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Summary of the fishery and assessments of the major stocks of tuna exploited in the eastern Pacific Ocean

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TUNAS AND BILLFISHES IN THE EASTERN PACIFIC OCEAN IN 2012

INTRODUCTION

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 2012. It is based on data available to the IATTC staff in March 2013. As a result, some of the data tables for 2012 are incomplete, and all data for 2011 and 2012 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

[1] not elsewhere included

YFT	Yellowfin tuna (*Thunnus albacares*)
Fishing gears:	
FPN	Trap
GN	Gillnet
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 FLT: Flotsam FAD: Fish-aggregating device

Flags:	
IATTC Members & Cooperating non-Members	
BLZ	Belize
BOL	Bolivia
CAN	Canada
CHN	China
COK	Cook Islands
COL	Colombia
CRI	Costa Rica
ECU	Ecuador
EU (SPN)	European Union (Spain)
EU (PRT)	European Union (Portugal)
FRA	France
GTM	Guatemala
JPN	Japan
KIR	Kiribati
KOR	Republic of Korea
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	
BMU	Bermuda
CHL	Chile
CYM	Cayman Islands
CYP	Cyprus
FSM	Federated States of Micronesia
HND	Honduras
LBR	Liberia
NZL	New Zealand
RUS	Russia
SEN	Senegal
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 report 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 report 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 2000-2012 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 2012 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 2011 and 2012 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 1983-2012 are shown in Tables A-2a-c. The catches of yellowfin, bigeye, and skipjack tunas, by gear and flag, during 1983-2012 are shown in Tables A-3a-e, and the purse-seine and pole-and-line catches of tunas and bonitos during 2011-2012 are summarized by flag in Table A-4. 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 1998-2012. 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 1983-2012 are shown in Table A-1. The EPO totals for 1993-2012 include discards from purse-seine vessels with carrying capacities greater than 363 t. In the EPO, catches increased steadily to a high of 443 thousand t in 2002. During 2004-2009 the catch decreased substantially, and the catch during 2012, 191 thousand t, was comparable to the lowest catches of the 2006-2008 period, and less than half the highest catches of the 2001-2003 period. 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 WCPO, the catches of yellowfin increased steadily, to 551 thousand t in 1998, and remained high through 2011. They peaked at 573 thousand t in 2008, and declined to 477 thousand t by 2011.

The annual retained catches of yellowfin in the EPO by purse-seine and pole-and-line vessels during 1983-2012 are shown in Table A-2a. The average annual retained catch during 1997-2011 was 264 thousand t (range: 167 to 412 thousand t). The preliminary estimate of the retained catch in 2012, 190 thousand t, was 6% less than that of 2011, and 28% less than the average for 1997-2011. The average amount of yellowfin discarded at sea during 1997-2011 was about 1.3% of the total purse-seine catch (retained catch plus discards) of yellowfin (range: 0.3 to 2.4%) (Table A-2a).

The annual retained catches of yellowfin in the EPO by longliners during 1983-2012 are shown in Table A-2a. During 1993-2003 they remained relatively stable, averaging about 22 thousand t (range: 12 to 30 thousand t), or about 7% of the total retained catches of yellowfin. Longline catches have declined steadily since 2003, reaching a low of 6 thousand t in 2011, or about 3% of the total retained catches. 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 1997-2011 they averaged about 1 thousand t.

1.1.2. Skipjack tuna

The annual catches of skipjack during 1983-2012 are shown in Table A-1. Most of the skipjack catch in the Pacific Ocean is taken in the WCPO. The greatest reported catch in the WCPO, about 1.8 million t, occurred in 2009, and the greatest total catch in the EPO, 310 thousand t, occurred in 2006.

The annual retained catches of skipjack in the EPO by purse-seine and pole-and-line vessels during 1983-2012 are shown in Table A-2a. During 1997-2011 the annual retained catch averaged 217 thousand t (range 141 to 297 thousand t). The preliminary estimate of the retained catch in 2012, 271 thousand t, is 25% greater than the average for 1997-2011, and 9% less than the previous record-high retained catch of 2006. Discards of skipjack at sea decreased steadily during 1997-2011, from a high of 20% in 1997 to a low of 2% in 2011. During the period about 7% of the total catch of the species was discarded at sea (Table A-2a).

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

1.1.3. Bigeye tuna

The annual catches of bigeye during 1983-2012 are shown in Table A-1. Overall, the catches in both the EPO and WCPO have increased, but with considerable fluctuations. The catches in the EPO reached 105 thousand t in 1986, and have fluctuated between about 73 and 149 thousand t since then, with the greatest catch 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 in the late 1980s, with lesser fluctuations, until 1998, when they reached more than 164 thousand t. They reached a high of 174 thousand t in 2004, and then fluctuated between 130 and 160 thousand t during 2005-2011.

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. Prior to 1994, the annual retained catch of bigeye taken by purse-seine vessels in the EPO was about 8 thousand t (Table A-2a). Following the development of FADs, the annual retained catches of bigeye increased from 35 thousand t in 1994 to between 44 and 95 thousand t during 1995-2011. The preliminary estimate of the retained catch in the EPO in 2012 is 69 thousand t.

During 1997-2011 about 3.5% of the purse-seine catch of the species was discarded at sea (range: 1 to 9%). Small amounts of bigeye have been caught in some years by pole-and-line vessels, as shown in Table A-2a.

Prior to 1994, longliners caught an average of 94% of the bigeye in the EPO (average 80 thousand t; range; 46 to 104 thousand t). During 1997-2011 this percentage dropped to an average of 40%, with a low of 25% in 2008 (average: 44 thousand t; range: 26 to 74 thousand t) (Table A-2a). The preliminary estimate of the longline catch in the EPO in 2012 is 19 thousand t (Table A-2a).

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

1.1.4. Bluefin tuna

The catches of Pacific bluefin in the entire Pacific Ocean, by flag and gear, are shown in Table A-5. 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.

The catches of Pacific bluefin in the EPO during 1983-2012, by gear, are shown in Table A-2a. Purse-seine vessels accounted for over 90% of the total EPO retained catch during 1997-2011. During this period the annual retained catch of bluefin in the EPO by purse-seine vessels averaged 4.2 thousand t (range 1.2 to 9.9 thousand t). The preliminary estimate of the retained purse-seine catch of bluefin in 2012, 6.7 thousand t, is 2.5 thousand t more than the average for 1997-2011 (Table A-2a).

1.1.5. Albacore tuna

The catches of albacore in the entire Pacific Ocean, by gear and area (north and south of the equator) are shown in Table A-6a-b. 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. The catch data were obtained from IATTC data for the EPO and from data compiled by the SPC for the WCPO.

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 1983-2012 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 12.5 thousand t in 2012, which is greater than the 1997-2011 annual average retained catch of 5.5 thousand t (range: 500 t 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. The longline catch of swordfish in 2011 was 24 thousand t, but during 2005-2008 averaged about 14 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 1997-2011 were about 3.5 thousand and 2.5 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 1997-2011 purse seiners accounted for less than 2% 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 South and Central America. Although the catches are greater than 50 thousand t in some years, the gear types 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 2007-2011, are shown in Figures A-1a, A-2a, and A-3a, and preliminary estimates for 2012 are shown in Figures A-1b, A-2b, and A-3b.

The majority of the yellowfin catches in 2012 were taken from the areas north of 5°N and east of 140°W. Catches of yellowfin on dolphins were greatest in the inshore areas off the coast of Central America. Offshore catches on dolphins around the equator were higher than the 2007-2011 average.

Yellowfin catches on unassociated schools in 2012 were concentrated mainly in the inshore areas off southern Mexico. Inshore catches around the equator were lower than the 2007-2011 average.

Yellowfin catches on floating objects in the coastal area between 10°S and 20°S were greater than the 2007-2011 average.

Inshore skipjack catches in 2012 were similar to those of previous years. Catches were higher than the 2007-2011 average in the area west of 130°W, and were almost exclusively caught on floating objects, except for catches around 10°N, which were mostly on unassociated schools.

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, Chinese Taipei, French Polynesia, Japan, the Republic of Korea, Spain, 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 Japanese, Korean, and Chinese Taipei longline vessels during 2007-2011 are shown in Figure A-4. Data for the Japanese longline fishery in the EPO during 1956-2003 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 2007-2012 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 2012, and the second shows the combined data for each year of the 2007-2012 period. For bluefin, the histograms show the 2007-2012 catches by commercial and recreational gear combined. For black skipjack, the histograms show the 2006-2011 catches by commercial gear. Only a small amount of catch was taken by pole-and-line vessels in 2012, 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 954 wells sampled during 2012, 592 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 and in unassociated sets. Most of the larger yellowfin (>100 cm) were caught in the Northern dolphin fishery in the second and third quarters and the Inshore dolphin fishery in the first quarter, with lesser catches in the Southern dolphin fishery in the second and third quarters. Smaller yellowfin (<100 cm) were caught primarily in the Inshore floating-object fishery during the first quarter, and in the Northern unassociated fishery during the third quarter.

The estimated size compositions of the yellowfin caught by all fisheries combined during 2007-2012 are shown in Figure A-6b. The average weight of the yellowfin caught in 2012 (13.0 kg) was greater than that of 2011 (10.3 kg) and 2010 (8.8 kg).

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 954 wells sampled, 546 contained skipjack. The estimated size compositions of the fish caught during 2012 are shown in Figure A-7a. Large amounts of skipjack in the 40- to 50-cm size range were caught in the Northern unassociated fishery during the third quarter, in the Southern unassociated fishery during the first and fourth quarters, in the Inshore floating-object fishery in the first quarter, in the Northern and Equatorial floating-object fisheries primarily in the third and fourth quarters, and in the Southern floating-object fishery throughout the year. Larger skipjack in the 60- to 70-cm size range were taken in the Northern unassociated fishery during the third and fourth quarters, in the Southern unassociated fishery in the first and second quarters, and in the Equatorial floating-object fishery during the second and third quarters.

The estimated size compositions of the skipjack caught by all fisheries combined during 2007-2012 are shown in Figure A-7b. The average weight of skipjack in 2012 (2.1 kg) was less than that of 2011 (2.4 kg), but only slightly less than the average for the previous five years.

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 954 wells sampled, 196 contained bigeye. The estimated size compositions of the fish caught during 2012 are shown in Figure A-8a. In 2000 the majority of the catch was taken in floating-object sets in the Equatorial area, whereas from 2001 to 2003 the majority of the bigeye catch was taken in sets on floating objects in the Southern area. In 2012, most of the bigeye was taken in the Northern, Equatorial, and Southern floating-object fisheries. Larger bigeye (>100 cm) were caught in the Equatorial floating-object fishery primarily in the second quarter, with lesser amounts in the third quarter, and in the Southern floating-object fishery in the first and fourth quarters. Smaller bigeye in the 40- to 80-cm size range were caught in the Northern floating-object fishery in the third and fourth quarters, and in the Equatorial and Southern floating-object fishery throughout the year.

The estimated size compositions of the bigeye caught by all fisheries combined during 2007-2012 are shown in Figure A-8b. The average weight of bigeye in 2012 (6.7 kg) was less than that of 2011 (8.0 kg), but greater than those of 2009 and 2010 (6.0 and 5.2 kg. respectively).

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.

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 2006-2011 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 2007-2011 are shown in Figures A-11 and A-12. The average weight of yellowfin in 2011 (35.4 kg) was considerably less than those of 2009 and 2010 (46.1 and 48.5 kg respectively), but close to that of 2007-2008 (about 38 kg). The average weight of bigeye fell sharply from 49.4 kg in 2009 and 44.9 kg in 2010, to 29.0 kg in 2011. Information on the size compositions of fish caught by the Japanese longline fishery in the EPO during 1958-2003 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 1983-2012, 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 and pole-and-line catches of tunas and bonitos in 2011 and 2012, by flag, are summarized in Table A-4. Of the 549 thousand t of tunas and bonitos caught in 2012, 42% were caught by Ecuadorian vessels, and 23% by Mexican vessels. Other countries with significant catches of tunas and bonitos in the EPO included Panama (9%), Venezuela (8%), and Colombia (7%).

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 1997-2012 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.

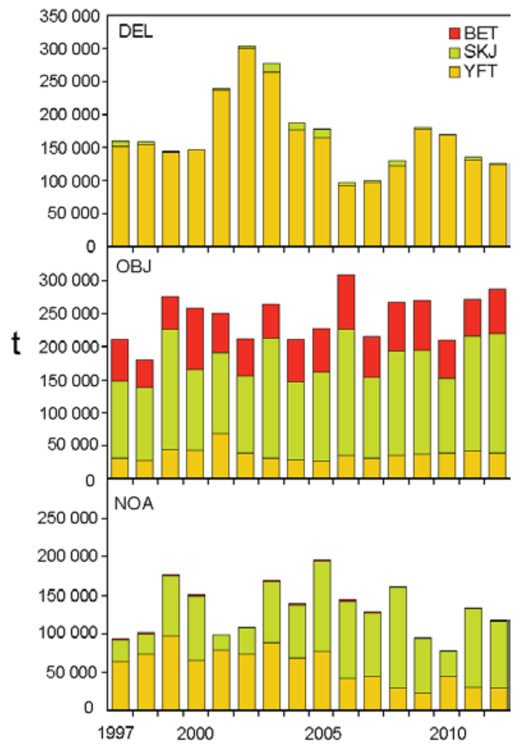

Figure 1. Purse-seine catches of tunas, by species and set type, 1997-2012

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 60% of all floating-object sets. Their relative importance has continued to increase since then, reaching 95% of all floating-object sets 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.

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 2012 the number of pole-and-line vessels decreased from 93 to 3, and their total well volume from about 11 thousand to about 268 m^3. During the same period the number of purse-seine vessels increased from 125 to 211, and their total well volume from about 32 thousand to about 219 thousand m^3, an average of about 1,038 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).

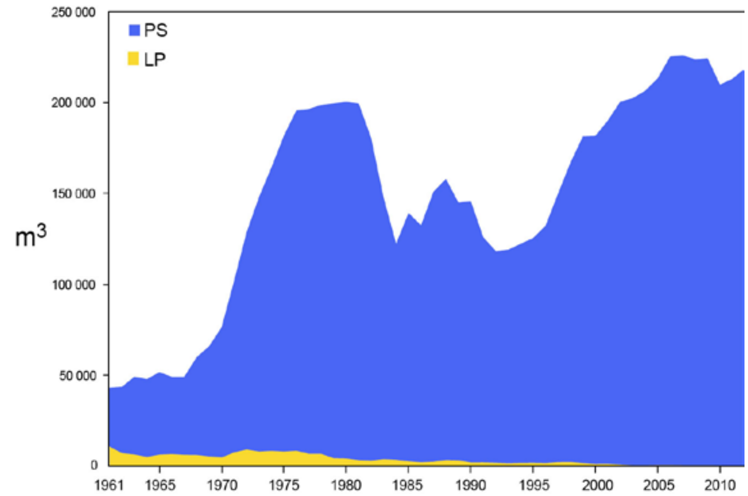

Figure 2. Carrying capacity, in cubic meters of well volume, of the purse-seine and pole-and-line fleets in the EPO, 1961-2012

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 2012 was 219 thousand m^3.

The 2011 and preliminary 2012 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 2012, the fleet was dominated by vessels operating under the Ecuadorian and Mexican flags, with about 36% and 22%, respectively, of the total well volume; they were followed by Venezula (10%), Panama (8%), Colombia (7%), European Union (Spain) (5%), Nicaragua (4%), El Salvador (3%), and Guatemala and United States (2% each).

The cumulative capacity at sea during 2012 is compared to those of the previous five years in Figure 3.

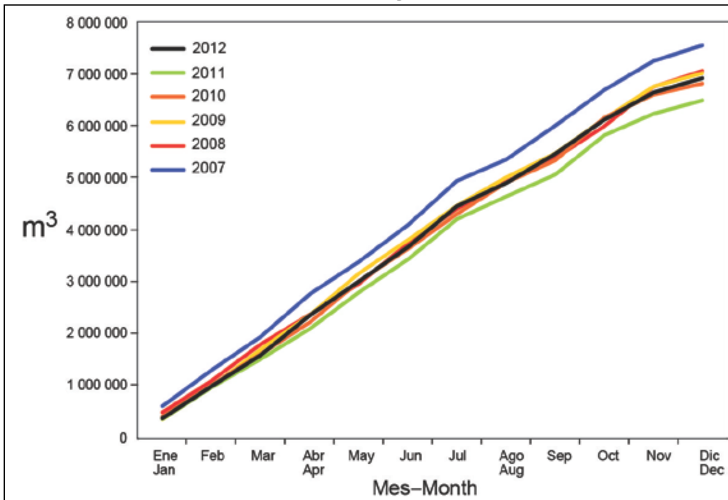

Figure 3. Cumulative capacity of the purse-seine and pole-and-line fleet at sea, by month, 2007-2012

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 2002-2011, and the 2012 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 1998-2012, so the VAS values for September-December 2012 are not comparable to the average VAS values for those months of 1998-2012. The average VAS values for 2002-2011 and 2012 were 133 thousand m^3 (62% of total capacity) and 134 thousand m^3 (61% 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. 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 2012, or ever.

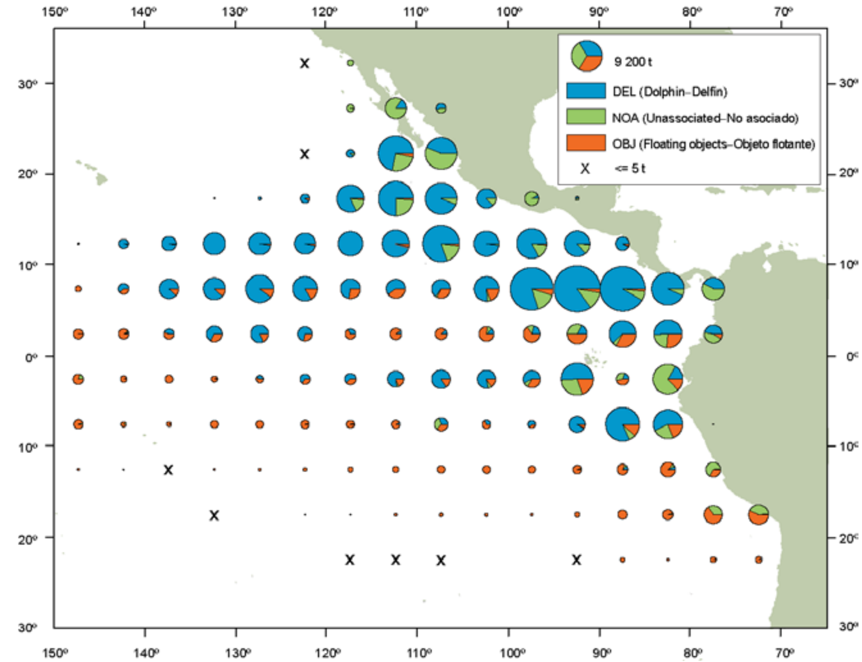

FIGURE A-1a. Average annual distributions of the purse-seine catches of yellowfin, by set type, 2007-2011. The sizes of the circles are proportional to the amounts of yellowfin caught in those 5° by 5° areas.
FIGURA A-1a. Distribución media anual de las capturas cerqueras de aleta amarilla, por tipo de lance, 2007-2011. El tamaño de cada círculo es proporcional a la cantidad de aleta amarilla capturado en la cuadrícula de 5° x 5° correspondiente.

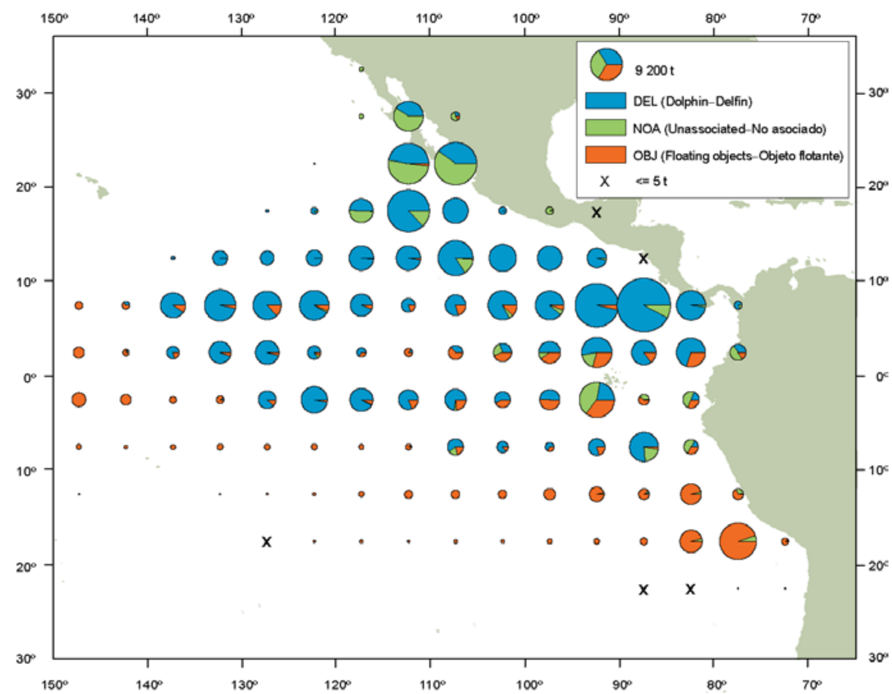

FIGURE A-1b. Annual distributions of the purse-seine catches of yellowfin, by set type, 2012. The sizes of the circles are proportional to the amounts of yellowfin caught in those 5° by 5° areas.
FIGURA A-1b. Distribución anual de las capturas cerqueras de aleta amarilla, por tipo de lance, 2012. El tamaño de cada círculo es proporcional a la cantidad de aleta amarilla capturado en la cuadrícula de 5° x 5° correspondiente.

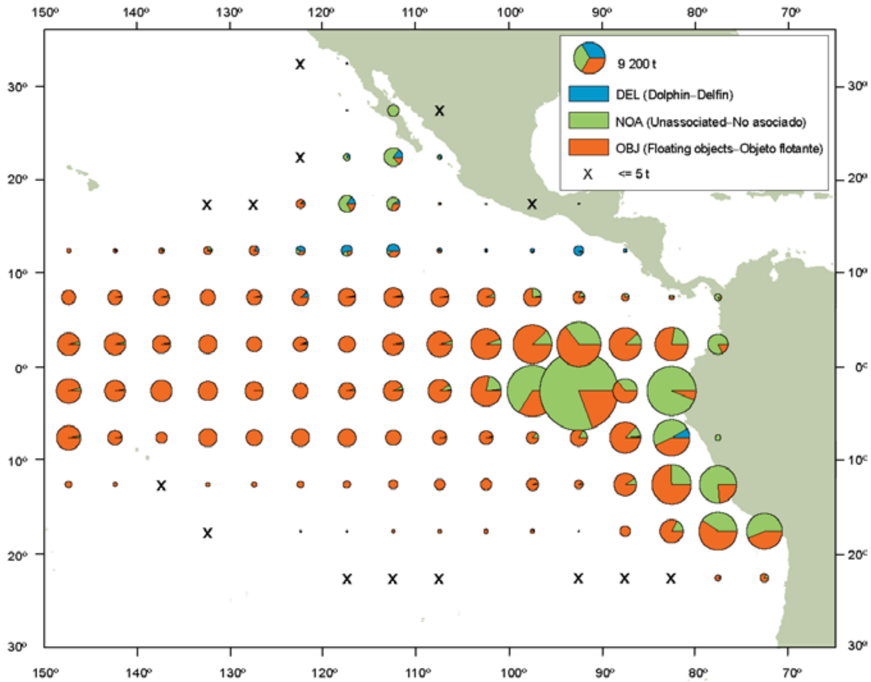

FIGURE A-2a. Average annual distributions of the purse-seine catches of skipjack, by set type, 2007-2011. The sizes of the circles are proportional to the amounts of skipjack caught in those 5° by 5° areas.
FIGURA A-2a. Distribución media anual de las capturas cerqueras de barrilete, por tipo de lance, 2007-2011. El tamaño de cada círculo es proporcional a la cantidad de barrilete capturado en la cuadrícula de 5° x 5° correspondiente.

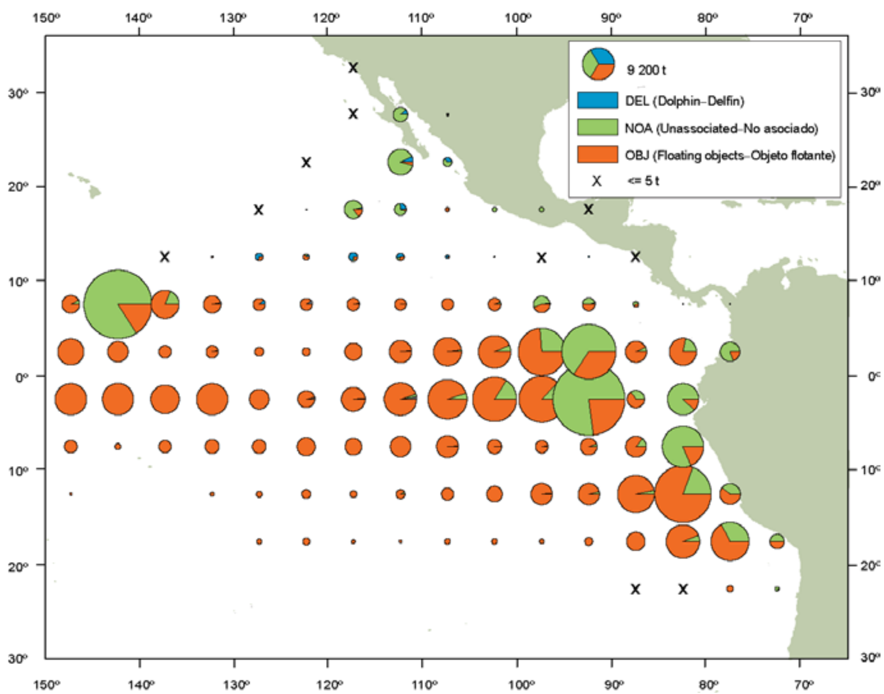

FIGURE A-2b. Annual distributions of the purse-seine catches of skipjack, by set type, 2012. The sizes of the circles are proportional to the amounts of skipjack caught in those 5° by 5° areas.
FIGURA A-2b. Distribución anual de las capturas cerqueras de barrilete, por tipo de lance, 2012. El tamaño de cada círculo es proporcional a la cantidad de barrilete capturado en la cuadrícula de 5° x 5° correspondiente.

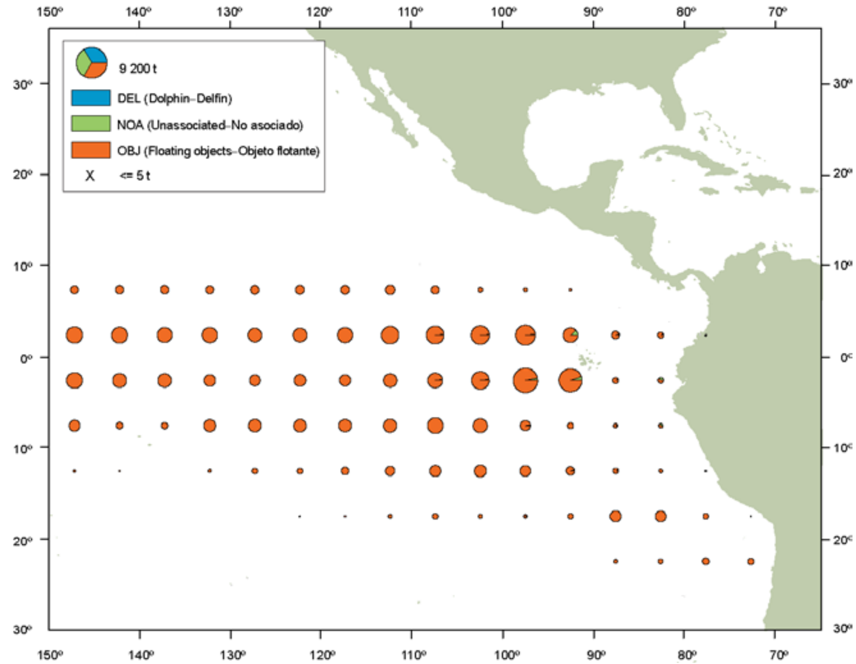

FIGURE A-3a. Average annual distributions of the purse-seine catches of bigeye, by set type, 2007-2011. The sizes of the circles are proportional to the amounts of bigeye caught in those 5° by 5° areas.
FIGURA A-3a. Distribución media anual de las capturas cerqueras de patudo, por tipo de lance, 2007-2011. El tamaño de cada círculo es proporcional a la cantidad de patudo capturado en la cuadrícula de 5° x 5° correspondiente.

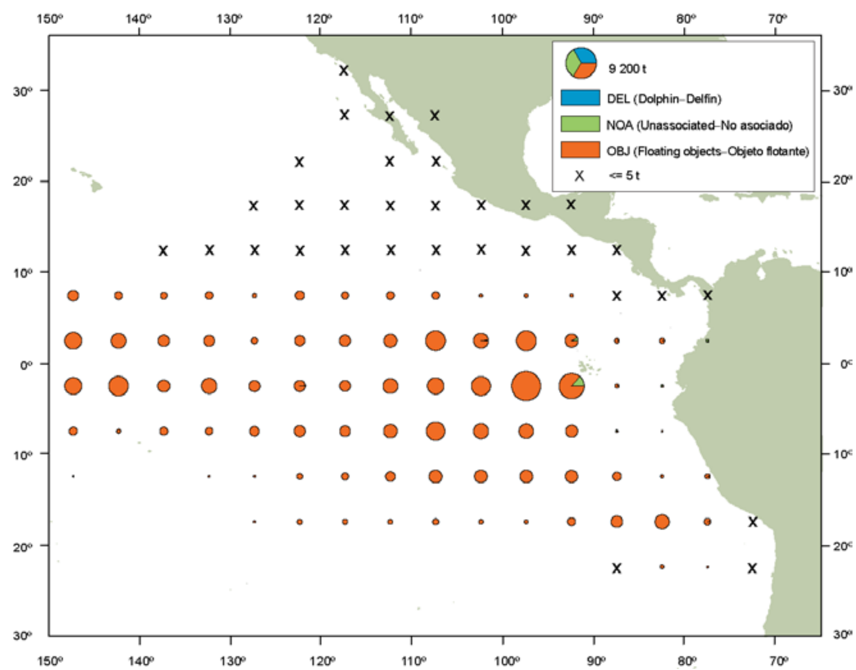

FIGURE A-3b. Annual distributions of the purse-seine catches of bigeye, by set type, 2012. The sizes of the circles are proportional to the amounts of bigeye caught in those 5° by 5° areas.
FIGURA A-3b. Distribución anual de las capturas cerqueras de patudo, por tipo de lance, 2012. El tamaño de cada círculo es proporcional a la cantidad de patudo capturado en la cuadrícula de 5° x 5° correspondiente.

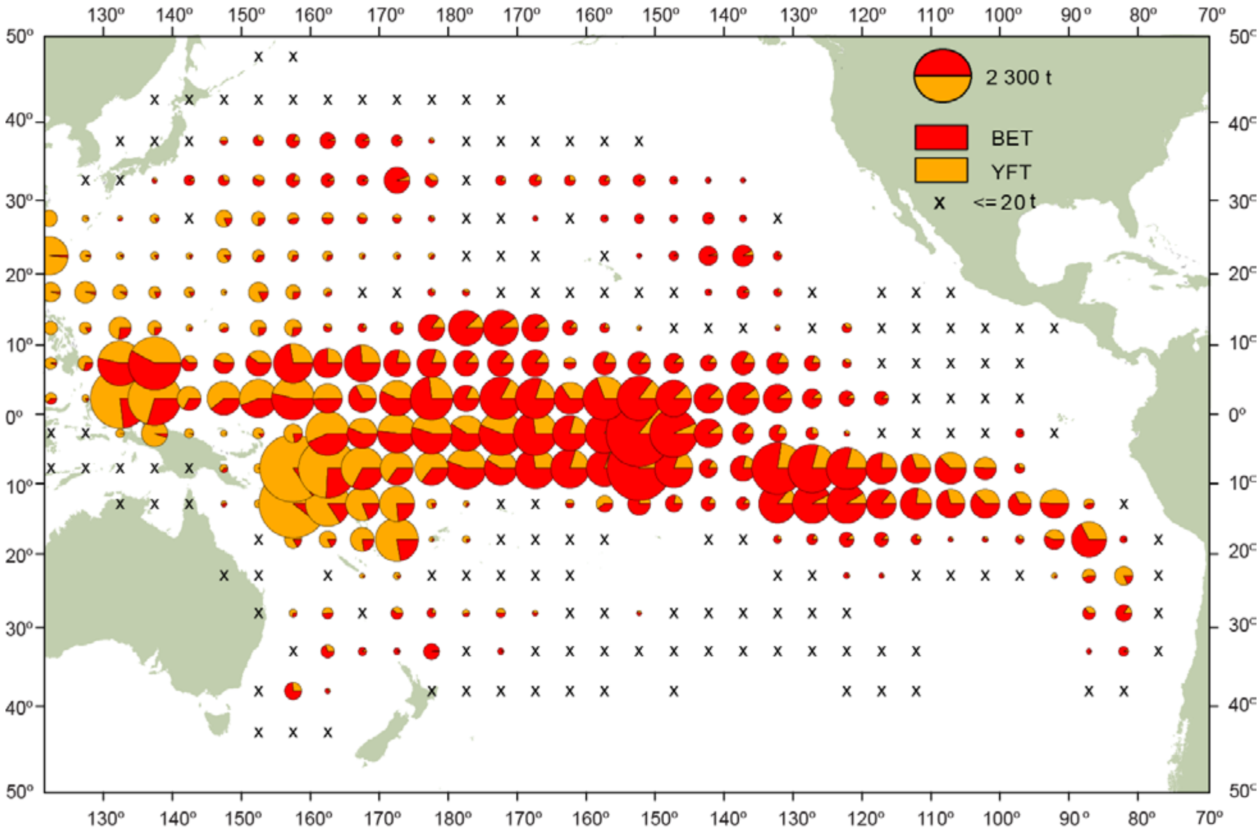

FIGURE A-4. Distributions of the average annual catches of bigeye and yellowfin tunas in the Pacific Ocean, in metric tons, by Chinese, Japanese, Korean and Chinese Taipei longline vessels, 2007-2011. The sizes of the circles are proportional to the amounts of bigeye and yellowfin caught in those 5° 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 2007-2011. El tamaño de cada círculo es proporcional a la cantidad de patudo y aleta amarilla capturado en la cuadrícula de 5° x 5° correspondiente.

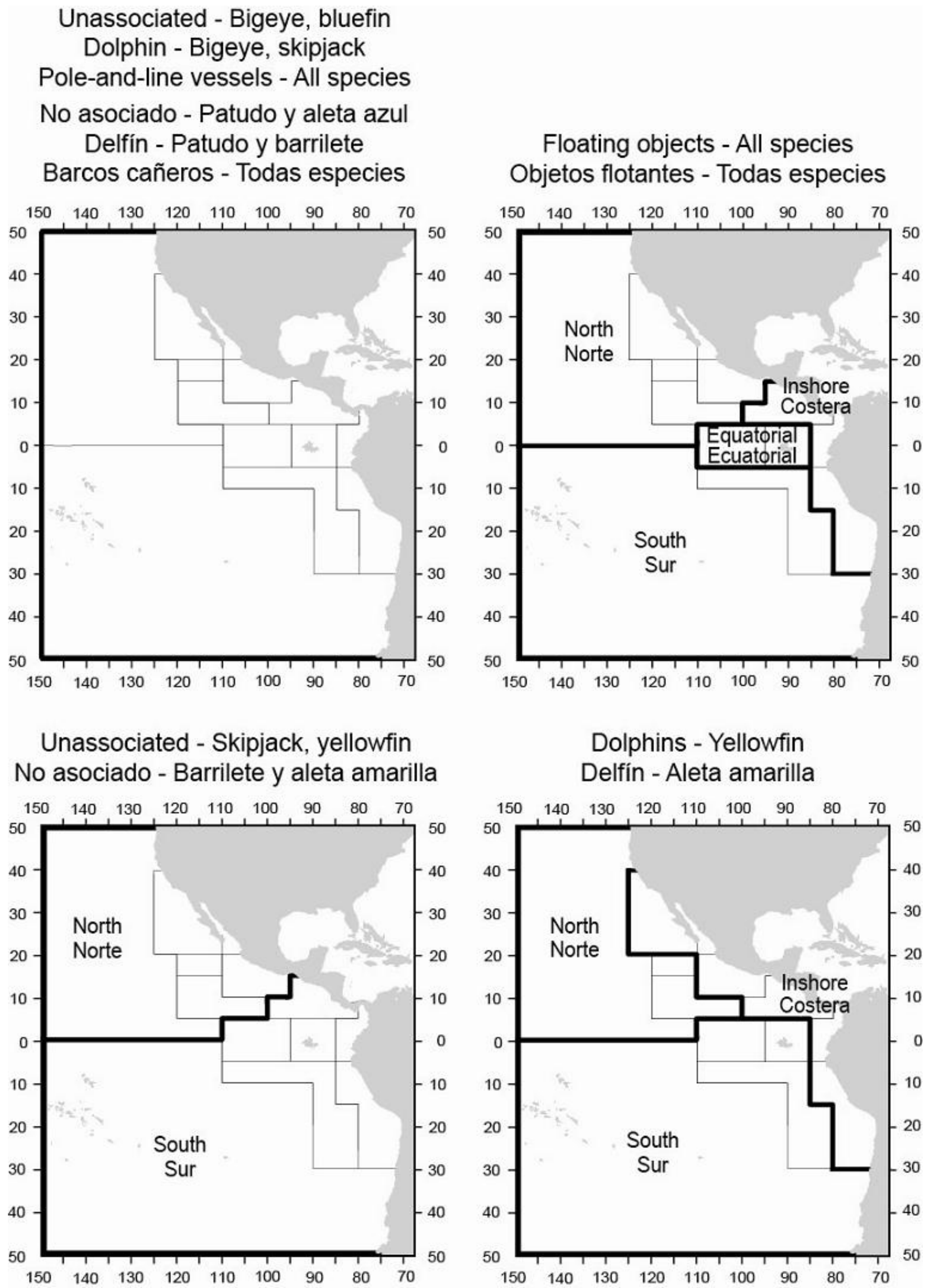

FIGURE A-5. The fisheries defined by the IATTC staff for stock assessment of yellowfin, skipjack, and bigeye in the EPO. The thin lines indicate the boundaries of the 13 length-frequency sampling areas, and the bold lines the boundaries of the fisheries.

