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TUNAS AND BILLFISHES IN THE EASTERN PACIFIC OCEAN IN 2009

INTRODUCTION

This report provides a summary of the fishery for tunas in the eastern Pacific Ocean (EPO), 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 2009.

The report is based on data available to the IATTC staff in August 2009. Sections F (albacore tuna), G (swordfish), and H (blue marlin) are essentially the same as the corresponding sections of IATTC Fishery Status Report 7, published in 2010, except for updates of the figures.

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 (*Kajakia audax*[2])
MZZ	Osteichthyes, marine fishes nei
PBF	Pacific bluefin tuna (*Thunnus orientalis*)
SFA	Indo-Pacific sailfish (*Istiophorus platypterus)*
SKJ	Skipjack tuna (*Katsuwonus pelamis*)
SKX	Unidentified elasmobranchs
SSP	Shortbill spearfish (*Tetrapturus angustirostris*)
SWO	Swordfish (*Xiphias gladius*)
TUN	Unidentified tunas
YFT	Yellowfin tuna (*Thunnus albacares*)

[1] not elsewhere included
[2] Formerly *Tetrapturus audax*

Fishing gears:	
FPN	Trap
GN	Gillnet
HAR	Harpoon
LL	Longline
LP	Pole and line
LTL	Troll
LX	Hook and line
OTR	Other[3]
NK	Unknown
PS	Purse seine
RG	Recreational
TX	Trawl
Ocean areas:	
EPO	Eastern Pacific Ocean
WCPO	Western and Central Pacific Ocean
Stock assessment:	
MSY	Maximum sustainable yield
B	Biomass
C	Catch
CPUE	Catch per unit of effort
F	Coefficient of fishing mortality
S	Index of spawning biomass
SBR	Spawning biomass ratio
SSB	Spawning stock biomass
Set types:	
DEL	Dolphin
NOA	Unassociated school
OBJ	Floating object
	FLT: Flotsam
	FAD: Fish-aggregating device

Flags:	
	IATTC members
BLZ	Belize
CAN	Canada
CHN	China
COL	Colombia
CRI	Costa Rica
ECU	Ecuador
ESP	Spain
GTM	Guatemala
JPN	Japan
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
BOL	Bolivia
CHL	Chile
COG	Congo
COK	Cook Islands
CYM	Cayman Islands
CYP	Cyprus
FSM	Federated States of Micronesia
HND	Honduras
LBR	Liberia
NLD	Netherlands
NZL	New Zealand
PRT	Portugal
PYF	French Polynesia
RUS	Russia
SEN	Senegal
VCT	St. Vincent and the Grenadines
UNK	Unknown

[3] Used to group known gear types

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

CONTENTS

This section 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 section 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 2000-2009 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 2009 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 2008 and 2009 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 1980-2009 are shown in Table A-2. The catches of yellowfin, bigeye, and skipjack tunas, by gear and flag, during 1980-2009 are shown in Tables A-3a-e, and the purse-seine and pole-and-line catches of tunas and bonitos during 2008-2009 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 1998-2009. 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 1980-2009 are shown in Table A-1. Overall, the catches in both the EPO and WCPO have increased during this period. In the EPO, 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. The catch of yellowfin in the EPO, in 2002, 444 thousand t, was the greatest on record, but in 2004, 2005, 2006 and 2007 it decreased substantially, and the catch during 2009, 243 thousand t, was greater than the catches during 2005-2008, but less than the catches during 1986-2005. In the WCPO, the catches of yellowfin reached 341 thousand t in 1990, peaked at 425 thousand t in 1998, and remained high through 2003; they fell to 384 thousand t in 2004, increased to 546 thousand t in 2008, and fell again in 2009, to 430 thousand t.

The annual retained catches of yellowfin in the EPO by purse-seine and pole-and-line vessels during 1980-2009 are shown in Table A-2a. The average annual retained catch during 1994-2008 was 264 thousand t (range: 167 to 413 thousand t). The preliminary estimate of the retained catch in 2009, 237 thousand t, was 26% greater than that of 2008, but 10% less than the average for 1994-2008. The average amount of yellowfin discarded at sea during 1994-2008 was about 2% of the total purse-seine catch (retained catch plus discards) of yellowfin (range: 1 to 3%) (Table A-2a).

The annual retained catches of yellowfin in the EPO by longliners during 1980-2009 are shown in Table A-2a. During 1994-2008 they remained relatively stable, averaging about 18 thousand t (range: 7 to 30 thousand t), or about 6% of the total retained catches of yellowfin. 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 1994-2008 they averaged about 1 thousand t.

1.1.2. Skipjack tuna

The annual catches of skipjack during 1980-2009 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, 311 thousand t, occurred in 2006.

The annual retained catches of skipjack in the EPO by purse-seine and pole-and-line vessels during 1980-2009 are shown in Table A-2a. During 1994-2008 the annual retained catch averaged 195 thousand t (range 73 to 298 thousand t). The preliminary estimate of the retained catch in 2009, 230 thousand t, is 18% greater than the average for 1994-2008, and 23% less than the previous record-high retained catch of 2006. The average amount of skipjack discarded at sea during 1994-2008 was about 9% of the total catch of skipjack (range: 3 to 19%) (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 1980-2009 are shown in Table A-1. Overall, the catches in both the EPO and WCPO have increased, but with considerable fluctuation. The catches in the EPO reached 105 thousand t in 1986, and have fluctuated between about 73 and 148 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 1980s, and then increased, with lesser fluctuations, until 1999, when the catches reached more than 114 thousand t. Catches of bigeye in the WCPO increased significantly in 2006 to 125 thousand t. In 2007, 2008 and 2009 the catches of bigeye in the WCPO were 119, 118, and 111 thousand t, respectively.

Prior to 1994, the average annual retained catch of bigeye taken by purse-seine vessels in the EPO was about 8 thousand t (range 1 to 22 thousand t) (Table A-2a). Following the development of fish-aggregating devices (FADs), placed in the water by fishermen to aggregate tunas, the annual retained catches of bigeye increased from 35 thousand t in 1994 to between 44 and 95 thousand t during 1995-2008. A preliminary estimate of the retained catch in the EPO in 2009 is 77 thousand t. The average amount of bigeye discarded at sea during 1994-2008 was about 5% of the purse-seine catch of the species (range: 2 to 9%). Small amounts of bigeye have been caught in some years by pole-and-line vessels, as shown in Table A-2a.

During 1980-1993, prior to the increased use of FADs and the resulting greater catches of bigeye by purse-seine vessels, the longline catches of bigeye in the EPO ranged from 46 to 104 thousand t (average: 75 thousand t) about 91%, on average, of the retained catches of this species from the EPO. During 1994-2008 the annual retained catches of bigeye by the longline fisheries ranged from about 26 to 74 thousand t (average: 49 thousand t), an average of 43% of the total catch of bigeye in the EPO (Table A-2a). The preliminary estimate of the longline catch in the EPO in 2009 is 28 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 1980-2009, by gear, are shown in Table A-2. During 1994-2008 the annual retained catch of bluefin from the EPO by purse-seine and pole-and-line vessels averaged 3,900 t (range 600 t to 10 thousand t). The preliminary estimate of the retained catch of bluefin in 2009, 3,400 t, is 500 t less than the average for 1994-2008. Small amounts of bluefin are discarded at sea by purse-seine vessels (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-6. The catches of albacore in the EPO, by gear, are shown in Table A-2a. A significant portion of the albacore catch is taken by troll gear, included under "Other gears" (OTR) in Table A-2a. 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 1980-2009 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 about 14 thousand t in 2009, which is greater than the 1994-2008 annual average retained catch of about 8 thousand t (range: 3 thousand t to 22 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 average annual longline catch of swordfish during 1994-2008 was 12 thousand t, but during 2001-2004 was about 18 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 1994-2008 were about 4 thousand and 2 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.

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 of other species 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 10 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 2004-2008, are shown in Figures A-1a, A-2a, and A-3a, and preliminary estimates for 2009 are shown in Figures A-1b, A-2b, and A-3b. The catches of yellowfin in 2009 showed an increase in effort on dolphins in the northern area compared to the average annual distributions for 2004-2008. Catches of yellowfin on dolphins were greater in the inshore area between 5°N and 15°N, and somewhat greater in the offshore areas from about 5°S to 10°N in sets on dolphins and floating objects. Yellowfin catches were smaller in the inshore areas off southern Ecuador and Peru. Catches of skipjack were somewhat smaller in the areas north of 10°N, and in the inshore areas off Ecuador, compared to the average annual distributions for 2004-2005. Greater catches of skipjack were observed in the areas between 5°S and 5°N and from 85°W to 100°W, and also in the far offshore equatorial area from about 125°W to 150°W. Catches were slightly higher in the south from about 15°S to 20°S. The catches of bigeye in 2009 were very similar to the average annual distribution of catches during 2004-2008, with slightly higher catches observed in the inshore areas off Peru from about 15°S to 25°S.

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 2004-2008 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 2004-2009 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 2009, and the second shows the combined data for each year of the 2004-2009 period. For bluefin, the histograms show the 2004-2009 catches by commercial and recreational gear combined. For black skipjack, the histograms show the 2004-2009 catches by commercial gear. Only a small amount of catch was taken by pole-and-line vessels in 2009, 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 854 wells sampled, 573 contained yellowfin. The estimated size compositions of the fish caught during 2009 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 throughout the year in the Inshore dolphin fishery, and during the second, third, and fourth quarters in the Northern and Southern dolphin-associated fisheries. Larger yellowfin were also caught during the fourth quarter in the Southern unassociated fishery. A small amount of large yellowfin was taken in the Southern floating-object fishery in the second and third quarters. Yellowfin, ranging from 40 to 60 cm in length, were evident in North and Equatorial floating-object fisheries primarily in the third and fourth quarters.

The estimated size compositions of the yellowfin caught by all fisheries combined during 2004-2009 are shown in Figure A-6b. The average weights of the yellowfin caught in 2009 (15.0 kg) were considerably greater than those of the previous five years.

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 854 wells sampled, 547 contained skipjack. The estimated size compositions of the fish caught during 2009 are shown in Figure A-7a. Large amounts of skipjack in the 40- to 50-cm size range were caught in the Northern, Equatorial, and Southern floating-object fisheries in the second, third, and fourth quarters, and in the Inshore floating-object fishery during the first and second quarters. Larger skipjack in the 60- to 70-cm size range were caught primarily in the Southern unassociated fishery during the first and third quarters, and in the Equatorial floating-object fishery during the first and second quarters.

The estimated size compositions of the skipjack caught by all fisheries combined during 2004-2009 are shown in Figure A-7b. The average weight of skipjack in 2009, 2.0 kg, was less than the average weights 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 854 wells sampled, 227 contained bigeye. The estimated size compositions of the fish caught during 2009 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 2009, as in 2004-2008, nearly equal amounts of bigeye were taken in the Northern, Equatorial, and Southern floating-object fisheries throughout the year, and in the Inshore floating-object fishery during the first and second quarters. Smaller bigeye in the 40- to 80-cm size range were caught throughout the year in the Northern, Equatorial and Southern floating-object fishery. Larger bigeye (>100 cm.) were caught throughout the year in the Equatorial floating-object fishery, in the second and third quarters in the Southern floating-object fishery, in the second quarter in the Inshore floating-object fishery, and in the fourth quarter in the Northern floating-object fishery.

The estimated size compositions of the bigeye caught by all fisheries combined during 2004-2009 are shown in Figure A-8b. The average weight of bigeye in 2009 (6.0 kg) was considerably lower than in 2008 (7.4 kg).

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 2009 bluefin were caught between 26°N and 32°N from June through August. The majority of the catches of bluefin by both commercial and recreational vessels were taken during June and July. Prior to 2004, the sizes of the fish in the commercial and recreational catches have been reported separately. During 2004-2009, 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 2004-2009 period. The average weight of the fish caught during 2009 was considerably greater than that of 2008. 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. Twenty-one samples of black skipjack were taken in 2009. The estimated size compositions for each year of the 2004-2009 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 2004-2008 are shown in Figures A-11 and A-12. The average weights of both yellowfin and bigeye taken by that fishery have remained about the same throughout its existence. 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 1980-2009, 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 historic data for tunas, billfishes, sharks, carangids, dorado, and miscellaneous fishes are available on the IATTC web site. The purse-seine and pole-and-line catches of tunas and bonitos in 2008 and 2009, by flag, are summarized in Table A-4. Of the 561 thousand t of tunas and bonitos caught in 2009, 33% was caught by Ecuadorian vessels, and 21% by Mexican vessels. Other countries with significant catches of tunas and bonitos in the EPO included Panama (14%), Venezuela (9%), and Nicaragua (2%).

