con captura incidental o captura ≥ 5% de esa especie. En la Tabla L-3a se definen los códigos de tres letras al lado de cada gráfica de sectores.

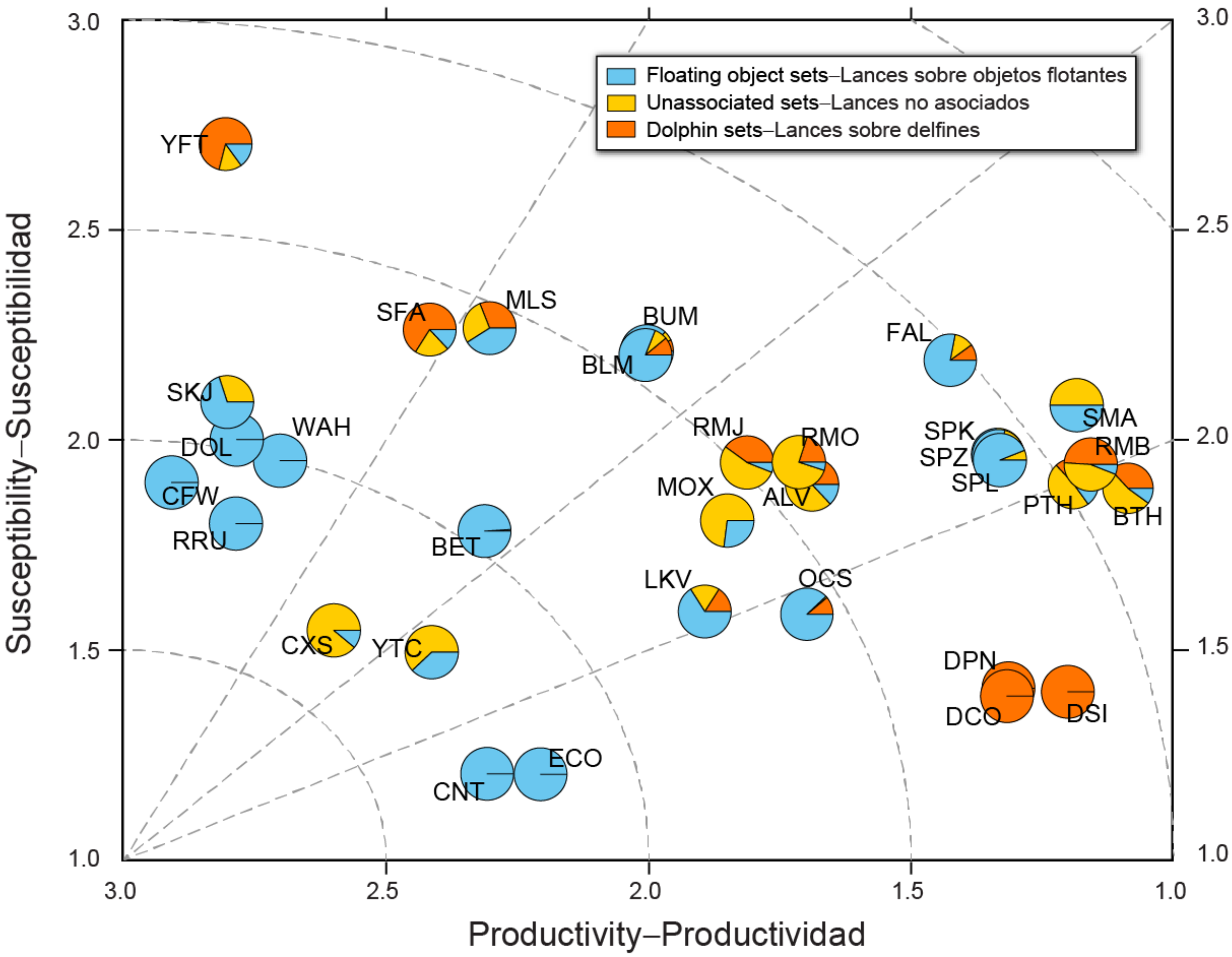

FIGURE L-4b. Productivity and susceptibility x-y plot for target and bycatch species caught by the purse-seine fishery of the EPO during 2005-2013, based on s_j^2. The pie charts show the proportion of bycatch (non-tuna species) or proportion of catch (tuna species), by set type, for those set types with bycatch or catch ≥ 5% for the species. The 3-alpha species codes next to each pie chart are defined in Table L-3b.