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.

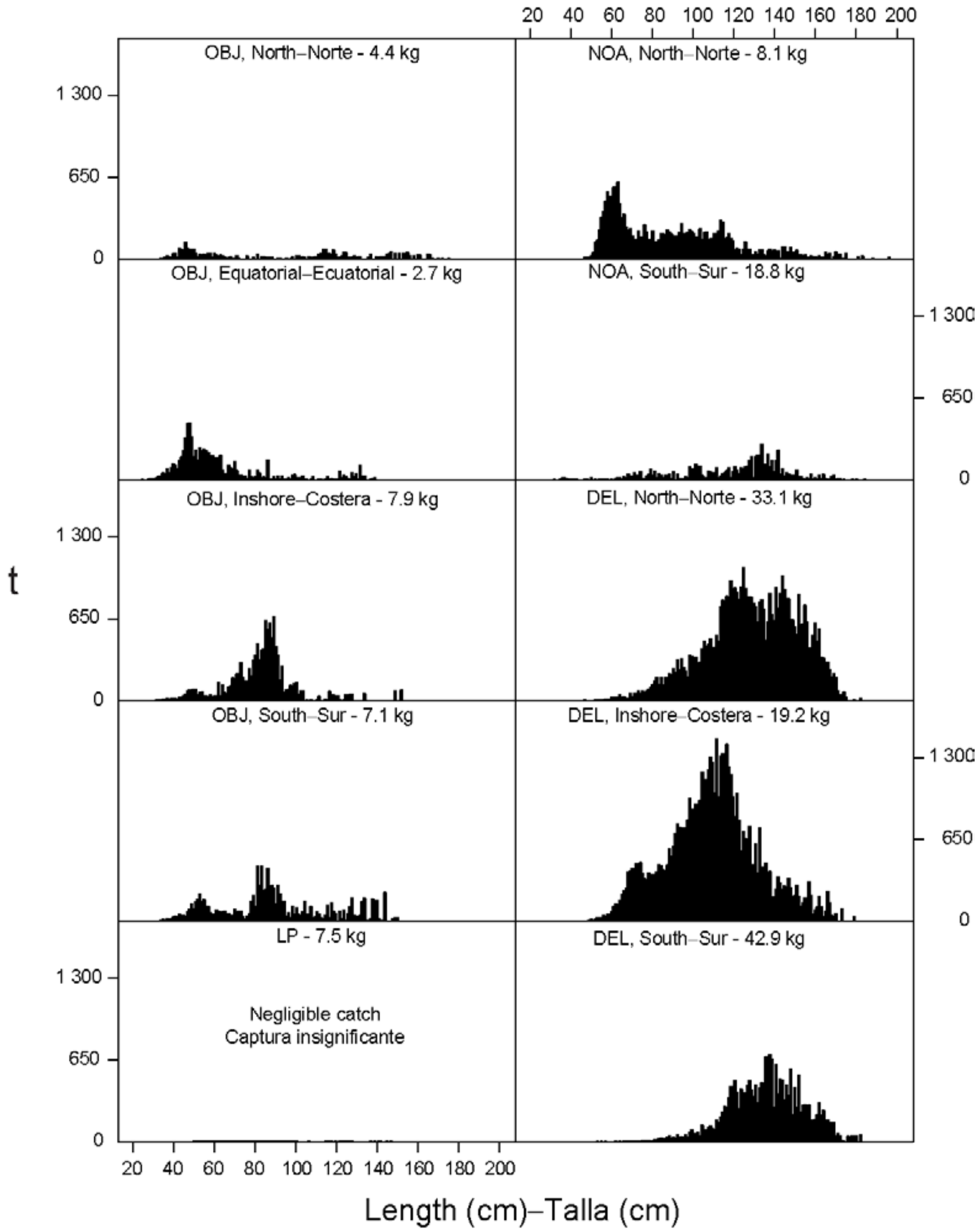

FIGURE A-6a. Estimated size compositions of the yellowfin caught in the EPO during 2012 for each fishery designated in Figure A-5. The average weights of the fish in the samples are given at the tops of the panels.

FIGURA A-6a. Composición por tallas estimada del aleta amarilla capturado en el OPO durante 2012 en cada pesquería ilustrada en la Figura A-5. En cada recuadro se detalla el peso promedio de los peces en las muestras.

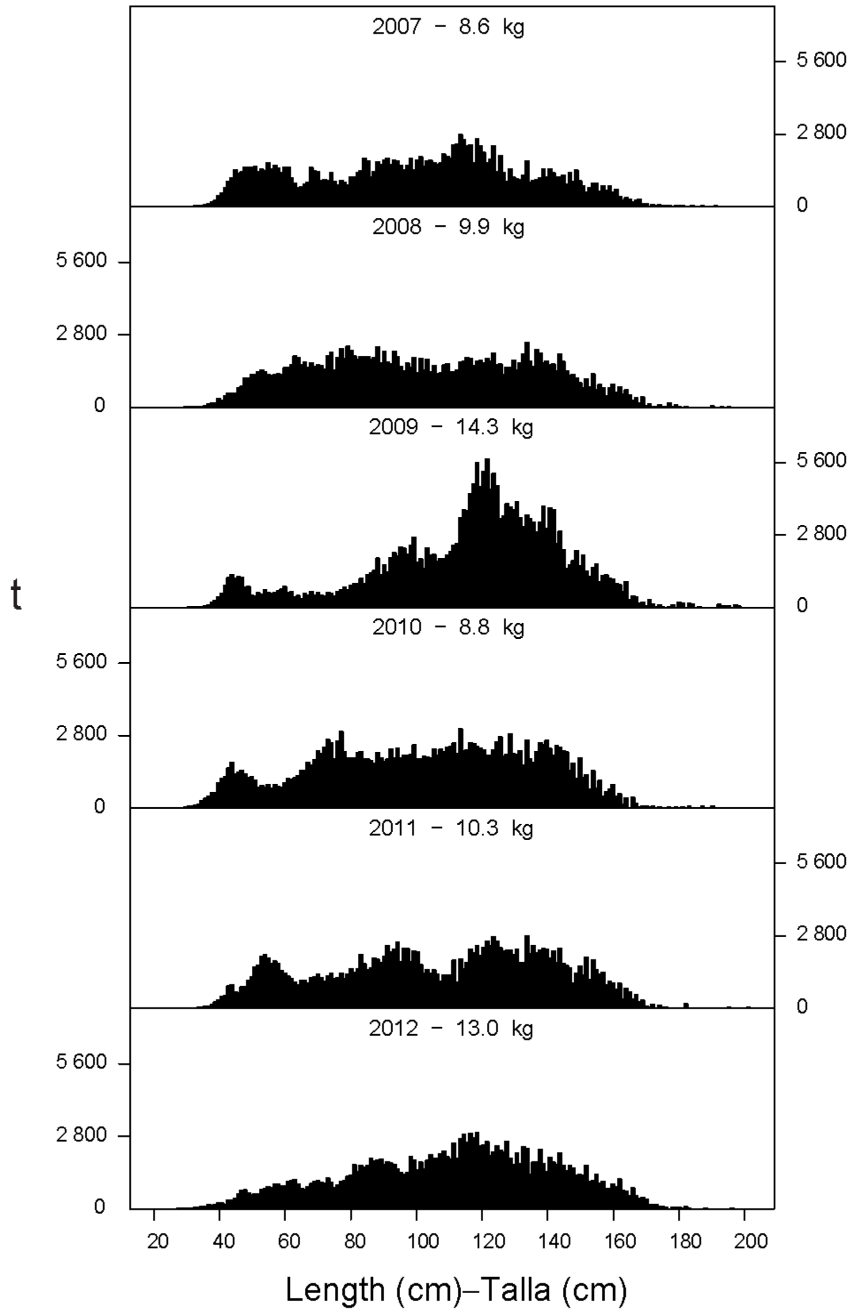

FIGURE A-6b. Estimated size compositions of the yellowfin caught by purse-seine and pole-and-line vessels in the EPO during 2007-2012. The average weights of the fish in the samples are given at the tops of the panels.

FIGURA A-6b. Composición por tallas estimada del aleta amarilla capturado por buques cerqueros y cañeros en el OPO durante 2007-2012. En cada recuadro se detalla el peso promedio de los peces en las muestras.

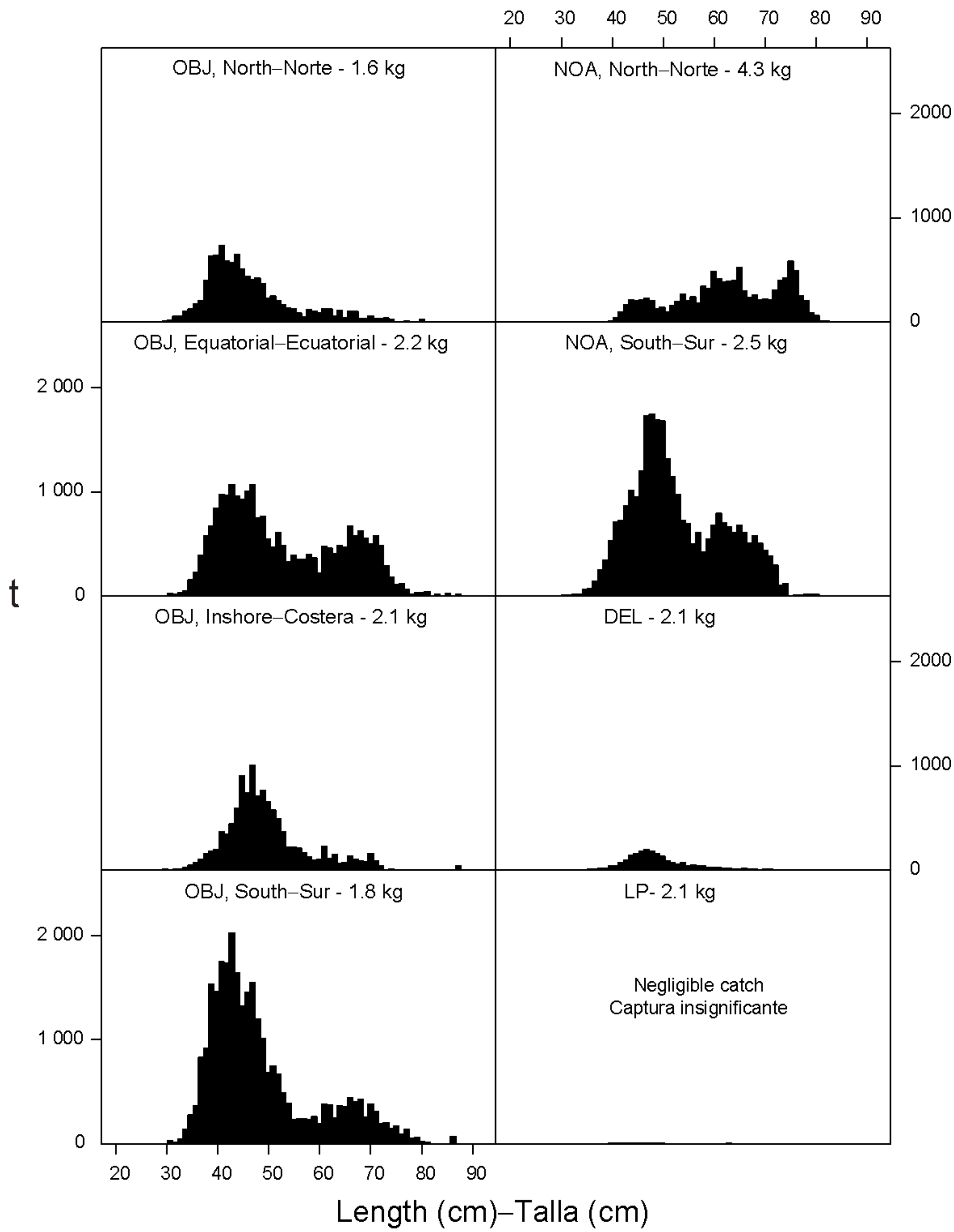

FIGURE A-7a. Estimated size compositions of the skipjack caught in the EPO during 2012 for each fishery designated in Figure A-5. The average weights of the fish in the samples are given at the tops of the panels.
FIGURA A-7a. Composición por tallas estimada del barrilete capturado en el OPO durante 2012 en cada pesquería ilustrada en la Figura A-5. En cada recuadro se detalla el peso promedio de los peces en las muestras.

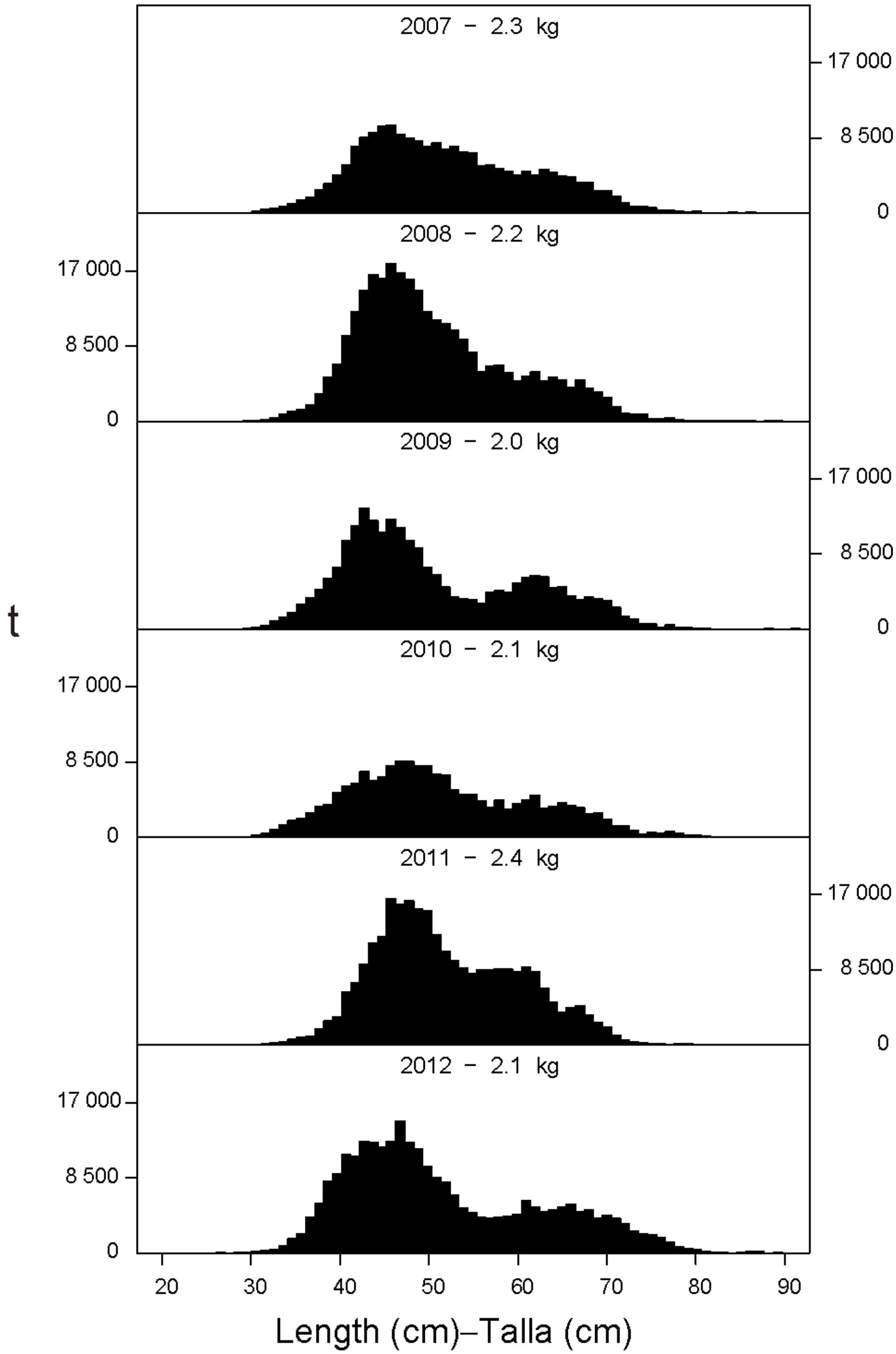

FIGURE A-7b. Estimated size compositions of the skipjack caught by purse-seine and pole-and-line vessels in the EPO during 2007-2012. The average weights of the fish in the samples are given at the tops of the panels.

FIGURA A-7b. Composición por tallas estimada del barrilete capturado por buques cerqueros y cañeros en el OPO durante 2007-2012. En cada recuadro se detalla el peso promedio de los peces en las muestras.

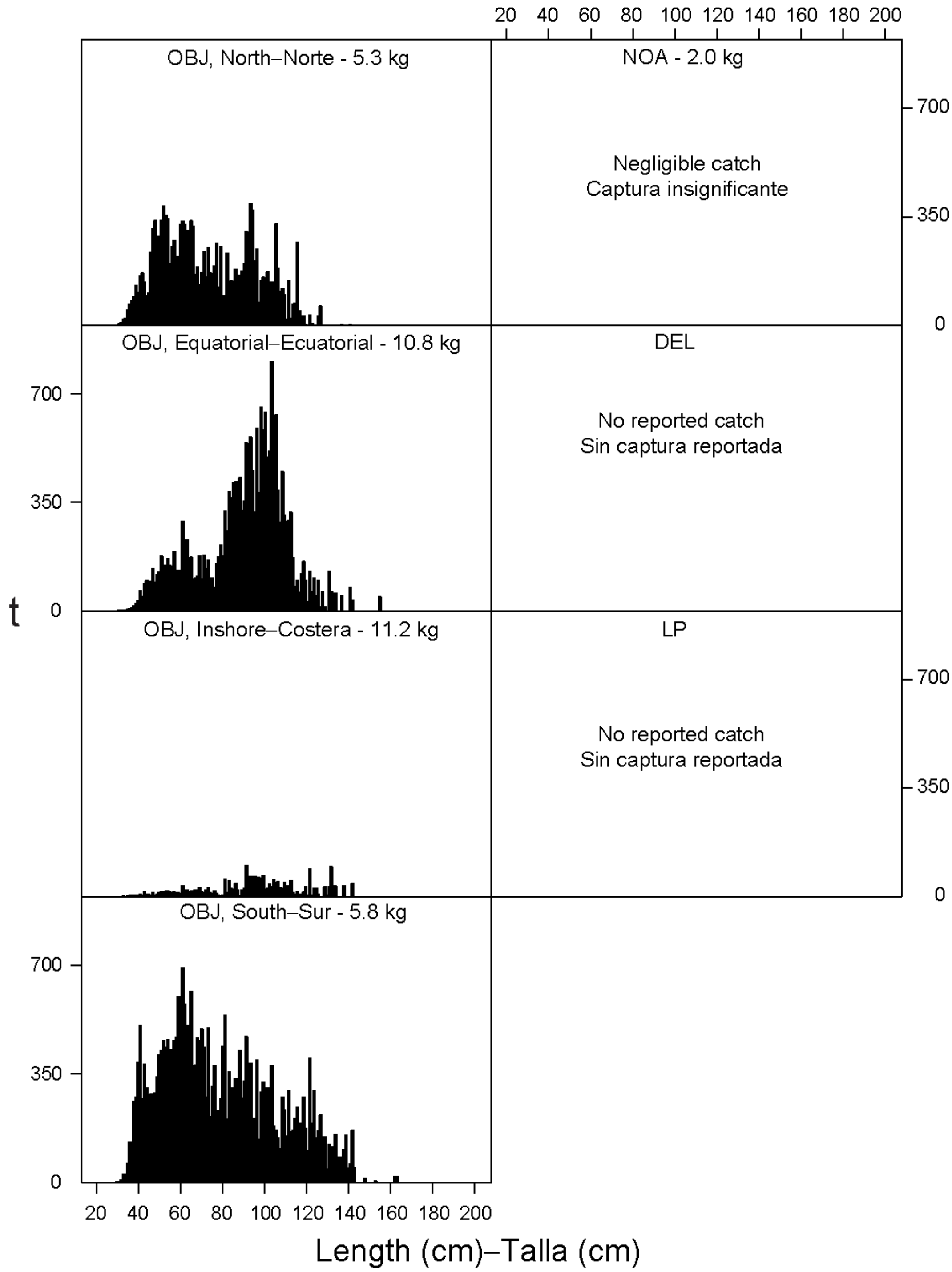

FIGURE A-8a. Estimated size compositions of the bigeye caught in the EPO during 2012 for each fishery designated in Figure A-5. The average weights of the fish in the samples are given at the tops of the panels.

FIGURA A-8a. Composición por tallas estimada del patudo capturado e en el OPO durante 2012 en cada pesquería ilustrada en la Figura A-5. En cada recuadro se detalla el peso promedio de los peces en las muestras.

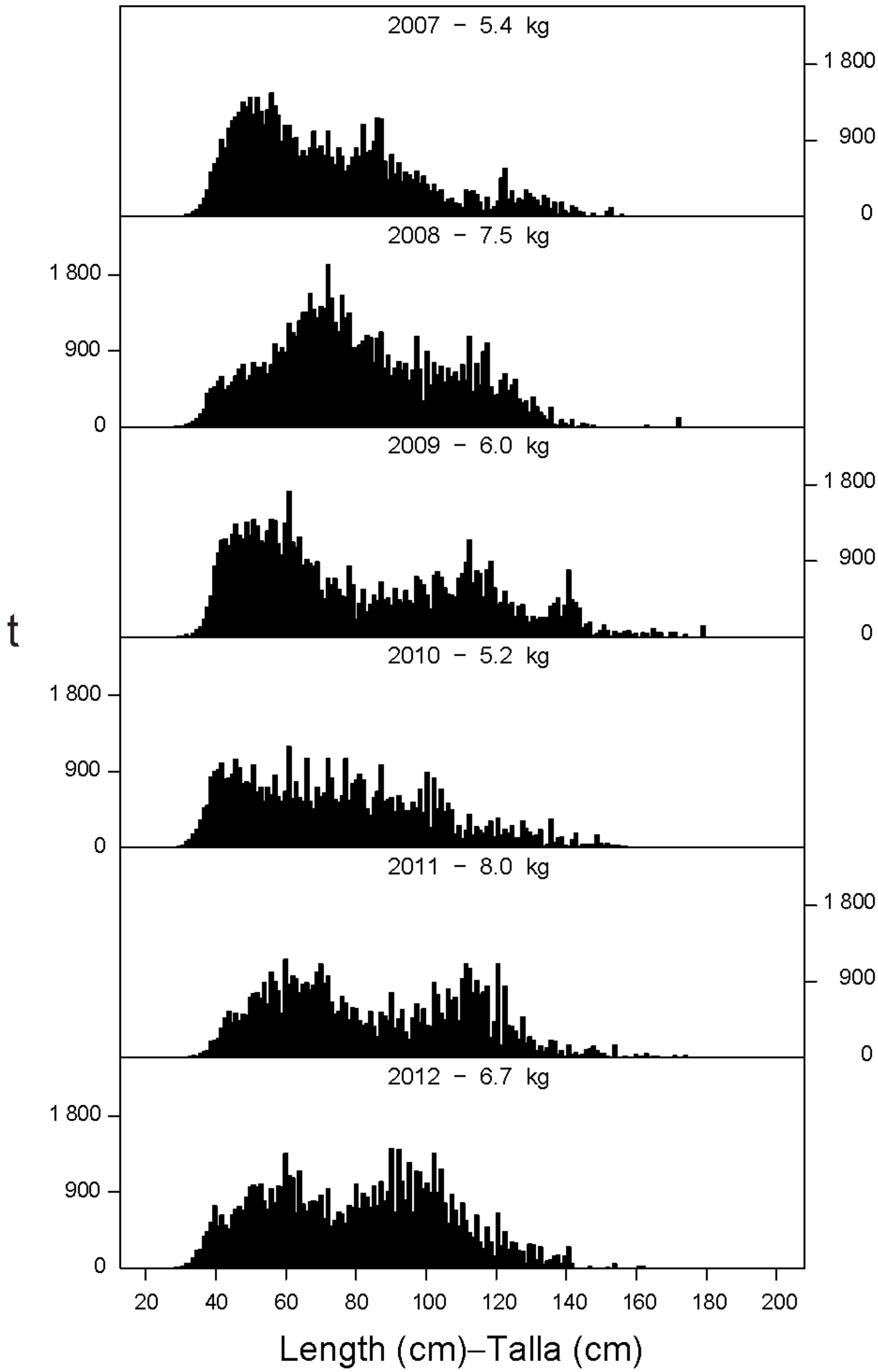

FIGURE A-8b. Estimated size compositions of the bigeye caught by purse-seine vessels in the EPO during 2007-2012. The average weights of the fish in the samples are given at the tops of the panels.
FIGURA A-8b. Composición por tallas estimada del patudo capturado por buques cerqueros en el OPO durante 2007-2012. En cada recuadro se detalla el peso promedio de los peces en las muestras.

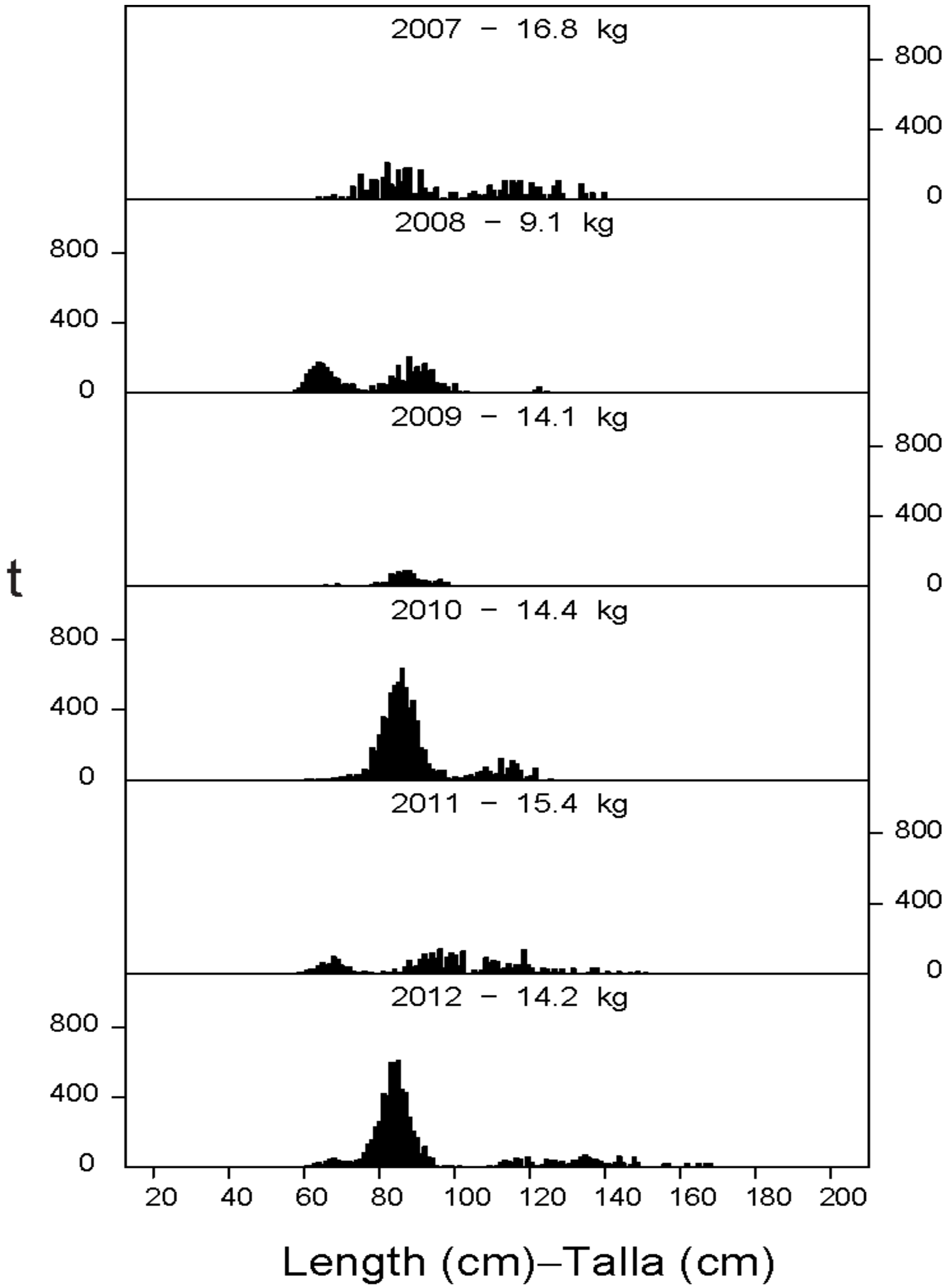

FIGURE A-9. Estimated catches of Pacific bluefin by purse-seine and recreational gear in the EPO during 2007-2012. The values at the tops of the panels are the average weights.

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.

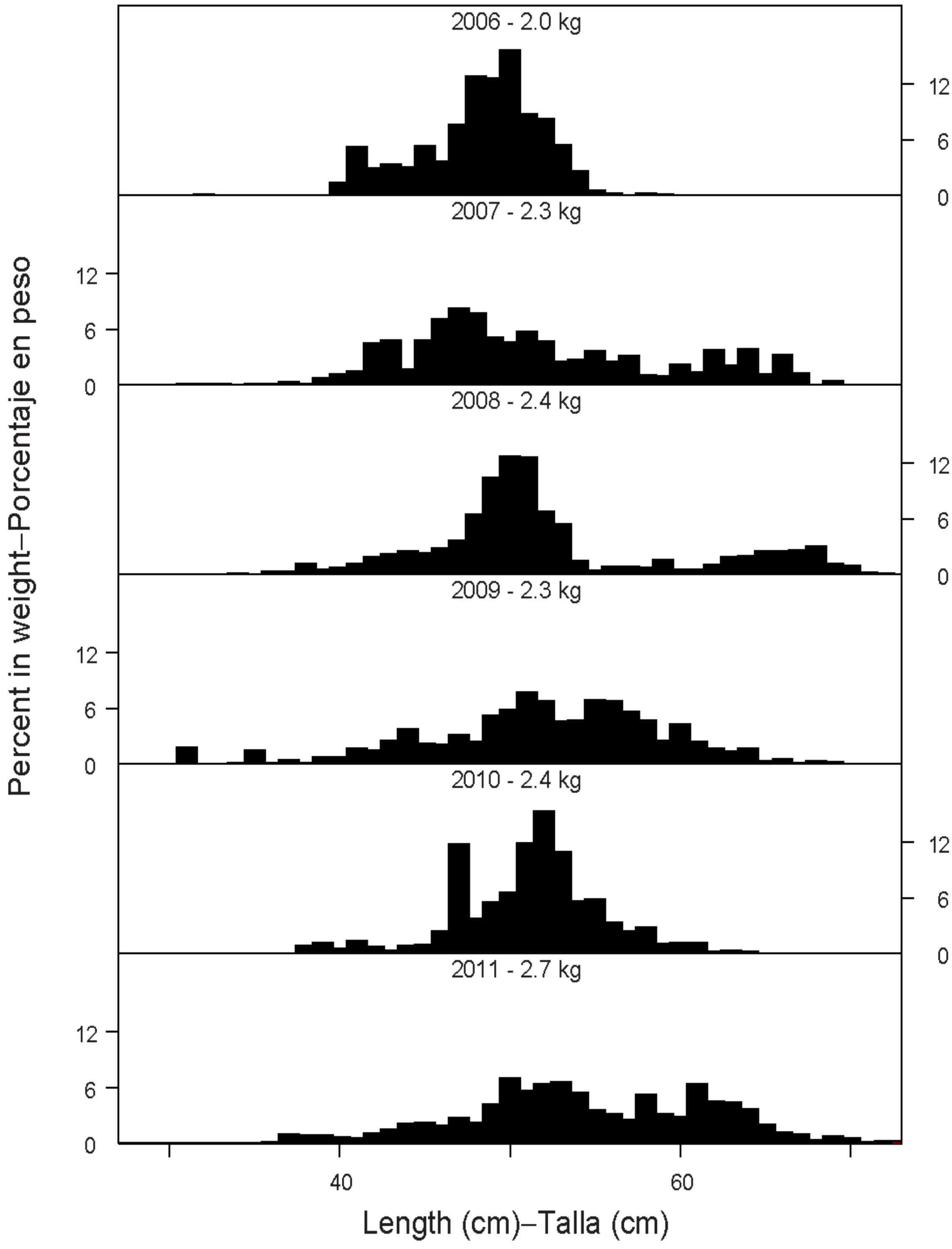

FIGURE A-10. Estimated size compositions of the catches of black skipjack by purse-seine vessels in the EPO during 2006-2011. The values at the tops of the panels are the average weights.

FIGURA A-10. Composición por tallas estimada del barrilete negro capturado por buques cerqueros en el OPO durante 2006-2011. El valor en cada recuadro representa el peso promedio.

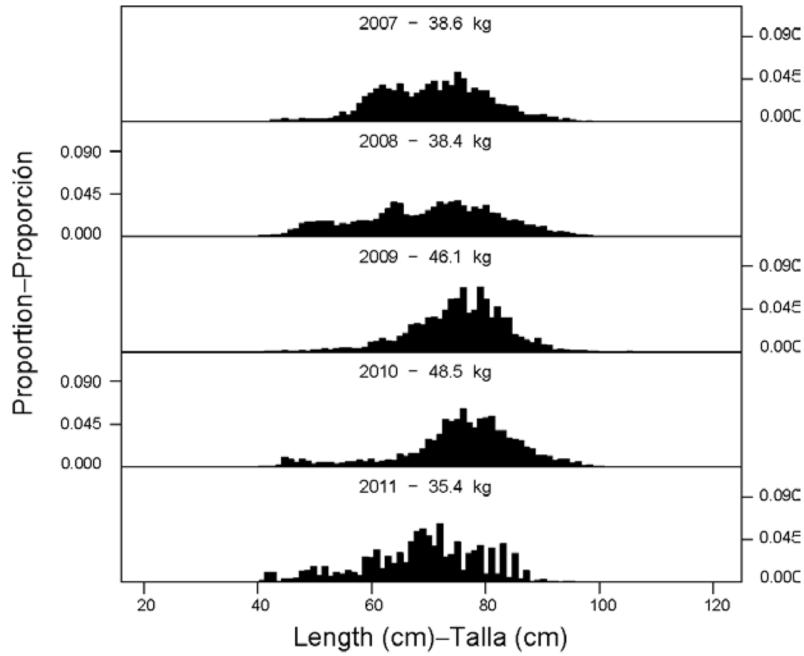

FIGURE A-11. Estimated size compositions of the catches of yellowfin tuna by the Japanese longline fishery in the EPO, 2007-2011.
FIGURA A-11. Composición por tallas estimada de las capturas de atún aleta amarilla por la pesquería palangrera japonesa en el OPO, 2007-2011.