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 1994-2009 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.

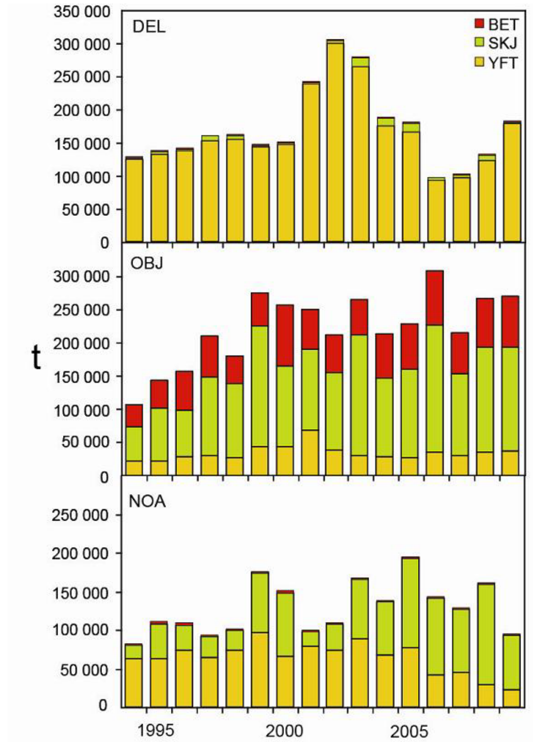


Figure 1. Purse-seine catches of tunas, by species and set type, 1994-2009

There are two types of floating objects, flotsam and 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. FADs have been widely used for about 15 years, and their relative importance has increased during this period, while that of flotsam has decreased, as shown by the data in Table A-8.

2.2. Longline

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

3. THE FLEETS

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

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

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

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

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

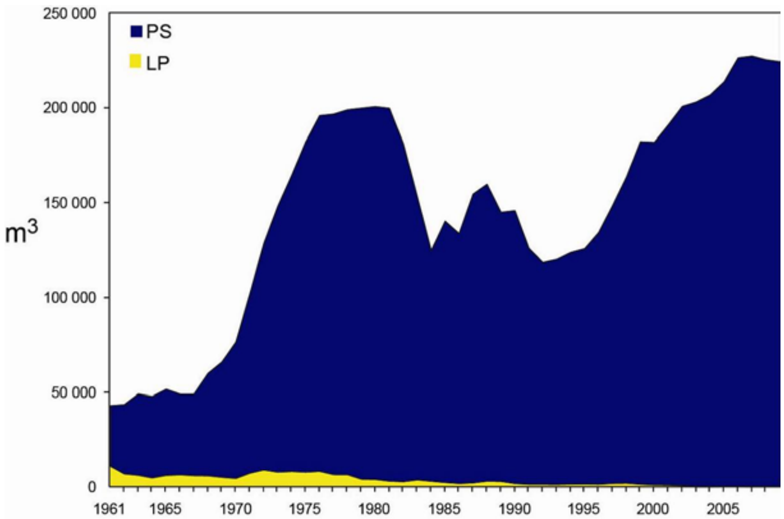


Figure 2. Carrying capacity, in cubic meters of well volume, of the purse-seine and pole-and-line fleets in the EPO, 1961-2009

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 2009 the number of pole-and-line vessels decreased from 93 to 4, and their total well volume from about 11 thousand to about 380 m^3. During the same period the number of purse-seine vessels increased from 125 to 220, and their total well volume from about 32 thousand to about 225 thousand m^3, an average of about 1,000 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).

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 122 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 2009 was 224 thousand m^3.

The 2008 and preliminary 2009 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 2009, the fleet was dominated by vessels operating under the Ecuadorian and Mexican flags, with about 27% and 22%, respectively, of the total well volume; they were followed by Panama (14%), Venezuela (13%), Colombia (7%), Spain (4%), El Salvador and Nicaragua (3% each), and Guatemala, United States, and Vanuatu (2%).

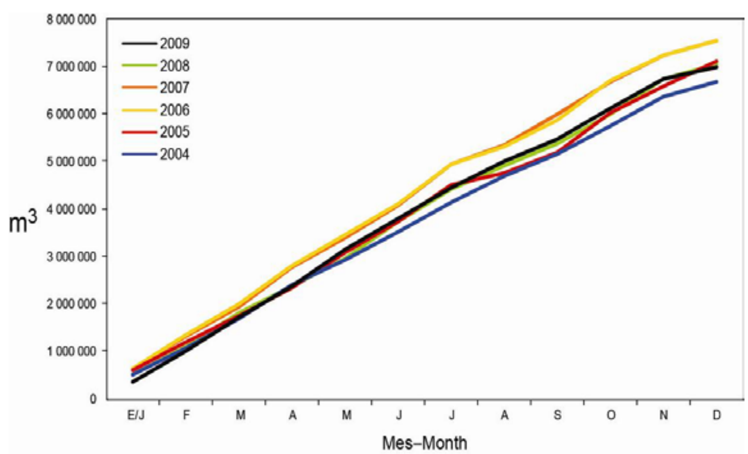


Figure 3. Cumulative capacity of the purse-seine and pole-and-line fleet at sea, by month, 2004-2009

The cumulative capacity at sea

during 2009 is compared to those of the previous five years in Figure 3.

The monthly average, minimum, and maximum total well volumes at sea (VAS), in thousands of cubic meters, of purse-seine and pole-and-line vessels that fished for tunas in the EPO during 1999-2008, and the 2009 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 1998-2009, so the VAS values for September-December 2009 are not comparable to the average VAS values for those months of 1998-2008. The average VAS values for 1999-2008 and 2009 were 125 thousand m^3 (61% of total capacity) and 137 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 on the IATTC's Regional Vessel Register, on the IATTC web site. 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 2009, or ever.

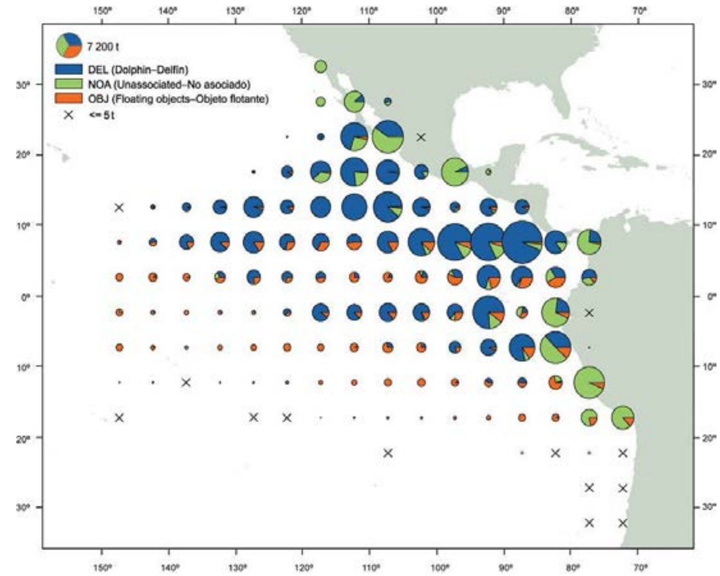


FIGURE A-1a. Average annual distributions of the purse-seine catches of yellowfin, by set type, 2004-2008. The sizes of the circles are proportional to the amounts of yellowfin caught in those 5° by 5° areas.
FIGURA A-1a. Distribución media anual de las capturas cerqueras de aleta amarilla, por tipo de lance, 2004-2008. El tamaño de cada círculo es proporcional a la cantidad de aleta amarilla capturado en la cuadrícula de 5° x 5° correspondiente.

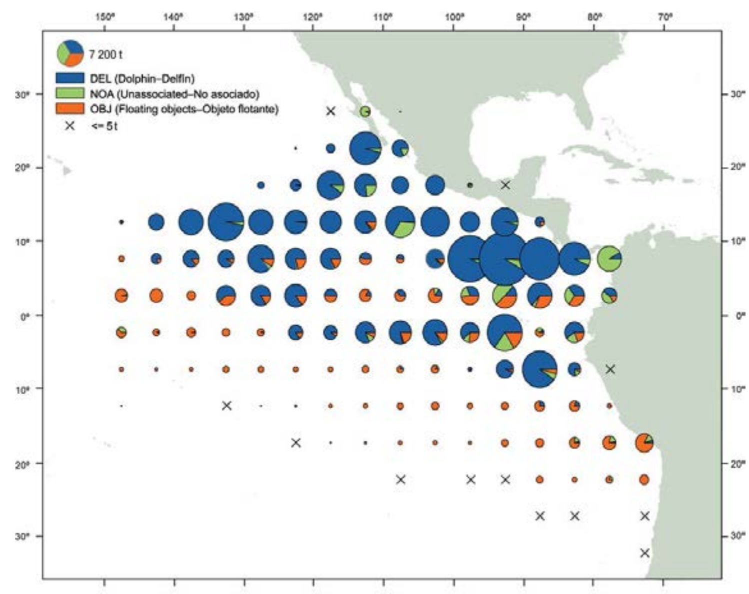


FIGURE A-1b. Annual distributions of the purse-seine catches of yellowfin, by set type, 2009. The sizes of the circles are proportional to the amounts of yellowfin caught in those 5° by 5° areas.
FIGURA A-1b. Distribución anual de las capturas cerqueras de aleta amarilla, por tipo de lance, 2009. El tamaño de cada círculo es proporcional a la cantidad de aleta amarilla capturado en la cuadrícula de 5° x 5° correspondiente.

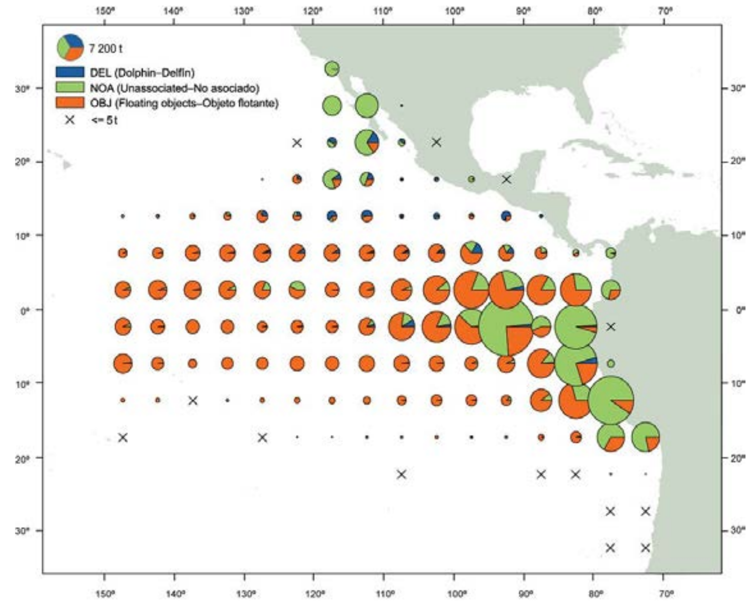


FIGURE A-2a. Average annual distributions of the purse-seine catches of skipjack, by set type, 2004-2008. The sizes of the circles are proportional to the amounts of skipjack caught in those 5° by 5° areas.
FIGURA A-2a. Distribución media anual de las capturas cerqueras de barrilete, por tipo de lance, 2004-2008. El tamaño de cada círculo es proporcional a la cantidad de barrilete capturado en la cuadrícula de 5° x 5° correspondiente.