FIGURA L-4b. Gráfica x-y de productividad y susceptibilidad de especies objetivo y de captura incidental capturadas por la pesquería de cerco del OPO durante 2005-2013, basada en s_j^2. Las gráficas de sectores ilustran la proporción de captura incidental (especies aparte de los atunes) o proporción de la captura (especies de atunes), por tipo de lance, en aquellos tipos de lance con captura incidental o captura ≥ 5% de esa especie. En la Tabla L-3b se definen los códigos de tres letras al lado de cada gráfica de sectores.

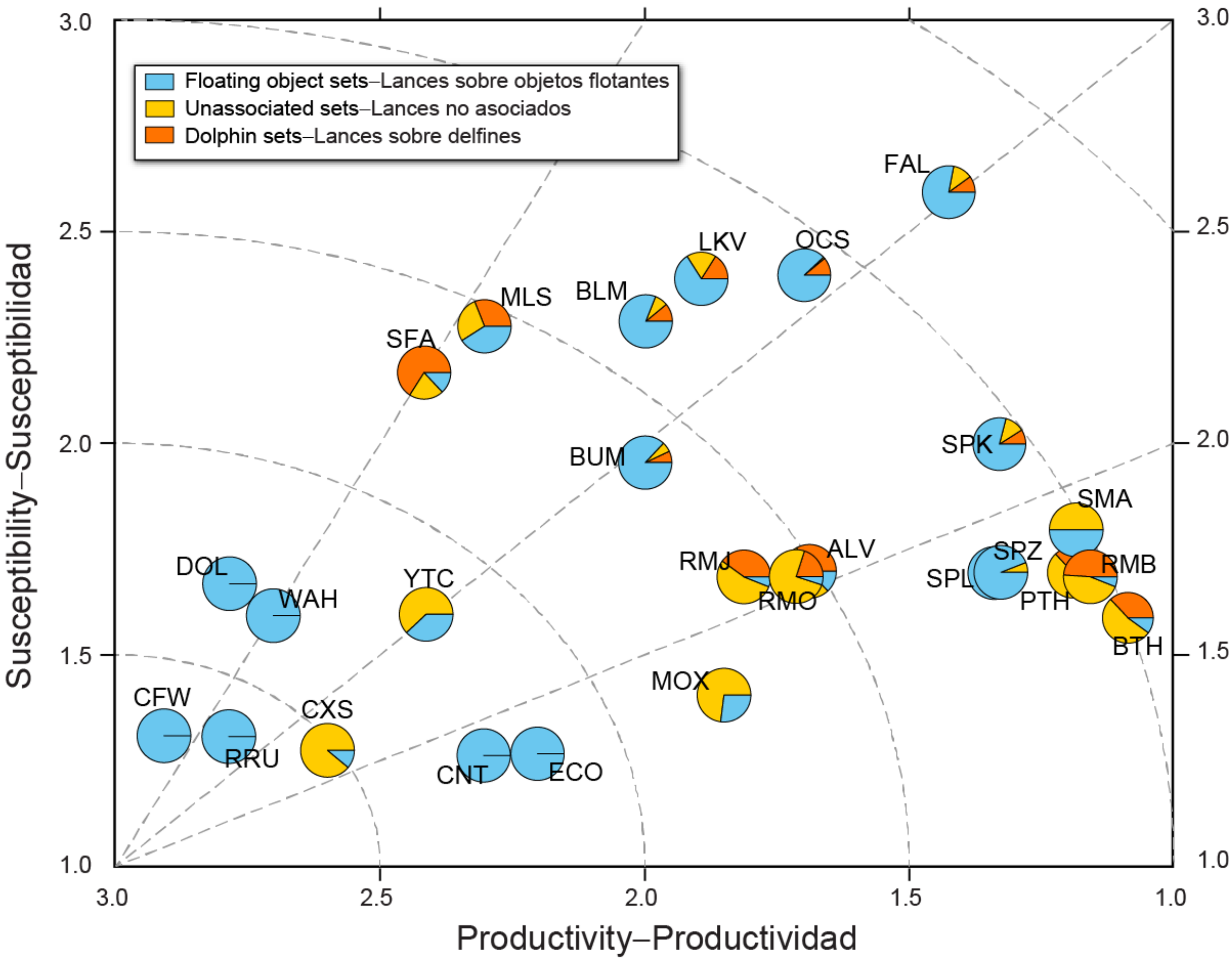

FIGURE L-4c. Productivity and susceptibility x-y plot for bycatch species caught by the purse-seine fishery of the EPO during 2005-2013, based on s_j^3. s_j^3 was not computed for species for which full assessments (or management indicators) exist or for which the fishery data have been determined to be unsuitable for trend estimation; *i.e.*, for the three target tuna species and the dolphin species. The pie charts show the proportion of bycatch (non-tuna species), by set type, for those set types with bycatch ≥ 5% for the species. The 3-alpha species codes next to each pie chart are defined in Table L-3c.

FIGURA L-4c. Gráfica x-y de productividad y susceptibilidad de especies objetivo y de captura incidental capturadas por la pesquería de cerco del OPO durante 2005-2013, basada en s_j^3. No se computó s_j^3 para especies para las cuales existen evaluaciones completas (o indicadores de ordenación), o para las cuales se determinó que los datos de