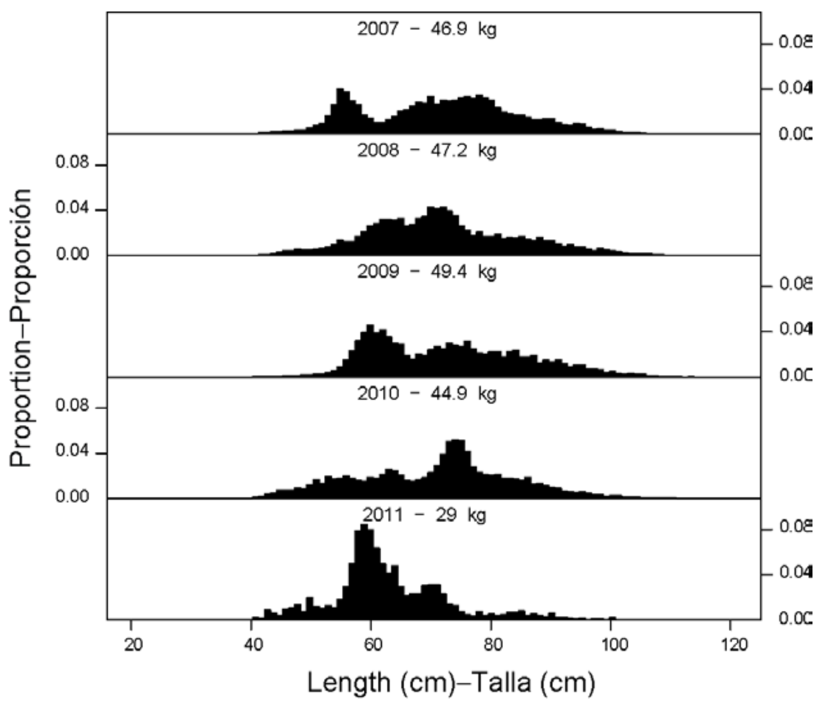

FIGURE A-12. Estimated size compositions of the catches of bigeye tuna by the Japanese longline fishery in the EPO, 2007-2011.
FIGURA A-12. Composición por tallas estimada de las capturas de atún patudo por la pesquería palangrera japonesa en el OPO, 2007-2011.

TABLE A-1. Annual catches of yellowfin, skipjack, and bigeye, by all types of gear combined, in the Pacific Ocean. The EPO totals for 1993-2012 include discards from purse-seine vessels with carrying capacities greater than 363 t.

TABLA A-1. Capturas anuales de aleta amarilla, barrilete, y patudo, por todas las artes combinadas, en el Océano Pacífico. Los totales del OPO de 1993-2012 incluyen los descartes de buques cerqueros de más de 363 t de capacidad de acarreo.

	YFT			SKJ			BET			Total		
	EPO	WCPO	Total	EPO	WCPO	Total	EPO	WCPO	Total	EPO	WCPO	Total
1983	99,680	263,312	362,992	61,975	667,402	729,377	64,694	70,028	134,722	226,349	1,000,742	1,227,091
1984	149,465	253,624	403,089	63,611	753,966	817,577	55,268	75,492	130,760	268,344	1,083,082	1,351,426
1985	225,939	270,832	496,771	52,002	581,309	633,311	72,398	79,734	152,132	350,339	931,875	1,282,214
1986	286,071	240,216	526,287	67,745	747,821	815,566	105,185	81,866	187,051	459,001	1,069,903	1,528,904
1987	286,164	271,488	557,652	66,466	700,808	767,274	101,347	98,464	199,811	453,977	1,070,760	1,524,737
1988	296,428	291,415	587,843	92,127	798,332	890,459	74,313	90,961	165,274	462,868	1,180,708	1,643,576
1989	299,436	321,684	621,120	98,921	795,695	894,616	72,994	97,193	170,187	471,351	1,214,572	1,685,923
1990	301,522	355,402	656,924	77,107	863,143	940,250	104,851	112,983	217,834	483,480	1,331,528	1,815,008
1991	265,970	375,467	641,437	65,890	1,113,831	1,179,721	109,121	94,365	203,486	440,981	1,583,663	2,024,644
1992	252,514	364,632	617,146	87,294	1,029,432	1,116,726	92,000	111,181	203,181	431,808	1,505,245	1,937,053
1993	256,244	297,031	553,275	100,518	988,850	1,089,368	82,843	96,023	178,866	439,605	1,381,904	1,821,509
1994	248,073	344,957	593,030	84,674	1,043,745	1,128,419	109,331	112,970	222,301	442,078	1,501,672	1,943,750
1995	244,639	366,918	611,557	150,661	1,045,708	1,196,369	108,210	100,619	208,829	503,510	1,513,245	2,016,755
1996	266,928	351,284	618,212	132,344	970,704	1,103,048	114,706	99,579	214,285	513,978	1,421,567	1,935,545
1997	277,575	457,798	735,373	188,285	909,269	1,097,554	122,274	145,869	268,143	588,134	1,512,936	2,101,070
1998	280,607	551,299	831,906	165,490	1,189,144	1,354,634	93,954	164,431	258,385	540,051	1,904,874	2,444,925
1999	304,638	474,893	779,531	291,249	1,100,901	1,392,150	93,078	144,854	237,932	688,965	1,720,648	2,409,613
2000	286,865	518,666	805,531	230,520	1,145,569	1,376,089	148,557	130,809	279,366	665,942	1,795,044	2,460,986
2001	425,008	507,591	932,599	157,676	1,041,299	1,198,975	130,546	133,583	264,129	713,230	1,682,473	2,395,703
2002	443,458	471,379	914,837	167,048	1,220,791	1,387,839	132,806	161,404	294,210	743,312	1,853,574	2,596,886
2003	416,018	512,222	928,240	300,470	1,220,440	1,520,910	115,175	131,694	246,869	831,663	1,864,356	2,696,019
2004	296,856	503,768	800,624	217,355	1,308,319	1,525,674	110,897	173,576	284,473	625,108	1,985,663	2,610,771
2005	286,822	561,562	848,384	283,766	1,378,194	1,661,960	111,249	146,802	258,051	681,837	2,086,558	2,768,395
2006	179,756	486,062	665,818	310,316	1,481,027	1,791,343	120,065	159,816	279,881	610,137	2,126,905	2,737,042
2007	182,075	507,815	689,890	216,902	1,646,738	1,863,640	94,380	143,006	237,386	493,357	2,297,559	2,790,916
2008	196,200	573,155	769,355	307,489	1,645,736	1,953,225	103,480	152,024	255,504	607,169	2,370,915	2,978,084
2009	248,436	506,876	755,312	238,873	1,794,790	2,033,663	109,200	153,750	262,950	596,509	2,455,416	3,051,925
2010	260,271	541,822	802,093	152,069	1,678,949	1,831,018	94,991	130,014	225,005	507,331	2,350,785	2,858,116
2011	208,509	476,843	685,352	286,759	1,550,377	1,837,136	87,908	153,521	241,429	583,176	2,180,741	2,763,917
2012	191,358	*	191,358	275,226	*	275,226	88,842	*	88,842	555,426	*	555,426

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 2011-2012 are preliminary.

TABLA A-2a. Estimaciones de las capturas retenidas (Ret.), por arte de pesca, y de los descartes (Dis.), por buques cerqueros de más de 363 t de capacidad de acarreo únicamente, de atunes y bonitos, en toneladas métricas, en el OPO. Los datos de los atunes aleta amarilla, barrilete, y patudo de las pesquerías cerquera y cañera fueron ajustados a la estimación de composición por especie, y son preliminares. Los datos de 2011-2012 son preliminares.

	Yellowfin—Aleta amarilla						Skipjack—Barrilete						Bigeye—Patudo					
	PS		LP	LL	OTR + NK	Total	PS		LP	LL	OTR + NK	Total	PS		LP	LL	OTR + NK	Total
	Ret.	Dis.					Ret.	Dis.					Ret.	Dis.				
1983	83,929	-	4,007	10,895	849	99,680	56,851	-	4,387	28	709	61,975	4,575	-	39	60,043	37	64,694
1984	135,785	-	2,991	10,345	344	149,465	59,859	-	2,884	32	836	63,611	8,861	-	2	46,394	11	55,268
1985	211,459	-	1,070	13,198	212	225,939	50,829	-	946	44	183	52,002	6,056	-	2	66,325	15	72,398
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	4,758	4,951	24,009	3,034	256,244	83,830	10,599	3,772	61	2,256	100,518	9,657	653	-	72,498	35	82,843
1994	208,408	4,527	3,625	30,026	1,487	248,073	70,126	10,504	3,240	73	731	84,674	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	24,503	2,555	52	1,261	132,344	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	4,698	5,085	15,336	1,529	280,607	140,631	22,644	1,684	294	237	165,490	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	24,508	231	68	66	230,520	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	5,950	470	25,174	1,145	416,018	273,968	22,453	638	634	2,777	300,470	53,052	2,326	-	59,776	21	115,175
2004	272,557	3,009	1,884	18,779	627	296,856	197,824	17,182	530	713	1,106	217,355	65,471	1,749	-	43,483	194	110,897
2005	268,101	2,929	1,822	12,118	1,852	286,822	263,229	17,228	1,299	231	1,779	283,766	67,895	1,952	-	41,377	25	111,249
2006	166,631	1,665	686	9,316	1,458	179,756	296,268	12,403	435	224	986	310,316	83,838	2,385	-	33,802	40	120,065
2007	170,016	1,947	894	7,779	1,439	182,075	208,295	7,159	276	107	1,065	216,902	63,450	1,039	-	29,847	44	94,380
2008	185,057	1,019	812	8,371	941	196,200	296,603	9,166	501	56	1,163	307,489	75,028	2,287	-	26,137	28	103,480
2009	236,772	1,482	709	8,479	994	248,436	230,523	6,903	151	185	1,111	238,873	76,799	1,104	-	31,282	15	109,200
2010	251,009	1,145	460	6,699	958	260,271	147,192	3,419	47	142	1,269	152,069	57,752	653	-	36,584	2	94,991
2011	201,693	564	274	5,557	421	208,509	280,401	6,087	4	102	165	286,759	57,190	730	-	29,987	1	87,908
2012	189,838	583	386	551	*	191,358	271,115	3,948	144	19	*	275,226	68,598	773	-	19,471	*	88,842

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.				
1983	836	-	-	2	38	876	7	-	449	7,433	7,840	15,729	1,222	-	-	-	13	1,235
1984	839	-	-	3	51	893	3,910	-	1,441	6,712	9,794	21,857	662	-	-	-	3	665
1985	3,996	-	-	1	77	4,074	42	-	877	7,268	6,654	14,841	288	-	-	-	7	295
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	801	-	-	-	-	801
1990	1,430	-	61	12	103	1,606	39	-	170	6,536	4,105	10,850	787	-	-	-	4	791
1991	419	-	-	5	55	479	0	-	834	7,893	2,754	11,481	421	-	-	-	25	446
1992	1,928	-	-	21	147	2,096	0	-	255	17,080	5,740	23,075	105	-	-	3	-	108
1993	580	0	-	11	325	916	0	-	1	11,194	4,410	15,605	104	4,144	-	31	-	4,279
1994	969	0	-	12	111	1,092	0	-	85	10,390	10,154	20,629	188	857	-	40	-	1,085
1995	659	0	-	25	300	984	0	-	465	6,185	7,427	14,077	203	1,448	-	-	-	1,651
1996	8,333	0	-	19	84	8,436	11	-	72	7,631	8,398	16,112	704	2,304	-	12	-	3,020
1997	2,608	3	2	14	245	2,872	1	-	59	9,678	7,540	17,278	100	2,512	-	11	-	2,623
1998	1,772	0	-	94	525	2,391	42	-	81	12,635	13,158	25,916	489	1,876	39	-	-	2,404
1999	2,553	54	5	152	564	3,328	47	-	227	11,633	14,510	26,417	171	3,412	-	-	-	3,583
2000	3,712	0	61	46	378	4,197	71	-	86	9,663	13,453	23,273	293	1,995	-	-	-	2,288
2001	1,155	3	1	148	401	1,708	3	-	157	19,410	13,727	33,297	2,258	1,019	-	-	-	3,277
2002	1,758	1	3	71	653	2,486	31	-	381	15,289	14,433	30,134	1,459	2,283	8	-	-	3,750
2003	3,233	0	3	87	404	3,727	34	-	59	24,901	20,397	45,391	433	1,535	6	13	117	2,104
2004	8,880	19	-	16	62	8,977	105	-	126	18,444	22,011	40,686	884	387	-	27	862	2,160
2005	4,743	15	-	-	85	4,843	2	-	66	11,398	15,738	27,204	1,472	2,124	-	-	22	3,618
2006	9,928	0	-	-	101	10,029	109	-	1	13,728	19,154	32,992	1,999	1,972	-	-	-	3,971
2007	4,189	0	-	-	15	4,204	187	-	21	11,031	19,889	31,128	2,306	1,625	-	-	54	3,985
2008	4,392	14	15	-	103	4,524	49	-	1,050	8,963	16,565	26,627	3,624	2,251	-	-	8	5,883
2009	3,428	24	0	0	179	3,631	59	2	2,218	12,187	17,155	31,621	4,362	1,020	-	-	-	5,382
2010	7,746	0	0	3	123	7,872	25	-	0	13,888	20,119	34,032	3,425	1,079	-	-	184	4,688
2011	2,829	4	-	1	474	3,308	51	-	0	17,828	16,972	34,851	2,317	719	-	-	*	3,036
2012	6,705	0	-	*	*	6,705	-	-	*	*	*	*	4,379	440	-	-	*	4,819

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.				
1983	3,827	-	2	-	7,291	11,120	60	-	-	-	4,711	4,771	151,307	-	8,884	78,401	21,488	260,080
1984	3,514	-	0	-	7,291	10,805	6	-	-	-	2,524	2,530	213,436	-	7,318	63,486	20,854	305,094
1985	3,599	-	5	-	7,869	11,473	19	-	-	-	678	697	276,288	-	2,900	86,836	15,695	381,719
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	388,179	-	7,929	94,811	5,160	496,079
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	2,014	-	10	4,082	6,115	314,271	22,180	8,725	107,814	14,578	467,568
1994	8,331	147	362	-	185	9,025	9	498	-	1	464	972	322,930	18,799	7,312	111,902	13,938	474,881
1995	7,929	55	81	-	54	8,119	11	626	-	-	1,004	1,641	396,604	27,028	7,067	85,152	14,131	529,982
1996	647	1	7	-	16	671	37	1,028	-	-	1,038	2,103	413,623	39,837	6,396	71,280	13,184	544,320
1997	1,097	4	8	-	34	1,143	71	3,383	-	7	1,437	4,898	466,483	48,158	7,747	84,588	9,972	616,948
1998	1,330	4	7	-	588	1,929	13	1,233	-	24	18,158	19,428	442,365	33,277	6,896	74,758	34,823	592,119
1999	1,719	-	-	24	369	2,112	27	3,092	-	2,113	4,279	9,511	599,160	44,083	4,059	62,255	24,359	733,916
2000	636	-	-	75	56	767	190	1,410	-	1,992	1,468	5,060	559,094	39,537	2,809	83,304	16,783	701,527
2001	17	-	0	34	19	70	191	679	-	2,448	55	3,373	591,243	22,798	4,522	121,617	14,775	754,955
2002	-	-	-	-	1	1	576	1,863	-	482	1,422	4,343	627,077	21,742	1,958	116,058	17,191	784,026
2003	-	0	1	-	25	26	80	1,238	-	215	750	2,283	714,079	33,502	1,177	110,800	25,636	885,194
2004	15	35	1	8	3	62	256	973	-	349	258	1,836	545,992	23,354	2,541	81,819	25,123	678,829
2005	313	18	0	-	11	342	190	1,922	-	363	427	2,902	605,945	26,188	3,187	65,487	19,939	720,746
2006	3,507	80	12	-	3	3,602	50	1,910	-	3	193	2,156	562,330	20,415	1,134	57,073	21,935	662,887
2007	15,906	628	107	-	-	16,641	598	1,221	-	2,194	301	4,314	464,947	13,619	1,298	50,958	22,807	553,629
2008	7,874	37	9	-	26	7,946	136	1,380	1	727	876	3,120	572,763	16,154	2,388	44,254	19,710	655,269
2009	10,053	15	0	0	165	10,233	162	469	-	1,933	67	2,631	562,158	11,019	3,078	54,066	19,686	650,007
2010	2,820	19	4	-	0	2,843	136	709	-	1,754	36	2,635	470,105	7,024	511	59,070	22,691	559,401
2011	7,969	29	18	*	9	8,025	108	784	-	3,173	*	4,065	552,558	8,917	296	56,648	18,042	636,461
2012	8,187	-	*	*	*	8,187	41	354	-	1,939	*	2,334	548,863	6,098	530	21,980	0	577,471

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 2011-2012 are preliminary. PS dis. = discards by purse-seine vessels.

TABLA A-2b. Estimaciones de las capturas retenidas, por arte de pesca, y de los descartes, por buques cerqueros de más de 363 t de capacidad de acarreo únicamente, de peces picudos, en toneladas métricas, en el OPO. Los datos de 2011-2012 son preliminares. PS dis. = descartes por buques cerqueros.

	Swordfish—Pez espada					Blue marlin—Marlín azul					Black marlin—Marlín negro					Striped marlin—Marlín rayado				
	PS		LL	OTR	Total	PS		LL	OTR	Total	PS		LL	OTR	Total	PS		LL	OTR	Total
	Ret.	Dis.				Ret.	Dis.				Ret.	Dis.				Ret.	Dis.			
1983	-	-	3,341	2,338	5,679	-	-	4,460	-	4,460	-	-	240	-	240	-	-	4,472	-	4,472
1984	-	-	2,752	3,336	6,088	-	-	5,198	-	5,198	-	-	248	-	248	-	-	2,662	-	2,662
1985	-	-	1,885	3,768	5,653	-	-	3,589	-	3,589	-	-	180	-	180	-	-	1,599	-	1,599
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	0	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	1	4,495	2,974	7,473	70	16	7,288	-	7,374	43	23	158	-	224	18	8	3,249	296	3,571
1996	1	0	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	0	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	0	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	0	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	353	18,518	185	21	4,015	-	4,221	121	26	73	-	220	31	4	1,904	417	2,356
2004	2	0	15,372	309	15,683	140	21	3,783	-	3,944	62	5	41	-	108	23	1	1,547	390	1,961
2005	2	0	8,987	4,304	13,293	209	14	3,407	-	3,630	95	9	52	-	156	37	4	1,559	553	2,153
2006	7	0	9,164	3,800	12,971	164	21	2,396	105	2,686	124	21	43	-	188	54	3	1,627	490	2,174
2007	4	-	9,586	4,390	13,980	124	13	2,394	106	2,637	74	8	48	-	130	32	4	1,391	1,024	2,451
2008	6	0	11,593	3,071	14,670	125	8	1,711	114	1,958	76	9	100	-	185	33	2	1,009	1,045	2,089
2009	4	0	14,384	3,809	18,197	159	15	2,116	131	2,421	76	8	99	-	183	23	2	1,019	7	1,051
2010	4	0	17,151	5,141	22,296	176	12	2,451	170	2,809	62	9	159	0	230	21	2	1,671	37	1,731
2011	3	-	18,261	5,945	24,209	150	6	1,392	38	1,586	59	7	184	*	250	28	1	1,993	31	2,053
2012	5	-	846	3	854	174	15	9	*	198	72	4	0	*	76	28	0	121	*	149

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

	Shortbill spearfish—Marlín trompa corta					Sailfish—Pez vela					Unidentified istiophorid billfishes—Picudos istiofóridos no identificados					Total billfishes—Total de peces picudos				
	PS		LL	OTR	Total	PS		LL	OTR	Total	PS		LL	OTR	Total	PS		LL	OTR	Total
	Ret.	Dis.				Ret.	Dis.				Ret.	Dis.				Ret.	Dis.			
1983	-	-	-	-	-	-	-	890	-	890	-	-	2	-	2	-	-	13,405	2,338	15,743
1984	-	-	-	-	-	-	-	345	-	345	-	-	-	-	-	-	-	11,205	3,336	14,541
1985	-	-	-	-	-	-	-	395	-	395	-	-	1	-	1	-	-	7,649	3,768	11,417
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	0	0	1	-	1	26	32	2,266	-	2,324	29	68	1,650	-	1,747	246	172	20,468	4,673	25,558
1994	0	0	144	-	144	18	21	1,682	-	1,721	7	16	1,028	-	1,051	154	84	20,523	4,079	24,841
1995	1	0	155	-	156	12	15	1,351	-	1,378	4	9	232	-	245	151	72	16,928	3,270	20,421
1996	1	0	126	-	127	10	12	738	-	760	7	13	308	-	328	147	73	15,157	2,916	18,293
1997	1	0	141	-	142	12	11	1,891	-	1,914	3	5	1,324	-	1,332	243	57	24,478	2,110	26,888
1998	0	0	200	-	200	28	31	1,382	-	1,441	5	8	575	55	643	258	90	20,539	3,810	24,697
1999	1	0	278	-	279	33	8	1,216	-	1,257	6	12	1,136	-	1,154	332	111	16,605	2,341	19,390
2000	1	0	285	-	286	33	17	1,380	-	1,430	3	6	879	136	1,024	244	70	17,102	2,923	20,339
2001	0	0	304	-	304	18	45	1,539	325	1,927	2	5	1,742	204	1,953	222	147	25,872	2,835	29,075
2002	1	0	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	291	-	296	38	49	1,174	-	1,261	6	5	1,389	-	1,400	385	110	27,007	770	28,271
2004	1	0	207	-	208	19	13	1,400	17	1,449	4	4	1,385	-	1,393	251	44	23,735	716	24,746
2005	1	0	229	-	230	32	11	805	15	863	5	3	901	-	909	381	41	15,940	4,872	21,234
2006	1	0	231	-	232	30	13	1,007	35	1,085	23	4	490	1	518	403	62	14,958	4,431	19,854
2007	1	0	240	-	241	41	8	930	64	1,043	13	4	107	15	139	289	37	14,696	5,599	20,621
2008	1	0	257	-	258	28	7	383	72	490	16	5	85	8	114	285	31	15,138	4,310	19,764
2009	1	0	444	-	445	17	6	194	8	225	11	1	28	12	52	291	32	18,284	3,967	22,574
2010	1	0	488	31	520	27	20	316	4	367	8	2	534	-	544	299	45	22,770	5,383	28,497
2011	-	-	285	31	316	18	5	271	28	322	15	1	358	3	377	273	20	22,744	6,076	29,113
2012	1	-	-	-	1	14	2	77	-	93	10	1	224	-	235	304	22	1,277	3	1,606

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 2011-2012 are preliminary.

TABLA A-2c. Estimaciones de las capturas retenidas (Ret.), por arte de pesca, y de los descartes (Dis.), por buques cerqueros de más de 363 t de capacidad de acarreo únicamente, de otras especies, en toneladas métricas, en el OPO. Los datos de 2011-2012 son preliminares.

	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.			
1983	1,240	-	-	0	1,240	88	-	-	3,374	3,462	34	-	85	695	814	288	-	-	1	289
1984	414	-	-	0	414	102	-	-	202	304	48	-	6	1,039	1,093	415	-	-	3	418
1985	317	-	-	4	321	93	-	-	108	201	27	-	13	481	521	76	-	7	-	83
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	-	-	0	116	57	-	7	613	677	1	-	1,112	1,352	2,465	463	-	458	1	922
1992	116	-	-	0	116	69	-	37	708	814	-	-	2,294	1,190	3,484	555	-	183	-	738
1993	31	43	-	2	76	266	477	17	724	1,484	277	1,154	1,028	916	3,375	145	554	184	2	885
1994	19	28	-	16	63	687	826	46	3,459	5,018	372	1,029	1,234	1,314	3,949	243	567	251	-	1,061
1995	27	32	-	9	68	465	729	39	2,127	3,360	278	1,093	922	1,075	3,368	177	760	211	-	1,148
1996	137	135	-	57	329	548	885	43	183	1,659	239	1,001	1,120	2,151	4,511	155	467	457	-	1,079
1997	38	111	-	39	188	567	703	6,866	3,109	11,245	413	1,232	956	2,328	4,929	261	654	848	-	1,763
1998	83	149	-	4	236	426	426	2,528	9,167	12,547	279	1,404	2,099	4,393	8,175	302	1,133	1,340	-	2,775
1999	108	136	-	1	245	568	751	6,284	1,160	8,763	260	843	5,997	2,088	9,188	245	748	976	-	1,969
2000	95	66	4	4	169	813	785	3,537	1,041	6,176	263	772	8,418	405	9,858	148	408	1,490	-	2,046
2001	15	145	18	26	204	1,028	1,275	15,941	2,825	21,069	183	641	12,540	107	13,471	391	1,130	1,727	-	3,248
2002	19	111	15	20	165	932	938	9,464	4,137	15,471	137	758	12,398	99	13,392	355	722	1,913	-	2,990
2003	9	141	54	0	204	583	346	5,301	288	6,518	118	833	14,722	372	16,045	279	406	4,682	-	5,367
2004	39	103	1	0	143	811	317	3,986	4,645	9,759	157	622	11,273	173	12,225	339	1,031	670	-	2,040
2005	80	79	-	0	159	863	295	3,854	8,667	13,679	199	496	12,127	224	13,046	439	276	676	-	1,391
2006	247	146	-	0	393	1,002	385	3,404	13,125	17,916	235	674	6,613	297	7,819	496	381	525	100	1,502
2007	174	183	6	17	380	1,264	350	2,980	7,827	12,421	343	395	8,807	424	9,969	830	675	2,246	120	3,871
2008	85	55	5	17	162	933	327	4,423	5,458	11,141	540	357	9,112	529	10,538	522	429	1,297	86	2,334
2009	63	42	10	16	131	1,923	476	4,239	51,328	57,966	279	339	7,908	386	8,912	1,036	374	1,938	220	3,568
2010	80	15	8	23	126	1,242	253	2,073	48,066	51,634	335	463	15,834	306	16,938	884	192	1,469	205	2,750
2011	71	24	8	0	103	1,291	386	1,934	20,715	24,326	280	316	13,028	226	13,850	511	219	692	-	1,422
2012	53	23	1	0	77	1,789	401	460	0	2,650	229	278	4,370	51	4,928	838	230	287	*	1,355

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
1983	-	C	7,579	-	18,576	-	2,444	943	-	43,780	7,840	-	2,767	83,929
1984	-	2,702	10,526	C	53,697	-	C	C	-	57,162	9,268	-	2,430	135,785
1985	-	2,785	8,794	C	80,422	-	10,887	C	-	84,364	20,696	C	3,511	211,459
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	253,263
2001	12,950	-	55,347	18,448	130,087	C	9,552	-	C	5,670	108,974	10,729	32,180	383,936
2002	17,574	-	32,512	16,990	152,864	C	15,719	C	7,412	7,382	123,264	7,502	31,068	412,286
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	272,557
2005	C	-	40,596	11,947	110,898	4,838	33,393	-	6,470	C	28,684	C	31,276	268,101
2006	C	-	26,049	8,409	69,449	4,236	22,521	-	C	C	13,286	C	22,679	166,631
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	43,744	236,772
2010	20,493	-	34,764	2,820	104,969	9,422	34,538	C	C	-	21,244	C	22,758	251,009
2011	18,384	-	25,923	1,077	102,613	7,774	18,410	-	C	C	18,344	C	9,167	201,693
2012	19,620	-	23,029	958	96,700	7,038	14,290	C	C	C	22,689	C	5,514	189,838

[1] Includes—Incluye: BLZ, BMU, BOL, CAN, CHN, CYM, CYP, GTM, HND, KOR, LBR, NZL, RUS, VCT, 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 2011-2012 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 2011-2012 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]
1983	-	-	-	9,404	1,382	49	-	60	-	-	*	10,895	94,824	4,856
1984	-	-	-	9,134	1,155	-	-	56	-	-	*	10,345	146,130	3,335
1985	-	-	-	10,633	2,505	2	-	58	-	-	*	13,198	224,657	1,282
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	1	1,782	2,422	7	223	182	12,118	280,219	3,674
2006	246	1,402	537	2,968	-	0	2,164	1,671	21	199	108	9,316	175,947	2,144
2007	224	1,204	408	4,582	353	8	-	745	11	154	90	7,779	177,795	2,333
2008	469	1,248	335	5,383	83	5	-	247	33	167	401	8,371	193,428	1,753
2009	629	1,003	590	4,268	780	10	-	636	84	259	220	8,479	245,251	1,703
2010	459	3	301	3,639	737	6	-	872	54	259	369	6,699	257,708	1,418
2011	1,807	-	-	2,011	754	6	-	646	54	173	106	5,557	207,250	695
2012	-	515	-	-	-	7	-	-	-	29	*	551	190,389	386

[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	
1983	-	C	12,590	-	6,277	-	764	170	-	32,009	3,352	-	1,689	56,851	5,124
1984	-	31	18,085	-	8,550	-	C	-	-	23,966	7,797	-	1,430	59,859	3,752
1985	-	87	22,806	C	5,334	-	1,197	-	-	9,907	8,184	C	3,314	50,829	1,173
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	22,382	205,647	365
2001	9,445	-	66,144	13,454	8,169	C	6,967	-	C	4,135	3,215	7,824	23,813	143,165	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	296,268	1,645
2007	C	-	93,553	2,879	21,542	4,286	28,475	-	C	C	21,990	C	35,571	208,295	1,448
2008	C	-	143,431	4,841	21,638	7,005	43,230	C	C	C	28,333	C	48,125	296,603	1,720
2009	C	-	132,712	6,021	6,847	5,119	26,973	C	C	C	19,370	C	33,481	230,523	1,447
2010	11,400	-	82,280	1,569	3,010	5,242	19,213	C	C	-	11,818	C	12,660	147,192	1,458
2011	23,746	-	154,814	5,442	8,596	4,021	30,549	-	C	C	27,417	C	25,816	280,401	271
2012	16,662	-	159,008	15,077	14,568	4,077	25,734	C	C	C	21,335	C	14,653	271,115	163

[1] Includes—Incluye: BLZ, BMU, BOL, CAN, CHN, CYM, 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
1983	-	*	457	-	16	-	663	*	-	1,801	1,319	-	319	4,575
1984	-	3	1,164	*	40	-	*	*	-	5,335	2,181	-	138	8,861
1985	-	17	2,970	C	19	-	-	-	-	1,806	939	C	305	6,056
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	95,282
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	57,421
2003	3,664	-	22,896	4,605	0	-	6,222	C	C	1,350	424	3,500	10,390	53,052
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	83,838
2007	C	-	40,445	711	0	1,058	7,029	*	C	C	5,428	C	8,780	63,450
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	76,799
2010	4,206	-	34,902	579	11	1,934	7,089	C	C	-	4,360	C	4,672	57,752
2011	2,993	-	33,007	3,902	635	2,131	7,438	*	C	C	279	C	6,803	57,190
2012	2,275	-	43,582	4,455	730	1,596	8,896	C	C	C	1,044	C	6,019	68,598

[1] Includes—Incluye: BLZ, BOL, CHN, CYM, 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 2011-2012 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 2011-2012 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]
1983	-	-	-	57,185	2,614	-	-	244	-	-	*	60,043	64,618	76
1984	-	-	-	44,587	1,613	-	-	194	-	-	*	46,394	55,255	13
1985	-	-	-	61,627	4,510	0	-	188	-	-	*	66,325	72,381	17
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	1,001	151	41,377	109,272	25
2006	709	18	388	16,235	8,694	-	37	6,412	85	1,029	195	33,802	117,640	40
2007	2,324	15	361	13,977	5,611	-	-	6,057	417	992	93	29,847	93,297	44
2008	2,379	16	367	14,908	4,150	-	-	1,852	1,277	731	456	26,137	101,165	28
2009	2,481	13	484	15,490	6,758	-	-	3,396	730	1,130	800	31,282	108,081	15
2010	2,490	4	314	15,847	9,244	-	-	5,276	1,357	1,439	613	36,584	94,336	2
2011	5,450	-	-	11,782	6,617	-	-	3,956	1,051	1,006	127	29,987	87,177	1
2012	1,993	1	-	7,424	6,892	-	-	2,937	-	224	*	19,471	88,069	*

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

[2] Includes gillnets, pole-and-line, recreational, and unknown gears—Incluye red de transmalle, caña, artes deportivas, y desconocidas

TABLE A-4. Preliminary estimates of the retained catches in metric tons, of tunas and bonitos caught by purse-seine, pole-and-line, and recreational vessels in the EPO in 2011 and 2012, 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-4. Estimaciones preliminares de las capturas retenidas, en toneladas métricas, de atunes y bonitos por buques cerqueros, cañeros, y recreacionales en el OPO en 2011 y 2012, 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	%
2011	**Retained catches–Capturas retenidas**									
COL	18,384	23,746	2,993	-	10	-	-	-	45,133	8.2
ECU	25,923	154,814	33,007	-	-	186	3	40	213,973	38.7
EU(ESP)	1,077	5,442	3,902	-	-	-	-	-	10,421	1.9
MEX	102,887	8,600	635	2,730	-	2,023	7,984	43	124,902	22.6
NIC	7,774	4,021	2,131	-	-	-	-	-	13,926	2.5
PAN	18,410	30,549	7,438	-	-	-	-	-	56,397	10.2
VEN	18,344	27,417	279	-	-	39	-	10	46,089	8.3
OTR[1]	9,168	25,816	6,805	99	41	69	-	15	42,013	7.6
Total	201,967	280,405	57,190	2,829	51	2,317	7,987	108	552,854	
2012	**Retained catches–Capturas retenidas**									
COL	19,620	16,662	2,275	-	-	-	-	-	38,557	7.0
ECU	23,029	159,008	43,582	-	-	752	3,837	38	230,246	41.9
EU(ESP)	958	15,077	4,455	-	-	5	-	-	20,495	3.7
MEX	97,086	14,713	730	6,667	-	3,614	4,325	-	127,135	23.1
NIC	7,038	4,077	1,596	-	-	-	-	-	12,711	2.3
PAN	14,290	25,734	8,896	-	-	-	25	-	48,945	8.9
VEN	22,689	21,335	1,044	-	-	7	-	2	45,077	8.2
OTR[2]	5,514	14,653	6,020	38	-	1	-	1	26,227	4.8
Total	190,224	271,259	68,598	6,705	-	4,379	8,187	41	549,393	

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

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

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

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

TABLE A-5. Annual retained catches of Pacific bluefin tuna, by gear type and flag, in metric tons. The data for 2010 and 2011 are preliminary.

TABLA A-5. Capturas retenidas anuales de atún aleta azul del Pacífico, por arte de pesca y bandera, en toneladas métricas. Los datos de 2010 y 2011 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			
1983	14,774	356	224	4,116	13	-	9	175	2	19,670	214	-	629	44	887	-	20,557
1984	4,433	587	164	4,977	4	-	5	477	8	10,655	166	-	673	78	917	-	11,573
1985	4,154	1,817	115	5,587	1	-	80	210	11	11,975	676	-	3,320	117	4,113	-	16,089
1986	7,412	1,086	116	5,100	344	-	16	70	13	14,157	189	-	4,851	69	5,109	-	19,266
1987	8,653	1,565	244	3,524	89	-	21	365	14	14,474	119	-	861	54	1,033	-	15,507
1988	3,605	907	187	2,464	32	-	197	108	62	7,562	447	1	923	56	1,427	-	8,989
1989	6,190	754	241	1,933	71	-	259	205	54	9,707	57	-	1,046	134	1,236	-	10,943
1990	2,989	536	336	2,421	132	-	149	189	315	7,067	50	-	1,380	157	1,587	-	8,653
1991	9,808	286	238	4,204	265	-	-	342	119	15,262	9	-	410	98	517	2	15,781
1992	7,162	166	529	3,205	288	-	73	464	8	11,896	-	-	1,928	171	2,099	-	13,995
1993	6,600	129	822	1,759	40	-	1	471	3	9,825	-	-	580	401	981	6	10,811
1994	8,131	162	1,226	5,667	50	-	-	559	-	15,795	63	2	906	148	1,118	2	16,916
1995	18,909	270	688	7,224	821	-	-	335	2	28,248	11	-	657	308	975	2	29,225
1996	7,644	94	909	5,360	102	-	-	956	-	15,066	3,700	-	4,639	110	8,449	4	23,519
1997	13,152	34	1,312	4,354	1,054	-	-	1,814	-	21,720	367	-	2,240	290	2,897	14	24,632
1998	5,390	85	1,266	4,439	188	-	-	1,910	-	13,277	1	-	1,771	694	2,466	20	15,763
1999	16,173	35	1,174	5,192	256	-	-	3,089	-	25,919	2,369	35	184	625	3,213	21	29,153
2000	16,486	102	960	6,935	2,401	-	-	2,780	2	29,666	3,019	99	693	403	4,214	21	33,901
2001	7,620	180	797	5,477	1,176	10	-	1,839	4	17,103	863	-	292	404	1,559	50	18,712
2002	8,903	99	846	4,158	932	1	-	1,523	4	16,466	1,708	2	50	666	2,426	65	18,957
2003	5,768	44	1,249	3,124	2,601	-	-	1,863	21	14,670	3,211	43	22	412	3,688	60	18,418
2004	8,257	132	1,856	3,592	773	-	-	1,714	3	16,327	8,880	14	-	60	8,954	77	25,358
2005	12,817	549	1,939	6,136	1,318	-	-	1,368	2	24,129	4,542	-	201	86	4,829	27	28,985
2006	8,880	108	1,132	3,742	1,012	-	-	1,149	1	16,024	9,928	-	-	98	10,026	24	26,074
2007	6,840	236	2,095	5,097	1,281	-	-	1,401	10	16,960	4,147	-	42	16	4,205	25	21,190
2008	10,221	64	1,503	5,624	1,866	-	-	979	2	20,259	4,392	15	-	94	4,501	25	24,785
2009	8,077	50	1,319	5,024	936	-	-	877	11	16,294	3,019	-	410	181	3,610	25	19,929
2010	3,742	83	914	3,822	1,196	-	-	373	36	10,166	7,745	-	-	122	7,867	25	18,058
2011	8,331	63	713	4,217	670			292	24	14,310	2,730	-	99	474	3,303	25	17,638

[1] Source: International Scientific Committee, 11th Plenary Meeting, PBFWG workshop report on Pacific Bluefin Tuna, November 2012—Fuente: Comité Científico Internacional, 11ª Reunión Plenaria, Taller PBFWG sobre Atún Aleta Azul del Pacífico, noviembre de 2012

TABLE A-6a. Annual retained catches of North Pacific albacore by region and gear, in metric tons, compiled from IATTC data (EPO) and SPC data (WCPO). The data for 2010 and 2011 are preliminary.
TABLA A-6a. Capturas retenidas anuales de atún albacora del Pacífico Norte por región, en toneladas métricas, compiladas de datos de la CIAT (OPO) y la SPC (WCPO). Los datos de 2010 y 2011 son preliminares.