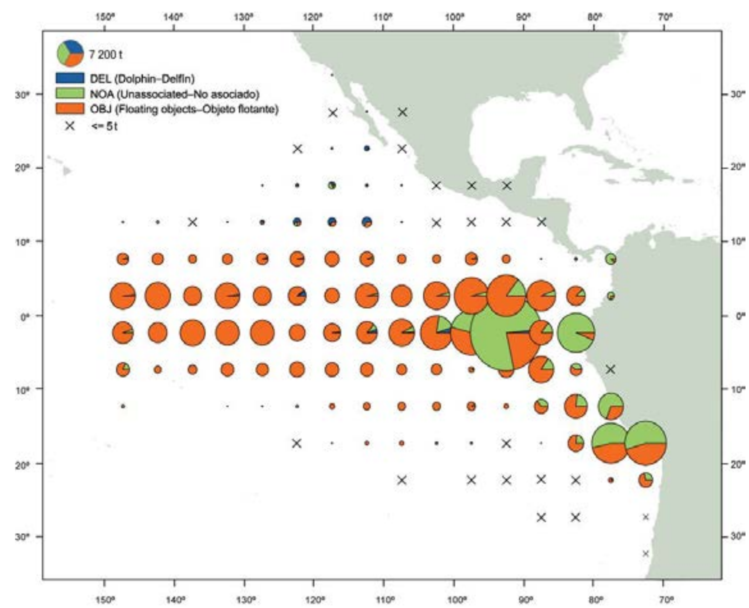


FIGURE A-2b. Annual distributions of the purse-seine catches of skipjack, by set type, 2009. The sizes of the circles are proportional to the amounts of skipjack caught in those 5° by 5° areas.
FIGURA A-2b. Distribución anual de las capturas cerqueras de barrilete, por tipo de lance, 2009. El tamaño de cada círculo es proporcional a la cantidad de barrilete capturado en la cuadrícula de 5° x 5° correspondiente.

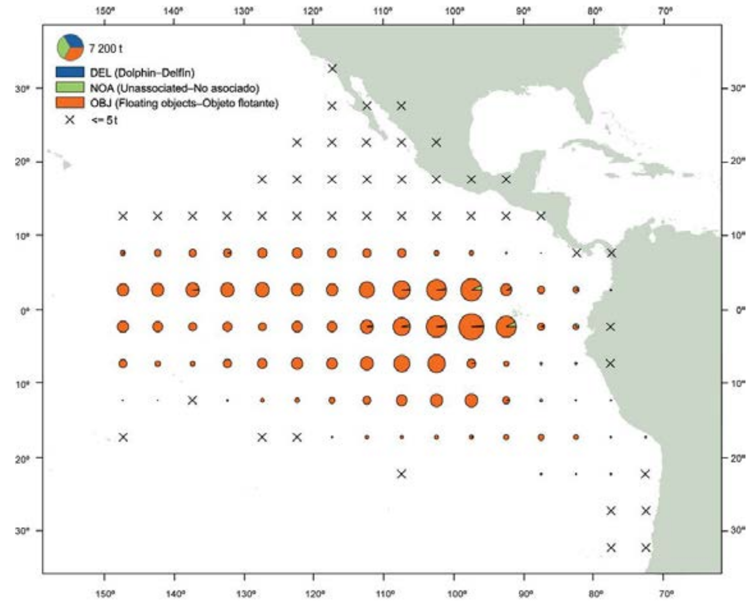


FIGURE A-3a. Average annual distributions of the purse-seine catches of bigeye, by set type, 2004-2008. The sizes of the circles are proportional to the amounts of bigeye caught in those 5° by 5° areas.
FIGURA A-3a. Distribución media anual de las capturas cerqueras de patudo, por tipo de lance, 2004-2008. El tamaño de cada círculo es proporcional a la cantidad de patudo capturado en la cuadrícula de 5° x 5° correspondiente.

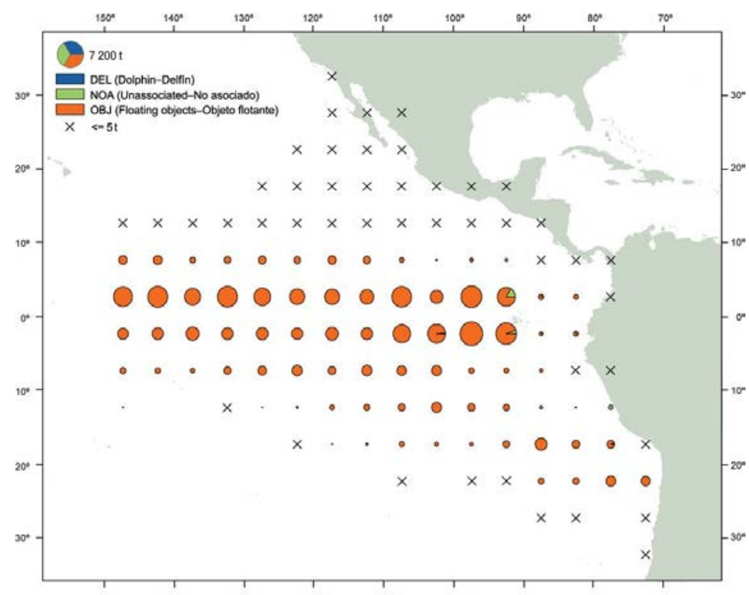


FIGURE A-3b. Annual distributions of the purse-seine catches of bigeye, by set type, 2009. The sizes of the circles are proportional to the amounts of bigeye caught in those 5° by 5° areas.
FIGURA A-3b. Distribución anual de las capturas cerqueras de patudo, por tipo de lance, 2009. El tamaño de cada círculo es proporcional a la cantidad de patudo capturado en la cuadrícula de 5° x 5° correspondiente.

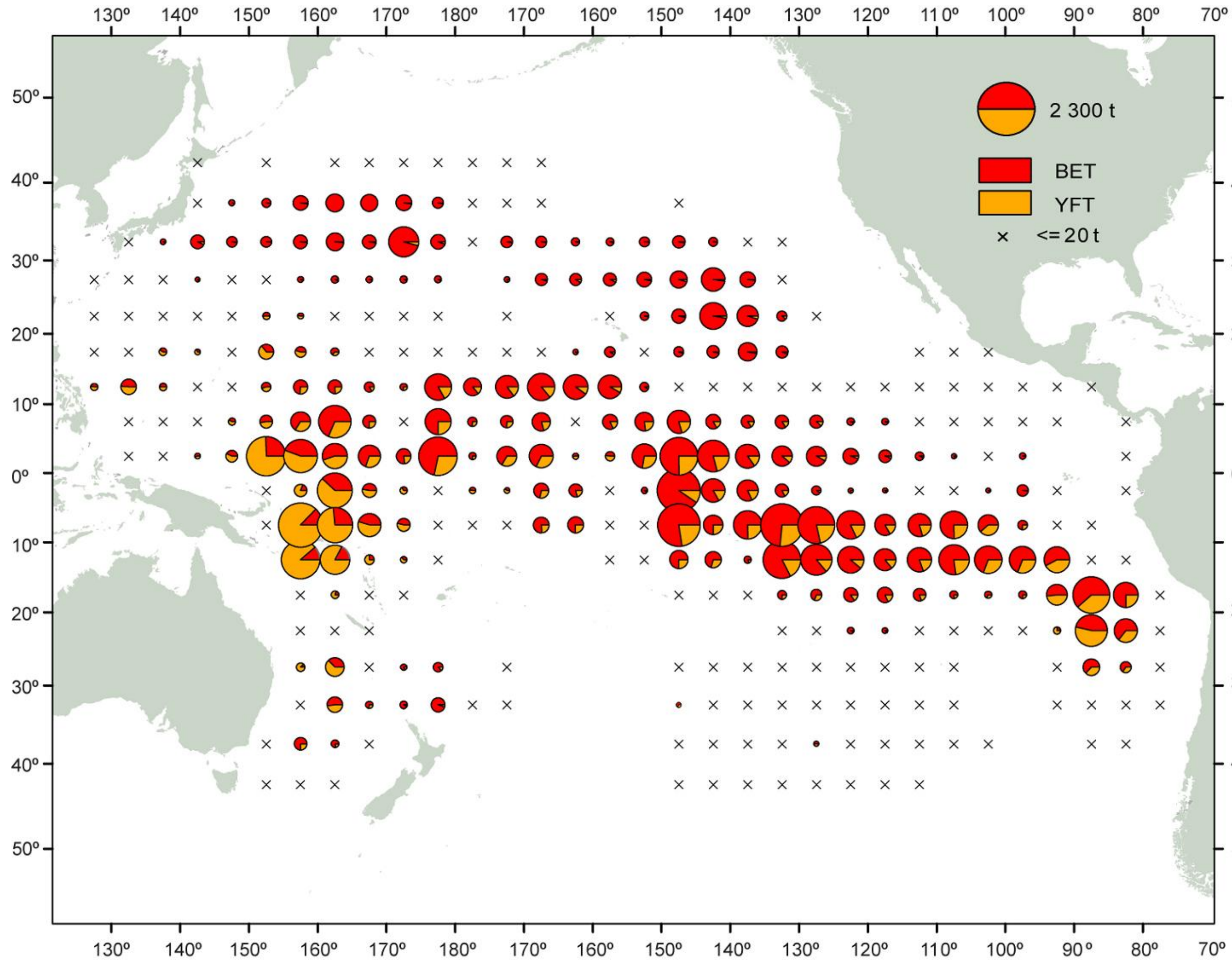


FIGURE A-4. Distributions of the average annual catches of bigeye and yellowfin tunas in the Pacific Ocean, in metric tons, by Chinese Taipei, Japanese and Korean longline vessels, 2004-2008. The sizes of the circles are proportional to the amounts of bigeye and yellowfin caught in those 5° by 5° areas.

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 Corea, Japón y Taipei Chino 2004-2008. El tamaño de cada círculo es proporcional a la cantidad de patudo y aleta amarilla capturado en la cuadrícula de 5° x 5° correspondiente.

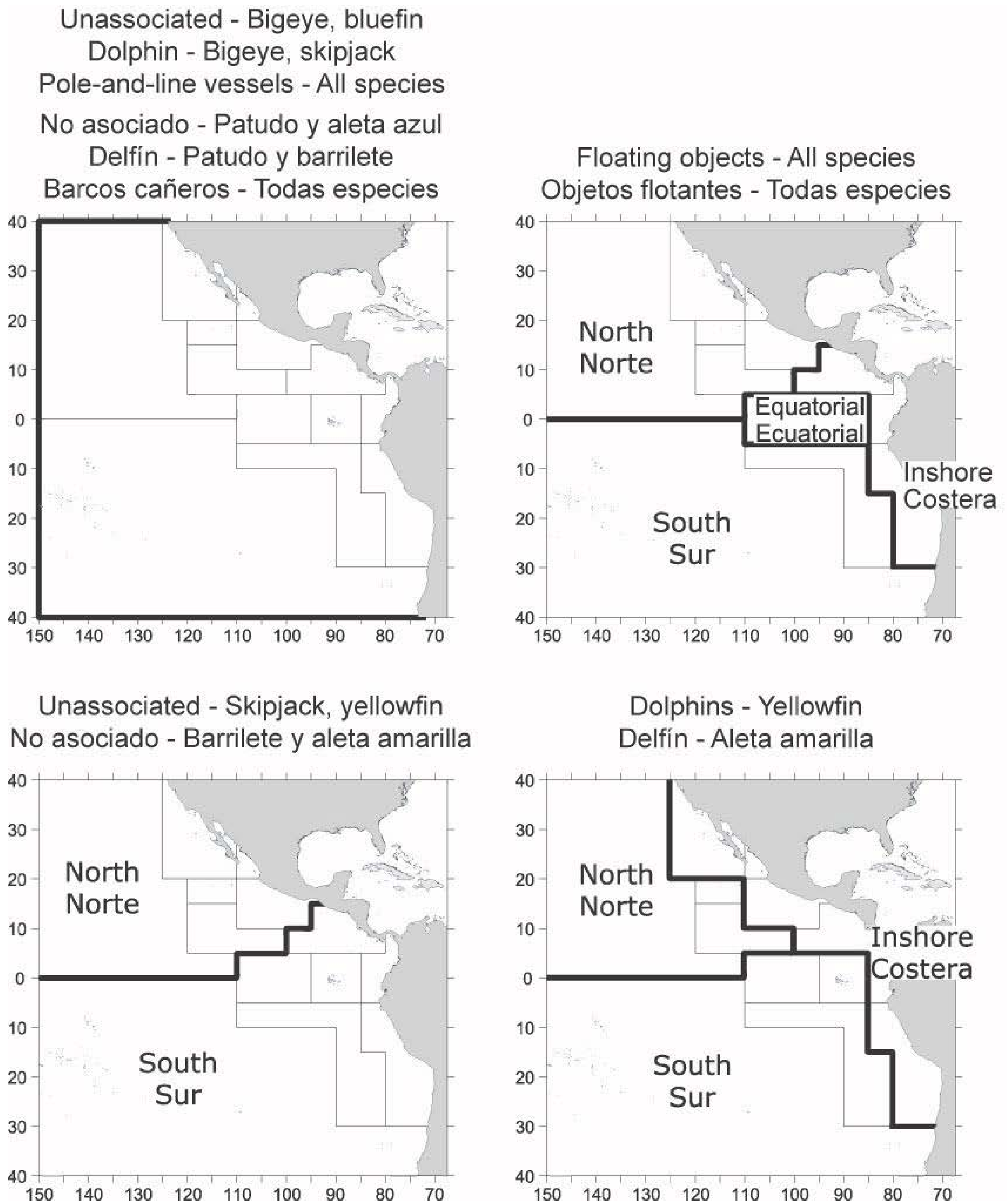


FIGURE A-5. The fisheries defined by the IATTC staff for stock assessment of yellowfin, skipjack, and bigeye in the EPO. The thin lines indicate the boundaries of the 13 length-frequency sampling areas, and the bold lines the boundaries of the fisheries.