pesca no son adecuados para la estimación de tendencias; es decir, para las tres especies de atunes objetivo y las especies de delfines. Las gráficas de sectores ilustran la proporción de captura incidental (especies aparte de los atunes), por tipo de lance, en aquellos tipos de lance con captura incidental ≥ 5% de esa especie. En la Tabla L-3c se definen los códigos de tres letras al lado de cada gráfica de sectores.

TABLE L-1. Productivity attributes and scoring thresholds used in the IATTC PSA.
TABLA L-1. Atributos de productividad y umbrales de puntuación usados en el APS de la CIAT.

	Ranking – Clasificación		
Productivity attribute **Atributo de productividad**	**Low –** **Bajo (1)**	**Moderate –** **Moderado (2)**	**High –** **Alto (3)**
Intrinsic rate of population growth (*r*) Tasa intrínseca de crecimiento de la población (*r*)	≤ 0.1	> 0.1, ≤ 1.3	>1.3
Maximum age (years) Edad máxima (años)	≥ 20	> 11, < 20	≤ 11
Maximum size (cm) Talla máxima (cm)	> 350	> 200, ≤ 350	≤ 200
von Bertalanffy growth coefficient (*k*) Coeficiente de crecimiento de von Bertalanffy (*k*)	< 0.095	0.095 – 0.21	> 0.21
Natural mortality (*M*) Mortalidad natural (*M*)	< 0.25	0.25 – 0.48	> 0.48
Fecundity (measured) Fecundidad (medida)	< 10	10 – 200,000	> 200,000
Breeding strategy Estrategia de reproducción	≥ 4	1 to-a 3	0
Age at maturity (years) Edad de madurez (años)	≥ 7.0	≥ 2.7, < 7.0	< 2.7
Mean trophic level Nivel trófico medio	> 5.1	4.5 – 5.1	< 4.5

TABLE L-2. Susceptibility attributes and scoring thresholds used in the IATTC PSA.