ALB (N)	Eastern Pacific Ocean Océano Pacífico oriental					Western and central Pacific Ocean Océano Pacífico occidental y central					Total
	LL	LP	LTL	OTR	Subtotal	LL	LP	LTL	OTR	Subtotal	
1983	1,572	449	7,751	94	9,866	15,014	21,256	1,833	7,582	45,685	55,551
1984	2,592	1,441	8,343	5,337	17,713	13,541	25,602	1,011	13,333	53,487	71,200
1985	1,313	877	5,308	1,218	8,716	13,468	21,335	1,163	13,729	49,695	58,411
1986	698	86	4,282	243	5,309	12,442	16,442	456	10,695	40,035	45,344
1987	1,114	320	2,300	172	3,906	14,297	18,920	570	11,337	45,124	49,030
1988	899	271	4,202	81	5,453	14,702	6,543	165	18,887	40,297	45,750
1989	952	21	1,852	161	2,986	13,584	8,662	148	19,825	42,219	45,205
1990	1,143	170	2,440	63	3,816	15,465	8,477	465	26,096	50,503	54,319
1991	1,514	834	1,783	6	4,137	16,535	6,269	201	10,792	33,797	37,934
1992	1,635	255	4,515	2	6,407	18,356	13,633	419	16,578	48,986	55,393
1993	1,772	1	4,331	25	6,129	29,371	12,796	2,417	4,087	48,671	54,800
1994	2,356	85	9,581	106	12,128	28,469	26,304	3,553	3,380	61,706	73,834
1995	1,380	465	7,308	102	9,255	31,568	20,596	3,450	1,623	57,237	66,492
1996	1,675	72	8,195	99	10,041	37,708	20,224	13,654	971	72,557	82,598
1997	1,365	59	6,056	1,019	8,499	47,000	32,252	12,618	1,717	93,587	102,086
1998	1,730	81	11,938	1,250	14,999	46,320	22,924	8,136	1,987	79,367	94,366
1999	2,701	227	10,801	3,668	17,397	44,066	50,202	3,052	7,487	104,807	122,204
2000	1,880	86	10,874	1,869	14,709	39,735	21,533	4,371	3,116	68,755	83,464
2001	1,822	157	11,570	1,638	15,187	35,922	29,412	5,168	1,364	71,866	87,053
2002	1,227	381	11,905	2,388	15,901	32,684	48,451	4,418	3,831	89,384	105,285
2003	1,129	59	17,749	2,260	21,197	32,164	36,114	4,137	924	73,339	94,536
2004	854	126	20,162	1,623	22,765	29,321	32,254	2,093	7,354	71,022	93,787
2005	643	66	13,811	1,741	16,261	32,385	16,133	256	1,442	50,216	66,477
2006	3,482	1	18,688	408	22,579	30,788	15,422	243	729	47,182	69,761
2007	2,520	21	18,555	1,415	22,511	29,251	37,768	91	5,023	72,133	94,644
2008	1,085	1,050	16,147	308	18,590	27,390	18,010	1,766	2,618	49,784	68,374
2009	39	2,218	16,265	736	19,258	28,763	31,263	2,900	2,031	64,957	84,215
2010	1,602	-	19,145	753	21,500	26,634	21,801	630	128	49,193	70,693
2011	2,396	-	16,496	517	19,409	33,409	21,801	657	364	56,231	75,640

TABLE A-6b. Annual retained catches of South Pacific albacore by region, in metric tons, compiled from IATTC data (EPO) and SPC data (WCPO). The data for 2010 and 2011 are preliminary.

TABLA A-6b. Capturas retenidas anuales de atún albacora del Pacífico Sur por región, en toneladas métricas, compiladas de datos de la CIAT (OPO) y la SPC (WCPO). Los datos de 2010 y 2011 son preliminares.

ALB (S)	Eastern Pacific Ocean Océano Pacífico oriental				Western and central Pacific Ocean Océano Pacífico occidental y central					Total
	LL	LTL	OTR	Subtotal	LL	LP	LTL	OTR	Subtotal	
1983	5,861	0	2	5,863	18,448	0	744	37	19,229	25,092
1984	4,120	0	24	4,144	16,220	2	2,773	1,565	20,560	24,704
1985	5,955	0	170	6,125	21,183	0	3,253	1,767	26,203	32,328
1986	5,752	74	149	5,975	26,889	0	1,929	1,797	30,615	36,590
1987	8,880	188	3	9,071	13,099	9	1,946	927	15,981	25,052
1988	9,035	1,282	0	10,317	19,253	0	3,014	5,283	27,550	37,867
1989	5,832	593	90	6,515	12,906	0	7,777	21,878	42,561	49,076
1990	5,393	1,336	306	7,035	15,911	245	5,639	7,232	29,027	36,062
1991	6,379	795	170	7,344	19,913	14	7,010	1,319	28,256	35,600
1992	15,445	1,205	18	16,668	16,569	11	5,373	47	22,000	38,668
1993	9,422	35	19	9,476	21,576	74	4,261	51	25,962	35,438
1994	8,034	446	22	8,502	26,964	67	6,718	67	33,816	42,318
1995	4,805	2	15	4,822	25,703	139	7,714	89	33,645	38,467
1996	5,956	94	21	6,071	20,807	30	7,316	135	28,288	34,359
1997	8,313	466	0	8,779	26,344	21	4,213	133	30,711	39,490
1998	10,905	12	0	10,917	33,065	36	6,268	85	39,454	50,371
1999	8,932	81	7	9,020	27,023	138	3,366	67	30,594	39,614
2000	7,783	778	3	8,564	32,859	102	5,677	136	38,774	47,338
2001	17,588	516	5	18,109	35,267	37	4,737	194	40,235	58,344
2002	14,062	131	40	14,233	54,349	18	4,530	110	59,007	73,240
2003	23,772	419	3	24,194	32,579	12	5,565	127	38,283	62,477
2004	17,590	331	0	17,921	39,434	110	4,283	123	43,950	61,871
2005	10,754	181	7	10,942	49,143	29	3,322	130	52,624	63,566
2006	10,246	48	119	10,413	49,097	29	2,836	69	52,031	62,444
2007	8,511	19	87	8,617	47,989	17	1,995	0	50,001	58,618
2008	7,878	0	159	8,037	51,215	12	3,502	0	54,729	62,766
2009	12,148	0	213	12,361	68,532	21	2,031	0	70,584	82,945
2010	12,286	0	246	12,532	74,392	14	2,139	0	76,545	89,077
2011	15,432	0	10	15,442	53,849	21	3,119	223	57,212	72,654

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 in the EPO, by purse-seine vessels. The data for 2012 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 en el OPO. Los datos de 2012 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 con delfines**					
1997	43	8,977	9,020	152,052	8,149	0
1998	0	10,645	10,645	154,200	4,992	6
1999	0	8,648	8,648	143,128	1,705	5
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	131,485	4,443	2
2012	0	9,220	9,220	124,306	2,242	0
OBJ	**Sets on fish associated with floating objects Lances sobre peces asociados con objetos flotantes**					
1997	1,699	5,610	7,309	30,255	116,802	62,704
1998	1,198	5,465	6,663	26,769	110,335	41,919
1999	630	4,483	5,113	43,341	181,636	49,330
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	2,529	6,921	9,450	41,127	173,653	56,256
2012	2,953	7,610	10,563	37,529	181,207	67,630

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**					
1997	5,334	4,680	10,014	62,571	28,505	1,568
1998	5,700	4,607	10,307	72,990	25,304	2,204
1999	5,632	6,139	11,771	95,451	78,224	1,823
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	2,838	5,182	8,020	29,081	102,305	932
2012	2,881	5,369	8,250	28,003	87,666	968
ALL	**Sets on all types of schools Lances sobre todos tipos de cardumen**					
1997	7,076	19,267	26,343	244,878	153,456	64,272
1998	6,898	20,717	27,615	253,959	140,631	44,129
1999	6,262	19,270	25,532	281,920	261,565	51,158
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	5,367	21,707	27,074	201,693	280,401	57,190
2012	5,834	22,199	28,033	189,838	271,115	68,598

TABLE A-8. Types of floating objects on which sets were made. The 2012 data are preliminary.
TABLA A-8. Tipos de objetos flotantes sobre los que se hicieron lances. Los datos de 2012 son preliminares.

OBJ	Flotsam Naturales		FADs Plantados		Unknown Desconocido		Total
	No.	%	No.	%	No.	%	
1997	829	14.8	4,728	84.3	53	0.9	5,610
1998	751	13.7	4,612	84.4	102	1.9	5,465
1999	831	18.5	3,632	81.0	20	0.4	4,483
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	7,317	96.1	7	0.1	7,610

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		PYF		TWN		USA		OTR[1]
	E	C	E	C	E	C	E	C	E	C	E	C	C
1983	-	-	127,177	69,563	14,680	6,478	-	-	4,850	2,311	-	-	49
1984	-	-	119,628	57,262	11,770	4,490	-	-	3,730	1,734	-	-	-
1985	-	-	106,761	74,347	19,799	10,508	-	-	3,126	1,979	-	-	2
1986	-	-	160,572	111,673	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	82,384	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	88	33,025	14,142	325	106	128
1993	-	-	159,956	87,976	46,375	12,843	153	80	18,064	6,566	415	81	227
1994	-	-	163,999	92,606	44,788	13,249	1,373	574	12,588	4,883	303	26	523
1995	-	-	129,599	69,435	54,979	12,778	1,776	559	2,910	1,639	828	179	562
1996	-	-	103,649	52,298	40,290	14,120	2,087	931	5,830	3,554	510	181	184
1997	-	-	96,385	59,325	30,493	16,663	3,464	1,941	8,720	5,673	464	216	752
1998	-	-	106,568	50,167	51,817	15,089	4,724	2,858	10,586	5,039	1,008	405	1,176
1999	-	-	80,950	32,886	54,269	13,295	5,512	4,446	23,247	7,865	1,756	470	1,156
2000	-	-	79,327	45,216	33,585	18,758	8,090	4,382	18,152	7,809	736	204	4,868
2001	13,054	5,162	102,220	54,775	72,261	18,200	7,445	5,086	41,920	20,060	1,438	238	15,614
2002	34,894	10,398	103,912	45,401	96,273	14,370	943	3,238	78,018	31,773	611	138	10,258
2003	43,290	14,548	101,227	36,187	71,006	15,551	11,098	4,101	74,456	28,328	1,313	262	11,595
2004	15,886	4,033	76,828	30,937	55,861	14,540	13,757	3,030	49,979	19,535	1,047	166	9,193
2005	16,895	3,681	65,085	25,712	15,798	12,284	13,356	2,514	38,536	12,229	2,579	557	8,146
2006	588	969	56,525	21,432	*	8,752	11,786	3,220	38,139	12,375	234	121	10,201
2007	12,229	2,624	45,972	20,515	10,548	6,037	9,672	3,753	22,243	9,498	2,686	436	5,901
2008	11,519	2,984	44,555	21,375	3,442	4,256	10,255	3,017	12,544	4,198	6,314	1,369	6,328
2009	10,536	3,435	41,517	21,492	18,364	7,615	10,686	4,032	13,904	6,366	5,145	852	8,340
2010	11,900	3,590	47,807	21,017	51,139	10,477	8,976	3,139	25,223	10,396	8,879	1,480	7,216
2011	37,384	9,983	47,569	17,002	25,323	7,814	*	*	14,722	9,420	7,359	1,218	8,039

[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 2012 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 2012 son preliminares.

	PS		LP		Total	
	No.	Vol. (m^3)	No.	Vol. (m^3)	No.	Vol. (m^3)
1983	211	143,859	59	3,829	270	147,688
1984	164	118,964	49	3,499	213	122,463
1985	176	136,845	26	2,595	202	139,440
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	209	179,999	14	1,642	223	181,641
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	221	213,144	4	498	225	213,642
2006	225	225,166	4	498	229	225,664
2007	228	225,901	4	380	232	226,281
2008	219	223,804	4	380	223	224,184
2009	217	224,296	4	380	221	224,676
2010	201	209,870	3	255	204	210,125
2011	208	213,237	2	143	210	213,380
2012	211	219,091	3	268	214	219,359

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 2011, 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 2011, 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						
BOL	PS	1	-	-	-	-	1	222
COL	PS	2	2	7	3	-	14	14,860
ECU	PS	36	28	17	6	9	96	70,014
EU(ESP)	PS	-	-	-	-	4	4	10,116
GTM	PS	-	-	1	1	1	3	4,819
HND	PS	-	1	-	-	-	1	547
MEX	PS	3	3	20	15	-	41	47,274
	LP	2	-	-	-	-	2	143
NIC	PS	-	-	4	3	-	7	9,685
PAN	PS	-	3	7	6	3	19	25,443
SLV	PS	-	-	-	1	3	4	7,892
USA	PS	2	-	2	1	-	5	4,275
VEN	PS	-	-	10	8	-	18	24,007
VUT	PS	-	-	1	2	-	3	3,609
Grand total—Total general	PS	43	37	65	43	20	208	
	LP	2	-	-	-	-	2	
	PS + LP	45	37	65	43	20	210	
Well volume—Volumen de bodega (m^3)								
Grand total—Total general	PS	10,713	22,109	73,042	64,137	43,236		213,237
	LP	143	-	-	-	-		143
	PS + LP	10,856	22,109	73,042	64,137	43,236		213,380

- : 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 2012 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 2012, 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	31	19	6	11	103	79,222
EU(ESP)	PS	-	-	-	-	4	4	10,116
GTM	PS	-	-	-	1	1	2	3,575
MEX	PS	3	4	20	15	-	42	48,054
	LP	3	-	-	-	-	3	268
NIC	PS	-	-	3	4	-	7	9,966
PAN	PS	-	2	4	4	3	13	17,976
PER	PS	1	-	-	-	-	1	299
SLV	PS	-	-	-	1	3	4	7,892
USA	PS	1	-	1	1	1	4	5,009
VEN	PS	-	-	9	8	-	17	22,862
VUT	PS	-	-	-	1	-	1	1,360
Grand total—Total general	PS	43	39	63	44	22	211	
	LP	3	-	-	-	-	3	
	PS + LP	46	39	63	44	22	214	
		Well volume—Volumen de bodega (m^3)						
Grand total—Total general	PS	11,365	23,426	70,340	65,534	48,426		219,091
	LP	268	-	-	-	-		268
	PS + LP	11,633	23,426	70,340	65,534	48,426		219,359

- : 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 2002-2011 and in 2012, 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 2002-2011 y en 2012 por mes.

Month Mes	2002-2011			2012
	Min	Max	Ave.-Prom.	
1	88.6	157.7	124.6	92.8
2	116.0	175.3	150.9	153.6
3	115.1	159.9	141.5	148.6
4	120.5	165.0	148.0	152.7
5	115.8	164.4	144.8	163.1
6	110.7	175.0	149.6	165.2
7	125.7	170.4	155.1	156.7
8	62.2	140.2	108.4	110.6
9	105.5	137.7	120.0	112.2
10	127.5	172.2	156.0	163.7
11	102.9	150.8	130.9	130.0
12	39.1	116.4	69.4	55.4
Ave.-Prom.	102.5	157.1	133.3	133.7

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 3) was used in the assessment, which is based on the assumption that there is a single stock of yellowfin in the EPO. This model is the same as that used in the previous assessment (IATTC Stock Assessment Report 13).

Yellowfin are distributed across the Pacific Ocean, but the bulk of the catch is made in the eastern and western regions. The 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 unassociated schools (Figure B-1). The movements of tagged yellowfin are generally over hundreds, rather than thousands, of kilometers, and exchange between the eastern and western Pacific Ocean appears to be limited. This is consistent with the fact that longline catch-per-unit-of-effort (CPUE) trends differ among areas. It is likely that there is a continuous stock throughout the Pacific Ocean, with exchange of individuals at a local level, although there is some genetic evidence for local isolation. Movement rates between the EPO and the western Pacific cannot be estimated with currently-available tagging data.

The stock assessment requires substantial amounts of information, including data on retained catches, discards, indices of abundance, and the size compositions of the catches of the various fisheries. Assumptions have been made about processes such as growth, recruitment, movement, natural mortality, fishing mortality (*F*), and stock structure. The assessment for 2012 is identical to that of 2011 except for new and updated data. The staff performed substantial investigative analyses in preparation for the external review of its assessment of yellowfin tuna, held in October 2012. The review resulted in a series of recommendations (Document SAC-04-INF A), which will be incorporated in an updated model for future assessments.

The catch data for the surface fisheries have been updated and new data added for 2012. New or updated longline catch data are available for China (2009, 2011), Chinese Taipei (2010-2011), Japan (2009-2011), Korea (2011), the United States (2010-2011), and Vanuatu (2005-2011). Surface fishery CPUE data were updated, and new CPUE data added for 2012. New or updated CPUE data are available for the Japanese longline fleet (2008-2011). New surface-fishery size-composition data for 2012 were added. New or updated length-frequency data are available for the Japanese longline fleet (2006-2011). For fisheries with no new data for 2012, catches were assumed to be the same as in 2011.

In general, the recruitment of yellowfin to the fisheries in the EPO is variable, with a seasonal component. This analysis and previous analyses indicate that the yellowfin population has experienced two, or possibly three, different recruitment productivity regimes (1975-1982, 1983-2002, and 2003-2011) (Figure B-2). The recruitments for 2010 and 2011 were estimated to be below average. The most recent recruitment (2012) was estimated to be above average, but this estimate is highly uncertain. As in previous assessments, a retrospective pattern is evident in the estimation of most recent recruitments. The wide confidence intervals of the estimate of recent recruitment, combined with this retrospective pattern, result in uncertain estimates of recent biomass. The productivity regimes correspond to regimes in biomass, with higher-productivity regimes producing greater biomass levels. A stock-recruitment relationship is also supported by the data from these regimes, but the evidence is weak, and this is probably an artifact of the apparent regime shifts.

The average weights of yellowfin taken from the fishery have been fairly consistent over time, but vary substantially among the different fisheries. In general, the floating-object, northern unassociated, and pole-and-line fisheries capture younger, smaller yellowfin than do the southern unassociated, dolphin-associated, and longline fisheries. The longline fisheries and the dolphin-associated fishery in the southern region capture older, larger yellowfin than the northern and coastal dolphin-associated fisheries.

Substantial levels of fishing mortality have been estimated for the yellowfin fishery in the EPO (Figure B-3). These levels are highest for middle-aged yellowfin. 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. In more recent years, the impact of the floating-object fisheries has been slightly greater that that by unassociated fisheries. The impacts of the longline and purse-seine discard fisheries are much less, and have decreased in recent years (Figure B-4).

The spawning biomass ratio (the ratio of the spawning biomass to that of the unfished population; SBR) of yellowfin in the EPO was below the level corresponding to the maximum sustainable yield (MSY) during 1977-1983, coinciding with the low productivity regime, but above that level during most of the following years, except for the recent period (2005-2007 and 2010-2012) (Figure B-5). The 1984 increase in the SBR is attributed to the regime change, and the recent decrease may be a reversion to an intermediate productivity regime. The different productivity regimes may support different MSY levels and associated SBR levels. The SBR at the start of 2013 was estimated to be 0.22, below the MSY level (0.26). The recent SBR levels (2011-2012) estimated by the current assessment are more pessimistic than those produced by the previous assessment, which indicated a sharp decline in the levels of spawning biomass since 2009 followed by an increase in 2011 (IATTC Stock Assessment Report 13). In the current assessment, the recent SBR levels off. This result is due to an increase in the fishing mortality levels for middle-age yellowfin tuna since 2009, which is estimated by the current assessment (Figure B-3). The effort is estimated to be at the level that would support the MSY (based on the current distribution of effort among the different fisheries) (Figures B-6 and B-7), and recent catches are at that level (Table B-1). It is important to note that the curve relating the average sustainable yield to the long-term fishing mortality is flat around the MSY level (Figure B-8). Therefore, moderate changes in the long-term levels of effort will change the long-term catches only marginally, while changing the biomass considerably. Reducing fishing mortality below the MSY level would result in only a marginal decrease in the long-term average yield, with the benefit of a relatively large increase in the spawning biomass. In addition, if management is based on the base case assessment (which assumes that there is no stock-recruitment relationship), when in fact there is such a relationship, there would be a greater loss in yield than if management is based on assuming a stock-recruitment relationship when in fact there is no relationship (Figure B-8).

The MSY calculations indicate that, theoretically at least, catches could be increased if the fishing effort were directed toward longlining and purse-seine sets on yellowfin associated with dolphins. This would also increase the SBR levels.

The MSY has been stable during the assessment period (1975-2012) (Figure B-9), which suggests that the overall pattern of selectivity has not varied a great deal through time. However, the overall level of fishing effort has varied with respect to the MSY level.

If a stock-recruitment relationship is assumed, the outlook is more pessimistic, and current effort is estimated to be above the MSY level (Table B-1). Previous assessments have indicated that the status of the stock is also sensitive to the value assumed for the average size of the oldest fish, and more pessimistic results are obtained when larger values are assumed for this parameter. At current (2010-2012) levels of fishing mortality and average levels of recruitment, the spawning biomass is predicted to increase slightly and remain at the MSY level (Figure B-5). However, the confidence intervals are wide, a retrospective pattern exists in recent recruitment, and there is a moderate probability that the SBR will be substantially above or below this level. In addition, the spawning biomass is predicted to remain below the MSY level if a stock-recruitment relationship is assumed (Figure B-6). Fishing at F_{MSY} (as well as fishing at recent effort levels) is predicted to both increase the spawning biomass (Figure B-5) and the catches (Figure B-10) under the assumption of average recruitment and no stock-recruitment relationship (base case). Fishing at recent effort levels is predicted to produce slightly lower catches if in fact such a relationship exists (Figure B-10).

Key Results

1. There is uncertainty about recent and future levels of recruitment and biomass. There have been two, and possibly three, different productivity regimes, and the MSY levels and the biomasses corresponding to the MSY may differ among the regimes. The population may have recently switched from a high to an intermediate productivity regime.
2. The recent fishing mortality rates are at the MSY level, and the recent levels of spawning biomass are estimated to be below that level. As described in IATTC Stock Assessment Report 13 and previous assessments, these interpretations are uncertain, and highly sensitive to the assumptions made about the steepness parameter of the stock-recruitment relationship, the average size of the older fish, and the assumed levels of natural mortality. The results are more pessimistic if a stock-recruitment relationship is assumed, if a higher value is assumed for the average size of the older fish, and if lower rates of natural mortality are assumed for adult yellowfin;
3. The recent levels of spawning biomass predicted by the current assessment are more pessimistic than those from the previous assessment (IATTC Stock Assessment Report 13). This result is due to a recent increase in the fishing mortality levels for middle-age yellowfin tuna since 2008 which is estimated by the current assessment.
4. Increasing the average weight of the yellowfin caught could increase the MSY.

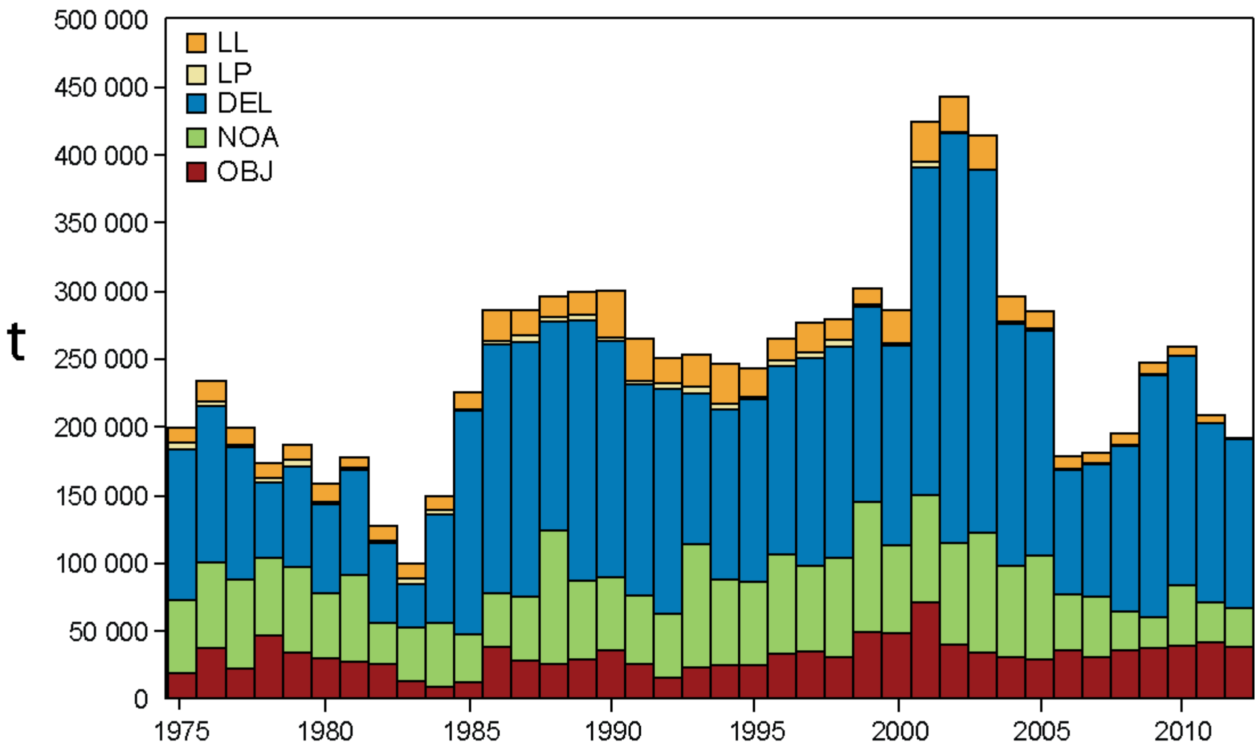

FIGURE B-1. Total catches (retained catches plus discards) for the purse-seine fisheries, and retained catches for the pole-and-line and longline fisheries, of yellowfin tuna in the eastern Pacific Ocean, 1975-2012. The purse-seine catches are adjusted to the species composition estimate obtained from sampling the catches. The 2012 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, 1975-2012. 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 2012 son preliminares.

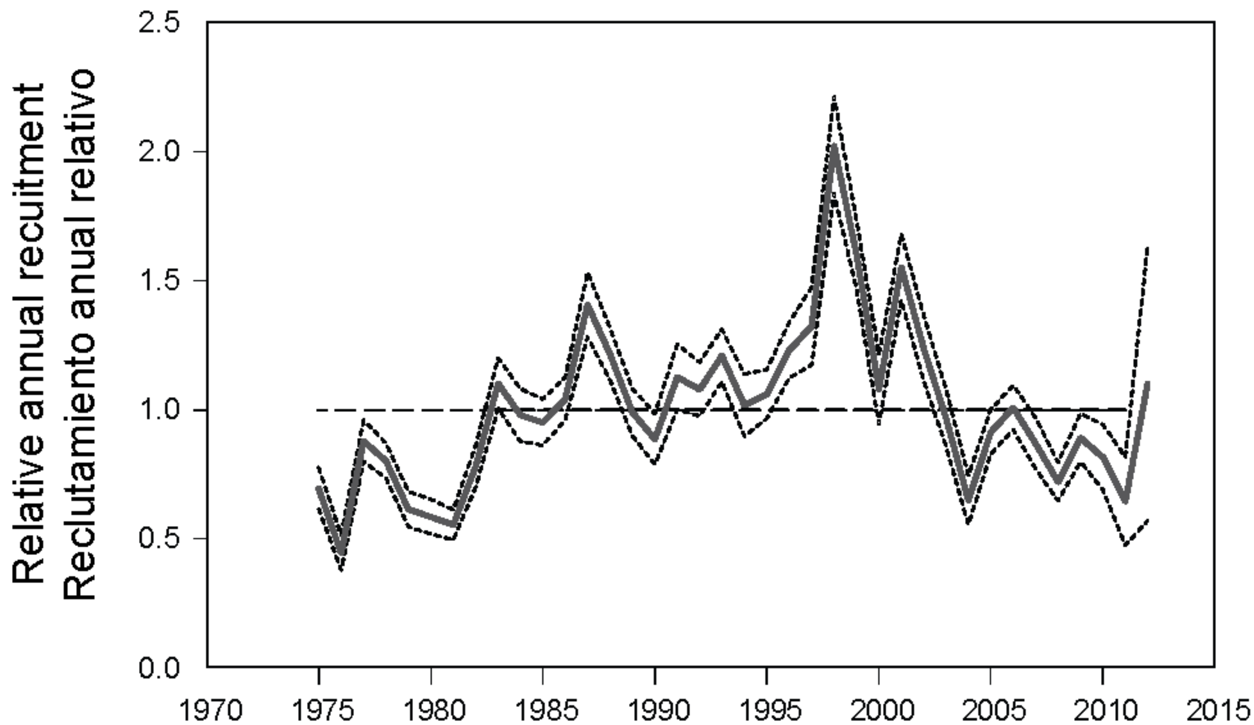

FIGURE B-2. Estimated annual recruitment at age zero of yellowfin tuna to the fisheries of the EPO. The estimates are scaled so that the average recruitment is equal to 1.0 (dashed horizontal line). The solid line illustrates the maximum likelihood estimates of recruitment, and the shaded area indicates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

FIGURA B-2. Reclutamiento anual estimado a edad cero del atún aleta amarilla a las pesquerías del OPO. Se escalan 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.

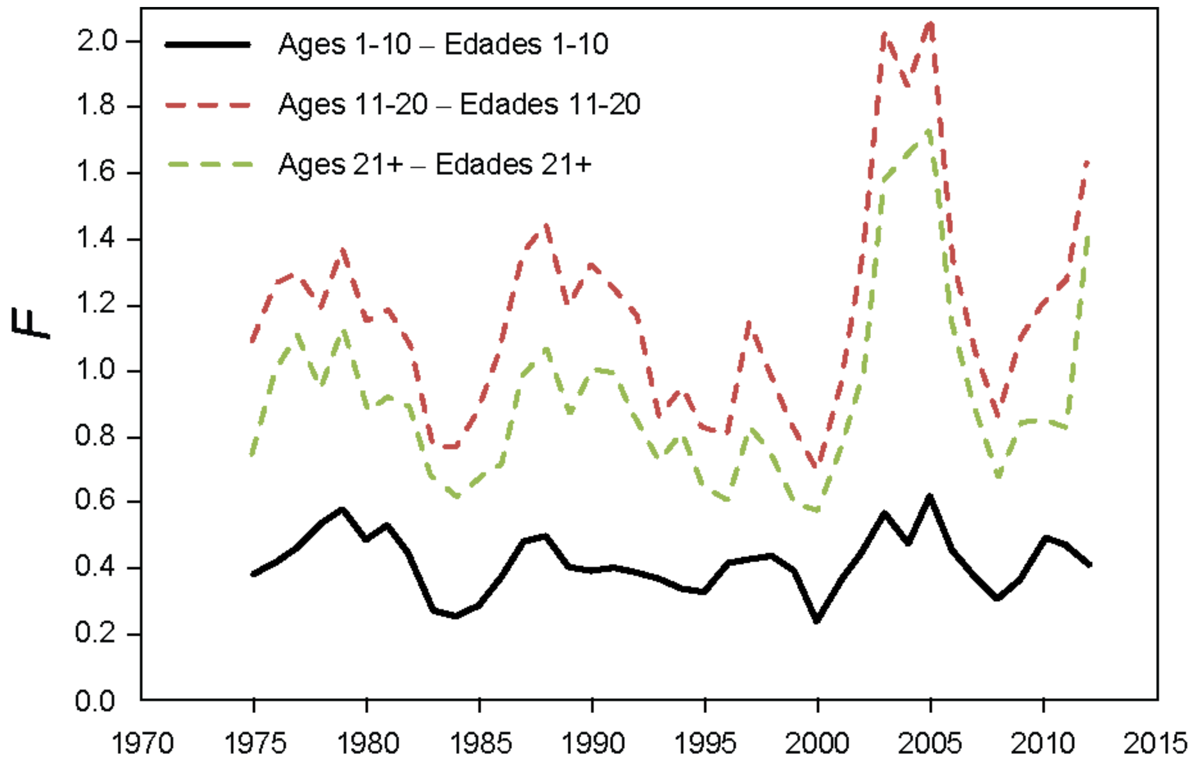

FIGURE B-3. Average annual fishing mortality (*F*) by age groups, by all gears, of yellowfin tuna recruited to the fisheries of the EPO. The age groups are defined by age in quarters.

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.

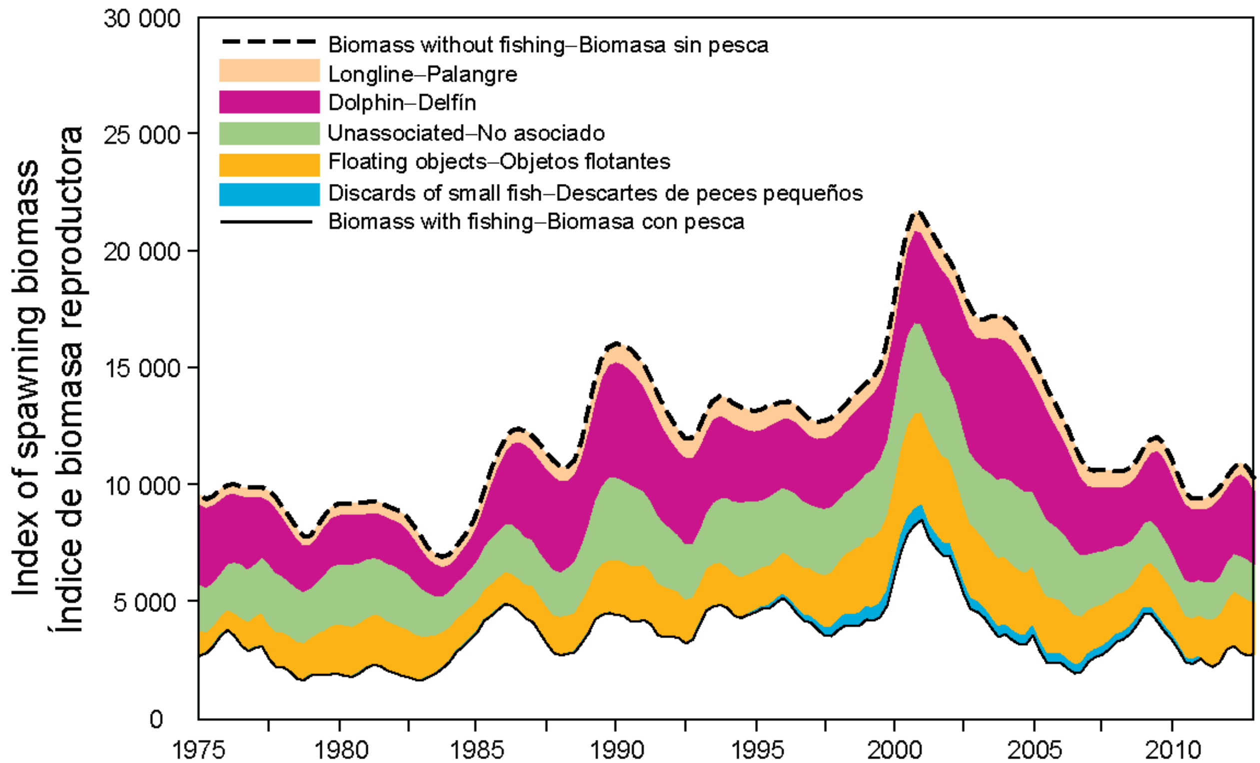

FIGURE B-4. Biomass trajectory of a simulated population of yellowfin tuna that was never exploited (dashed line) and that predicted by the stock assessment model (solid line). The shaded areas between the two lines show the portions of the fishery impact attributed to each fishing method.

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.