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.

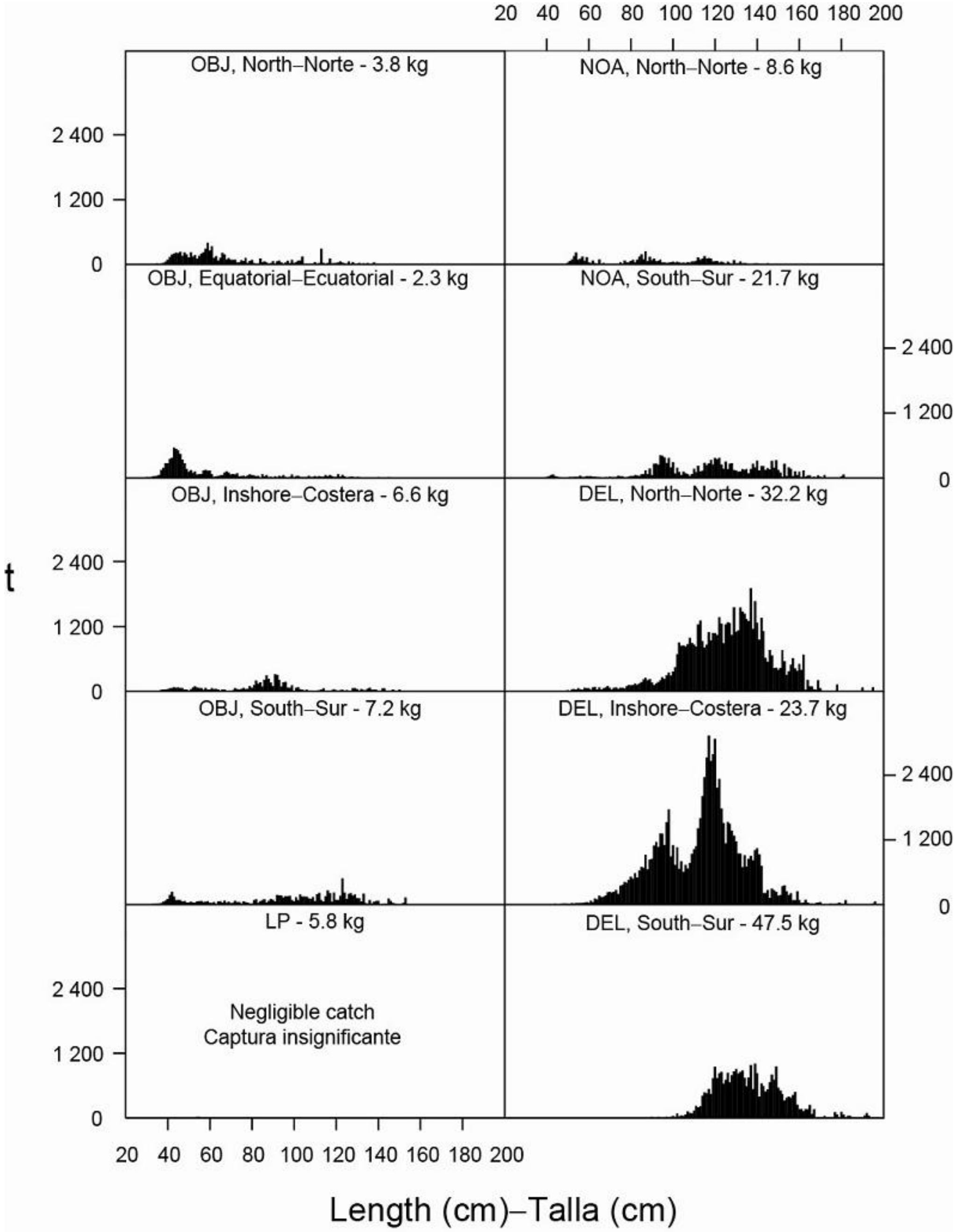


FIGURE A-6a. Estimated size compositions of the yellowfin caught in the EPO during 2009 for each fishery designated in Figure A-5. The average weights of the fish in the samples are given at the tops of the panels.

FIGURA A-6a. Composición por tallas estimada del aleta amarilla capturado en el OPO durante 2009 en cada pesquería ilustrada en la Figura A-5. En cada recuadro se detalla el peso promedio de los peces en las muestras.

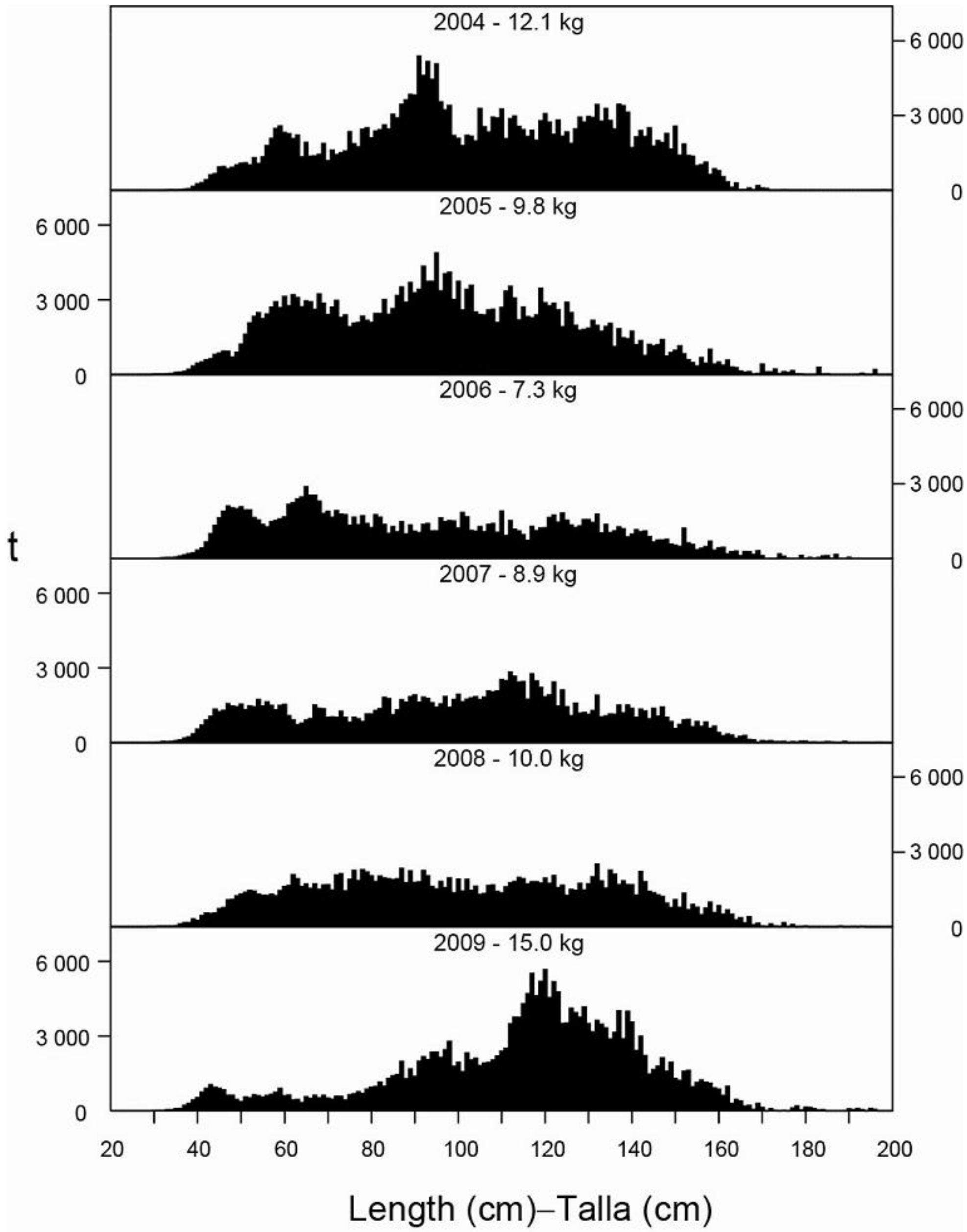


FIGURE A-6b. Estimated size compositions of the yellowfin caught by purse-seine and pole-and-line vessels in the EPO during 2004-2009. The average weights of the fish in the samples are given at the tops of the panels.

FIGURA A-6b. Composición por tallas estimada del aleta amarilla capturado por buques cerqueros y cañeros en el OPO durante 2004-2009. En cada recuadro se detalla el peso promedio de los peces en las muestras.

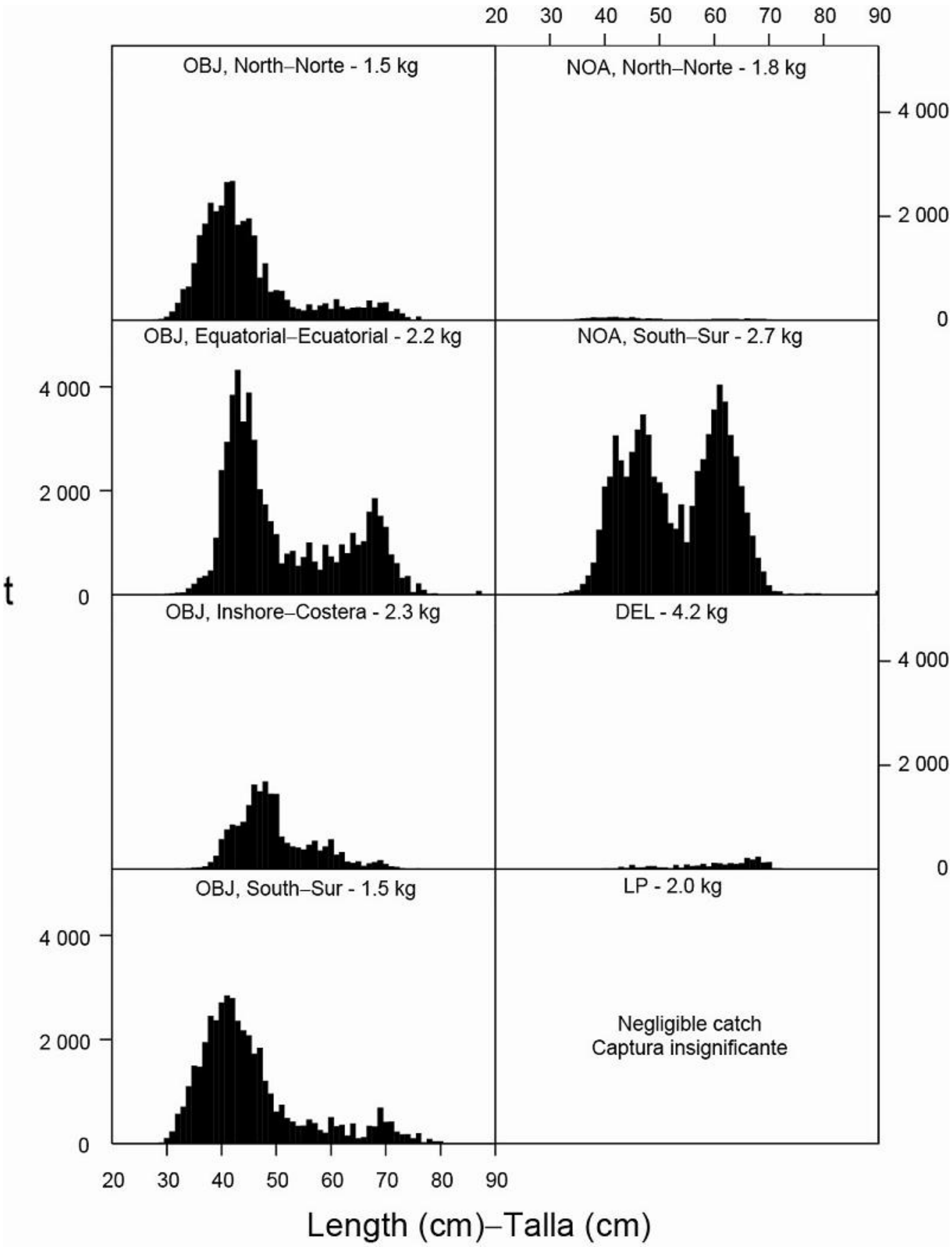


FIGURE A-7a. Estimated size compositions of the skipjack caught in the EPO during 2009 for each fishery designated in Figure A-5. The average weights of the fish in the samples are given at the tops of the panels.