Susceptibility attribute	Ranking		
	Low (1)	**Moderate (2)**	**High (3)**
Management strategy	Management and proactive accountability measures in place	Stocks specifically named in conservation resolutions; closely monitored	No management measures; stocks closely monitored
Areal overlap - geographical concentration index	Greatest bycatches outside areas with the most sets and stock not concentrated (or not rare)	Greatest bycatches outside areas with the most sets and stock concentrated (or rare), OR Greatest bycatches in areas with the most sets and stock not concentrated (or not rare)	Greatest bycatches in areas with the most sets and stock concentrated (or rare)
Vertical overlap with gear	< 25% of stock occurs at the depths fished	Between 25% and 50% of the stock occurs at the depths fished	> 50% of the stock occurs in the depths fished
Seasonal migrations	Seasonal migrations decrease overlap with the fishery	Seasonal migrations do not substantially affect the overlap with the fishery	Seasonal migrations increase overlap with the fishery
Schooling/Aggregation and other behavioral responses to gear	Behavioral responses decrease the catchability of the gear	Behavioral responses do not substantially affect the catchability of the gear	Behavioral responses increase the catchability of the gear
Potential survival after capture and release under current fishing practices	Probability of survival > 67%	33% < probability of survival ≤ 67%	Probability of survival < 33%
Desirability/value of catch (percent retention)	Stock is not highly valued or desired by the fishery (< 33% retention)	Stock is moderately valued or desired by the fishery (33-66% retention)	Stock is highly valued or desired by the fishery (> 66% retention)

TABLE L-3a. Preliminary productivity and susceptibility scores used to compute the overall vulnerability measure v_1. Dolphin=DEL, unassociated=NOA, and floating-object sets=OBJ. Individual susceptibility scores, $s_{jk,}$ are shown for each fishery and as a weighted combination of the individual fishery values, s_j^1; see text for details. Productivity, p, and vulnerability, v_1, scores are provided. These values are preliminary as this year's PSA is considered a proof of concept.

					s_{jk} scores by fishery					
GROUP	**Scientific name**	**Common name**	**3-alpha species code**	**IUCN***	**DEL**	**NOA**	**OBJ**	p	s_j^1	v_1
Tunas	*Thunnus albacares*	Yellowfin tuna	YFT	NT	2.38	2.38	2.38	2.78	2.38	1.40