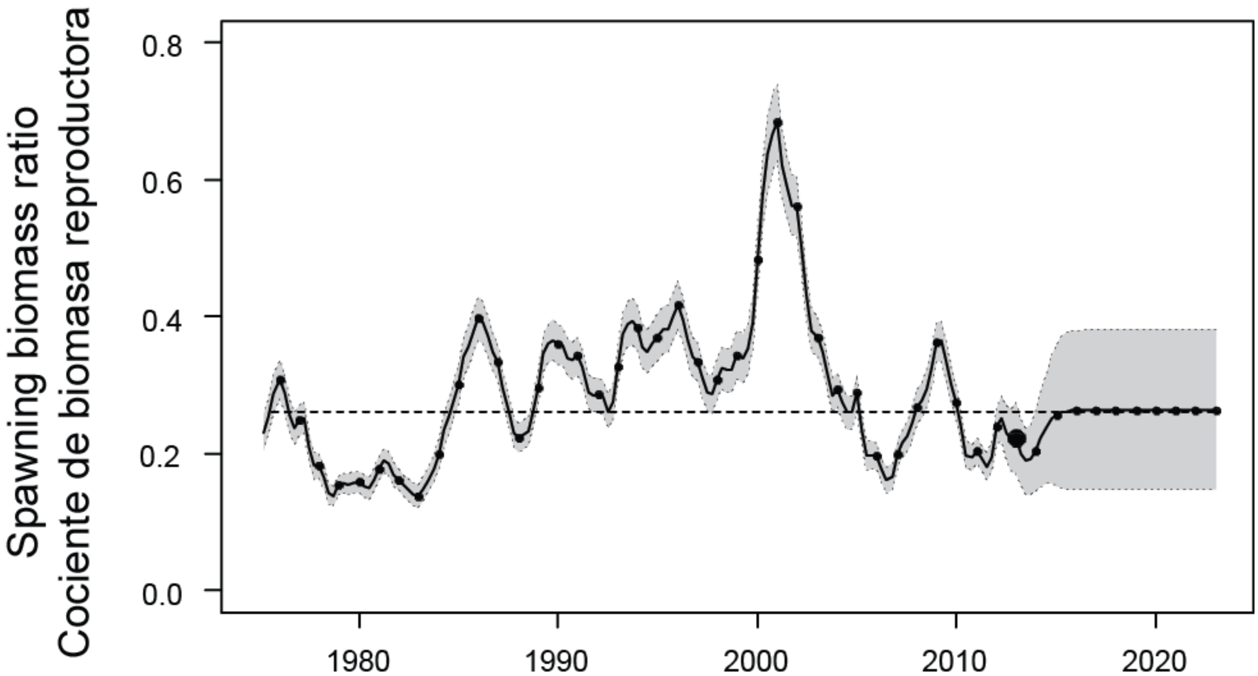

FIGURE B-5 Estimated spawning biomass ratios (SBRs) for yellowfin tuna in the EPO, including projections for 2013-2023 based on average fishing mortality rates during 2010-2012. The dashed horizontal line (at 0.26) identifies the SBR at MSY. The solid curve illustrates the maximum likelihood estimates, and the estimates after 2013 (the large dot) indicate the SBR predicted to occur if fishing mortality rates continue at the average of that observed during 2010-2012, and average environmental conditions 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 2013-2023 basadas en las tasas de mortalidad por pesca medias durante 2010-2012. La línea de trazos horizontal (en 0.26) identifica el SBR correspondiente al RMS. La curva sólida ilustra las estimaciones de verosimilitud máxima, y las estimaciones a partir de 2013 (punto grande) indican el SBR que se predice ocurrirá con tasas de mortalidad por pesca en el promedio de aquellas observadas durante 2010-2012, y con condiciones ambientales medias durante los 10 años próximos. El área sombreada indica los intervalos de confianza de 95% aproximados alrededor de esas estimaciones.

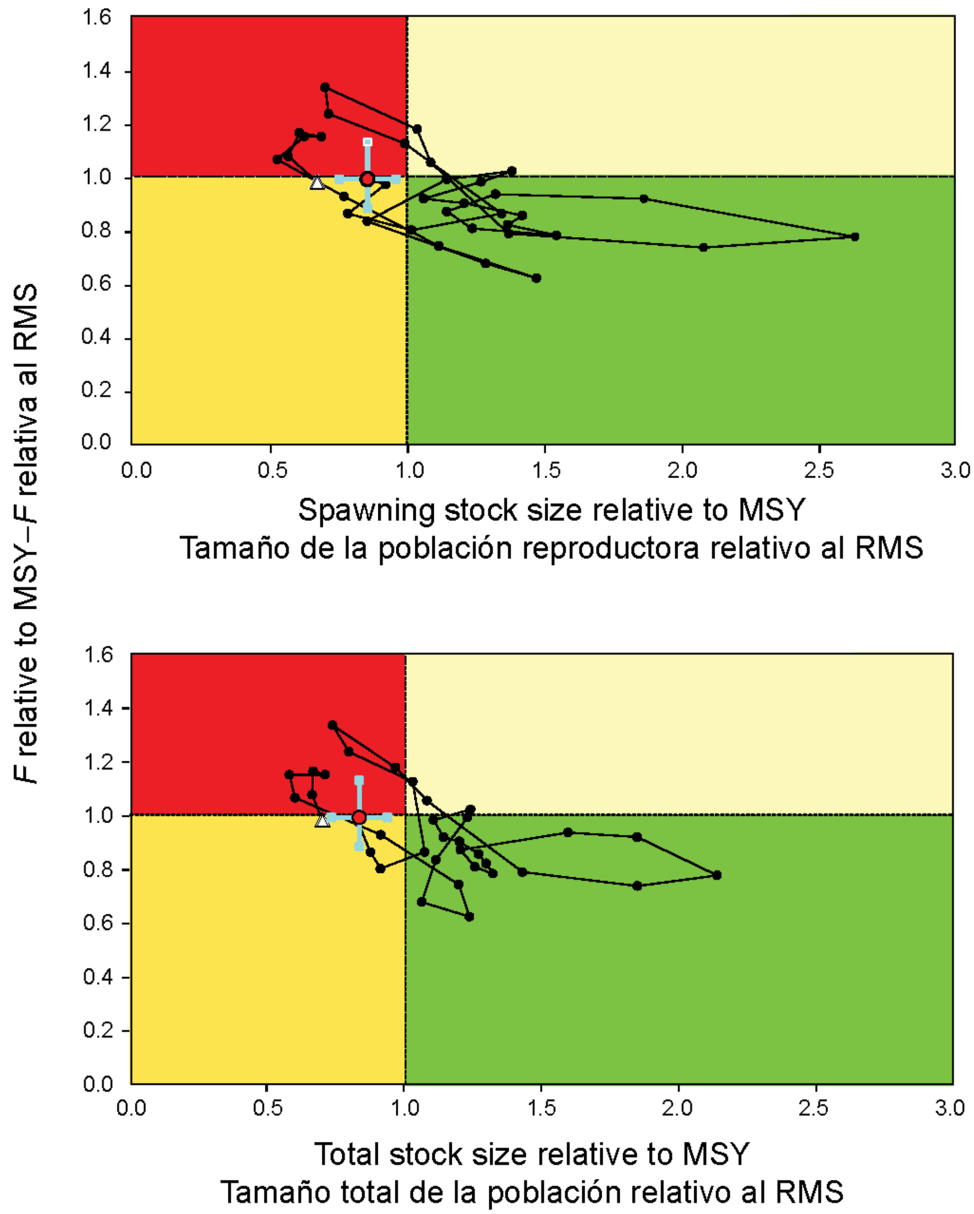

FIGURE B-6. Target Kobe (phase) plot of the time series of estimates of stock size (top: spawning biomass; bottom: summary biomass) and fishing mortality relative to their MSY reference points. The panels represent proposed target reference points (S_{MSY} and F_{MSY}). Each dot is based on the average exploitation rate over three years; the large red dot indicates the most recent estimate. The squares around the most recent estimate represent its approximate 95% confidence interval. The triangle is the first estimate (1975).

FIGURA B-6. Gráfica de Kobe (fase) objetivo de la serie de tiempo de las estimaciones del tamaño de la población (arriba: biomasa reproductora; abajo: biomasa sumaria) y la mortalidad por pesca en relación con sus puntos de referencia de RMS. Los paneles representan puntos de referencia objetivo propuestos (S_{RMS} and F_{RMS}). Cada punto se basa en la tasa de explotación media de tres años; el punto rojo grande indica la estimación más reciente. Los cuadrados alrededor de la estimación más reciente representan su intervalo de confianza de 95% aproximado. El triángulo es la primera estimación (1975).

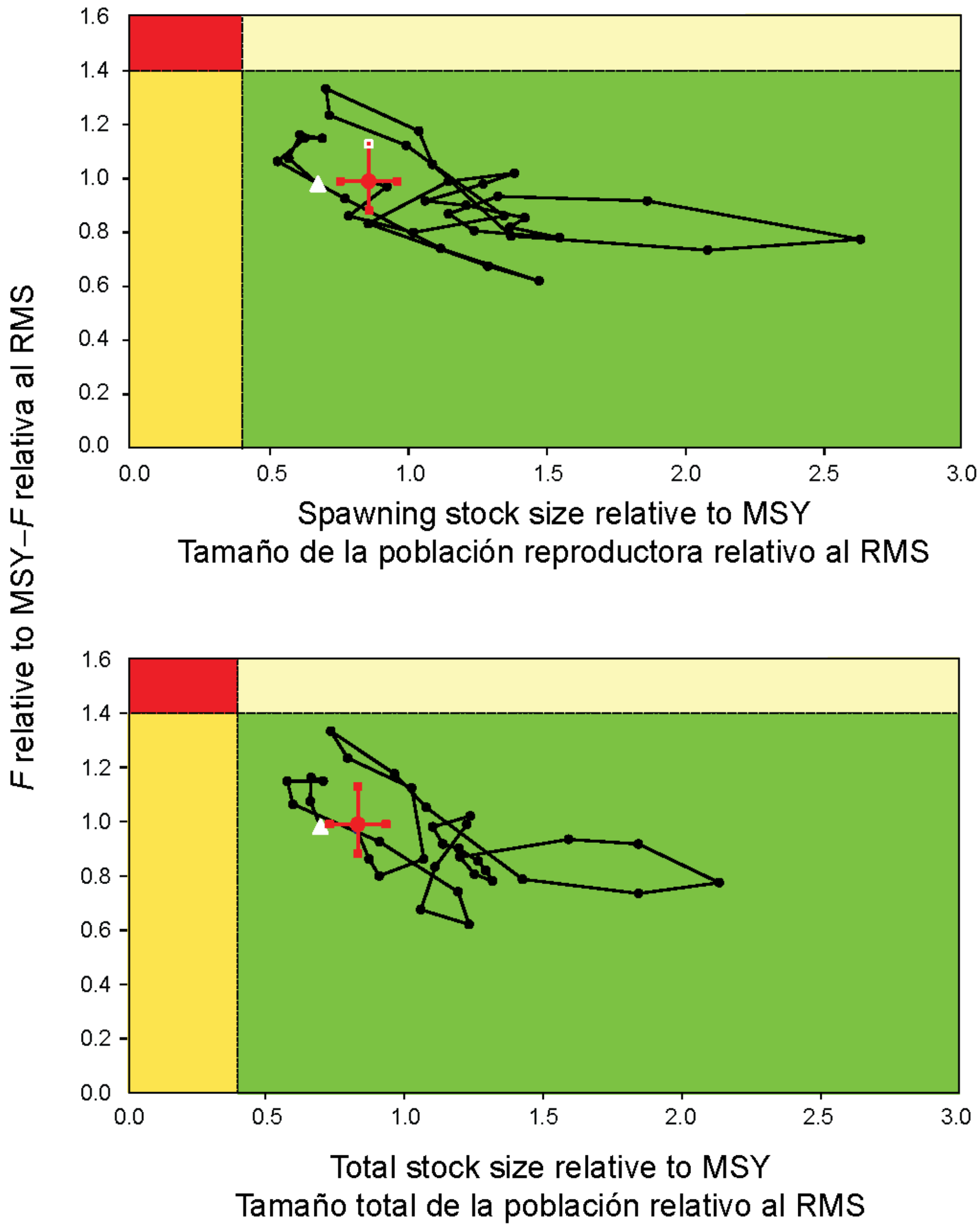

FIGURE B-7. Limit Kobe (phase) plot of the time series of estimates of stock size (top: spawning biomass; bottom: summary biomass) and fishing mortality relative to their MSY reference points. The panels represent proposed limit reference points (0.4*S_{MSY} and 1.4*F_{MSY}). Each dot is based on the average exploitation rate over three years; the large red dot indicates the most recent estimate. The squares around the most recent estimate represent its approximate 95% confidence interval. The triangle is the first estimate (1975).

FIGURA B-7. Gráfica de Kobe (fase) límite de la serie de tiempo de las estimaciones del tamaño de la población (arriba: biomasa reproductora; abajo: biomasa sumaria) y la mortalidad por pesca en relación con sus puntos de referencia de RMS. Los paneles representan puntos de referencia límite propuestos (0.4*S_{RMS} y 1.4*F_{RMS}). Cada punto se basa en la tasa de explotación media de tres años; el punto rojo grande indica la estimación más reciente. Los cuadrados alrededor de la estimación más reciente representan su intervalo de confianza de 95% aproximado. El triángulo es la primera estimación (1975).

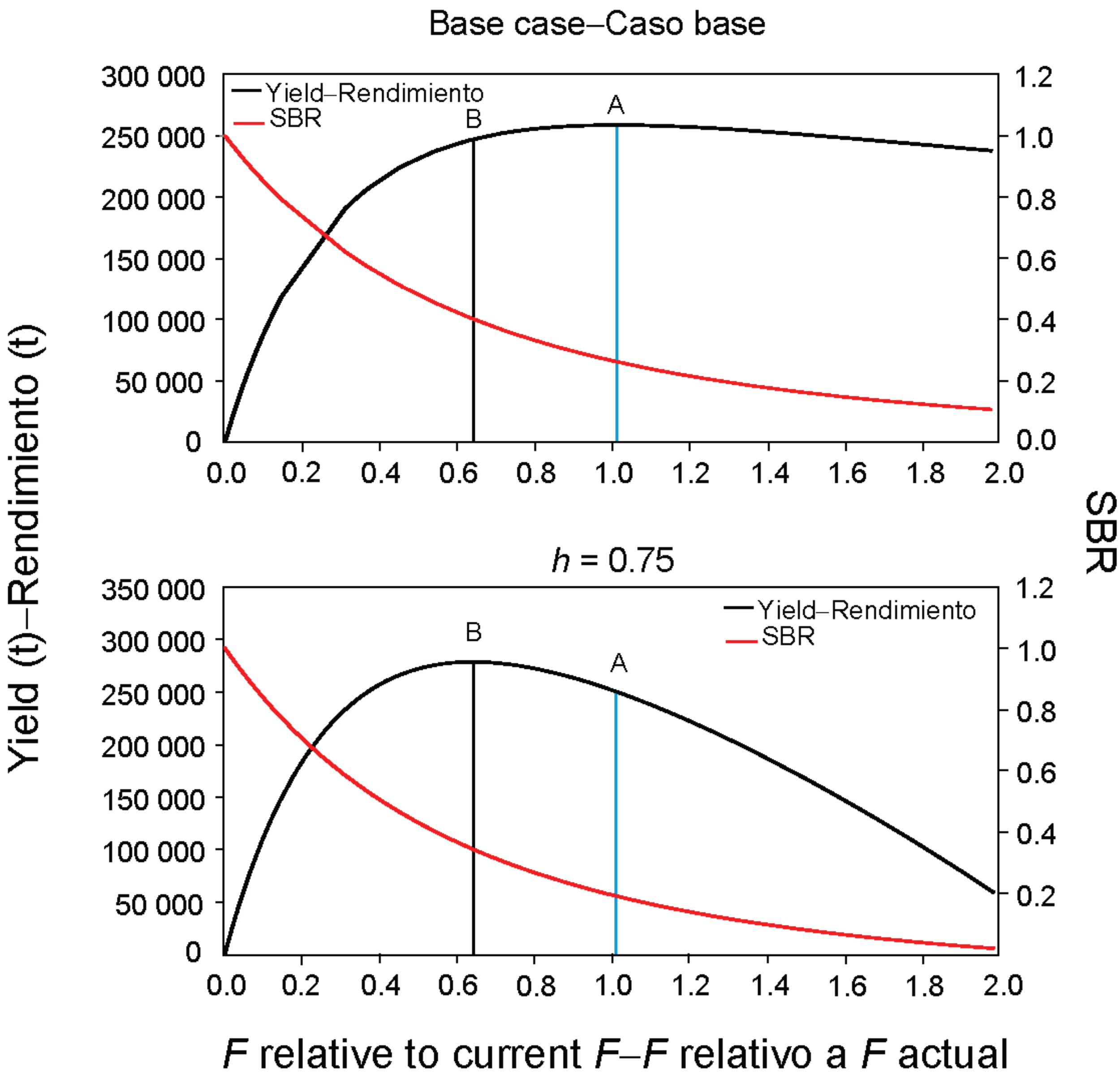

FIGURE B-8. Yield and spawning biomass ratio (SBR) as a function of fishing mortality relative to the current fishing mortality. The vertical lines represent the fishing mortality corresponding to MSY for the base case and the sensitivity analysis that assumes a stock-recruitment relationship (*h* = 0.75). The vertical lines A and B represent the fishing mortality corresponding to MSY for the base case and *h* = 0.75, respectively.

FIGURA B-8. Rendimiento y cociente de biomasa reproductora (SBR) como función de la mortalidad por pesca relativa a la mortalidad por pesca actual. Las líneas verticales representan la mortalidad por pesca correspondiente al RMS del caso base y del análisis de sensibilidad que supone una relación población-reclutamiento (*h* = 0.75). Las líneas verticales A y B representan la mortalidad por pesca correspondiente al RMS del caso base y de *h* = 0.75, respectivamente.

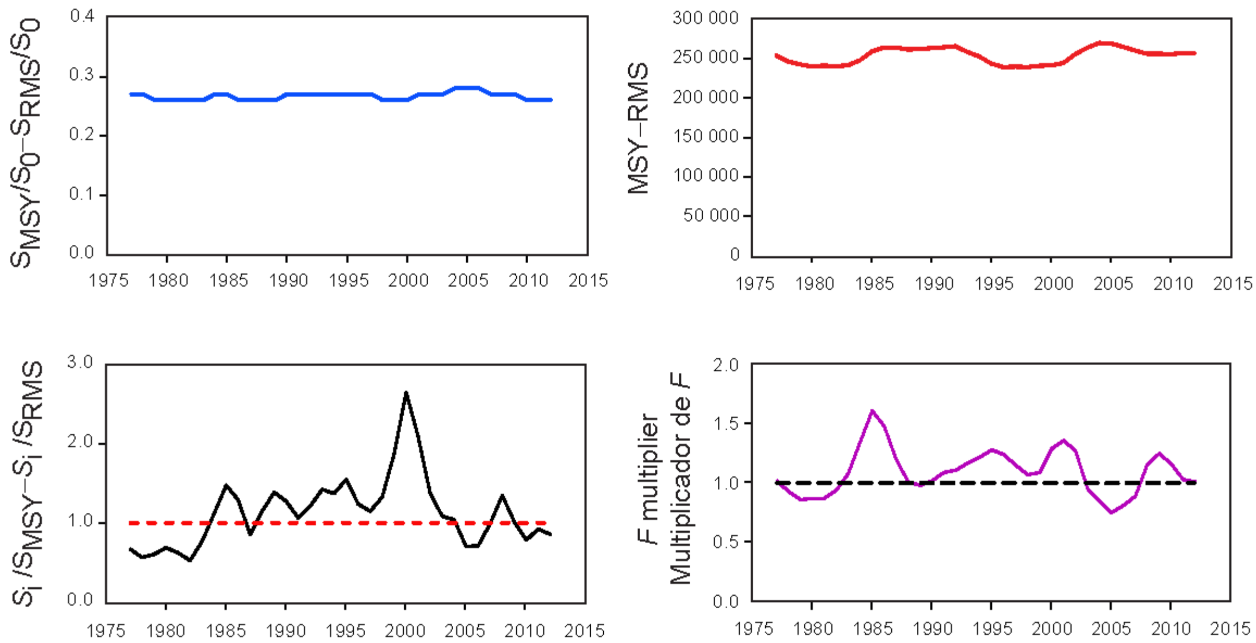

FIGURE B-9. Estimates of MSY-related quantities calculated using the average age-specific fishing mortality for each year (S_i is the index of spawning biomass at the end of the last year in the assessment).
FIGURA B-9. Estimaciones de cantidades relacionadas con el RMS calculadas a partir de la mortalidad por pesca media por edad para cada año. (S_i es el índice de la biomasa reproductora al fin del último año en la evaluación).

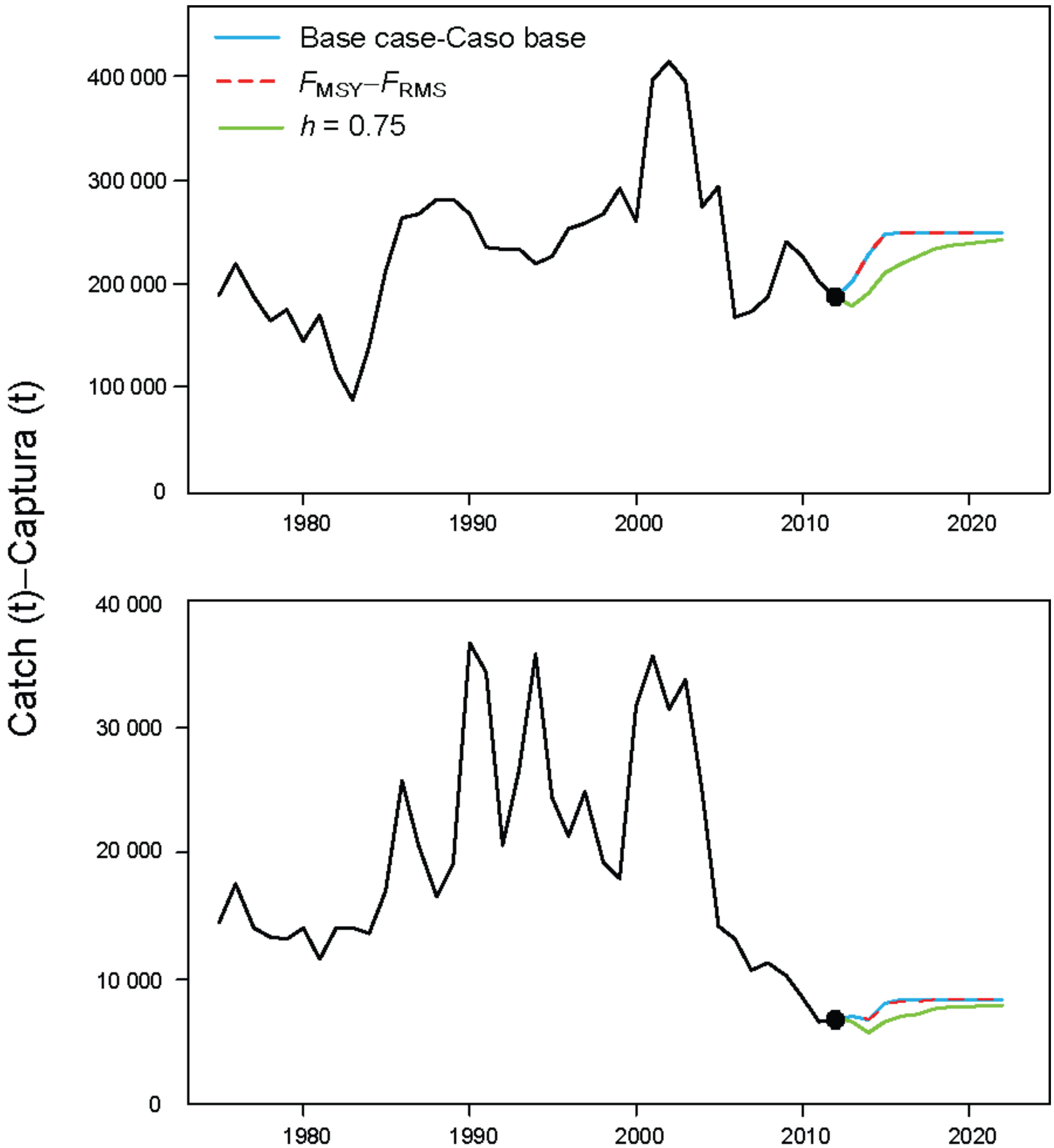

FIGURE B-10. Historic and projected annual catches of yellowfin tuna by surface (top panel) and longline (bottom panel) fisheries from the base case while fishing with the current effort, the base case while fishing at the fishing mortality corresponding to MSY (F_{MSY}), and the analysis of sensitivity to steepness (labeled h = 0.75) of the stock-recruitment relationship while fishing with the current effort. The large dot indicates the most recent catch (2012).

FIGURA B-10. Capturas históricas y proyectadas de atún aleta amarilla por las pesquerías de superficie (panel superior) y palangre (panel inferior) del caso base con la pesca en el nivel actual de esfuerzo, del caso base con la pesca en la mortalidad por pesca correspondiente al RMS (F_{RMS}), y el análisis de sensibilidad a la inclinación (identificado como h = 0.75) de la relación población-reclutamiento al pescar con el esfuerzo actual. El punto grande indica la captura más reciente (2012).

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 2010-2012. 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 2013 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 2012.

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 2010-2012. Se definen $B_{reciente}$ y B_{RMS} como la biomasa, en toneladas, de peces de 3+ trimestres de edad al principio del primer trimestre de 2013 y en RMS, respectivamente, y $S_{reciente}$ y S_{RMS} como índices de biomasa reproductora (por lo tanto, no se expresan en toneladas). $C_{reciente}$ es la captura total estimada de 2012.

YFT	Base case Caso base	h = 0.75
MSY-RMS	258,836	278,453
B_{MSY}- B_{RMS}	349,480	535,094
S_{MSY}- S_{RMS}	3,269	5,715
B_{MSY}/B_0- B_{RMS}/B_0	0.32	0.36
S_{MSY}/S_0- S_{RMS}/S_0	0.26	0.34
C_{recent}/MSY- $C_{reciente}$/RMS	0.75	0.70
B_{recent}/B_{MSY}- $B_{reciente}/B_{RMS}$	0.83	0.48
S_{recent}/S_{MSY}-$S_{reciente}/S_{RMS}$	0.85	0.46
F multiplier-Multiplicador de *F*	1.01	0.64

C. SKIPJACK TUNA

An age-structured catch-at-length analysis (A-SCALA) has been used to assess skipjack tuna in the eastern Pacific Ocean (EPO). The methods of analysis are described in IATTC Bulletin, Vol. 22, No. 5. This method was used most recently for skipjack tuna in 2004 (IATTC Stock Assessment Report 5; available on the IATTC web site), and included data up to and including 2003. More recently, data- and model-based indicators have been used to evaluate the status of the stock. In 2012 several alternative methods were used to assess the status of skipjack tuna in addition to the fishery and biological indicators: a) analysis of tag data; b) a length-structured stock assessment model; c) a Spatial Ecosystem and Population Dynamic Model (SEAPODYM). None of these methods were considered appropriate and fishery and biological indicators are used this year.

The catches of skipjack tuna are presented in Figure C-1.

Yield-per-recruit analysis indicates that maximum yields are achieved with infinite fishing mortality because the critical weight (weight at which the gain to the total weight of a cohort due to growth is equal to the weight loss to that cohort due to natural mortality) is less than the average weight at recruitment to the fishery. However, this result is uncertain because of uncertainties in the estimates of natural mortality and growth.

The results of an analysis described in IATTC Stock Assessment Report 7, in which an index of relative abundance was developed from the ratio of skipjack to bigeye tuna in the floating-object fishery, were consistent with previous assessments, and suggest that there is no management concern for skipjack tuna, apart from the associated catch of bigeye in floating-object sets.

Eight data- and model-based indicators are shown in Figure C-2. The standardized effort, which is a measure of exploitation rate, is calculated as the sum of the effort, in days fished, for the floating-object (OBJ) and unassociated (NOA) fisheries. The floating object effort is standardized to be equivalent to the unassociated effort by multiplying the floating-object effort by the ratio of the average floating-object catch per unit of effort (CPUE) to the average unassociated CPUE.

The purse-seine catch has been increasing since 1985, and has fluctuated around the upper reference level since 2003. The floating-object CPUE has generally fluctuated above the average level since 1990 and was at the upper reference level in 2011. The unassociated CPUE has been higher than average since about 2003, and was at its highest level in 2008; it declined in 2010, then increased to around the upper reference level in 2012. The standardized effort indicator of exploitation rate increased starting in about 1991, but decreased in 2009 and 2010. The average weight of skipjack has been declining since 2000, and in 2009 was below the lower reference level, but increased slightly in 2010 and 2011, although it declined again in 2012. The biomass, recruitment, and exploitation rate have been increasing over the past 20 years, and have fluctuated at high levels since 2003. The biomass and recruitment were close to the upper reference level in 2012.

The main concern with the skipjack stock is the constantly increasing exploitation rate. However, this appears to have leveled off in recent years, and the effort has declined. The data- and model-based indicators have yet to detect any adverse consequence of this increase. The average weight was below its lower reference level in 2009, which can be a consequence of overexploitation, but can also be caused by recent recruitments being greater than past recruitments or expansion of the fishery into areas occupied by smaller skipjack. Any continued decline in average length is a concern and, combined with leveling off of catch and CPUE, may indicate that the exploitation rate is approaching, or above, the level associated with MSY.

Key Results

1. There is uncertainty about the status of skipjack tuna in the EPO.
2. There may be differences in the status of the stock among regions.

3. There is no evidence that indicates a credible risk to the skipjack stock(s).

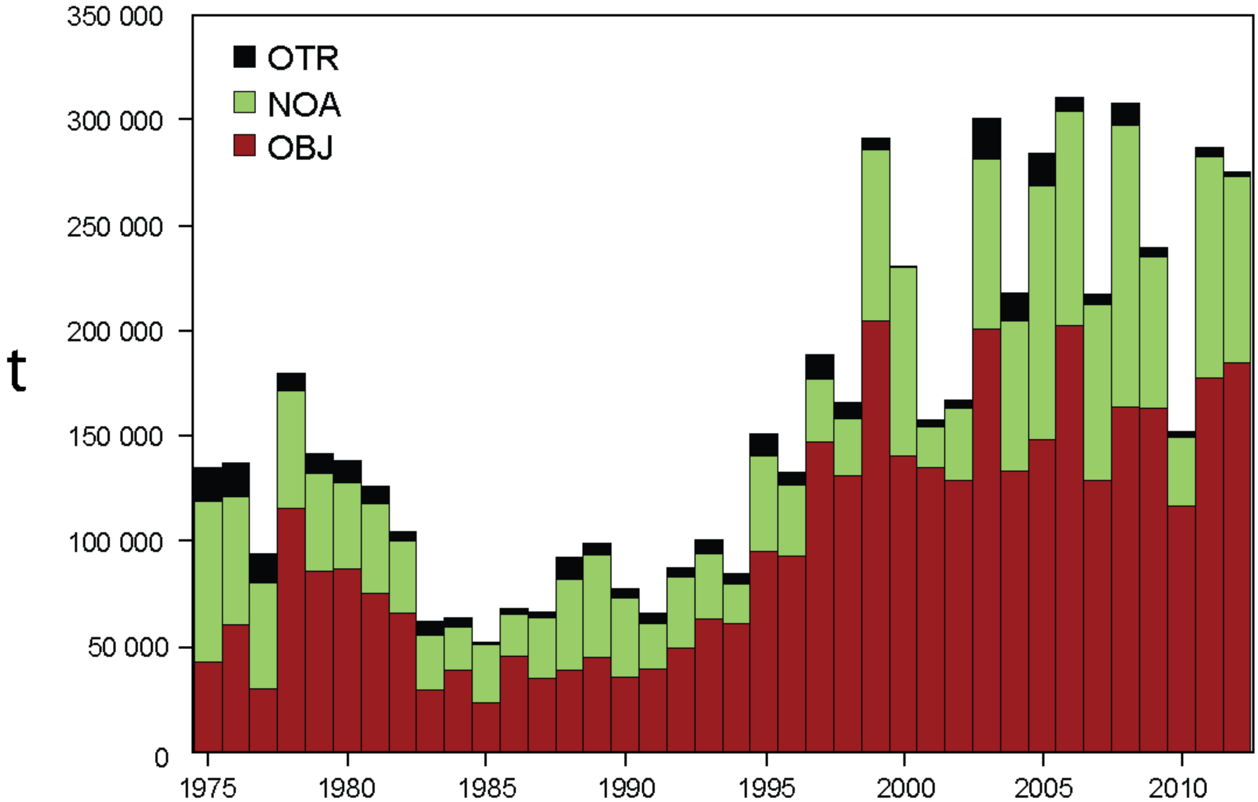

FIGURE C-1. Total catches (retained catches plus discards) of skipjack tuna by the purse-seine fisheries on floating objects and unassociated schools, and by other fisheries combined, in the eastern Pacific Ocean. The purse-seine catches are adjusted to the species composition estimate obtained from sampling the catches. The 2011 catch data are preliminary.

FIGURA C-1. Capturas totales (capturas retenidas más descartes) de atún barrilete por las pesquerías de cerco sobre objetos flotantes y cardúmenes no asociados, y de las demás pesquerías combinadas, en el Océano Pacífico oriental. Las capturas cerqueras están ajustadas a la estimación de la composición por especie obtenida del muestreo de las capturas. Los datos de captura de 2011 son preliminares.

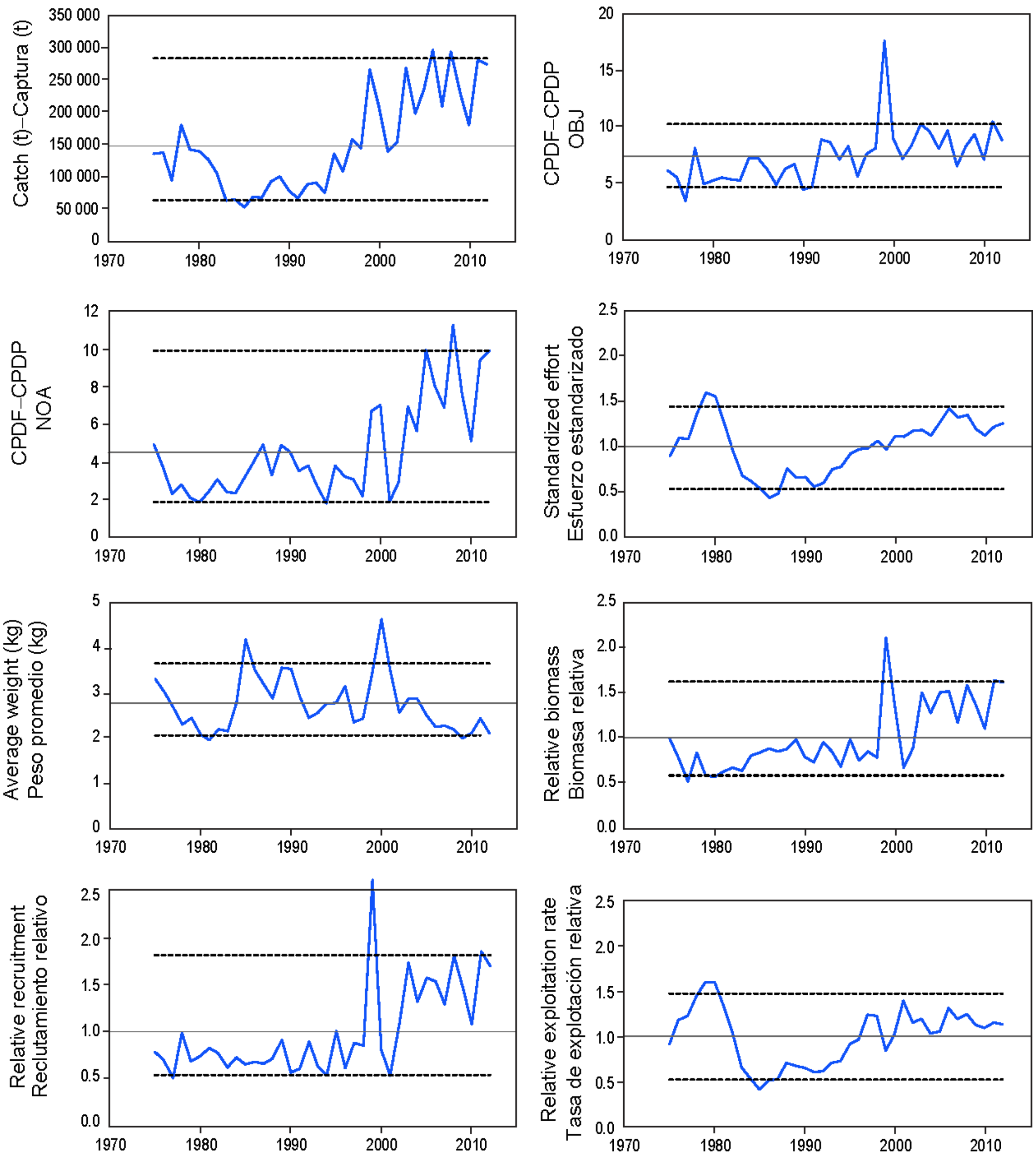

FIGURE C-2. Indicators of stock status for skipjack tuna in the eastern Pacific Ocean. OBJ: floating-object fishery; NOA: unassociated fishery. All indicators are scaled so that their average equals one.