FIGURA A-7a. Composición por tallas estimada del barrilete capturado en el OPO durante 2009 en cada pesquería ilustrada en la Figura A-5. En cada recuadro se detalla el peso promedio de los peces en las muestras.

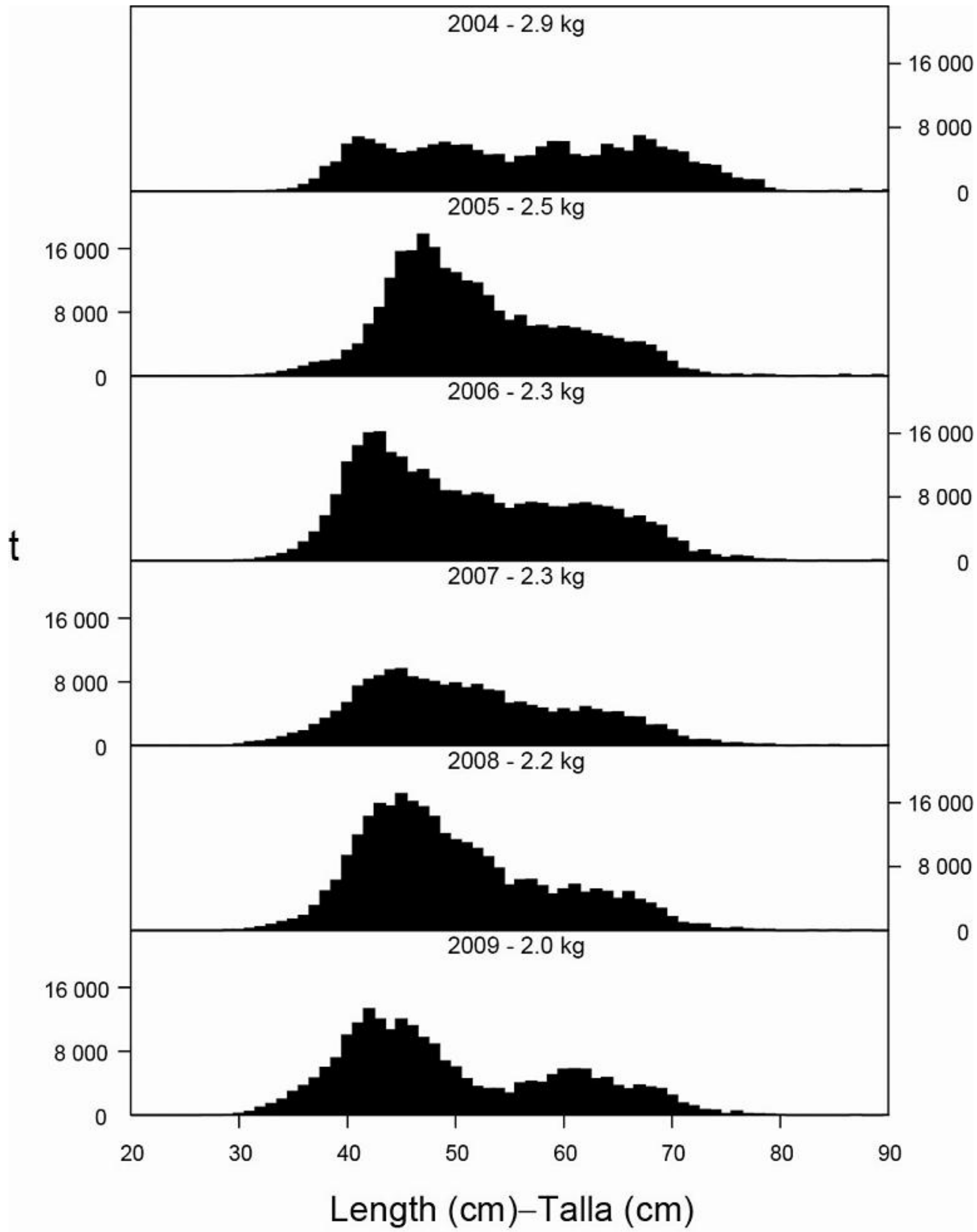


FIGURE A-7b. Estimated size compositions of the skipjack caught by purse-seine and pole-and-line vessels in the EPO during 2004-2009. The average weights of the fish in the samples are given at the tops of the panels.

FIGURA A-7b. Composición por tallas estimada del barrilete capturado por buques cerqueros y cañeros en el OPO durante 2004-2009. En cada recuadro se detalla el peso promedio de los peces en las muestras.

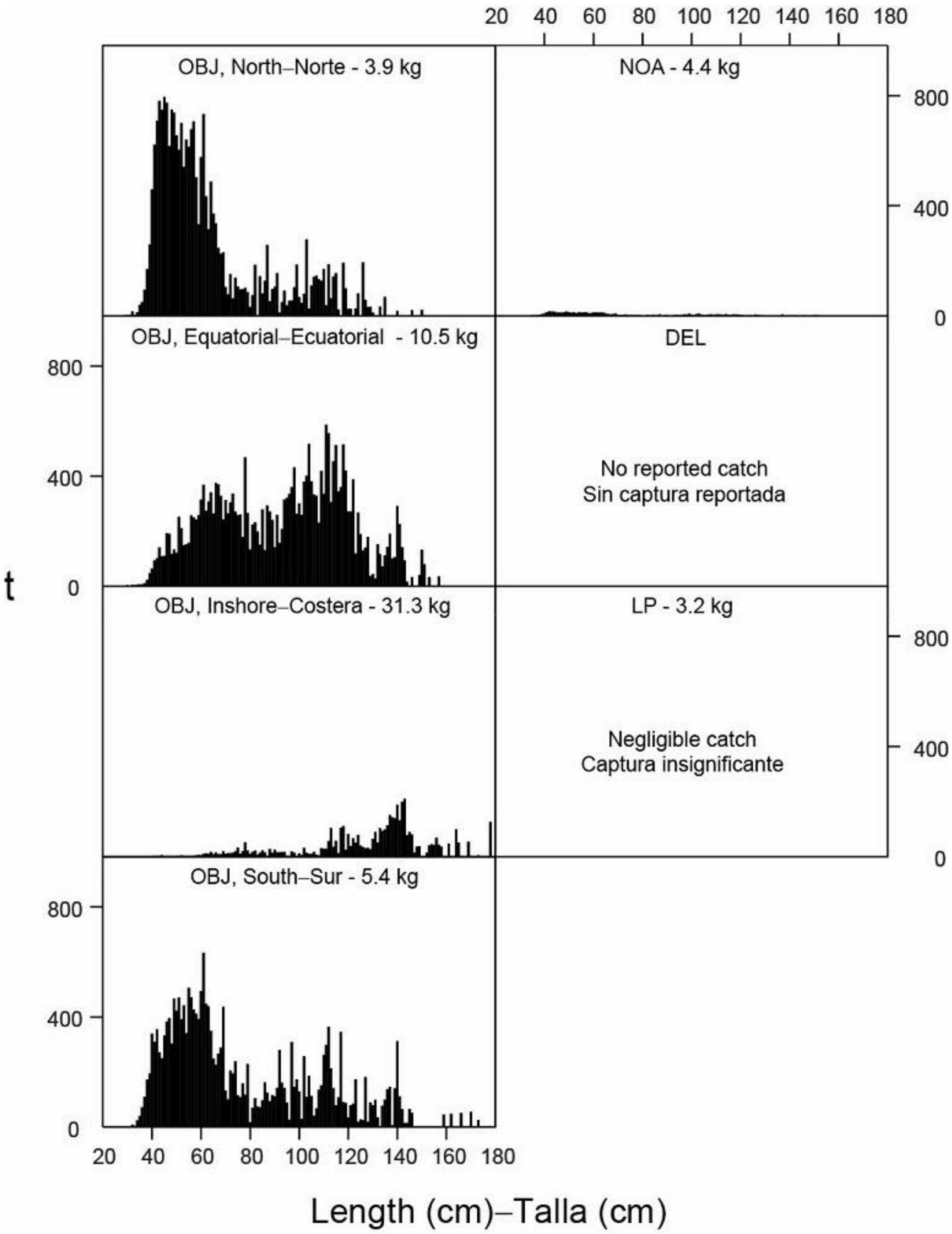


FIGURE A-8a. Estimated size compositions of the bigeye caught in the EPO during 2009 for each fishery designated in Figure A-5. The average weights of the fish in the samples are given at the tops of the panels.

FIGURA A-8a. Composición por tallas estimada del patudo capturado e en el OPO durante 2009 en cada pesquería ilustrada en la Figura A-5. En cada recuadro se detalla el peso promedio de los peces en las muestras.