	Thunnus obesus	Bigeye tuna	BET	VU	1.00	2.23	2.38	2.33	1.70	0.97
	Katsuwonus pelamis	Skipjack tuna	SKJ	LC	1.00	2.38	2.38	2.78	1.73	0.76
Billfishes	*Makaira nigricans*	Blue marlin	BUM	VU	2.23	2.23	2.69	2.00	2.39	1.71
	Istiompax indica	Black marlin	BLM	DD	2.23	2.23	2.69	2.00	2.39	1.71
	Kajikia audax	Striped marlin	MLS	NT	2.54	2.54	2.54	2.33	2.54	1.68
	Istiophorus platypterus	Indo-Pacific sailfish	SFA	LC	2.54	2.54	2.54	2.44	2.54	1.64
Dolphins	*Stenella longirostris*	Unidentified spinner dolphin	DSI	DD	1.77	1.00	1.00	1.22	1.36	1.82
	Stenella attenuata	Unidentified spotted dolphin	DPN	LC	1.77	1.00	1.00	1.33	1.36	1.71
	Delphinus delphis	Common dolphin	DCO	LC	1.62	1.00	1.00	1.33	1.29	1.70
Large fishes	*Coryphaena hippurus*	Common dolphinfish	DOL	LC	1.00	2.00	2.31	2.78	1.64	0.68
	Coryphaena equiselis	Pompano dolphinfish	CFW	LC	1.00	1.00	2.38	2.89	1.48	0.50
	Acanthocybium solandri	Wahoo	WAH	LC	1.00	1.00	2.62	2.67	1.57	0.66
	Elagatis bipinnulata	Rainbow runner	RRU	NA	1.00	1.00	2.31	2.78	1.46	0.51
	Mola mola	Ocean sunfish, Mola	MOX	NA	1.00	1.92	1.92	1.78	1.49	1.31
	Caranx sexfasciatus	Bigeye trevally	CXS	LC	1.00	2.38	1.00	2.56	1.25	0.51
	Seriola lalandi	Yellowtail amberjack	YTC	NA	1.00	2.08	1.85	2.44	1.49	0.75
Rays	*Manta birostris*	Giant manta	RMB	VU	1.92	2.08	1.77	1.22	1.90	1.99
	Mobula japanica	Spinetail manta	RMJ	NT	1.92	2.08	1.77	1.78	1.90	1.51
	Mobula thurstoni	Smoothtail manta	RMO	NT	1.92	2.08	1.77	1.67	1.90	1.60
Sharks	*Carcharhinus falciformis*	Silky shark	FAL	NT	2.08	2.08	2.15	1.44	2.10	1.91
	Carcharhinus longimanus	Oceanic whitetip shark	OCS	VU	1.69	1.00	2.08	1.67	1.70	1.50
	Sphyrna zygaena	Smooth hammerhead shark	SPZ	VU	1.77	1.92	2.08	1.33	1.91	1.90
	Sphyrna lewini	Scalloped hammerhead shark	SPL	EN	1.77	1.92	2.08	1.33	1.91	1.90
	Sphyrna mokarran	Great hammerhead shark	SPK	EN	2.08	1.77	1.92	1.33	1.97	1.93
	Alopias pelagicus	Pelagic thresher shark	PTH	VU	1.92	1.92	1.77	1.22	1.87	1.98
	Alopias superciliosus	Bigeye thresher shark	BTH	VU	1.77	2.08	1.46	1.11	1.72	2.02
	Alopias vulpinus	Common thresher shark	ALV	VU	1.92	1.92	1.77	1.67	1.87	1.59
	Isurus oxyrinchus	Short fin mako shark	SMA	VU	2.23	2.23	1.92	1.22	2.12	2.10
Small fishes	*Canthidermis maculatus*	Ocean triggerfish	CNT	NA	1.00	1.00	2.00	2.33	1.35	0.76
	Sectator ocyurus	Bluestriped chub	ECO	NA	1.00	1.00	2.08	2.22	1.38	0.87
Turtles	*Lepidochelys olivacea*	Olive ridley turtle	LKV	VU	1.62	2.23	1.62	1.89	1.73	1.33