FIGURA C-2. Indicadores del estatus de la población de atún barrilete en el Océano Pacífico oriental. OBJ: pesquería sobre objetos flotantes; NOA: pesquería no asociada. 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) was used in the assessment.

Bigeye tuna are distributed across the Pacific Ocean, but the bulk of the catch is made to the east and to the west. The purse-seine catches of bigeye are substantially lower close to the western boundary (150ºW) of the EPO (Figure A-3); the longline catches are more continuous, but relatively low between 160ºW and 180º (Figure A-4). Bigeye are not often caught by purse seiners in the EPO north of 10ºN, but a substantial portion of the longline catches of bigeye in the EPO is made north of that parallel. It is likely that there is a continuous stock throughout the Pacific Ocean, with exchange of individuals at local levels. The assessment is conducted as if there were a single stock of bigeye in the EPO, and there is minimal net movement of fish between the EPO and the western and central Pacific Ocean. Its results are consistent with the results of other analyses of bigeye tuna on a Pacific-wide basis. Data from recent tagging programs, which will help to provide estimates of movement between the EPO and the western and central Pacific Ocean, are being collected and analyzed.

The assessment assumptions have been improved since the previous full assessment, conducted in 2010, which had already been modified following the recommendations of the external review of the IATTC staff's assessment of bigeye, held in May 2010. The current assessment includes several improvements. First of all, a new Richards growth curve estimated externally from an integrated analysis of otolith age-readings and tag-recapture observations was introduced. This curve reduced in particular the uncertainty about the average size of the oldest fish (L_2 parameter). In addition, the parameters which determine the variance of the length-at-age were also taken from the new externally-derived growth estimates. Diagnostic analyses with the previous base case model configuration indicated a dominant influence of the size-composition data in determining the productivity (the R_0 parameter) of the bigeye stock, and conflicts among datasets were also found. As a result, improvements were made in the current assessment on the weighting assigned to the different datasets. Specifically, the size-composition data of all fisheries were down-weighted. In addition, the number of catch per unit of effort (CPUE) data series used as indices of abundance was reduced in order to minimize conflict trends among data sets. Rather than fitting to a total of ten CPUE series (two purse-seine indices and eight longline indices), a reduced set of indices of abundance was chosen to best represent the bigeye stock trends (the early and late periods of the Central and Southern longline fisheries).

The stock assessment requires a substantial amount of information. Data on retained catch, discards, CPUE, and size compositions of the catches from several different fisheries have been analyzed. Several assumptions regarding processes such as growth, recruitment, movement, natural mortality, and fishing mortality, have also been made. Catch and CPUE data for the surface fisheries have been updated, and include new data for 2012. New or updated longline catch data are available for China (2009 and 2011), Chinese Taipei (2009-2011), Japan (2009-2011), Korea (2011), the United States (2010-2011), and Vanuatu (2005-2011). Longline catch data for 2012 are available for China, Chinese Taipei, Japan, Korea, and Vanuatu from the monthly report statistics. New or updated CPUE data are available for the Japanese longline fleet (2009-2011). New purse-seine length-frequency data are available for 2012 and updates are available for 2011. New or updated length-frequency data are available for the Japanese longline fleet (2006-2011).

A prominent feature in the time series of estimated bigeye recruitment is that the highest recruitment peaks of 1983 and 1998 coincide with the strongest El Niño events during the historic period of the assessment (Figure D-1). There was a period of above-average annual recruitment during 1994-1998, followed by a period of below-average recruitment in 1999-2000. The recruitments were above average from 2001 to 2006, and were particularly strong in 2005. More recently, the recruitments were below average during 2007-2009, and have fluctuated around average during 2010-2012. The most recent annual recruitment estimate (2012) is slightly below average levels. However, this estimate is highly uncertain, and should be regarded with caution, due to the fact that recently-recruited bigeye are represented in only a few length-frequency data sets.

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 (Figures D-2 and 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.

Over the range of spawning biomasses estimated by the base case assessment, the abundance of bigeye recruits appears to be unrelated to the spawning potential of adult females at the time of hatching.

Since the start of 2005, the spawning biomass ratio (SBR; the ratio of the spawning biomass at that time to that of the unfished stock) gradually increased, to a level of 0.31 at the start of 2010. This may be attributed to a combined effect of a series of above-average recruitments since 2001, the IATTC tuna conservation resolutions during 2004-2009, and decreased longline fishing effort in the EPO. However, although the resolutions have continued to date, the rebuilding trend was not sustained, and the SBR gradually declined to a low historic level of 0.22 at the start of 2013 (Figure D-5). This decline could be related to a period dominated by below-average recruitments that began in late 2007 and coincides with a series of particularly strong la Niña events.

At the beginning of 2013, the spawning biomass of bigeye tuna in the EPO appears to have been about 8% higher than S_{MSY}, and the recent catches are estimated to have been about 3% lower than the maximum sustainable yield (MSY). If fishing mortality is proportional to fishing effort, and the current patterns of age-specific selectivity are maintained, F_{MSY} is about 5% higher than the current level of effort (Table D-1).

According to the base case results, the most recent estimate indicates that the bigeye stock in the EPO is likely not overfished ($S>S_{\mathrm{MSY}}$) and that overfishing is not taking place ($F<F_{\mathrm{MSY}}$) (Figure D-6a). In fact, the current exploitation is very close to the MSY target reference points. Likewise, interim limit reference points (0.5 S_{MSY} and 1.3 F_{MSY}) have not been exceeded under the current base case model (Figure D-6b). These interpretations, however, are subject to uncertainty, as indicated by the approximate confidence intervals around the most recent estimate in the phase plots. Also, they are strongly dependent on the assumptions made about the steepness parameter of the stock-recruitment relationship, the assumed levels of adult natural mortality, and the weighting assigned to the size-composition data.

The MSY of bigeye in the EPO could be maximized if the age-specific selectivity pattern were similar to that of the longline fisheries, because they catch larger individuals that are close to the critical weight. Before the expansion of the floating-object fishery that began in 1993, the MSY was greater than the current MSY and the fishing mortality was much less than F_{MSY} (Figure D-7).

At current levels of fishing mortality, and if recent levels of effort and catchability continue and average recruitment levels persist, the SBR is predicted to further decline, to an historic low of 0.19 by 2015. After that, the SBR is predicted to gradually increase, and stabilize at about 0.21 around 2018, slightly above to the level corresponding to MSY (0.20) (Figure D-5). If a stock-recruitment relationship is assumed, it is estimated that catches will be lower in the future at current levels of fishing effort, particularly for the surface fisheries (Figure D-8).

These simulations are based on the assumption that selectivity and catchability patterns will not change in the future. Changes in targeting practices or increased catchability of bigeye as abundance declines (*e.g.*

density-dependent catchability) could result in differences from the outcomes predicted here.

Key Results

1. The results of this assessment indicate a recent recovery trend for bigeye tuna in the EPO (2005-2010), subsequent to IATTC tuna conservation resolutions initiated in 2004. However, a decline of the spawning biomass began at the start of 2011, persisted through 2012 and reduced both summary and spawning biomasses to their lowest historic levels at the start of 2013. This decline may be related to a series of recent below-average recruitments which coincide with a series of strong la Niña events. However, at current levels of fishing mortality, and if recent levels of effort and catchability continue and average recruitment levels persist, the SBR is predicted to stabilize at about 0.21, very close to the level corresponding to MSY.
2. There is uncertainty about recent and future recruitment and biomass levels.
3. The recent fishing mortality rates are estimated to be slightly below the level corresponding to MSY, and the recent levels of spawning biomass are estimated to slightly above that level. These interpretations are uncertain and highly sensitive to the assumptions made about the steepness parameter of the stock-recruitment relationship, the assumed rates of natural mortality for adult bigeye, and the weighting assigned to the size-composition data, in particular to the longline size-composition data. The results are more pessimistic if a stock-recruitment relationship is assumed, if lower rates of natural mortality are assumed for adult bigeye, and if a greater weight is assigned to the size-composition data, in particular the longline fisheries.

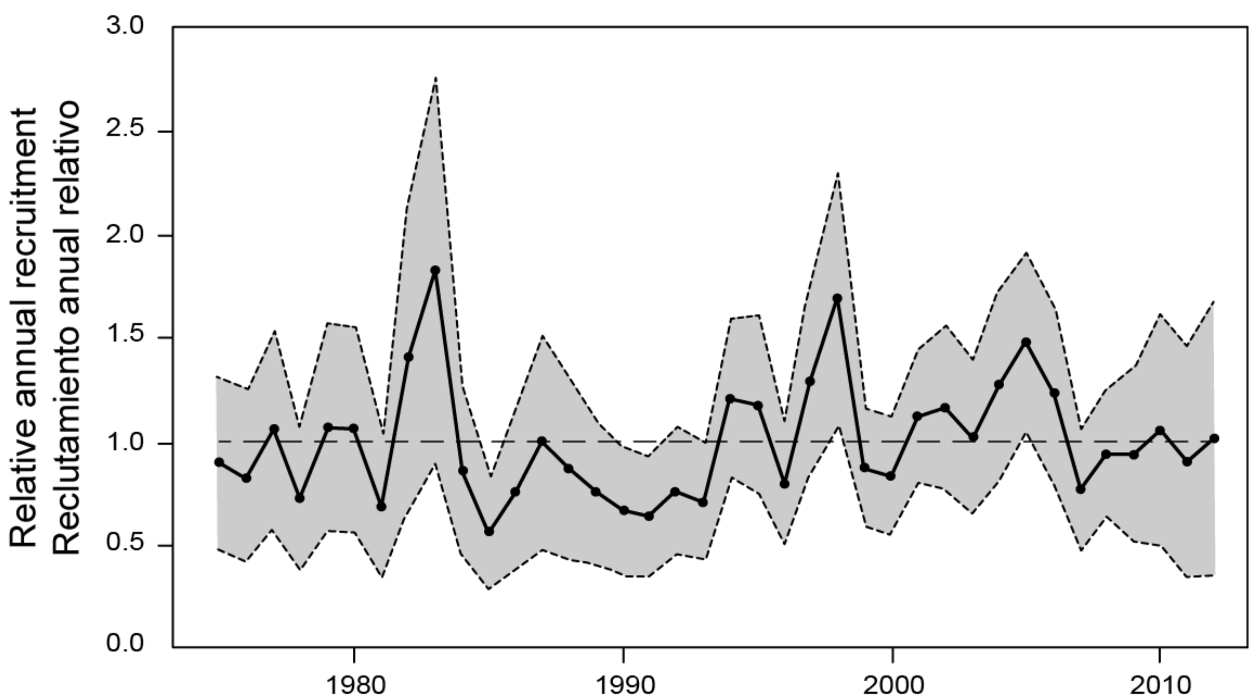

FIGURE D-1. Estimated annual recruitment of bigeye tuna to the fisheries of the EPO. The estimates are scaled so that the estimate of virgin recruitment is equal to 1.0 (dashed horizontal line). The solid line shows the maximum likelihood estimates of recruitment, and the shaded area indicates the approximate 95% intervals around those estimates.
FIGURA D-1. 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.

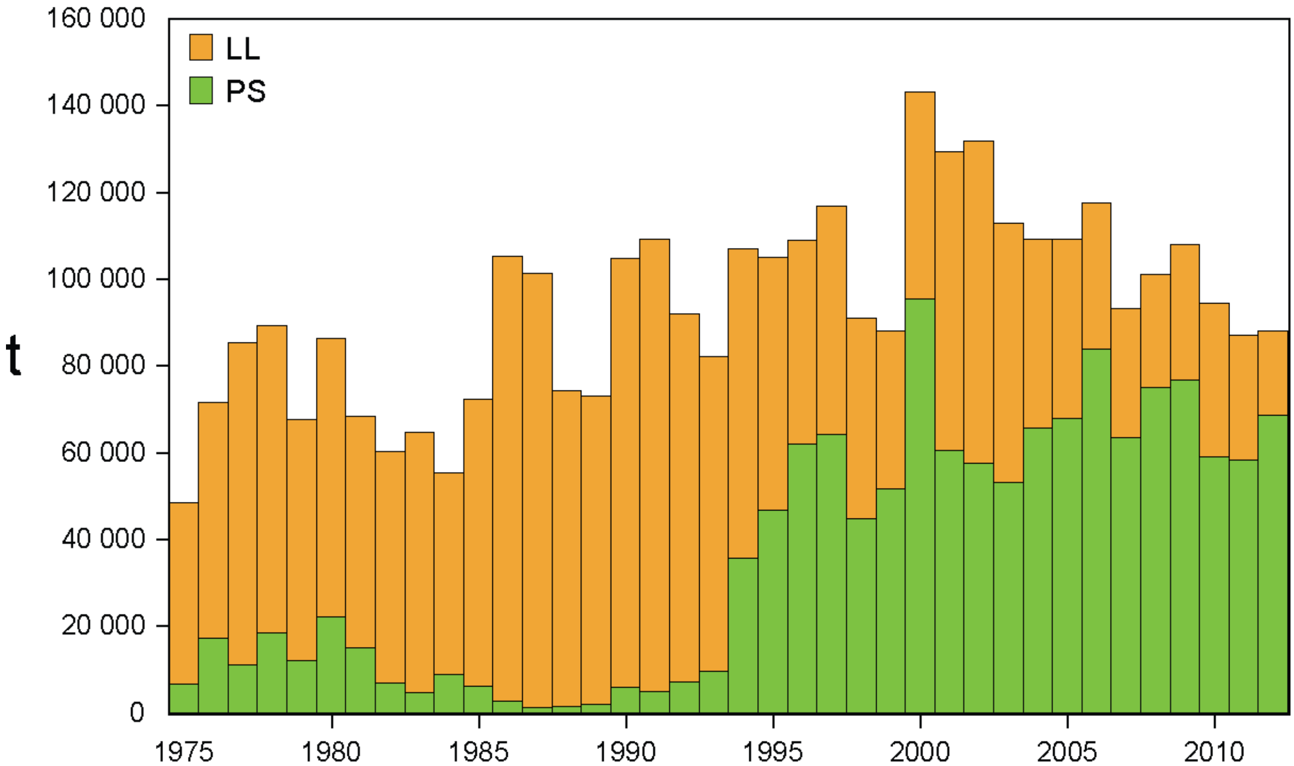

FIGURE D-2. Total catches (retained catches plus discards) of bigeye tuna by the purse-seine fisheries, and retained catches for the longline fisheries, in the eastern Pacific Ocean. The purse-seine catches are adjusted to the species composition estimate obtained from sampling the catches. The 2012 catch data are preliminary.

FIGURA D-2. 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. Las capturas cerqueras están ajustadas a la estimación de la composición por especie obtenida del muestreo de las capturas. Los datos de captura de 2012 son preliminares.

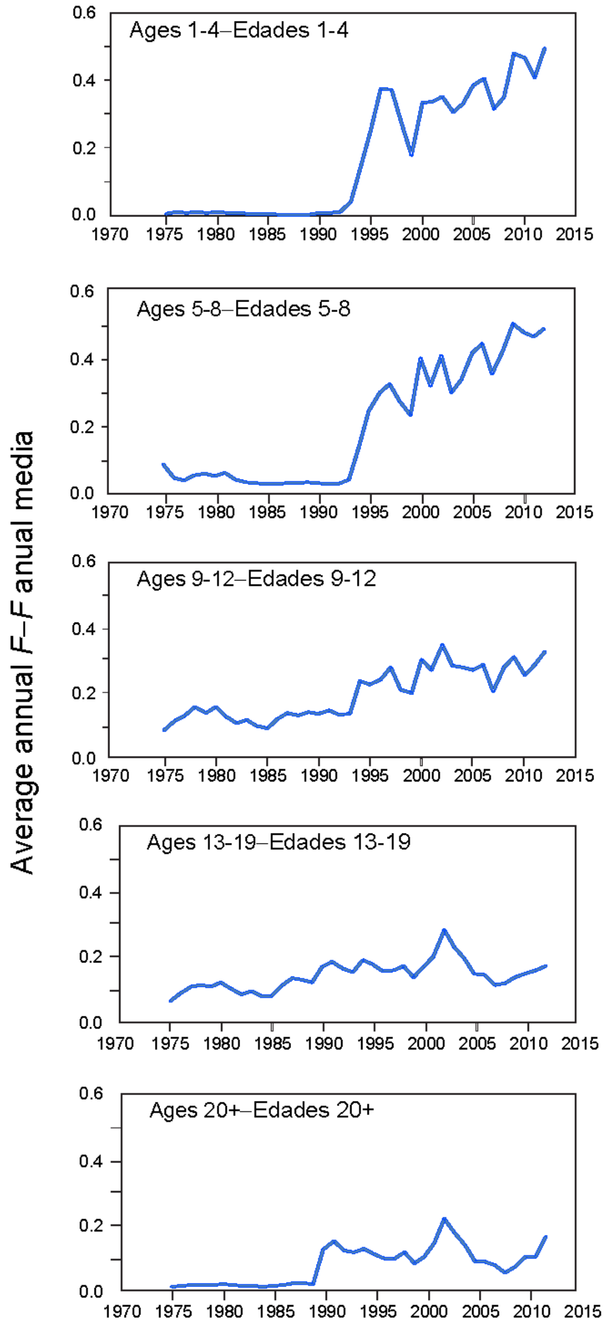

FIGURE D-3. Average annual fishing mortality, by all gears, of bigeye tuna recruited to the fisheries of the EPO. Each panel illustrates the average fishing mortality rates that affected the fish within the range of ages indicated in the title of each panel. For example, the trend illustrated in the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

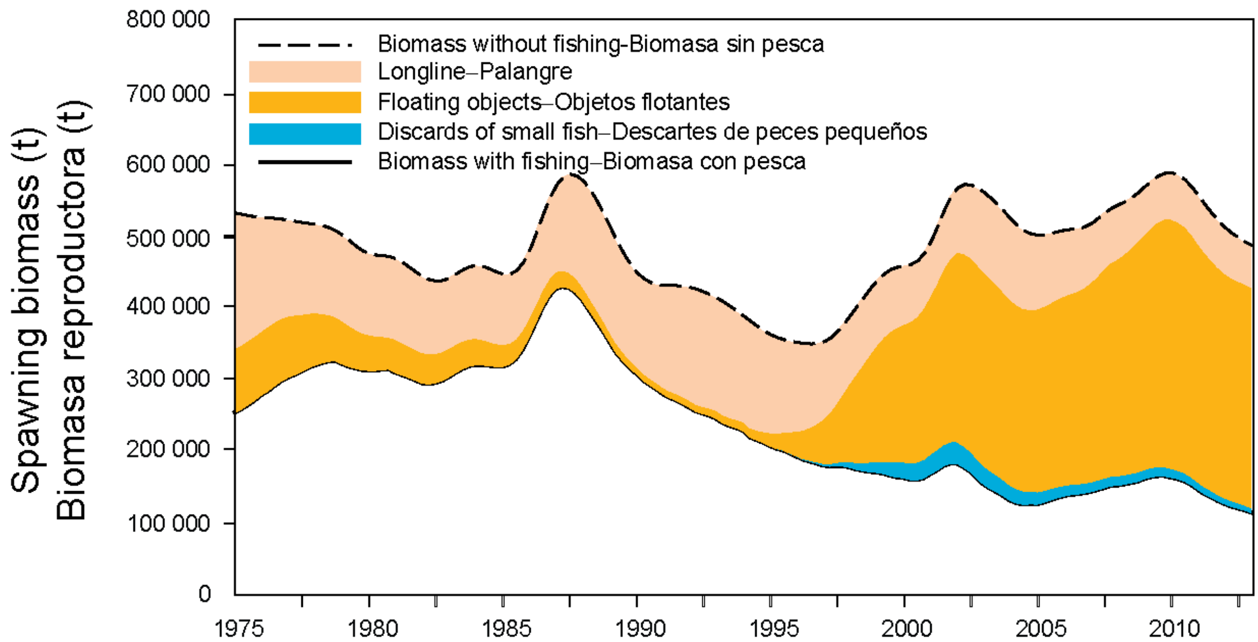

FIGURE D-4. Trajectory of the spawning biomass of a simulated population of bigeye tuna that was not exploited (top line) and that predicted by the stock assessment model (bottom line). The shaded areas between the two lines show the portions of the impact attributed to each fishing method. t = metric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

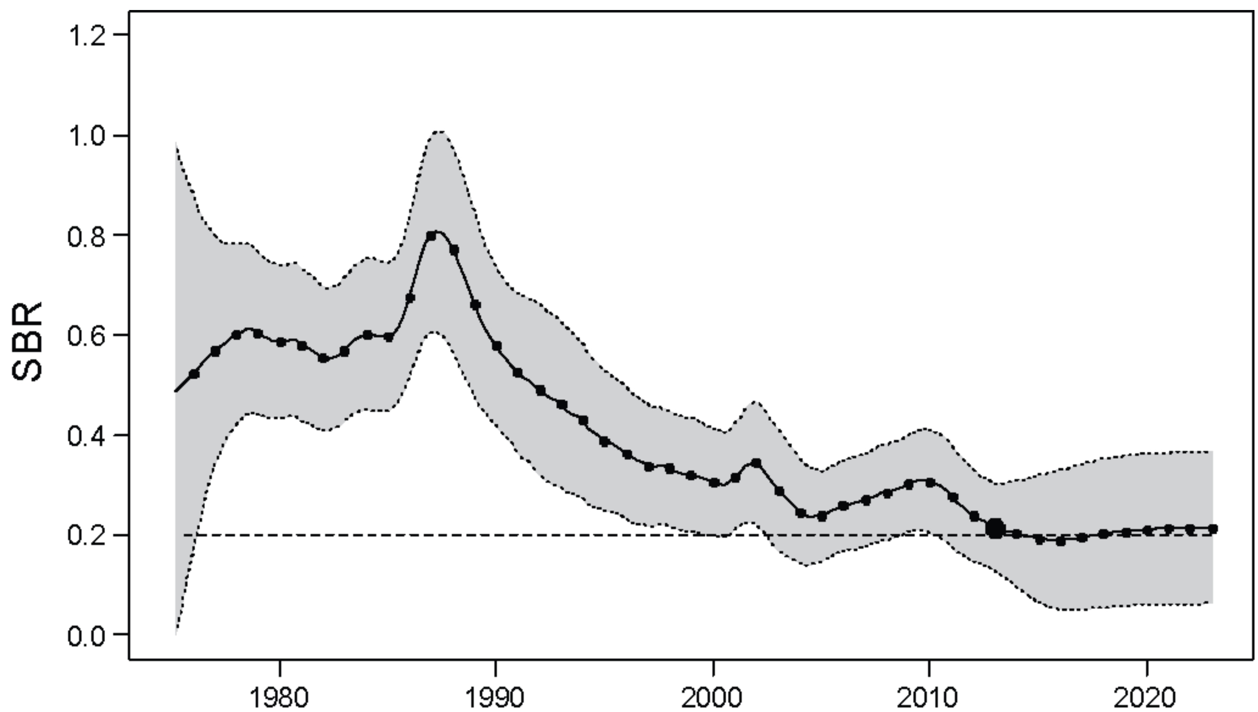

FIGURE D-5. Estimated spawning biomass ratios (SBRs) of bigeye tuna in the EPO, including projections for 2013-2022 based on average fishing mortality rates during 2010-2012. The dashed horizontal line (at about 0.20) identifies the SBR at MSY. The solid line illustrates the maximum likelihood estimates, and the estimates after 2013 (the large dot) indicate the SBR predicted to occur if fishing mortality rates continue at the average of that observed during 2010-2012. 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 2011-2020 basadas en las tasas medias de mortalidad por pesca durante 2010-2012. La línea sólida ilustra las estimaciones de verosimilitud máxima, y las estimaciones a partir de 2013 (el punto grande) señalan el SBR predicho si las tasas de mortalidad por pesca continúan en el promedio observado durante 2012-2013. Las líneas de trazos representan los intervalos de confianza de 95% alrededor de esas estimaciones.

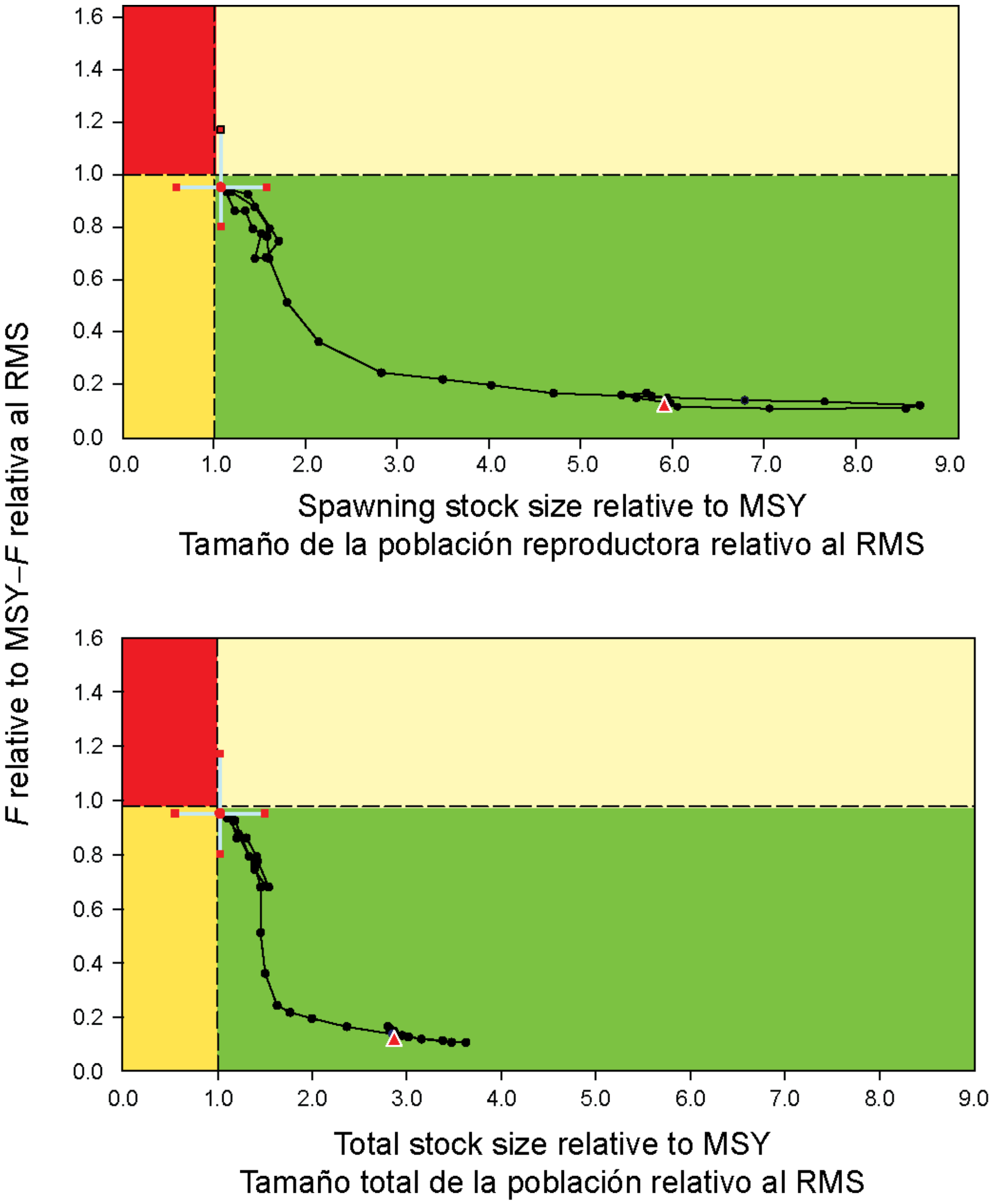

FIGURE D-6a. Target Kobe (phase) plot of the time series of estimates of stock size (top: spawning biomass; bottom: total biomass) and fishing mortality relative to their MSY reference points. The panels represent proposed target reference points (S_{MSY} and F_{MSY}). Each dot is based on the average 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 is the first estimate (1975).

FIGURA D-6a. Gráfica de Kobe (fase) objetivo de la serie de tiempo de las estimaciones del tamaño de la población (arriba: biomasa reproductora; abajo: biomasa total) y la mortalidad por pesca en relación con sus puntos de referencia de RMS. Los recuadros representan puntos de referencia objetivo propuestos (S_{RMS} and F_{RMS}). 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 el intervalo de confianza de 95% aproximado. El triángulo es la primera estimación (1975).

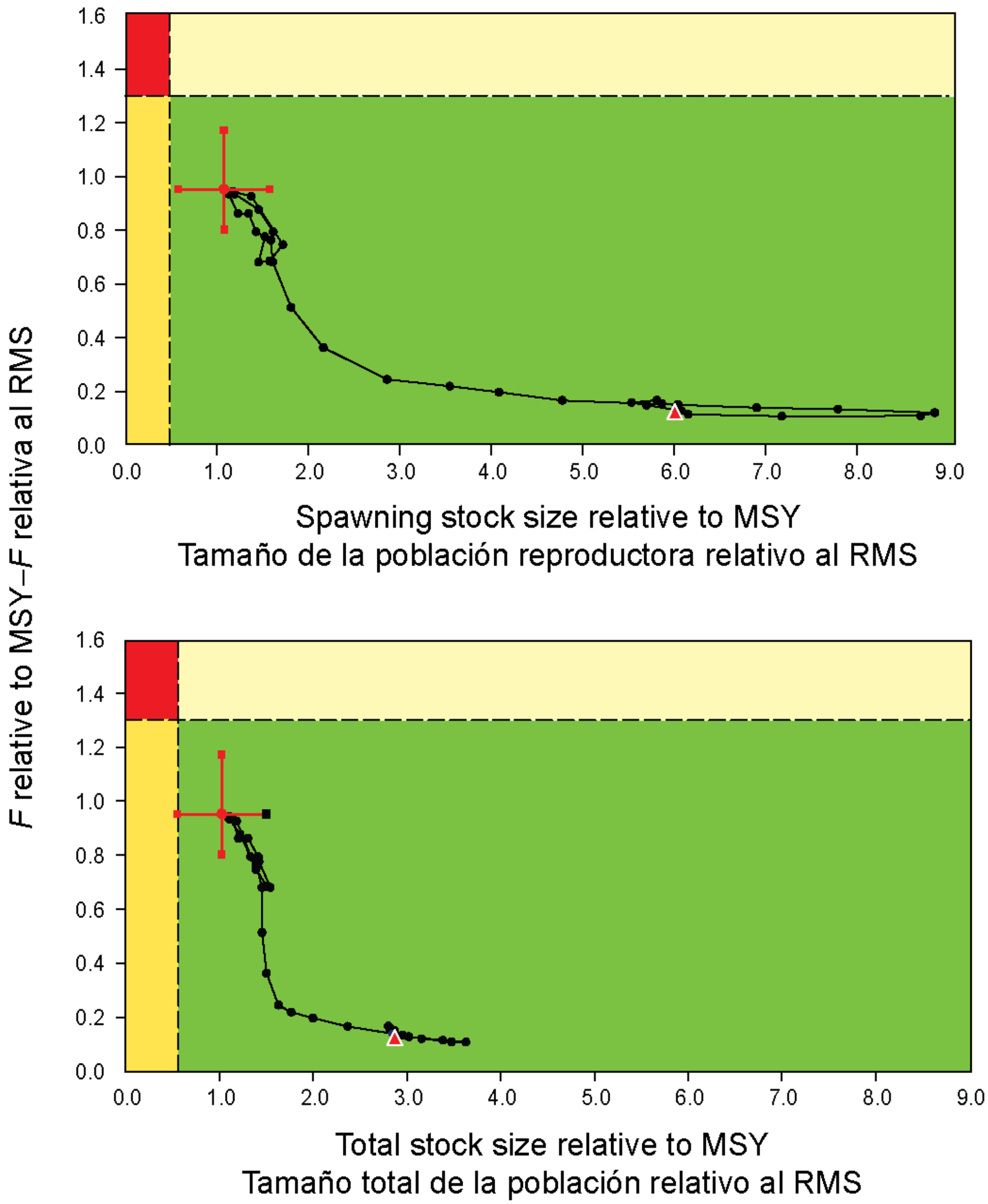

FIGURE D-6b. Limit Kobe (phase) plot of the time series of estimates of stock size (top: spawning biomass; bottom: total biomass) and fishing mortality relative to their MSY reference points. The panels represent proposed limit reference points (0.5 S_{MSY} and 1.3 F_{MSY}). Each dot is based on the 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 is the first estimate (1975).

FIGURA D-6b. Gráfica de Kobe (fase) límite de la serie de tiempo de las estimaciones del tamaño de la población (arriba: biomasa reproductora; abajo: biomasa total) y la mortalidad por pesca en relación con sus puntos de referencia de RMS. Los recuadros representan puntos de referencia límite propuestos (0,5 S_{RMS} and 1,3 F_{RMS}). 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 el intervalo de confianza de 95% aproximado. El triángulo es la primera estimación (1975).

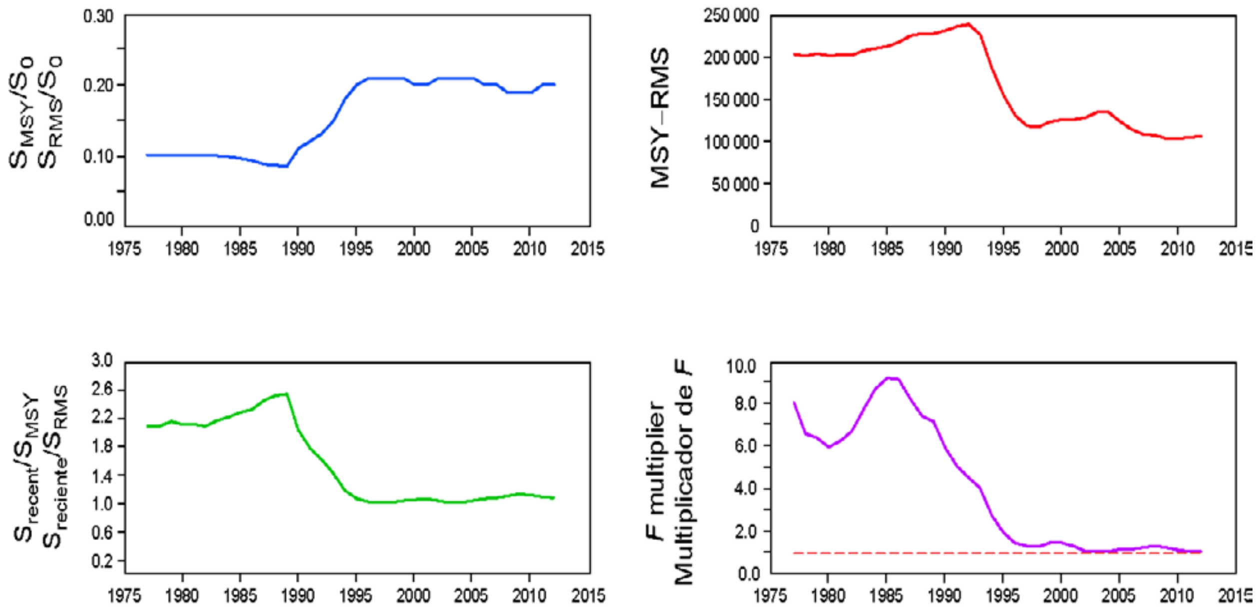

FIGURE D-7. Estimates of MSY-related quantities calculated using the average age-specific fishing mortality for each year. (S_{recent} is the spawning biomass at the beginning of 2013.)

FIGURA D-7. Estimaciones de cantidades relacionadas con el RMS calculadas usando la mortalidad por pesca por edad para cada año. ($S_{reciente}$ es la biomasa reproductora al principio de 2013.)