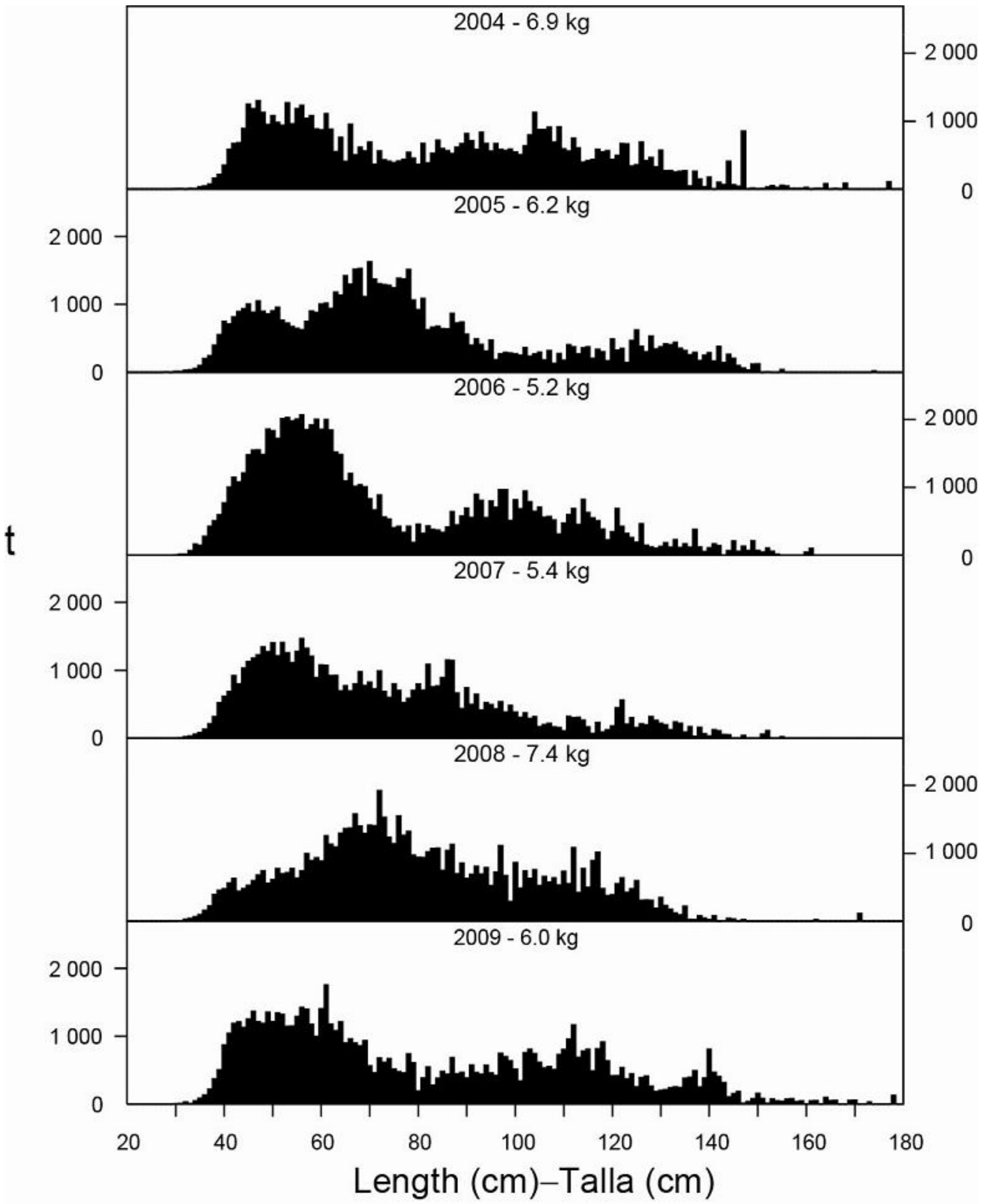


FIGURE A-8b. Estimated size compositions of the bigeye caught by purse-seine vessels in the EPO during 2004-2009. The average weights of the fish in the samples are given at the tops of the panels.
FIGURA A-8b. Composición por tallas estimada del patudo capturado por buques cerqueros en el OPO durante 2004-2009. En cada recuadro se detalla el peso promedio de los peces en las muestras.

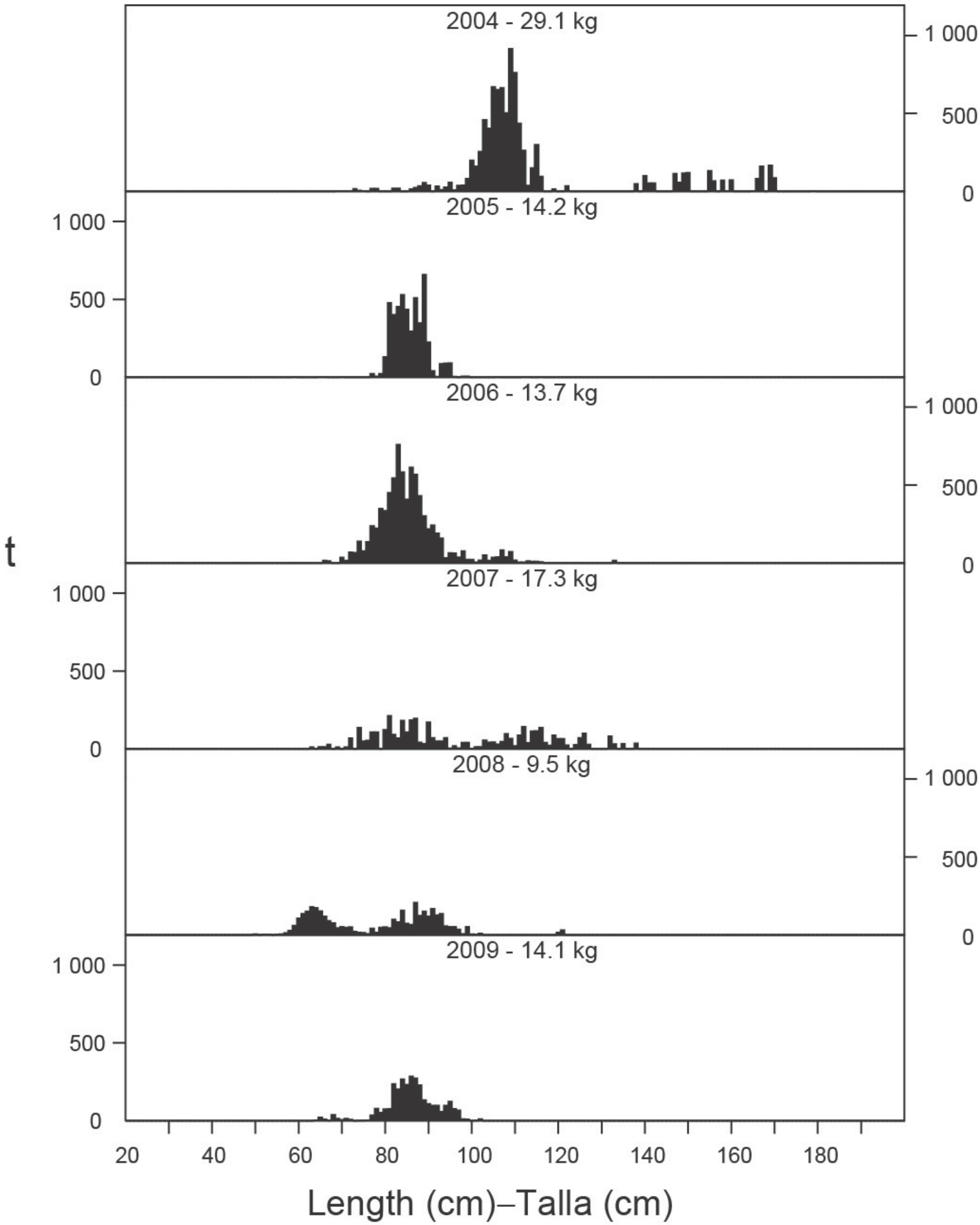


FIGURE A-9. Estimated catches of Pacific bluefin by purse-seine and recreational gear in the EPO during 2004-2009. The values at the tops of the panels are the average weights.

FIGURA A-9. Captura estimada de aleta azul del Pacífico con arte de cerco y deportiva en el OPO durante 2004-2009. El valor en cada recuadro representa el peso promedio.

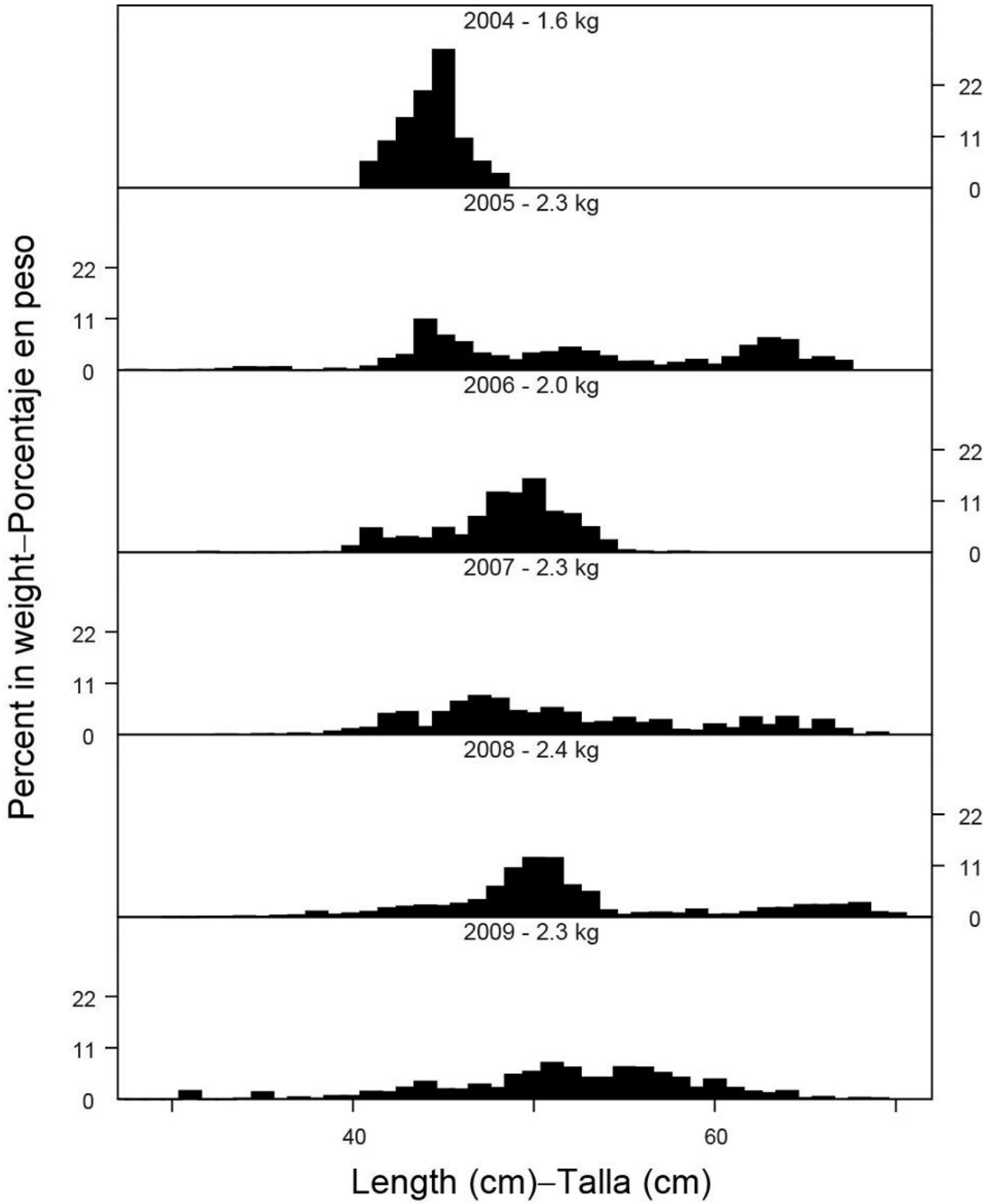


FIGURE A-10. Estimated size compositions of the catches of black skipjack by purse-seine vessels in the EPO during 2004-2009. The values at the tops of the panels are the average weights.

FIGURA A-10. Composición por tallas estimada del barrilete negro capturado por buques cerqueros en el OPO durante 2004-2009. El valor en cada recuadro representa el peso promedio.

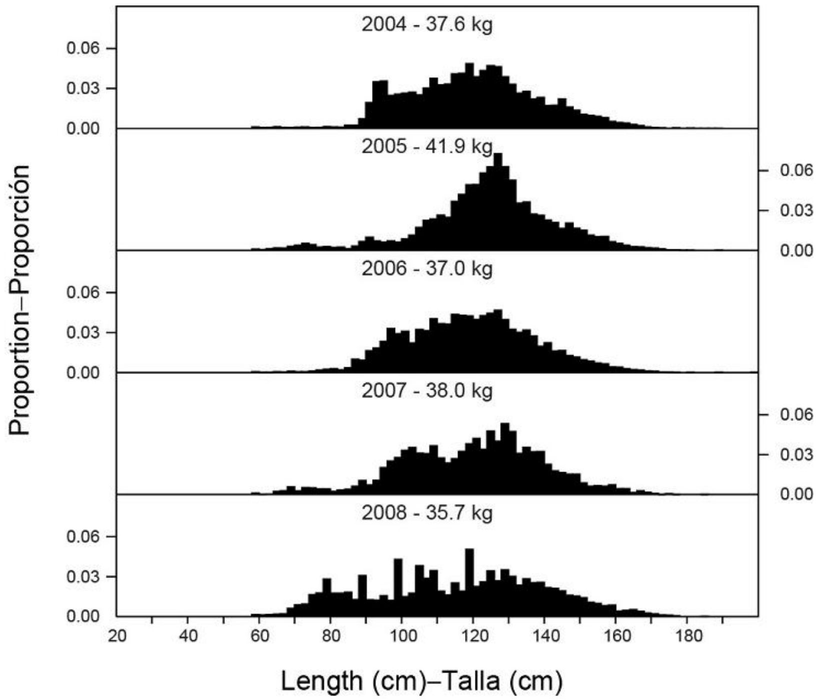


FIGURE A-11. Estimated size compositions of the catches of yellowfin tuna by the Japanese longline fishery in the EPO, 2004-2008.
FIGURA A-11. Composición por tallas estimada de las capturas de atún aleta amarilla por la pesquería palangrera japonesa en el OPO, 2004-2008.