*IUCN listings are defined as: EN=endangered, NT=near threatened, VU=vulnerable, LC=least concern, DD=data deficient, NA=not assessed

TABLE L-3b. Preliminary productivity and susceptibility scores used to compute the overall vulnerability measure v_2. Dolphin=DEL, unassociated=NOA, and floating-object sets=OBJ. Individual susceptibility scores, s^*_{jk}, are shown for each fishery and as a weighted combination of the individual fishery values, s^2_j; see text for details. Productivity, p, and vulnerability, v_2, scores are provided. These values are preliminary as this year's PSA is considered a proof of concept.

GROUP	Scientific name	Common name	3-alpha species code	IUCN*	s^*_{jk}, scores by fishery			p	s^2_j	v_2
					DEL	NOA	OBJ			
Tunas	*Thunnus albacares*	Yellowfin tuna	YFT	NT	2.38	2.38	2.38	2.78	2.69	1.70
	Thunnus obesus	Bigeye tuna	BET	VU	1.00	2.23	2.38	2.33	1.79	1.04
	Katsuwonus pelamis	Skipjack tuna	SKJ	LC	1.00	2.38	2.38	2.78	2.13	1.15
Billfishes	*Makaira nigricans*	Blue marlin	BUM	VU	2.23	2.23	2.69	2.00	2.20	1.56
	Istiompax indica	Black marlin	BLM	DD	2.23	2.23	2.69	2.00	2.20	1.56
	Kajikia audax	Striped marlin	MLS	NT	2.54	2.54	2.54	2.33	2.27	1.44
	Istiophorus platypterus	Indo-Pacific sailfish	SFA	LC	2.54	2.54	2.54	2.44	2.27	1.39
Dolphins	*Stenella longirostris*	Unidentified spinner dolphin	DSI	DD	1.77	1.00	1.00	1.22	1.42	1.83
	Stenella attenuata	Unidentified spotted dolphin	DPN	LC	1.77	1.00	1.00	1.33	1.42	1.72
	Delphinus delphis	Common dolphin	DCO	LC	1.62	1.00	1.00	1.33	1.38	1.71
Large fishes	*Coryphaena hippurus*	Common dolphinfish	DOL	LC	1.00	2.00	2.31	2.78	1.99	1.02
	Coryphaena equiselis	Pompano dolphinfish	CFW	LC	1.00	1.00	2.38	2.89	1.92	0.92
	Acanthocybium solandri	Wahoo	WAH	LC	1.00	1.00	2.62	2.67	1.96	1.01
	Elagatis bipinnulata	Rainbow runner	RRU	NA	1.00	1.00	2.31	2.78	1.67	0.70
	Mola mola	Ocean sunfish, Mola	MOX	NA	1.00	1.92	1.92	1.78	1.74	1.43
	Caranx sexfasciatus	Bigeye trevally	CXS	LC	1.00	2.38	1.00	2.56	1.56	0.72
	Seriola lalandi	Yellowtail amberjack	YTC	NA	1.00	2.08	1.85	2.44	1.51	0.76
Rays	*Manta birostris*	Giant manta	RMB	VU	1.92	2.08	1.77	1.22	1.95	2.02
	Mobula japanica	Spinetail manta	RMJ	NT	1.92	2.08	1.77	1.78	1.95	1.55
	Mobula thurstoni	Smoothtail manta	RMO	NT	1.92	2.08	1.77	1.67	1.95	1.63
Sharks	*Carcharhinus falciformis*	Silky shark	FAL	NT	2.08	2.08	2.15	1.44	2.23	1.98
	Carcharhinus longimanus	Oceanic whitetip shark	OCS	VU	1.69	1.00	2.08	1.67	1.62	1.47
	Sphyrna zygaena	Smooth hammerhead shark	SPZ	VU	1.77	1.92	2.08	1.33	1.95	1.92
	Sphyrna lewini	Scalloped hammerhead shark	SPL	EN	1.77	1.92	2.08	1.33	1.95	1.92
	Sphyrna mokarran	Great hammerhead shark	SPK	EN	2.08	1.77	1.92	1.33	1.98	1.94
	Alopias pelagicus	Pelagic thresher shark	PTH	VU	1.92	1.92	1.77	1.22	1.93	2.01
	Alopias superciliosus	Bigeye thresher shark	BTH	VU	1.77	2.08	1.46	1.11	1.86	2.08
	Alopias vulpinus	Common thresher shark	ALV	VU	1.92	1.92	1.77	1.67	1.93	1.63
	Isurus oxyrinchus	Short fin mako shark	SMA	VU	2.23	2.23	1.92	1.22	2.06	2.07
Small fishes	*Canthidermis maculatus*	Ocean triggerfish	CNT	NA	1.00	1.00	2.00	2.33	1.18	0.69
	Sectator ocyurus	Bluestriped chub	ECO	NA	1.00	1.00	2.08	2.22	1.19	0.80
Turtles	*Lepidochelys olivacea*	Olive ridley turtle	LKV	VU	1.62	2.23	1.62	1.89	1.63	1.28

*IUCN listings are defined as: EN=endangered, NT=near threatened, VU=vulnerable, LC=least concern, DD=data deficient, NA=not assessed

TABLE L-3c. Preliminary productivity and susceptibility scores used to compute the overall vulnerability measure v_3. Dolphin=DEL, unassociated=NOA, and floating-object sets=OBJ. Individual susceptibility scores, s_{jk}^{**}, are shown for each fishery and as a weighted combination of the individual fishery values, s_j^3; see text for details. Productivity, p, and vulnerability, v_3, scores are provided. These values are preliminary as this year's PSA is considered a proof of concept.