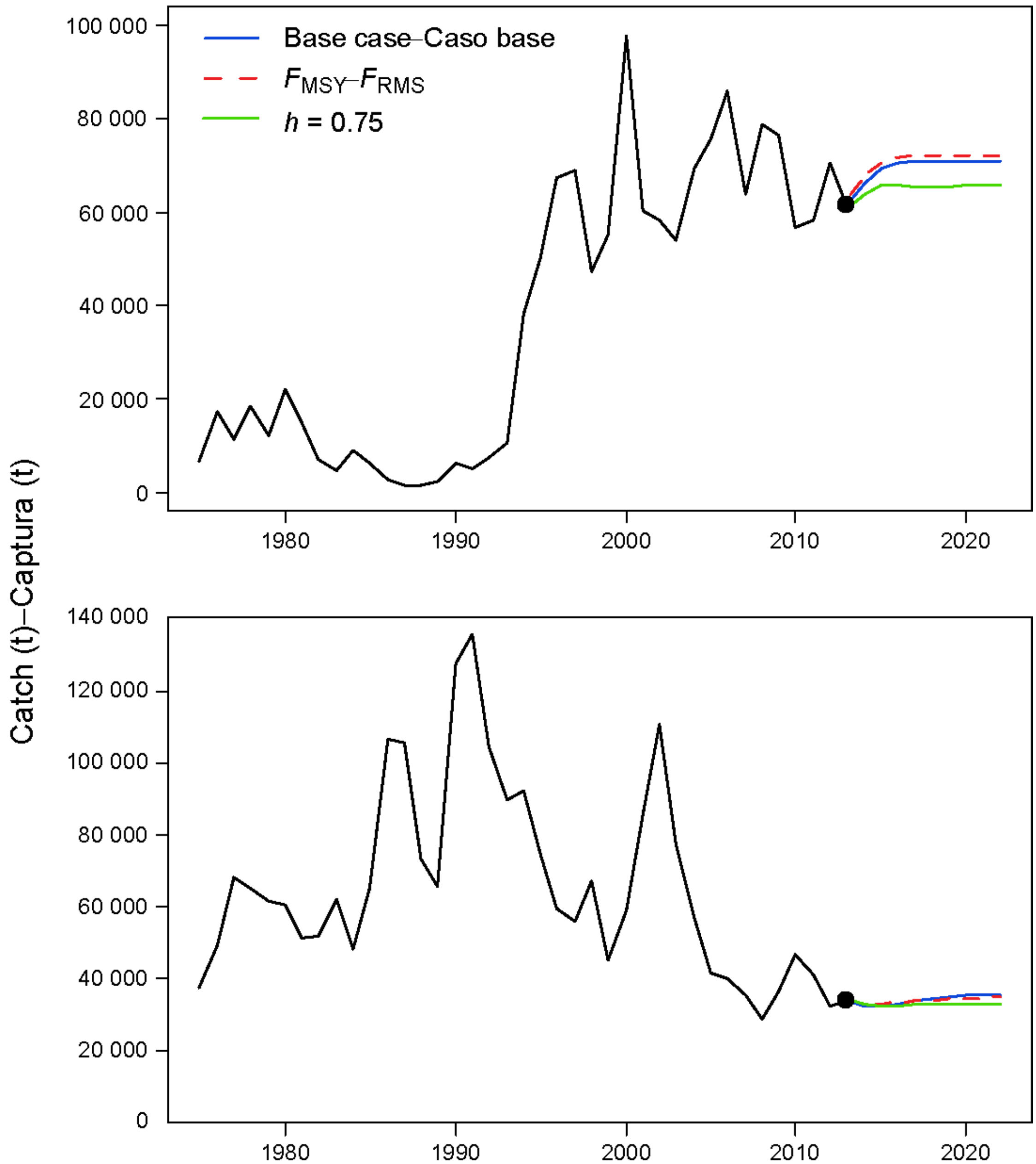

FIGURE D-8. Historic and predicted annual catches of bigeye tuna during 2013-2022 for the surface (top panel) and longline (bottom panel) fisheries, based on fishing mortality rates during 2010-2012. Predicted catches are compared between the base case, the analysis assuming F_{MSY} and the analysis in which a stock-recruitment relationship (h = 0.75) was used. t = metric tons.

FIGURA D-8. Capturas anuales históricas y predichas de atún patudo durante 2013-2022 en las pesquerías de superficie (recuadro superior) y de palangre (recuadro inferior), basadas en las tasas de mortalidad por pesca durante 2010-2012. Se comparan las capturas predichas entre el caso base, el análisis que supone F_{MSY} y el análisis en el que se usa una relación población-reclutamiento (h = 0.75). t = toneladas métricas.

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 2010-2012. B_{recent} and B_{MSY} are defined as the biomass of fish 3+ quarters old (in metric tons) at the beginning of 2013 and at MSY, respectively. S_{recent} and S_{MSY} are in metric tons. C_{recent} is the estimated total catch in 2012. 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 2010-2012.

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 2010-2012. Se definen B_{recent} y B_{RMS} como la biomasa de peces de 3+ trimestres de edad (en toneladas métricas) al principio de 2013 y en RMS, respectivamente. Se expresan S_{recent} y S_{MSY} en toneladas métricas. C_{recent} es la captura total estimada en 2012. 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 2010-2012.

	Base case-Caso base	***h* = 0.75**
MSY-RMS	106,706	101,994
B_{MSY}- B_{RMS}	418,468	754,430
S_{MSY}- S_{RMS}	105,969	210,470
B_{MSY}/B_0- B_{RMS}/B_0	0.24	0.33
S_{MSY}/S_0- S_{RMS}/S_0	0.20	0.30
C_{recent}/MSY- C_{recent}/RMS	0.97	1.01
B_{recent}/B_{MSY}- B_{recent}/B_{RMS}	1.02	0.80
S_{recent}/S_{MSY}-S_{recent}/S_{RMS}	1.08	0.81
F multiplier-Multiplicador de F	1.05	0.82

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 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 during every month of the year, but most of the fish are taken during May through October.

Bluefin are exploited by various gears in the WPO from Taiwan to Hokkaido. Age-0 fish about 15 to 30 cm in length are caught by trolling 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 by trolling 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. 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. The migrants, after crossing the ocean, 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 the portions of the juvenile fish there that migrate to the EPO, and also 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 2012. The assessment was conducted with Stock Synthesis 3, an integrated statistical age-structured stock assessment model. Uncertainties were found in the assessment, and these were characterized through a series of 20 models, each with alternative data weightings and strucutural assumptions. While no single model scenario provided a good fit to all sources of data deemed reliable, long-term fluctuations in spawning stock biomass (SSB) occurred throughout the assessment period (1952-2011), and the SSB has been declining for more than a decade; however, there is no evidence of reduced recruitment. Age-specific fishing mortality has increased 8-41% in the recent period (2007-2009) relative to the baseline period (2002-2004) used in recent WCPFC and IATTC conservation measures.

A model configuration was chosen as the base-case assessment model to determine stock status and provide management advice, acknowledging that while it represents the general conclusions above, the model was unable to reconcile all key data sources. According to this model, estimated age-specific fishing mortalities for the stock in the recent period (2007-2009) relative to 2002-2004 (the base period for the current WCPFC conservation measures) show increases of 4, 17, 8, 41 and 10% for ages 0, 1, 2, 3 and 4+, respectively. Although no target or limit reference points have been established for the Pacific bluefin stock, the current *F* (2007-2009 average) is above all target and limit biological reference points commonly used for management. The current (2010) Pacific bluefin SSB level is near historic low levels, and the ratio of SSB in 2010 relative to unfished SSB is low.

Stock projections of spawning biomass and catches of Pacific bluefin tuna from 2011 to 2030 were conducted assuming alternative harvest scenarios. Recent WCPFC and IATTC conservation and management measures that entered into force in 2011 and 2012, respectively, 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 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.

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 (Figure E-3).

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 (Figure E-3). 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.

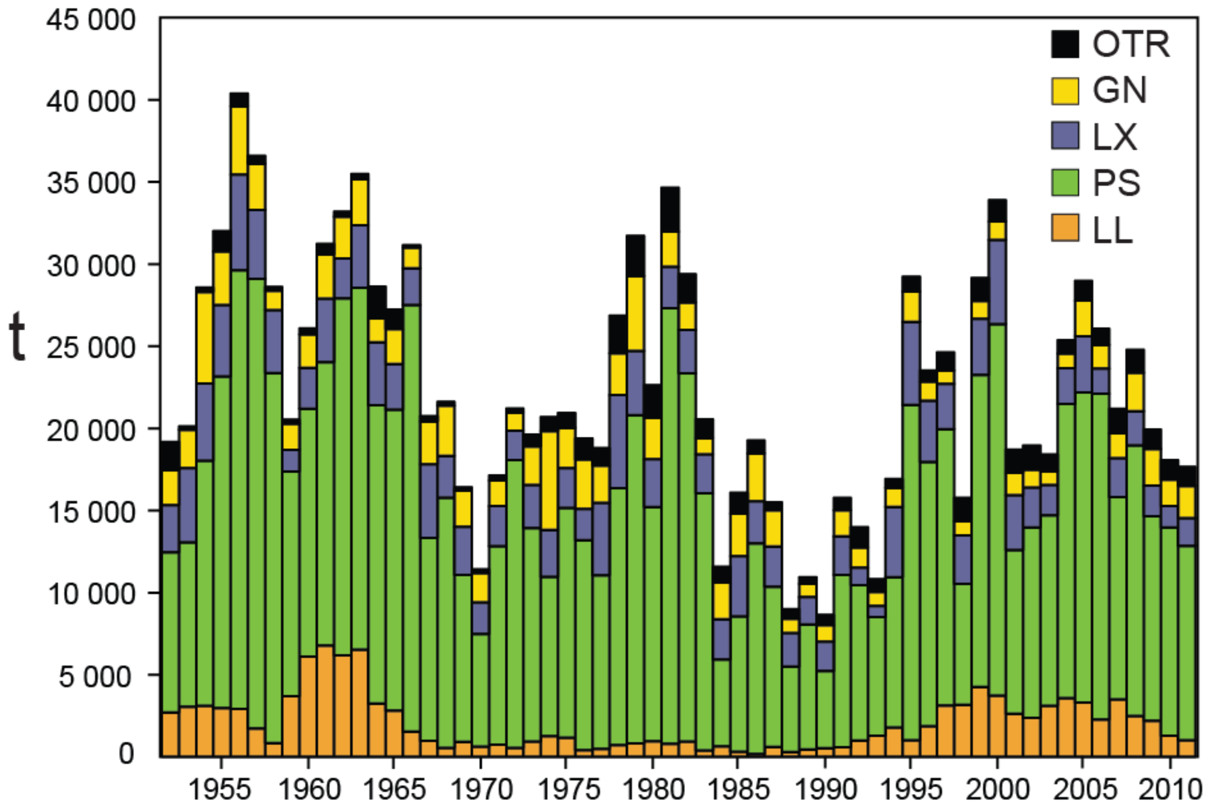

FIGURE E-1. Retained catches of Pacific bluefin tuna.
FIGURA E-1. Capturas retenidas de atún aleta azul del Pacífico.

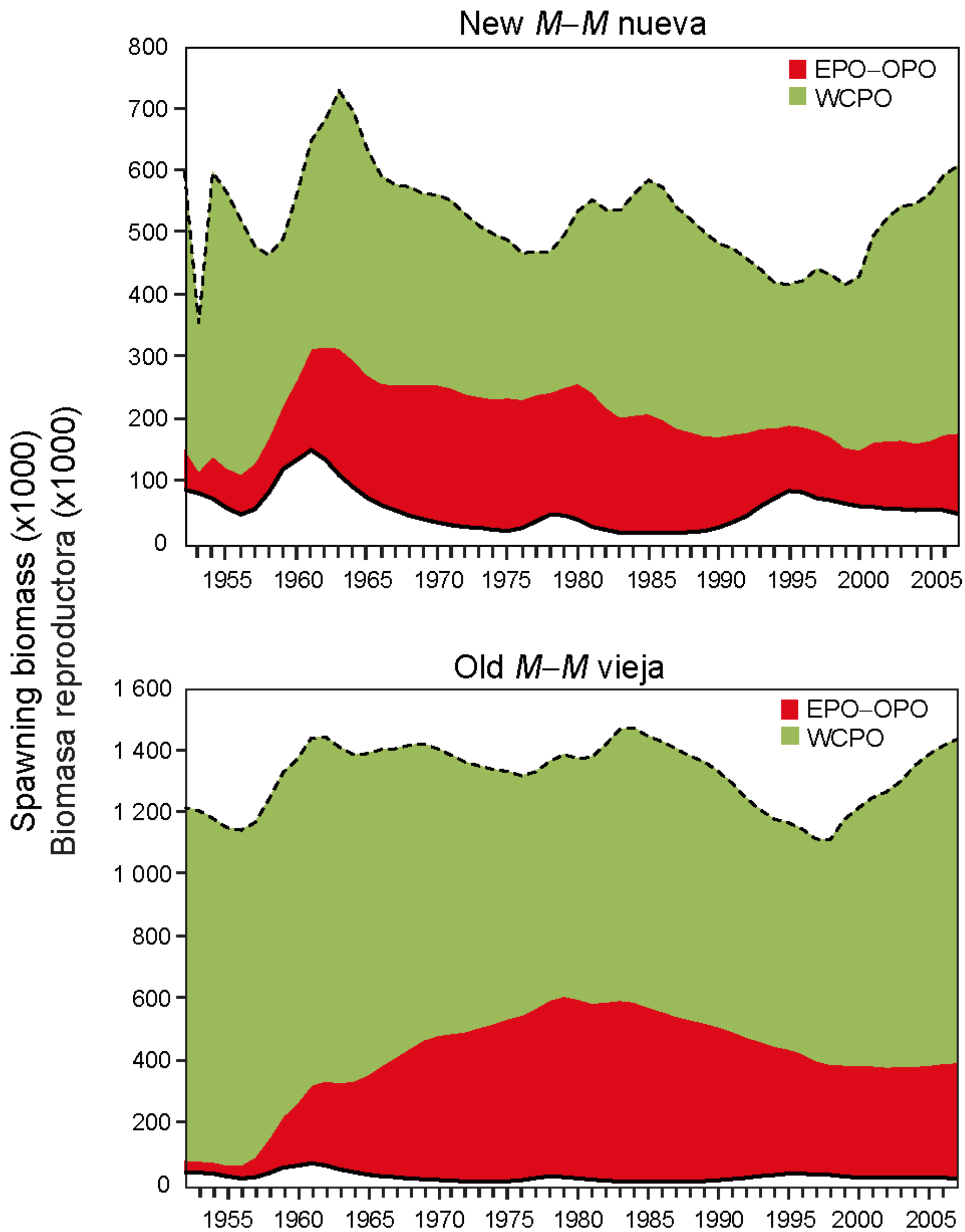

FIGURE E-2. Estimates of the impact on the Pacific bluefin tuna population of fisheries in the EPO and in the WPO for the new (upper panel) and old (lower panel) values of natural mortality (*M*). The dashed line represents the estimated hypothetical unfished spawning biomass, and the solid line the estimated actual spawning biomass. New *M* = *M* assumed in the current assessment; old *M* = *M* assumed in the previous assessment. The shaded areas indicate the impact attributed to each fishery.

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 correspondientes a los valores de mortalidad natural (*M*) nueva (panel superior) y vieja (panel inferior). La línea de trazos representa la biomasa reproductora no pescada hipotética estimada, y la línea sólida la biomasa reproductora real estimada. *M* nueva = *M* supuesta en la evaluación actual; *M* vieja = *M* supuesta en la evaluación previa. Las áreas sombreadas indican el impacto atribuido a cada pesquería.

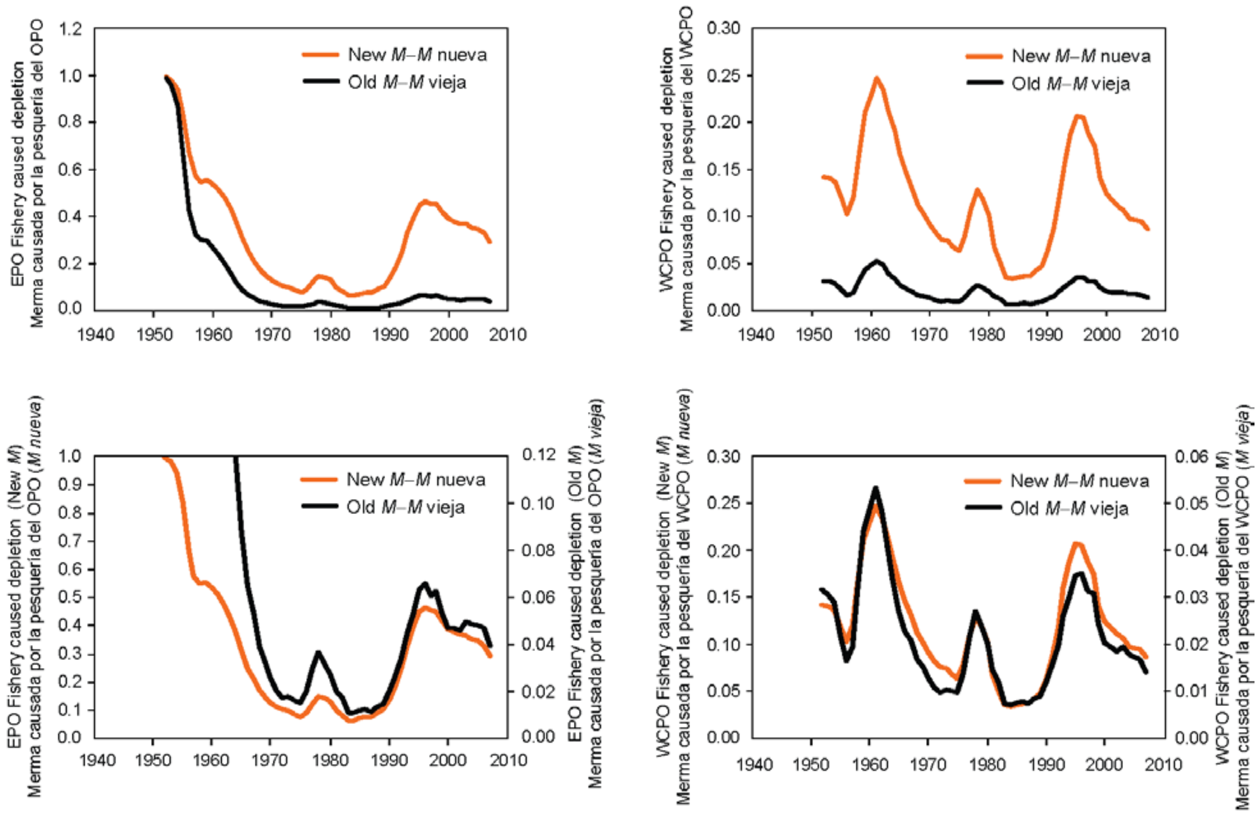

FIGURE E-3. Stock depletion (actual abundance as a fraction of the hypothetical abundance if the fishery were not operating) caused by the EPO fisheries (left) and WPO fisheries (right) for the new and old values of *M*, on the same scale (top) and on different scales (bottom). Higher values correspond to less depletion; *i.e.* actual abundance is closer to hypothetical abundance without the fishery operating.

FIGURA E-3. Merma de la población (abundancia real como fracción de la abundancia hipotética si no operara la pesquería) causada por las pesquerías del OPO (izquierda) y WPO (derecha) correspondientes a los valores nuevo y viejo de *M*, en la misma escala (arriba) y en escalas diferentes (abajo). Valores altos corresponden a menos merma; es decir, la abundancia real es más cercana a la abundancia hipotética sin la pesquería.

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 60% of the fish are taken in pole-and-line and troll fisheries that catch smaller, younger albacore, whereas about 90% 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). During 2005-2011 the average annual catch was about 75,000 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 58,000 to 89,000 t during 2001-2011 (Figure F-1b).

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. It has been hypothesized that there are two subgroups of North Pacific albacore, separated at about 40ºN in the EPO, with the northern subgroup more likely to migrate to the western and central Pacific Ocean.

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 2011, 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 biomass-based reference points $B_{current}/B_{MSY}$ and $SB_{current}/SB_{MSY}$ were estimated to be above 1.0, and therefore the stock was not in an overfished state. In addition, it was concluded that the risk for overfishing to be occuring was low (fishing mortality reference point $F_{current}/F_{MSY}$ with a median estimate of 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.

An assessment of North Pacific albacore using fisheries data through 2009 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 June 2011. The assessment methodology has been changed from Virtual Population Analysis (VPA) to an integrated statistical age-structured stock assessment model (Stock Synthesis 3). The conclusions reached at that workshop were presented to the eleventh plenary meeting of the ISC, held in August 2011. Among these were the following:

- The base-case model estimates that the spawning stock biomass (SSB) has likely fluctuated between 300,000 and 500,000 t between 1966 and 2009, and that recruitment has averaged 48 million fish annually during this period (Figure F-2).
- The pattern of *F*-at-age shows fishing mortality increasing to its highest level in 3-year-old fish, and then declining to a much lower and stable level in mature fish. Current *F* (geometric mean of 2006 to 2008, $F_{2006\text{-}2008}$) is lower than $F_{2002\text{-}2004}$ (current *F* in the 2006 assessment).
- Stochastic future projections of the stock were conducted to estimate the probability that future SSB will fall below the average of the ten historically lowest estimated SSBs (SSB-ATHL) in at least one year of a 25-year (2010-2035) projection period. Future SSB is expected to fluctuate around the historical median SSB (~405,000 t), assuming *F* remains constant at $F_{2006\text{-}2008}$ and average historical recruitment levels persist.
- Sensitivity and retrospective analyses assessed the impact of alternative assumptions on the assessment results. These analyses revealed scaling differences in estimated biomass (total and SSB) and, to a lesser extent, recruitment, but few differences in overall trends. Relative *F*-at-age patterns were not affected by different assumptions, except when the growth curve parameters from the 2006 assessment were used, and $F_{2006\text{-}2008}$ was consistently lower than $F_{2002\text{-}2004}$.
- The Working Group concluded that the north Pacific albacore stock is healthy at current levels of recruitment and fishing mortality. Since current $F_{2006\text{-}2008}$ is about 71% of $F_{SSB\text{-}ATHL}$ and the stock is expected to fluctuate around the long-term median SSB (~405,000 t) in the foreseeable future given average historical recruitment levels and constant fishing mortality at $F_{2006\text{-}2008}$, the Working Group concluded that overfishing is not occurring and that the stock is probably not overfished.

A full assessment for northern albacore is planned to be carried in out April 2014 by the Albacore Working Group of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC).

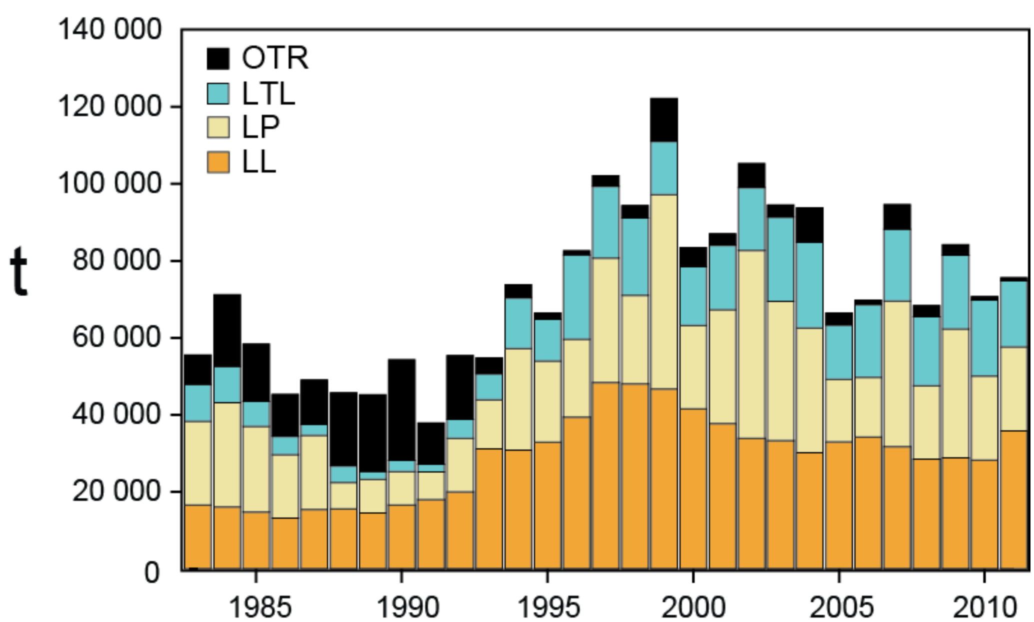

FIGURE F-1a. Retained catches of North Pacific albacore.
FIGURA F-1a. Capturas retenidas de albacora del Pacífico norte.

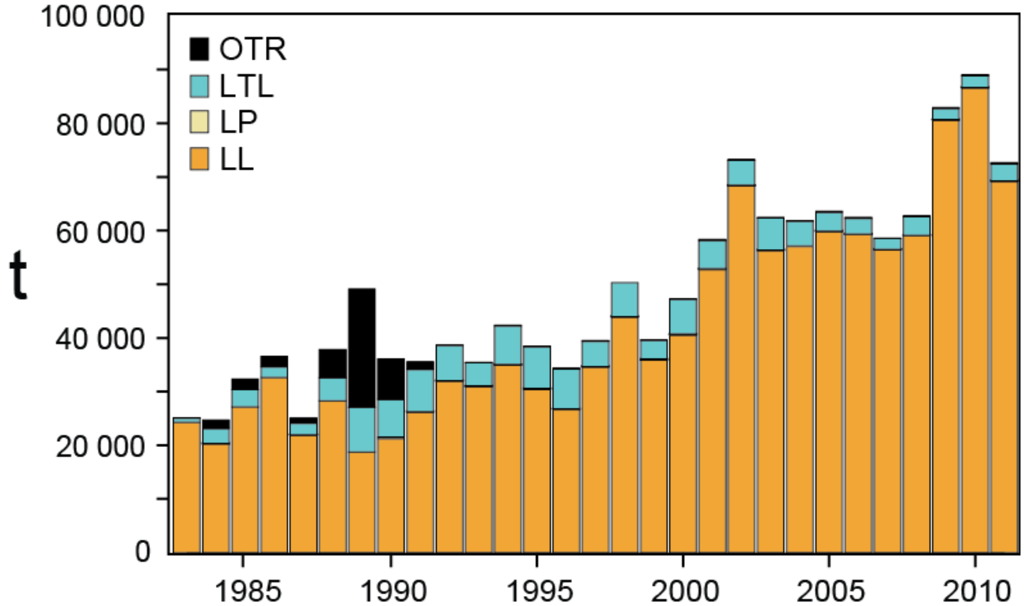

FIGURE F-1b. Retained catches of South Pacific albacore.
FIGURA F-1b. Capturas retenidas de albacora del Pacífico sur.

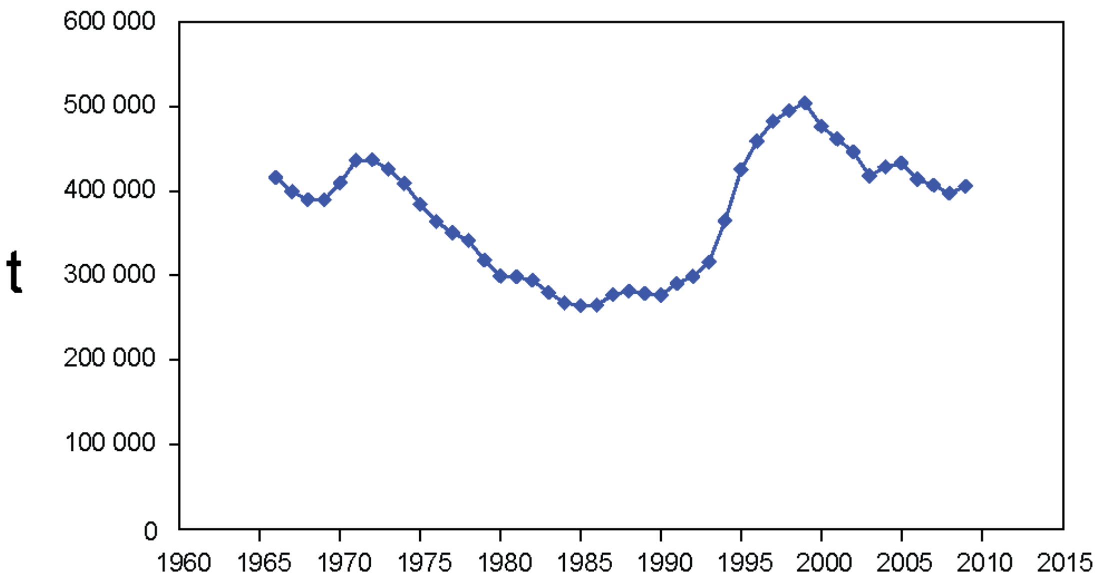

FIGURE F-2. Spawning stock biomass of North Pacific albacore tuna, from the North Pacific Albacore Workshop analysis of 2011.
FIGURA F-2. Biomasa de la población reproductora del atún albacora del Pacífico norte, de los análisis de la Reunión Técnica sobre el albacora del Pacífico norte de 2011.

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.

Significant effort has been devoted to studying the stock structure of swordfish in the Pacific, which is now moderately 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.

An 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 significantly below the estimated 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 237 million hooks in 2007 to about 439 million in 2011, remains significantly below the 2001-2003 average of 704 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 remain significantly below the estimated MSY, and there is no indication of a significant impact of fishing on this stock, or that it is experiencing overfishing or is overfished.

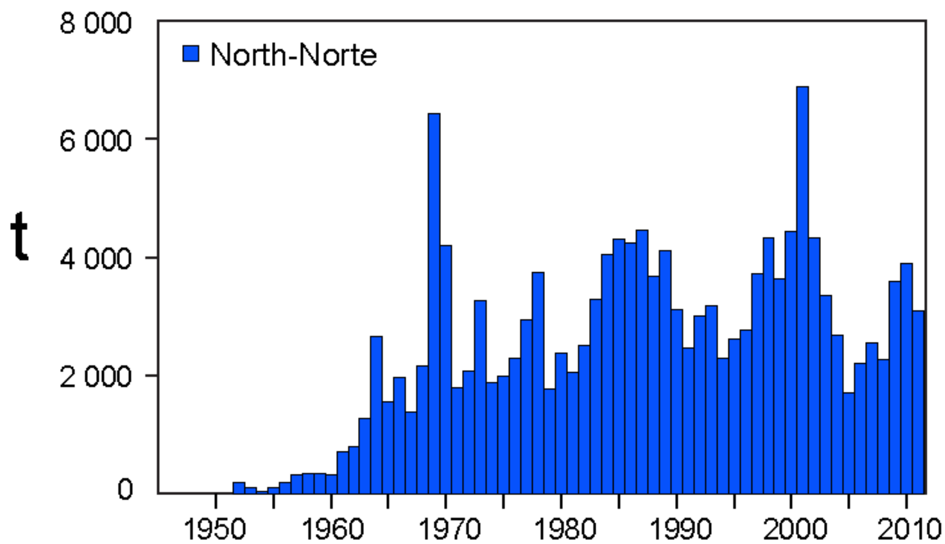

FIGURE G-1. Retained catches of swordfish in the northeastern Pacific Ocean.
FIGURA G-1. Capturas retenidas de pez espada en el Océano Pacífico noreste.

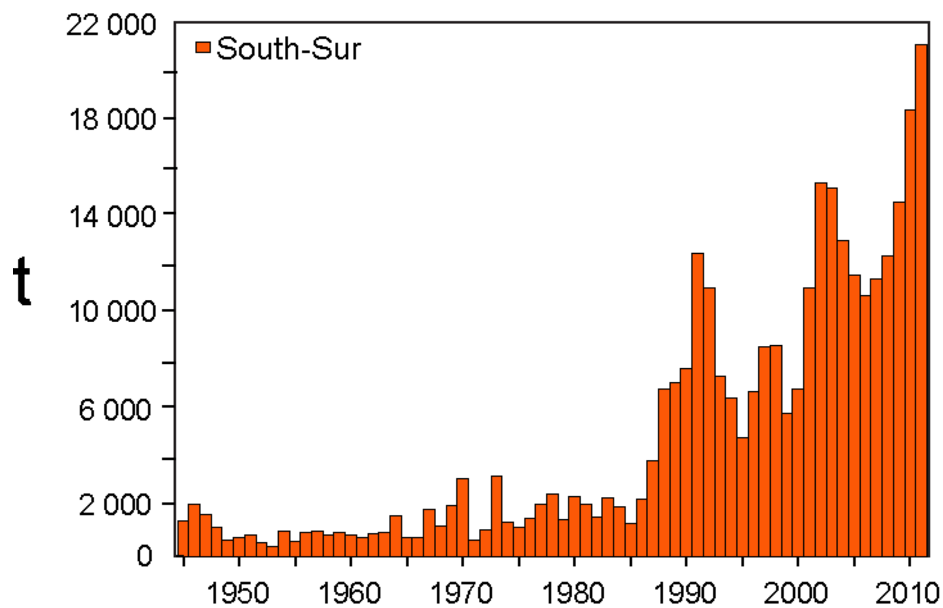

FIGURE G-2. Retained catches of swordfish in the southeastern Pacific Ocean
FIGURA G-2. Capturas retenidas de pez espada en el Océano Pacífico sudeste.

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 1999, and included data through 1997. A second analysis, using the same data but an alternative stock assessment model, was made in 2003. The first assessment concluded that the levels of biomass and fishing effort were near those corresponding to the maximum sustainable yield (MSY). These results indicate that there was considerable uncertainty regarding the levels of fishing effort that would produce the MSY. It indicated that blue marlin in the Pacific Ocean were close to fully exploited, *i.e*. that the population was being harvested at levels producing catches near the top of the yield curve.

Information on the status of the blue marlin population in the Pacific is being updated by an assessment being conducted this year (2013) in collaboration with the International Scientific Committee for Tunas and Tuna-like Species in the North Pacific (ISC). As part of the that process, the information in this report will be updated.

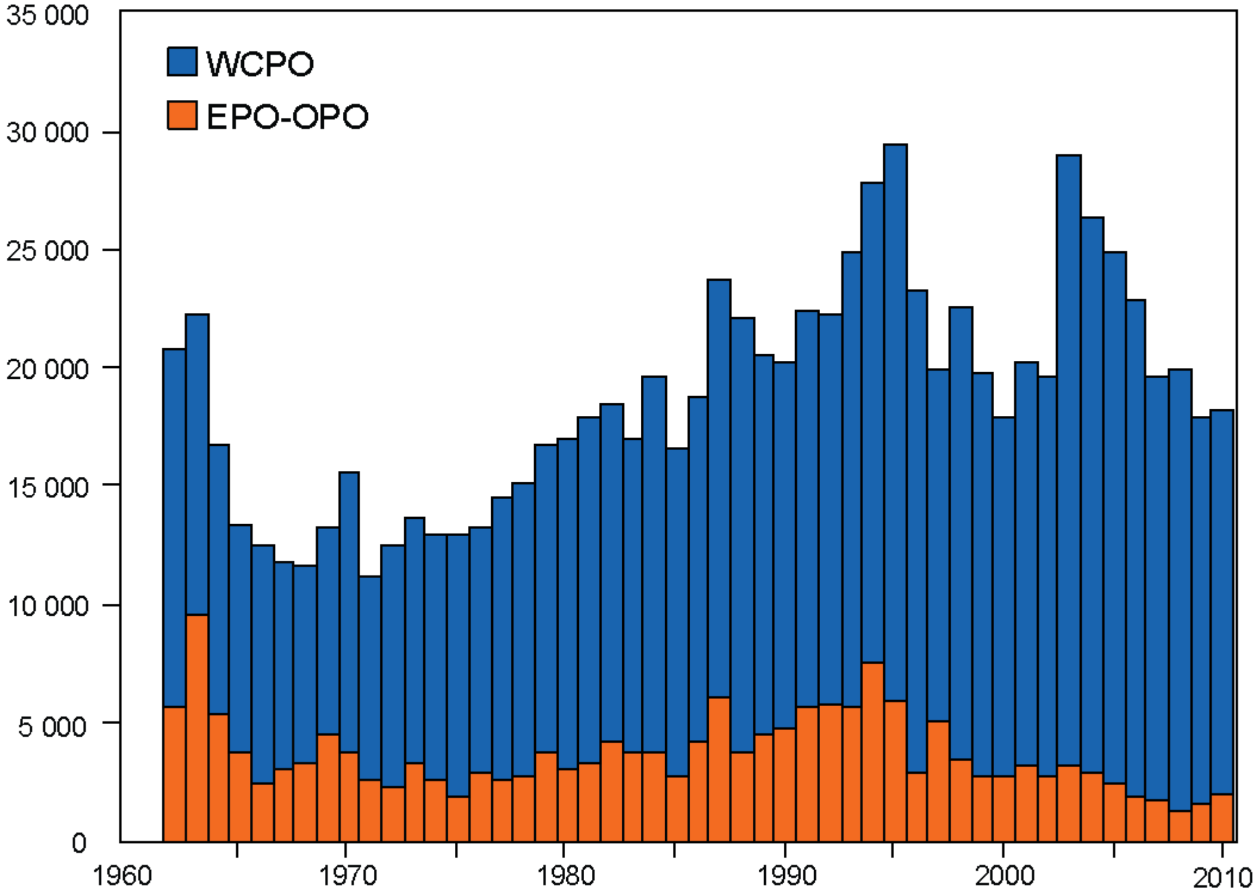

FIGURE H-1. Retained catches of blue marlin in Pacific Ocean by region.
FIGURA H-1. Capturas retenidas de marlín azul en el Océano Pacífico, por región.

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.