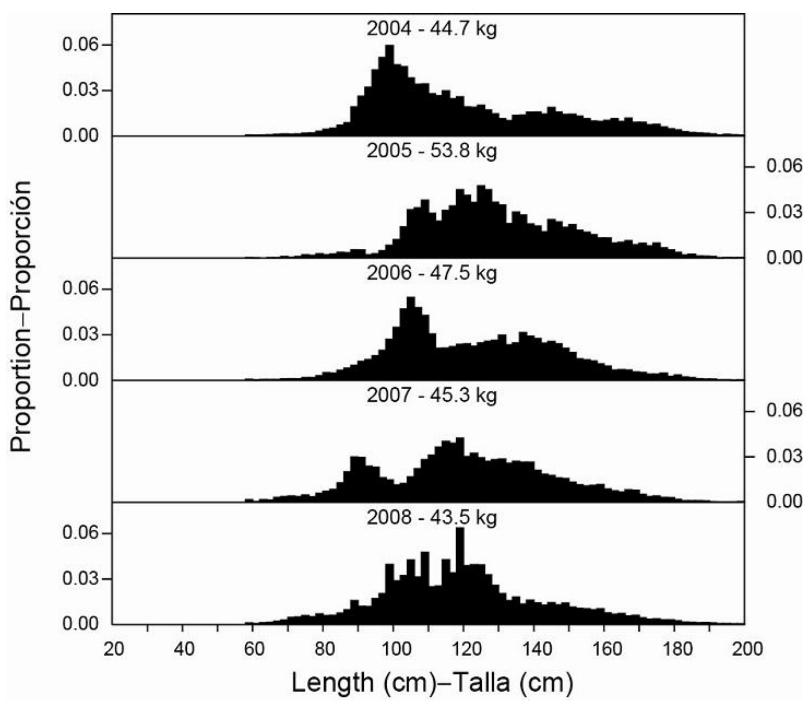


FIGURE A-12. Estimated size compositions of the catches of bigeye tuna by the Japanese longline fishery in the EPO, 2004-2008.
FIGURA A-12. Composición por tallas estimada de las capturas de atún patudo por la pesquería palangrera japonesa en el OPO, 2004-2008.

TABLE A-1. Annual catches of yellowfin, skipjack, and bigeye, by all types of gear combined, in the Pacific Ocean, 1980-2009. The EPO totals for 1993-2009 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, 1980-2009. Los totales del OPO de 1993-2009 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
1980	158,862	213,148	372,010	138,102	459,606	597,708	86,403	65,133	151,536	383,367	737,887	1,121,254
1981	178,510	225,939	404,449	126,001	438,259	564,260	68,344	53,346	121,690	372,855	717,544	1,090,399
1982	127,534	221,064	348,598	104,669	490,242	594,911	60,349	59,301	119,650	292,552	770,607	1,063,159
1983	99,680	257,160	356,840	61,975	683,684	745,659	64,694	59,896	124,590	226,349	1,000,740	1,227,089
1984	149,465	256,314	405,779	63,611	762,090	825,701	55,268	64,680	119,948	268,344	1,083,084	1,351,428
1985	225,939	259,544	485,483	52,002	603,624	655,626	72,398	68,706	141,104	350,339	931,874	1,282,213
1986	286,071	250,723	536,794	67,745	755,402	823,147	105,185	63,777	168,962	459,001	1,069,902	1,528,903
1987	286,164	303,613	589,777	66,466	687,880	754,346	101,347	79,269	180,616	453,977	1,070,762	1,524,739
1988	296,428	263,108	559,536	92,127	849,154	941,281	74,313	68,447	142,760	462,868	1,180,709	1,643,577
1989	299,436	313,866	613,302	98,921	823,468	922,389	72,994	77,237	150,231	471,351	1,214,571	1,685,922
1990	301,522	340,987	642,509	77,107	901,482	978,589	104,851	89,060	193,911	483,480	1,331,529	1,815,009
1991	265,970	372,123	638,093	65,890	1,140,243	1,206,133	109,121	71,297	180,418	440,981	1,583,663	2,024,644
1992	252,514	376,684	629,198	87,294	1,040,180	1,127,474	92,000	88,384	180,384	431,808	1,505,248	1,937,056
1993	256,244	367,076	623,320	100,517	937,322	1,037,839	82,843	77,506	160,349	439,604	1,381,904	1,821,508
1994	248,073	371,038	619,111	84,671	1,043,691	1,128,362	109,331	86,943	196,274	442,075	1,501,672	1,943,747
1995	244,639	355,378	600,017	150,661	1,077,501	1,228,162	108,210	79,941	188,151	503,510	1,512,820	2,016,330
1996	266,928	287,055	553,983	132,344	1,053,416	1,185,760	114,706	80,314	195,020	513,978	1,420,785	1,934,763
1997	277,575	411,454	689,029	188,285	990,520	1,178,805	122,274	110,402	232,676	588,134	1,512,376	2,100,510
1998	280,607	425,077	705,684	165,490	1,342,615	1,508,105	93,954	109,980	203,934	540,051	1,877,672	2,417,723
1999	304,638	366,154	670,792	291,249	1,209,508	1,500,757	93,078	112,076	205,154	688,965	1,687,738	2,376,703
2000	288,833	405,046	693,879	229,181	1,244,528	1,473,709	147,915	113,528	261,443	665,929	1,763,102	2,429,031
2001	423,774	405,303	829,077	158,072	1,140,384	1,298,456	131,184	104,828	236,012	713,030	1,650,515	2,363,545
2002	443,679	383,105	826,784	166,805	1,316,791	1,483,596	132,825	120,432	253,257	743,309	1,820,328	2,563,637
2003	413,846	416,604	830,450	301,031	1,305,537	1,606,568	116,297	110,752	227,049	831,174	1,832,893	2,664,067
2004	293,896	383,775	677,671	218,192	1,402,253	1,620,445	113,018	124,763	237,781	625,106	1,910,791	2,535,897
2005	286,096	463,936	750,032	282,319	1,490,739	1,773,058	113,235	115,863	229,098	681,650	2,070,538	2,752,188
2006	179,256	419,276	598,532	311,456	1,559,417	1,870,873	120,111	125,140	245,251	610,823	2,103,833	2,714,656
2007	181,996	446,993	628,989	216,619	1,671,746	1,888,365	94,085	118,550	212,635	492,700	2,237,289	2,729,989
2008	194,551	546,369	740,920	307,531	1,620,261	1,927,792	102,979	117,765	220,744	605,061	2,284,395	2,889,456
2009	243,300	429,844	673,144	236,802	1,784,956	2,021,758	105,540	111,468	217,008	585,642	2,326,268	2,911,910

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, 1980-2009 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 2008-2009 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, 1980-2009. 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 2008-2009 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.**				
1980	143,042	-	1,481	13,477	862	158,862	130,912	-	5,225	26	1,939	138,102	21,938	-	-	64,335	130	86,403
1981	168,234	-	1,477	7,999	800	178,510	119,165	-	5,906	20	910	126,001	14,921	-	-	53,416	7	68,344
1982	114,755	-	1,538	10,961	280	127,534	100,499	-	3,760	28	382	104,669	6,939	-	42	53,365	3	60,349
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	10,598	3,772	61	2,256	100,517	9,657	653	-	72,498	35	82,843
1994	208,408	4,527	3,625	30,026	1,487	248,073	70,126	10,501	3,240	73	731	84,671	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	255,231	6,207	2,431	23,855	1,109	288,833	204,307	24,508	231	68	67	229,181	94,640	5,417	-	47,605	253	147,915
2001	382,702	7,028	3,916	29,608	520	423,774	143,561	12,815	448	1,214	34	158,072	61,156	1,254	-	68,755	19	131,184
2002	412,507	4,140	950	25,531	551	443,679	153,303	12,506	616	261	119	166,805	57,440	949	-	74,424	12	132,825
2003	381,107	5,950	470	25,174	1,145	413,846	274,529	22,453	638	634	2,777	301,031	54,174	2,326	-	59,776	21	116,297
2004	269,597	3,009	1,884	18,779	627	293,896	198,664	17,182	528	713	1,105	218,192	67,592	1,749	-	43,483	194	113,018
2005	267,599	2,929	1,821	11,895	1,852	286,096	261,780	17,228	1,300	231	1,780	282,319	69,826	1,952	-	41,432	25	113,235
2006	166,330	1,665	686	9,117	1,458	179,256	297,408	12,403	435	224	986	311,456	83,978	2,385	-	33,708	40	120,111
2007	170,264	1,946	894	7,625	1,267	181,996	208,290	7,159	276	107	787	216,619	63,074	1,039	-	29,928	44	94,085
2008	185,087	1,019	812	6,722	911	194,551	296,648	9,166	499	55	1,163	307,531	75,040	2,287	-	25,624	28	102,979
2009	235,890	1,478	709	4,863	360	243,300	229,668	6,826	151	133	24	236,802	76,513	1,092	-	27,935	*	105,540

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.				
1980	2,909	-	-	-	32	2,941	194	-	407	5,319	5,649	11,569	3,653	-	27	-	-	3,680
1981	1,085	-	-	4	7	1,096	99	-	608	7,275	12,301	20,283	1,908	-	3	-	-	1,911
1982	3,145	-	-	7	6	3,158	355	-	198	8,407	3,562	12,522	1,338	-	-	-	-	1,338
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	-	-	11	325	916	0	-	1	11,194	4,410	15,605	104	4,144	-	31	-	4,279
1994	969	-	-	12	111	1,092	0	-	85	10,390	10,154	20,629	188	854	-	40	-	1,082
1995	629	-	-	25	300	954	0	-	465	6,185	7,427	14,077	203	1,448	-	-	-	1,651
1996	8,223	-	-	19	84	8,326	11	-	72	7,631	8,398	16,112	704	2,304	-	12	-	3,020
1997	2,607	3	2	14	245	2,871	1	-	59	9,678	7,540	17,278	100	2,512	-	11	-	2,623
1998	1,772	-	-	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	6	3	71	653	2,491	31	-	381	15,289	14,433	30,134	1,459	2,283	8	-	-	3,750
2003	3,233	-	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	8,861	15,649	24,578	1,472	2,124	-	-	22	3,618
2006	9,806	-	-	-	101	9,907	109	-	1	10,612	18,966	29,688	1,999	1,977	-	-	-	3,976
2007	4,270	-	-	-	16	4,286	187	-	21	8,934	19,296	28,438	2,307	1,625	-	-	48	3,980
2008	4,392	14	15	-	103	4,524	10	-	6	5,998	16,274	22,288	3,624	2,424	-	-	8	6,056
2009	3,378	24	20	*	183	3,605	51	2	8	4,008	5,685	9,754	3,992	1,241	-	-	*	5,233