					s_{jk}^{**} scores by fishery					
GROUP	**Scientific name**	**Common name**	**3-alpha species code**	**IUCN***	**DEL**	**NOA**	**OBJ**	p	s_j^3	v_3
Tunas	*Thunnus albacares*	Yellowfin tuna	YFT	NT	2.38	2.38	2.38	2.78		
	Thunnus obesus	Bigeye tuna	BET	VU	1.00	2.23	2.38	2.33		
	Katsuwonus pelamis	Skipjack tuna	SKJ	LC	1.00	2.38	2.38	2.78		
Billfishes	*Makaira nigricans*	Blue marlin	BUM	VU	2.23	2.23	2.69	2.00	1.95	1.38
	Istiompax indica	Black marlin	BLM	DD	2.23	2.23	2.69	2.00	2.34	1.67
	Kajikia audax	Striped marlin	MLS	NT	2.54	2.54	2.54	2.33	2.28	1.45
	Istiophorus platypterus	Indo-Pacific sailfish	SFA	LC	2.54	2.54	2.54	2.44	2.16	1.28
Dolphins	*Stenella longirostris*	Unidentified spinner dolphin	DSI	DD	1.77	1.00	1.00	1.22		
	Stenella attenuata	Unidentified spotted dolphin	DPN	LC	1.77	1.00	1.00	1.33		
	Delphinus delphis	Common dolphin	DCO	LC	1.62	1.00	1.00	1.33		
Large fishes	*Coryphaena hippurus*	Common dolphinfish	DOL	LC	1.00	2.00	2.31	2.78	1.67	0.70
	Coryphaena equiselis	Pompano dolphinfish	CFW	LC	1.00	1.00	2.38	2.89	1.33	0.35
	Acanthocybium solandri	Wahoo	WAH	LC	1.00	1.00	2.62	2.67	1.63	0.71
	Elagatis bipinnulata	Rainbow runner	RRU	NA	1.00	1.00	2.31	2.78	1.32	0.39
	Mola mola	Ocean sunfish, Mola	MOX	NA	1.00	1.92	1.92	1.78	1.38	1.28
	Caranx sexfasciatus	Bigeye trevally	CXS	LC	1.00	2.38	1.00	2.56	1.26	0.51
	Seriola lalandi	Yellowtail amberjack	YTC	NA	1.00	2.08	1.85	2.44	1.64	0.85
Rays	*Manta birostris*	Giant manta	RMB	VU	1.92	2.08	1.77	1.22	1.70	1.91
	Mobula japanica	Spinetail manta	RMJ	NT	1.92	2.08	1.77	1.78	1.70	1.41
	Mobula thurstoni	Smoothtail manta	RMO	NT	1.92	2.08	1.77	1.67	1.70	1.50
Sharks	*Carcharhinus falciformis*	Silky shark	FAL	NT	2.08	2.08	2.15	1.44	2.55	2.20
	Carcharhinus longimanus	Oceanic whitetip shark	OCS	VU	1.69	1.00	2.08	1.67	2.35	1.90
	Sphyrna zygaena	Smooth hammerhead shark	SPZ	VU	1.77	1.92	2.08	1.33	1.70	1.81
	Sphyrna lewini	Scalloped hammerhead shark	SPL	EN	1.77	1.92	2.08	1.33	1.70	1.81
	Sphyrna mokarran	Great hammerhead shark	SPK	EN	2.08	1.77	1.92	1.33	2.00	1.94
	Alopias pelagicus	Pelagic thresher shark	PTH	VU	1.92	1.92	1.77	1.22	1.68	1.91
	Alopias superciliosus	Bigeye thresher shark	BTH	VU	1.77	2.08	1.46	1.11	1.61	1.99
	Alopias vulpinus	Common thresher shark	ALV	VU	1.92	1.92	1.77	1.67	1.68	1.50
	Isurus oxyrinchus	Short fin mako shark	SMA	VU	2.23	2.23	1.92	1.22	1.81	1.96
Small fishes	*Canthidermis maculatus*	Ocean triggerfish	CNT	NA	1.00	1.00	2.00	2.33	1.26	0.72
	Sectator ocyurus	Bluestriped chub	ECO	NA	1.00	1.00	2.08	2.22	1.28	0.83
Turtles	*Lepidochelys olivacea*	Olive ridley turtle	LKV	VU	1.62	2.23	1.62	1.89	2.36	1.76

*IUCN listings are defined as: EN=endangered, NT=near threatened, VU=vulnerable, LC=least concern, DD=data deficient, NA=not assessed