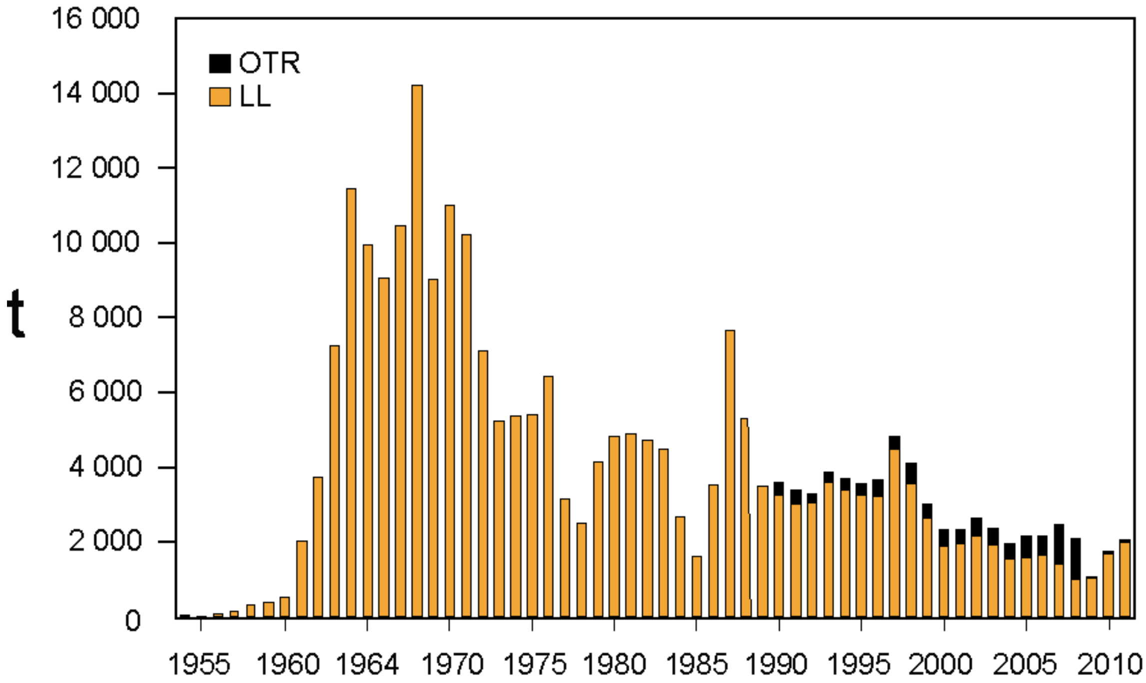

FIGURE I-1. Landings of striped marlin from the northern EPO by longline and recreational fisheries, 1954-2009.

FIGURA I-1. Descargas de marlín rayado del OPO norte por las pesquerías palangreras y recreativas, 1954-2009.

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 this year (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.

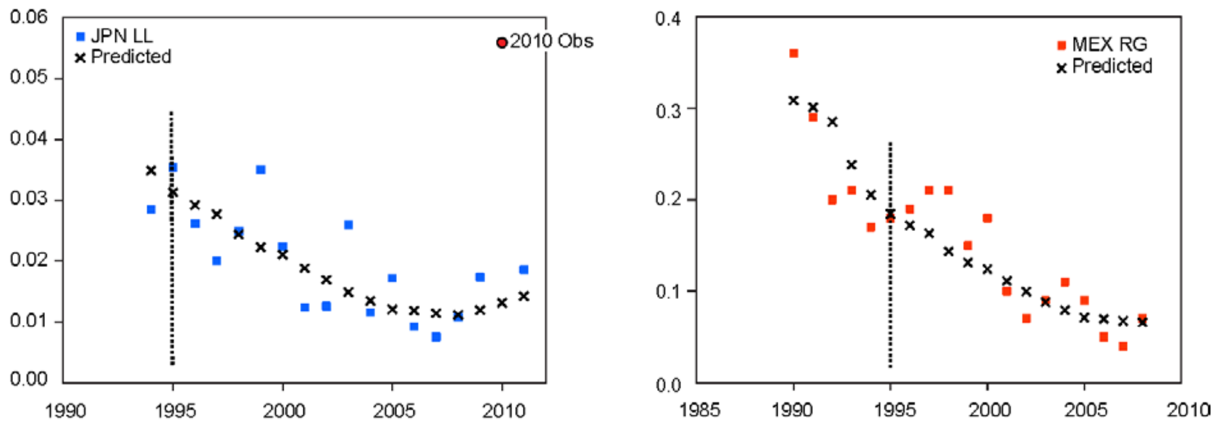

FIGURE J-1. Observed and predicted indices of relative abundance of sailfish in the EPO from Japanese longline (JPN LL) and Mexican recreational (MEX RG) fisheries. The 2010 observation in the JPN LL series was not included in the analyses.

FIGURAE 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.

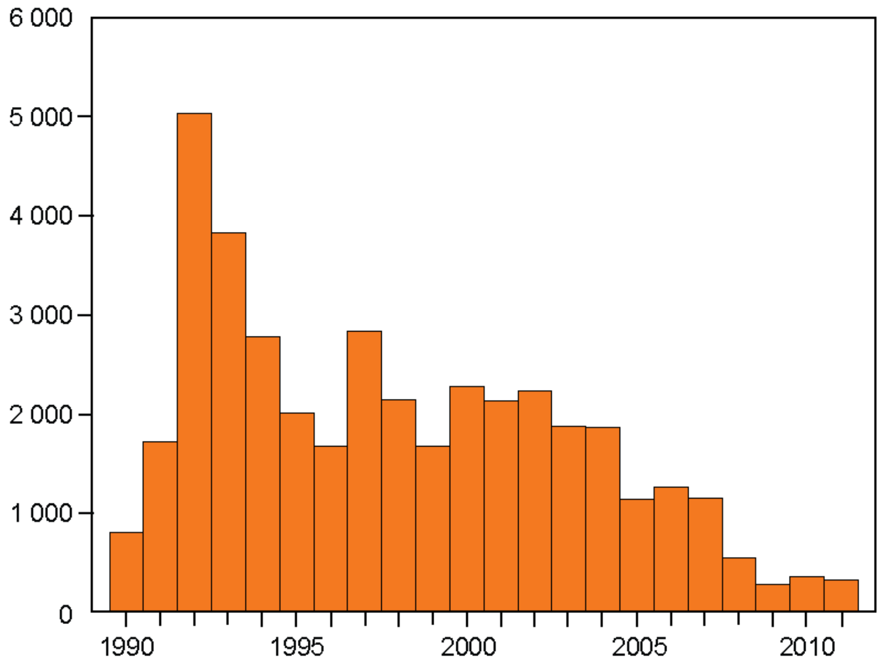

FIGURE J-2. Total reported catches of sailfish in the EPO, 1990-2011. The actual catches were probably greater.

FIGURA J-2. Capturas totales reportadas de pez vela en el OPO, 1990-2011. (Las capturas reales son probablemente mayores.)

K. ECOSYSTEM CONSIDERATIONS

1. INTRODUCTION

The FAO Code of Conduct for Responsible Fisheries provides that management of fisheries should ensure the conservation not only of target species, but also of the other species belonging to the same ecosystem. In 2001, the Reykjavik Declaration on Responsible Fisheries in the Ecosystem elaborated this standard with a commitment to incorporate an ecosystem approach into fisheries management.

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 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. 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, skipjack, and bigeye tunas is found in Sections B, C, and D, respectively, and Pacific bluefin and albacore tunas are addressed in Sections E and F, respectively, of this document.

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, respectively, of this document.

2.3.1. Black marlin and shortbill spearfish

No recent 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 2012 in the EPO are found in Tables A-2a and A-2b of this document.

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 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 2012 are shown in Table 1.

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 marine 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.

TABLE 1. Mortality of dolphins caused by the fishery in 2012

Species and stock	Incidental mortality	
	Number	**Metric tons**
Offshore spotted dolphin		
Northeastern	151	10
Western-southern	187	12
Spinner dolphin		
Eastern	324	14
Whitebelly	107	6
Common dolphin		
Northern	49	3
Central	4	0.3
Southern	30	2
Other mammals*	18	1
Total	**870**	**50**

*"Other mammals" includes the following species and stocks, whose observed mortalities were as follows: Central American spinner dolphins (*Stenella longirostris centroamericana*) 6 (0.3 t); bottlenose dolphins 2 (0.2 t), unidentified dophins 10 (0.6 t).

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. The STAR 2003 and 2006 cruises will provide further estimates of abundance of these mammals. 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.

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 2012, only three mortalities of leatherback 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 2012, by set type (on floating objects (OBJ), unassociated schools (NOA), and dolphins (DEL)), are shown in Table 2.

TABLE 2. Mortality of turtles caused by large purse-seine vessels in 2012

	Set type			Total
	OBJ	NOA	DEL	
Olive Ridley	5	-	-	5
Eastern Pacific green	-	-	-	-
Loggerhead	-	-	-	-
Hawksbill	-	-	-	-
Leatherback	-	-	-	-
Unidentified	3	-	-	3
Total	**8**	**0**	**0**	**8**

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, 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.

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, followed by oceanic whitetip sharks (*C. longimanus*). The longline fisheries also take silky sharks. A Pacific-wide analysis of longline and purse-seine fishing is necessary to estimate the impact of fishing on the stock(s). Estimated indices of relative abundance of silky sharks, based on data for purse-seine sets on floating objects, showed decreasing trends for large (>150 cm total length) and medium-sized sharks (90-150 cm total length) during 1994-2004, and remained relatively constant for large sharks and increased slightly for medium sharks between 2005 and 2009. The trends in unstandardized bycatch per set were similar for the other two types of purse-seine sets (standardized trends are not yet available). The unstandardized average bycatches per set of oceanic whitetip sharks also showed decreasing trends for all three set types during the same period. It is not known whether these decreasing trends were due to incidental capture by the fisheries, changes in the environment (perhaps associated with the 1997-1998 El Niño event), or other factors. The decreasing trends do not appear to be due to changes in the density of floating objects.

Apart from blue and silky sharks, there are no stock assessments available for shark species in the EPO, and hence the impacts of the bycatches on the stocks are unknown. Progress on a stock assessment for the silky shark in the EPO was achieved at the IATTC 4th Technical Meeting on Sharks in February 2013.

A stock assessment for blue sharks (*Prionace glauca*) in the North Pacific Ocean has been conducted by scientists of the NMFS and the NRIFSF. Preliminary results provided a range of plausible values for MSY of 1.8 to nearly 4 times the 2001 catch of blue sharks per year. A more recent assessment that used catch and effort data for 1971-2002 showed a decline in abundance in the 1980s, followed by a recovery to above the level of 1971. It was assumed that the blue shark population in 2009 was close to MSY level, and that fishing mortality may be approaching the MSY level in the future.

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 two stocks, one north and one south of the equator.

Preliminary estimates of the catches (including purse-seine discards), in metric tons, of sharks and other large fishes in the EPO during 2012, 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. The bycatch rates of sailfish (*Istiophorus platypterus*), manta rays (Mobulidae), and stingrays (Dasyatidae) are greatest in unassociated sets, followed by dolphin sets, and lowest in floating-object 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 figures. The estimated numbers of purse-seine sets of each type in the EPO during 1997-2012 are shown in Table A-7 of this document.

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

TABLE 3. Catches of sharks and other large fishes, rounded to nearest ton, in 2012.

	Set type			Total
	OBJ	NOA	DEL	
Silky shark (*Carcharhinus falciformis)*	200	33	52	285
Oceanic whitetip shark (*C. longimanus)*	<1	<1	0	<1
Hammerhead sharks (*Sphyrna* spp.)	49	8	3	60
Thresher sharks (*Alopias* spp.)	2	4	5	11
Other sharks	20	4	2	26
Manta rays (Mobulidae)	9	99	16	124
Pelagic sting rays (Dasyatidae)	<1	<1	<1	<1
Dorado (*Coryphaena* spp.)	2,167	23	<1	2,190
Wahoo (*Acanthocybium solandri)*	394	<1	<1	395
Rainbow runner (*Elagatis bipinnulata*) and yellowtail (*Seriola lalandi*)	44	32	<1	77
Other large fishes	227	250	14	492

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.

Scientists at the University of Washington have conducted an analysis of the temporal frequency of areas of high bycatches of silky sharks in purse-seine sets on floating objects, which will be useful for determining the effectiveness of area-time closures as a means of reducing shark bycatch. Results show that both model predictions and observed data tend to indicate that these bycatches occurred most frequently north of 4°N and west of 100-105°W. However, due to large tuna catches south of 5°N, the greatest reduction in bycatch from sets on floating objects with the least loss of tuna catch would be achieved north of approximately 6°N.

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.

The Humboldt or jumbo squid (*Dosidicus gigas*) populations in the EPO have increased in size and geographic range in recent years. For example, the squid expanded their 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 categories. 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 2012 are shown in Table 4.

TABLE 4. Catches of small fishes, in tons, by large purse-seine vessels with observers aboard in the EPO during 2012

	Set type			Total
	OBJ	NOA	DEL	
Triggerfishes (Balistidae) and filefishes (Monacanthidae)	110	<1	0	110
Other small fishes	58	15	0	72
Frigate and bullet tunas (*Auxis* spp.)	174	179	1	354

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 or jumbo 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.

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 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 or jumbo 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).

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.* phenyalanine, 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‰ 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 eastern more-productive waters.

5. PHYSICAL ENVIRONMENT [1]

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 reports monthly average oceanographic and meteorological data for the EPO, including a summary of current ENSO conditions, on a quarterly basis. In December 2011 there was a band of cool water along the equator from the coast of South America to west of 180°W. This began to dissipate in January 2012, and in February and March the area of cool water was less extensive. This area of cool water moved northward during the ensuing months and persisted through September, while a large area of warm water appeared off southern Peru and northern Chile in February 2012, and this persisted through July. The SSTs were mostly below normal from January through March and mostly above normal from June through November. The SST anomalies for December 2012 were quite different to those of December 2011, when there were large areas of cool water over much of the tropical EPO (plus a large area of warm water far offshore south of 20°S). According to the Climate Diagnostics Bulletin of

[1] 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.

the U.S. National Weather Service for December 2012, "Model predictions favor near-average SST … from the Northern Hemisphere winter 2012-13 into summer 2013 … Thus, it is considered unlikely that an El Niño or La Niña will develop during the next several months, and … neutral [conditions are] … favored through the Northern Hemisphere spring [of] 2013.]"

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 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 (2002-2006) recruitment. 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.

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.

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 K-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 and discards 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 2010 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 determined by average diet estimates for all species groups. The mean TLs of the summed catches of all purse-seine and pole-and-line fisheries were fairly constant from year to year, varying by less than 0.1 TL (Figure K-2: Average PS+LP). A slight downward trend for the unassociated sets, amounting to 0.4 TL over the 18-year period, resulted from increasing proportions of skipjack and decreasing proportions of yellowfin or bigeye tunas 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 K-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 2010 (Figure K-3). The discarded catches were much less than the retained catches, and thus the TL patterns of the total (retained plus discarded) catches (Figure K-2) were determined primarily by the TLs of the retained catches (Figure K-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 18-year period (Figure K-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. 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), and an increase in prey fishes (*e.g.* Clupeiformes, Nomeidae, Tetraodontiformes, and *Auxis* spp.; TL 3.19-3.86) in the bycatch. Although prey fishes were lower than 25% in unassociated sets, they reduced the average TLs of the unassociated-set discards substantially, especially when discard proportions of yellowfin tuna were low. For floating-object sets, the discards of bigeye were related to higher mean TLs.

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 is evaluating established methods for determining the vulnerability of data-poor, non-target species caught by the purse-seine fishery in the EPO. A version of productivity and susceptibility analysis (PSA[2]), used to evaluate other fisheries in recent years, 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

[2] 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.

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. When scoring the attributes, the data quality associated with each attribute score was assessed, and the attributes were weighted by the data-quality score. Stocks that received a low productivity score (*p*) and high susceptibility score (*s*) were considered to be at a high risk of becoming depleted, while stocks with a high productivity score and low susceptibility score were considered to be at low risk. Vulnerability scores (*v*) were 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 to assess 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. The PSA was focused on 33 species (Table K-1) that comprised the majority of the biomass removed by the purse-seine vessels with carrying capacity greater than 363 metric tons during 2005-2011. Nine productivity and eight susceptibility attributes (Tables K-2 and K-3, respectively) were based on established PSA methodology[2], and some were modified for more consistency with the tuna fisheries in the EPO.

Information corresponding to the productivity attributes for each species was compiled from a variety of published and unpublished literature 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 (Table K-2) were derived by dividing the compiled data into 1/3 percentiles. Scoring criteria for the susceptibility attributes (Table K-3) were taken from the example PSA[2] and modified where appropriate to better fit the EPO fisheries. The scores for each index were then averaged. Scatter plots of averaged productivity and susceptibility scores for subsets of the 33 species caught by three purse-seine fisheries (on dolphins, unassociated tunas, and floating objects) are shown in Figure K-4 by group (see Table K-1 for group species composition). The scale of the x-axis on the Figure K-4 is reversed because species/stocks with a high productivity score and a low susceptibility score (*i.e.* at the origin of the plots) are considered to be the least vulnerable.

In general, some of the sharks and the giant manta ray scored the highest in overall vulnerability to overfishing (equation above). The shortfin mako shark, scalloped, great, and smooth hammerhead sharks, and bigeye and pelagic thresher sharks had vulnerability scores greater than 2.0 (*i.e.* points to the right side of the semi-circle from susceptibility 3.0 to productivity 1.0 in Figure K-4).

The IATTC staff will continue working to improve and refine the productivity and susceptibility analysis for the EPO during 2013.

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.

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.

9.5. 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.

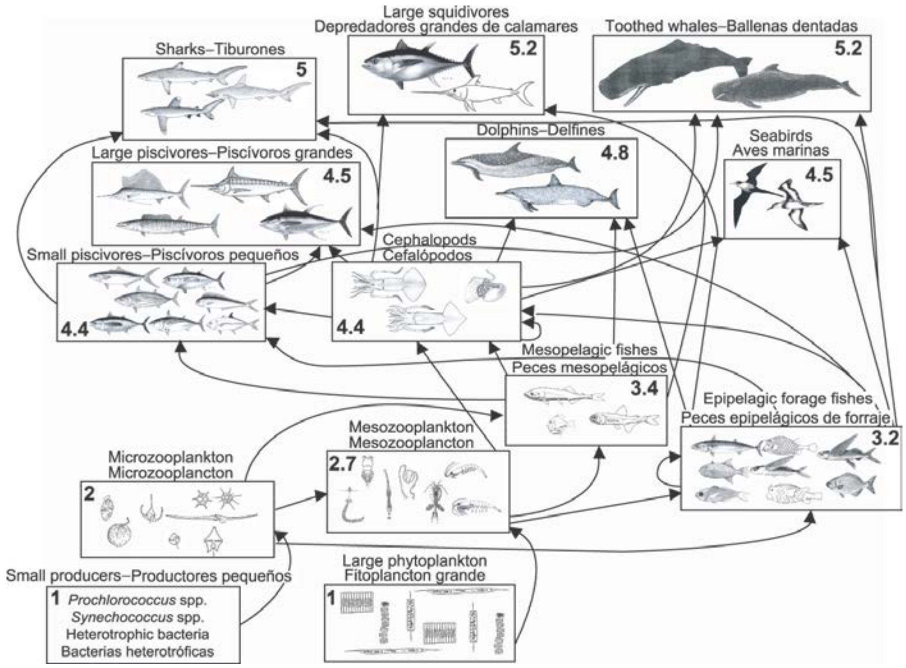

FIGURE K-1. Simplified food-web diagram of the pelagic ecosystem in the tropical EPO. The numbers inside the boxes indicate the approximate trophic level of each group.

FIGURA K-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.

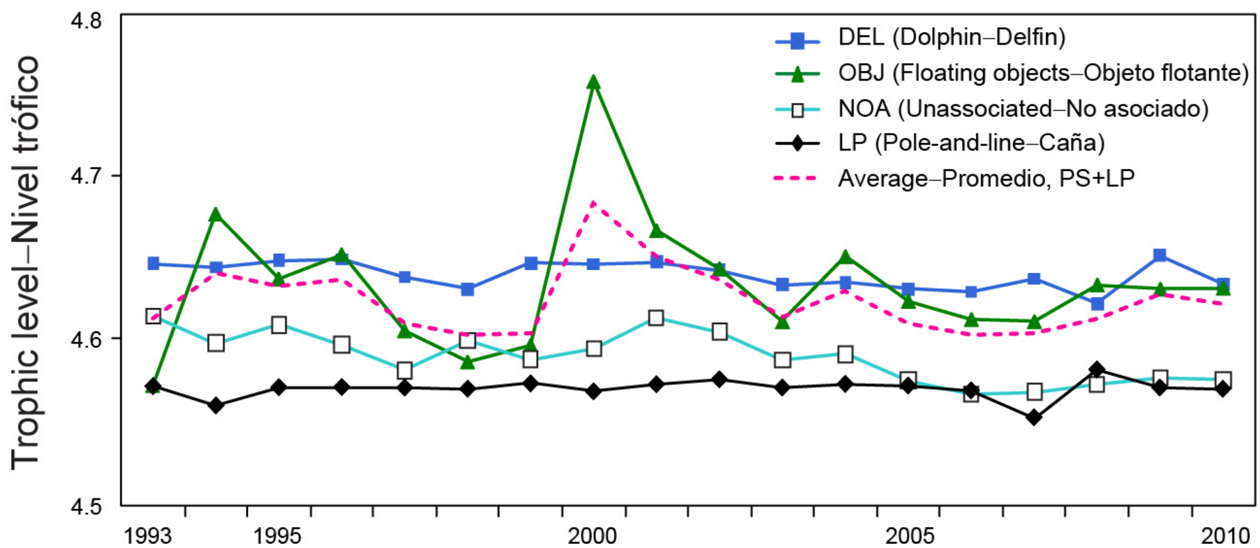

FIGURE K-2. Yearly mean trophic level estimates of the catches (retained and discarded) by the purse-seine and pole-and-line fisheries in the tropical EPO, 1993-2010. .

FIGURA K-2. Estimaciones anuales del nivel trófico de las capturas (retenidas y descartadas) de las pesquerías cerquera y cañera en el OPO tropical, 1993-2010.

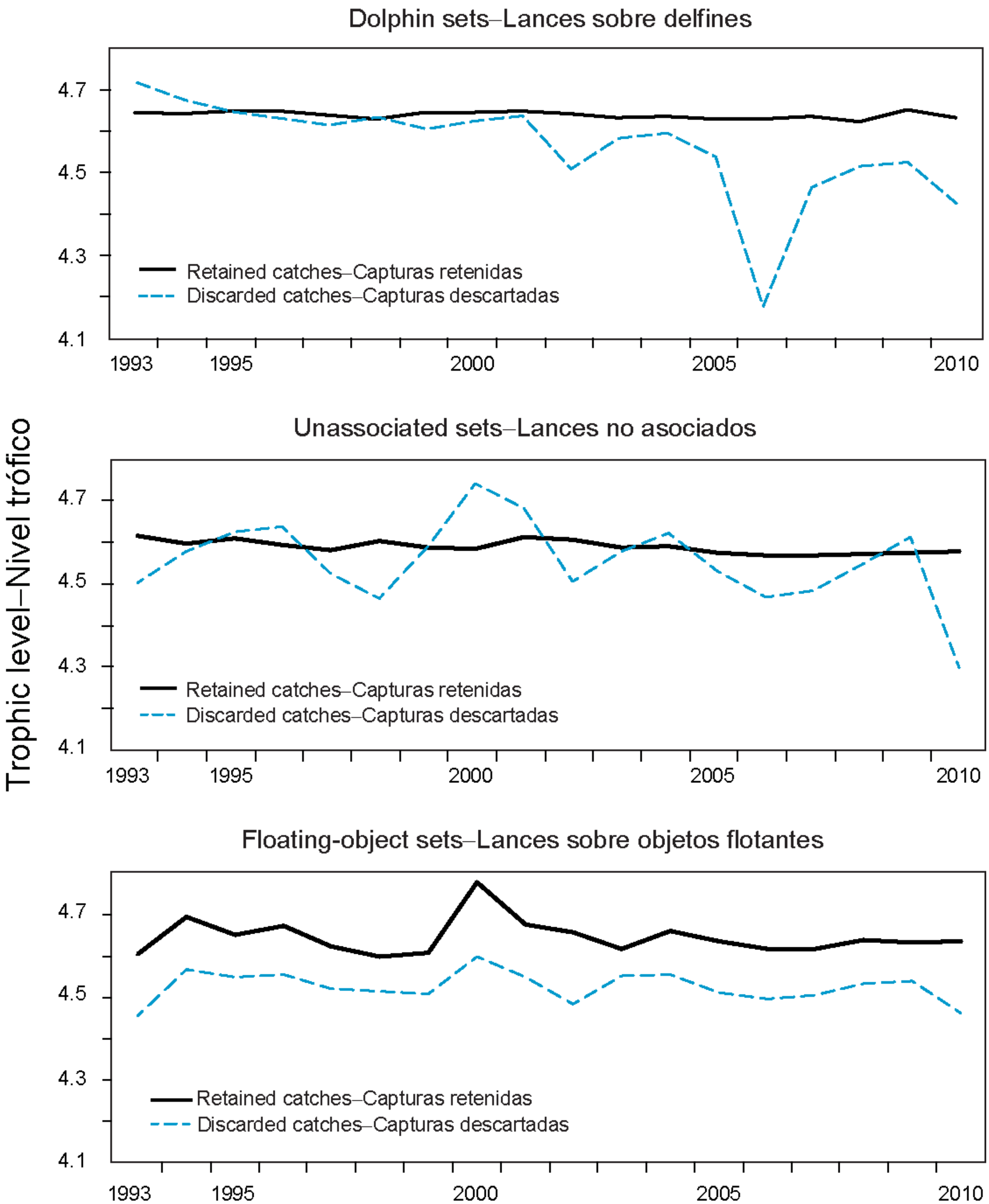

FIGURE K-3. Trophic level estimates of the retained catches and discarded catches by purse-seine fishing modes in the tropical EPO, 1993-2010.
FIGURA K-3. Estimaciones del nivel trófico de las capturas retenidas y descartadas por modalidad de pesca cerquera en el OPO tropical, 1993-2010.

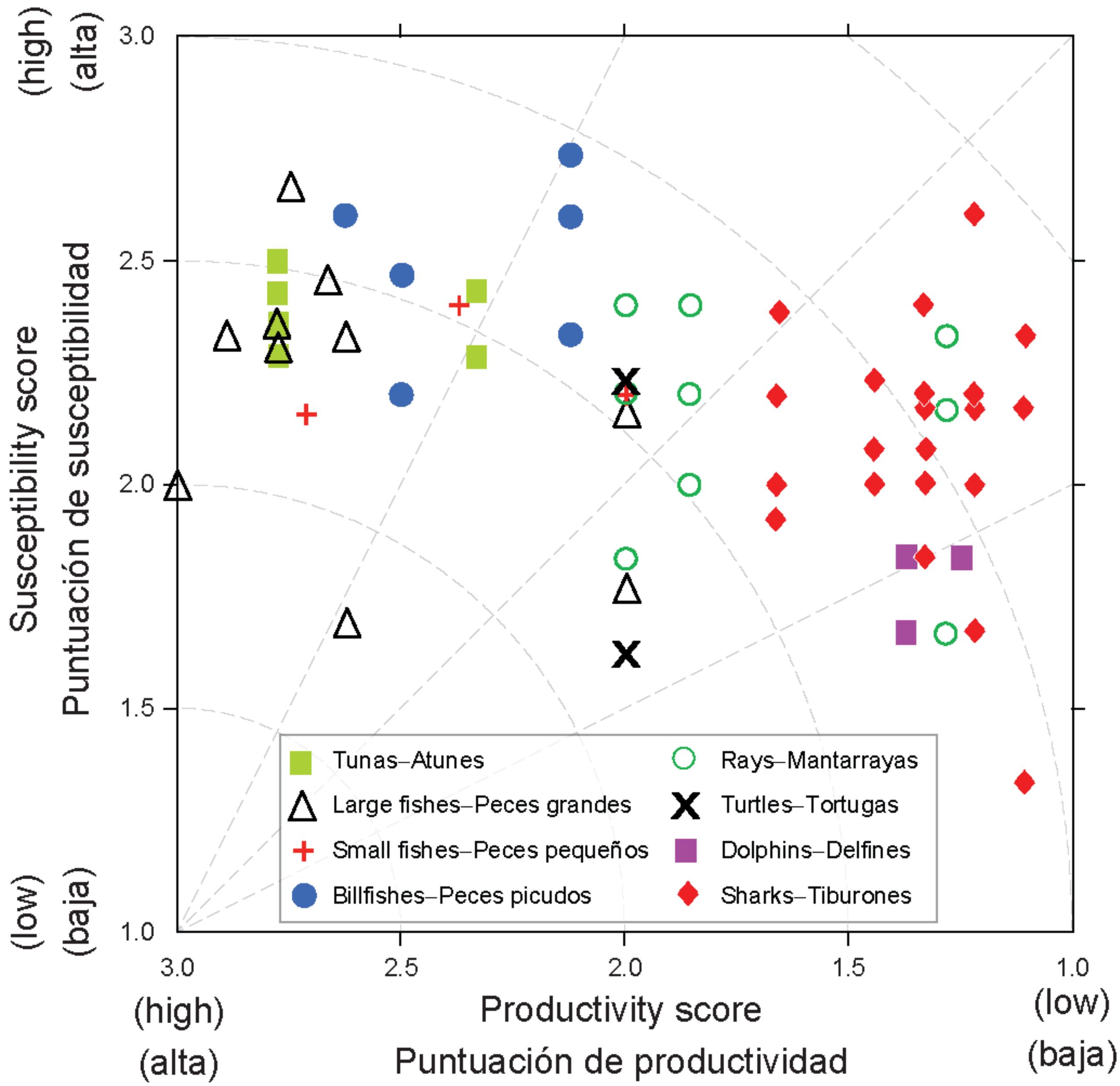

FIGURE K-4. Productivity and susceptibility x-y plot for target and bycatch species caught by the purse-seine fishery of the EPO during 2005-2011. Group species composition is shown in Table K-1.
FIGURA K-4. Gráfica x-y de productividad y susceptibilidad de especies objetivo y de captura incidental capturadas por la pesquería de cerco del OPO durante 2005-2011. En la Tabla K-1 se presenta la composición por especies de los grupos.

TABLE K-1. Annual bycatch per set (in kilograms) averaged over 2005-2011 for purse-seine vessels with carrying capacity greater than 363 metric tons, by three set methods. "n/a" indicates the tuna species that were included in the PSA analysis, but no values were given because tunas are not bycatches of these fisheries. Only species with a catch value (or n/a) were used in the PSA for the corresponding set type.

	Species		**Bycatch (kg) per set**		
Group	**Common name**	**Scientific name**	**DEL**	**NOA**	**OBJ**
Tunas	Yellowfin tuna	*Thunnus albacares*	n/a	n/a	n/a
	Bigeye tuna	*Thunnus obesus*	--	n/a	n/a
	Skipjack tuna	*Katsuwonus pelamis*	--	n/a	n/a
Billfishes	Black marlin	*Makaira indica*	1.0	1.1	10.7
	Blue marlin	*Makaira nigricans*[2]	1.1	1.8	23.3
	Striped marlin	*Kajikia audax*	1.1	1.6	2.3
	Indo-Pacific sailfish	*Istiophorus platypterus*	2.3	1.4	--
Dolphins	Spotted dolphin	*Stenella attenuata*	2.2	--	--
	Spinner dolphin	*Stenella longirostris*	2.3	--	--
	Common dolphin	*Delphinus delphis*	1.6	--	--
Large Fishes	Common dolphinfish	*Coryphaena hippurus*	--	3.2	169.6
	Pompano dolphinfish	*Coryphaena equiselis*	--	--	10.8
	Wahoo	*Acanthocybium solandri*	--	--	59.3
	Rainbow runner	*Elagatis bipinnulata*	--	--	9.5
	Bigeye trevally	*Caranx sexfasciatus*	--	4.2	--
	Yellowtail amberjack	*Seriola lalandi*	--	3.5	1.8
	Ocean sunfish	*Mola mola*	--	5.0	1.4
Rays	Giant manta	*Manta birostris*	2.6	2.9	0.5
	Spinetail manta	*Mobula japanica*[4]	1.3	2.7	0.3
	Smoothtail manta	*Mobula thurstoni*[4]	0.3	1.4	0.1
Sharks	Silky shark	*Carcharhinus falciformis*[4]	4.1	9.1	55.8
	Oceanic whitetip shark	*Carcharhinus longimanus*[2]	<0.1	--	0.4
	Bigeye thresher shark	*Alopias superciliosus*[2]	0.3	0.6	0.1
	Pelagic thresher shark	*Alopias pelagicus*[2]	0.3	0.6	0.2
	Common thresher shark	*Alopias vulpinus*[2]	<0.1	0.2	<0.1
	Scalloped hammerhead shark	*Sphyrna lewini*[3]	0.1	0.7	2.3
	Great hammerhead	*Sphyrna mokarran*[3]	<0.1	<0.1	0.2
	Smooth hammerhead shark	*Sphyrna zygaena*[2]	0.1	0.3	4.5
	Shortfin mako shark	*Isurus oxyrinchus*[2]	<0.1	0.3	0.2
Small Fishes	Ocean triggerfish	*Canthidermis maculatus*	--	--	7.7
	Bluestriped chub	*Sectator ocyurus*	--	--	2.0
	Scrawled filefish	*Aluterus scriptus*[1]	--	--	0.2
Turtles	Olive Ridley turtle	*Lepidochelys olivacea*[2]	<0.1	<0.1	<0.1

[1] Included due to numerical importance in bycatch (≥1 individual per set)
[2] "Vulnerable" status, IUCN Red List of Threatened Species
[3] "Endangered" status, IUCN Red List of Threatened Species
[4] "Near threatened" status, IUCN Red List of Threatened Species

TABLA K-1. Captura incidental anual por lance (en kilogramos) promediado durante 2005-2011 por buques cerqueros de más de 363 t de capacidad de acarreo, por tres métodos de lance. "n/a" indica las especies de atunes que fueron incluidas en el análisis de APS, pero no se presentan valores porque los atunes no son captura incidental de estas pesquerías. Solamente las especies con un valor de captura (o n/a) fueron usados en el APS para el tipo de lance correspondiente.

	Especie		**Captura incidental (kg) por lance**		
Grupo	**Nombre común**	**Nombre científico**	**DEL**	**NOA**	**OBJ**
Atunes	Atún aleta amarilla	*Thunnus albacares*	n/a	n/a	n/a
	Atún patudo	*Thunnus obesus*	--	n/a	n/a
	Atún barrilete	*Katsuwonus pelamis*	--	n/a	n/a
Peces picudos	Marlín negro	*Makaira indica*	1.0	1.1	10.7
	Marlín azul	*Makaira nigricans*[2]	1.1	1.8	23.3
	Marlín rayado	*Kajikia audax*	1.1	1.6	2.3
	Pez vela indopacífico	*Istiophorus platypterus*	2.3	1.4	--
Delfines	Delfín manchado	*Stenella attenuata*	2.2	--	--
	Delfín tornillo	*Stenella longirostris*	2.3	--	--
	Delfín común	*Delphinus delphis*	1.6	--	--
Peces grandes	Dorado	*Coryphaena hippurus*	--	3.2	169.6
	Dorado pompano	*Coryphaena equiselis*	--	--	10.8
	Peto	*Acanthocybium solandri*	--	--	59.3
	Salmón	*Elagatis bipinnulata*	--	--	9.5
	Jurel voráz	*Caranx sexfasciatus*	--	4.2	--
	Medregal rabo amarillo	*Seriola lalandi*	--	3.5	1.8
	Pez luna	*Mola mola*	--	5.0	1.4
Rayas		*Manta birostris*	2.6	2.9	0.5
		Mobula japanica[4]	1.3	2.7	0.3
		Mobula thurstoni[4]	0.3	1.4	0.1
Tiburones	Tiburón sedoso	*Carcharhinus falciformis*[4]	4.1	9.1	55.8
	Tiburón oceánico punta blanca	*Carcharhinus longimanus*[2]	<0.1	--	0.4
	Zorro ojón	*Alopias superciliosus*[2]	0.3	0.6	0.1
	Zorro pelágico	*Alopias pelagicus*[2]	0.3	0.6	0.2
	Zorro	*Alopias vulpinus*[2]	<0.1	0.2	<0.1
	Cornuda común	*Sphyrna lewini*[3]	0.1	0.7	2.3
	Cornuda gigante	*Sphyrna mokarran*[3]	<0.1	<0.1	0.2
	Cornuda cruz	*Sphyrna zygaena*[2]	0.1	0.3	4.5
	Marrajo dientuso	*Isurus oxyrinchus*[2]	<0.1	0.3	0.2
Peces pequeños	Pez ballesta oceánico	*Canthidermis maculatus*	--	--	7.7
	Chopa	*Sectator ocyurus*	--	--	2.0
	Lija trompa	*Aluterus scriptus*[1]	--	--	0.2
Tortugas	Tortuga golfina	*Lepidochelys olivacea*[2]	<0.1	<0.1	<0.1

[1] Incluido debido a su importancia numérica en la captura incidental (≥1 individuo por lance)
[2] Estatus « vulnerable », Lista Roja de Especies Amenazadas de la IUCN
[3] Estatus « en peligro », Lista Roja de Especies Amenazadas de la IUCN
[4] Estatus « casi amenazado », Lista Roja de Especies Amenazadas de la IUCN

TABLE K-2. Productivity attributes and scoring thresholds used in the IATTC PSA.
TABLA K-2. 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 K-3. 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)
Catch trends	Catch-per-set increased over time	No catch-per-set trend over time	Catch-per-set decreased over time