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.				
1980	6,089	-	36	-	2,727	8,852	442	-	-	-	836	1,278	309,179	-	7,176	83,157	12,175	411,687
1981	5,690	-	27	-	4,609	10,326	213	-	3	-	1,109	1,325	311,315	-	8,024	68,714	19,743	407,796
1982	2,122	-	0	-	6,776	8,898	47	-	-	-	382	429	229,200	-	5,538	72,768	11,391	318,897
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	2,013	-	10	4,082	6,114	314,271	22,178	8,725	107,814	14,578	467,566
1994	8,331	147	362	-	185	9,025	9	497	-	1	464	971	322,930	18,792	7,312	111,902	13,938	474,874
1995	7,929	55	81	-	54	8,119	11	626	-	-	1,004	1,641	396,574	27,028	7,067	85,152	14,131	529,952
1996	647	1	7	-	16	671	37	1,028	-	-	1,038	2,103	413,513	39,837	6,396	71,280	13,184	544,210
1997	1,097	4	8	-	34	1,143	71	3,383	-	7	1,437	4,898	466,482	48,158	7,747	84,588	9,972	616,947
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	0	-	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	559,080	39,537	2,809	83,304	16,784	701,514
2001	17	-	0	34	19	70	191	679	-	2,448	55	3,373	591,043	22,798	4,522	121,617	14,775	754,755
2002	-	-	-	-	1	1	576	1,863	-	482	1,422	4,343	627,074	21,747	1,958	116,058	17,191	784,028
2003	-	-	1	-	25	26	80	1,238	-	215	750	2,283	713,590	33,502	1,177	110,800	25,636	884,705
2004	15	35	1	8	3	62	256	973	-	349	258	1,836	545,993	23,354	2,539	81,819	25,122	678,827
2005	313	18	0	-	11	342	190	1,922	-	363	427	2,902	605,925	26,188	3,187	62,782	19,851	717,933
2006	3,507	80	12	-	3	3,602	49	1,910	-	21	193	2,173	563,186	20,420	1,134	53,682	21,747	660,169
2007	15,906	628	107	-	-	16,641	600	1,221	-	2,196	189	4,206	464,898	13,618	1,298	48,790	21,647	550,251
2008	7,386	38	9	-	10	7,443	136	1,850	-	727	876	3,589	572,323	16,798	1,341	39,126	19,373	648,961
2009	9,561	15	246	0	220	10,042	158	482	-	1,933	*	2,573	559,211	11,160	1,134	38,872	6,472	616,849

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, 1980-2009. Data for 2008-2009 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, 1980-2009. Los datos de 2008-2009 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.			
1980	-	-	3,746	1,107	4,853	-	-	4,016	-	4,016	-	-	335	-	335	-	-	4,827	-	4,827
1981	-	-	3,070	1,134	4,204	-	-	4,476	-	4,476	-	-	247	-	247	-	-	4,876	-	4,876
1982	-	-	2,604	1,551	4,155	-	-	4,745	-	4,745	-	-	213	-	213	-	-	4,711	-	4,711
1983	-	-	3,341	2,338	5,679	-	-	4,459	-	4,459	-	-	240	-	240	-	-	4,472	-	4,472
1984	-	-	2,752	3,336	6,088	-	-	5,197	-	5,197	-	-	248	-	248	-	-	2,662	-	2,662
1985	-	-	1,885	3,768	5,653	-	-	3,588	-	3,588	-	-	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	-	-	5,662	-	5,662	-	-	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	6,627	-	6,679	-	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	217	-	305	47	20	3,575	259	3,902
1994	1	0	4,990	3,822	8,814	69	15	9,027	-	9,111	38	23	256	-	317	20	9	3,396	257	3,681
1995	3	1	4,495	2,974	7,473	70	16	7,288	-	7,375	43	23	158	-	225	18	8	3,249	296	3,571
1996	1	0	7,071	2,486	9,558	62	15	3,596	-	3,672	46	24	99	-	169	20	9	3,218	430	3,677
1997	2	1	10,580	1,781	12,365	126	15	5,808	-	5,949	71	22	153	-	246	28	3	4,473	329	4,832
1998	3	0	9,800	3,246	13,049	130	20	5,057	-	5,208	72	28	168	-	268	20	3	3,558	509	4,090
1999	2	0	7,569	1,965	9,536	181	38	3,690	-	3,909	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	-	192	17	3	1,889	404	2,312
2001	3	1	16,007	1,964	17,975	119	40	4,197	-	4,356	67	48	123	-	238	13	8	1,961	342	2,324
2002	1	0	17,598	2,119	19,718	188	33	3,481	-	3,703	86	30	78	-	194	69	5	2,159	411	2,645
2003	3	1	18,161	354	18,519	185	21	4,016	-	4,222	121	26	72	-	218	31	4	1,906	411	2,359
2004	2	0	15,372	309	15,683	134	21	3,782	-	3,937	67	5	41	-	113	23	1	1,548	390	1,962
2005	2	0	8,910	4,304	13,217	207	14	3,328	-	3,549	96	9	37	-	142	37	4	1,521	553	2,116
2006	7	0	9,050	3,800	12,857	163	21	2,357	105	2,647	125	21	32	-	177	54	3	1,570	490	2,117
2007	4	0	4,218	4,377	8,599	124	13	2,349	106	2,592	75	8	35	-	118	32	4	1,349	1,018	2,409
2008	6	0	4,216	3,005	7,228	129	8	1,549	114	1,800	76	8	101	-	185	31	2	815	1,038	1,893
2009	3	0	2,915	*	2,918	164	15	970	*	1,149	72	7	29	-	108	23	2	503	*-	528

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

	Shortbill spearfish— Marlín trompa corta					Sailfish— Pez vela					Unidentified istiophorid billfishes— Picudos istioфóridos 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.			
1980	-	-	-	-	-	-	-	244	-	244	-	-	-	-	-	-	-	13,168	1,107	14,275
1981	-	-	-	-	-	-	-	379	-	379	-	-	9	-	9	-	-	13,057	1,134	14,191
1982	-	-	-	-	-	-	-	1084	-	1,084	-	-	3	-	3	-	-	13,360	1,551	14,911
1983	-	-	-	-	-	-	-	890	-	890	-	-	2	-	2	-	-	13,404	2,338	15,742
1984	-	-	-	-	-	-	-	345	-	345	-	-	-	-	-	-	-	11,204	3,336	14,540
1985	-	-	-	-	-	-	-	395	-	395	-	-	1	-	1	-	-	7,648	3,768	11,416
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	-	-	17,179	5,642	22,821
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	69	220	21,459	4,716	26,464
1992	-	1	1	-	2	-	-	1351	-	1,351	-	-	1,123	-	1,123	52	221	22,204	4,506	26,983
1993	0	0	1	-	1	26	32	2266	-	2,323	29	68	1,650	-	1,746	246	171	20,467	4,673	25,557
1994	0	0	144	-	144	18	21	1682	-	1,722	7	16	1,028	-	1,050	154	83	20,523	4,079	24,840
1995	1	0	155	-	156	12	15	1351	-	1,379	4	9	232	-	244	151	72	16,928	3,270	20,421
1996	1	0	126	-	127	10	12	738	-	760	6	13	308	-	327	145	73	15,156	2,916	18,290
1997	1	0	141	-	142	12	11	1217	-	1,241	3	5	1,324	-	1,332	243	57	23,696	2,110	26,106
1998	0	0	200	-	200	28	31	1382	-	1,441	5	8	575	54	642	259	89	20,740	3,809	24,897
1999	1	0	278	-	279	33	8	1216	-	1,258	6	12	1,136	-	1,153	332	111	16,604	2,341	19,388
2000	1	0	285	-	286	33	17	1380	-	1,429	3	6	879	136	1,024	242	69	17,102	2,923	20,336
2001	0	0	304	-	305	18	45	1539	325	1,927	2	5	1,742	204	1,952	223	146	25,873	2,835	29,077
2002	1	0	273	-	274	19	15	1792	17	1,843	4	5	1,862	14	1,885	369	88	27,243	2,562	30,262
2003	1	4	290	-	294	38	49	1174	0	1,260	6	5	1,389	-	1,400	384	109	27,008	771	28,272
2004	1	0	207	-	208	19	13	1400	17	1,449	4	4	1,384	-	1,392	250	44	23,734	716	24,744
2005	1	0	229	-	230	32	11	805	15	863	5	3	900	-	908	381	41	15,730	4,872	21,025
2006	1	0	231	-	233	30	13	1007	35	1,085	23	4	491	1	518	403	62	14,738	4,431	19,634
2007	1	0	239	-	240	41	8	930	32	1,011	13	4	104	15	136	289	38	9,224	5,554	15,106
2008	1	0	264	-	265	31	7	245	68	352	17	5	58	4	84	291	31	7,248	4,236	11,807
2009	1	0	449	-	450	20	10	6	*	37	11	1	*	*	12	294	36	4,872	*	5,202

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, 1980-2009. The data for 2008-2009 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, 1980-2009. Los datos de 2008-2009 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.**			
1980	224	-	-	2	226	124	-	-	1,001	1,125	16	-	7	858	881	301	-	-	-	301
1981	111	-	-	17	128	410	-	-	628	1,038	49	-	120	1,211	1,380	201	-	51	-	252
1982	122	-	-	-	122	274	-	-	980	1,254	22	-	215	864	1,101	288	-	59	-	347
1983	1,240	-	-	-	1,240	88	-	-	3,374	3,462	34	-	85	695	814	288	-	-	-	288
1984	414	-	-	-	414	103	-	-	202	305	47	-	6	1,039	1,092	415	-	-	3	418
1985	317	-	-	4	321	93	-	-	108	201	27	-	13	481	521	77	-	7	-	84
1986	188	-	-	19	207	632	-	-	1,828	2,460	29	-	1	1,979	2,009	94	-	-	-	94
1987	566	-	-	5	571	271	-	-	4,272	4,543	96	-	87	1,020	1,203	210	-	535	-	745
1988	825	-	-	1	826	69	-	-	1,560	1,629	1	-	23	1,041	1,065	321	-	360	-	681
1989	60	-	-	2	62	210	-	-	1,680	1,890	29	-	66	1,025	1,120	670	-	152	-	822
1990	234	-	-	1	235	63	-	-	1,491	1,554	-	-	280	1,095	1,375	433	-	260	14	707
1991	116	-	-	-	116	57	-	7	613	677	1	-	1,112	1,346	2,459	462	-	457	1	920
1992	116	-	-	-	116	69	-	37	708	814	-	-	2,293	1,190	3,483	555	-	182	-	737
1993	31	43	-	2	76	267	477	17	724	1,485	272	1,064	1,026	916	3,279	394	888	184	2	1,468
1994	19	28	-	16	63	687	826	46	3,459	5,018	366	967	1,234	1,314	3,881	398	862	251	-	1,512
1995	26	32	-	9	67	466	729	39	2,127	3,361	275	1,055	922	1,075	3,326	330	1,004	210	-	1,544
1996	136	135	-	57	328	548	885	43	183	1,660	237	938	1,121	2,151	4,446	302	671	456	-	1,428
1997	38	111	-	39	188	569	703	6866	3,109	11,246	406	1,194	956	2,328	4,885	505	859	848	-	2,212
1998	83	149	-	4	236	424	426	2528	9,167	12,545	277	1,359	2,099	4,393	8,128	563	1,324	1,340	-	3,226
1999	109	136	-	1	247	567	751	6284	1,160	8,762	255	762	5,995	2,088	9,100	579	936	975	-	2,490
2000	97	66	4	4	171	812	785	3537	1,041	6,176	260	722	8,621	405	10,008	392	569	1,490	-	2,450
2001	16	145	18	26	205	1,028	1275	15941	2,825	21,069	184	602	12,551	107	13,444	615	1,395	1,726	1	3,737
2002	20	111	15	20	166	932	938	9464	4,137	15,470	136	705	12,398	99	13,337	725	886	1,914	-	3,526
2003	13	141	54	-	208	582	346	5301	288	6,517	116	752	14,881	372	16,120	664	597	4,681	-	5,942
2004	41	103	1	-	145	810	317	3986	4,645	9,758	155	575	11,295	164	12,188	580	860	671	-	2,111
2005	82	79	-	-	161	864	295	3854	8,667	13,680	197	416	12,105	220	12,938	821	374	558	-	1,753
2006	380	146	-	-	526	1,001	385	3404	13,112	17,903	236	483	6,511	252	7,483	899	496	262	100	1,757
2007	184	183	6	17	391	1,266	350	2978	4,831	9,425	345	345	8,726	414	9,829	1,104	452	2,001	120	3,678
2008	102	55	2	4	163	916	327	440	5,160	6,843	504	279	6,090	253	7,126	805	358	561	75	1,800
2009	60	39	*	*	99	1,953	468	396	*	2,817	287	272	614	*	1,173	1,229	349	414	*	1,993

TABLE A-3a. Catches of yellowfin tuna by purse-seine vessels in the EPO, by vessel flag, 1980-2009. 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, 1980-2009. 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	ESP	MEX	NIC	PAN	PER	SLV	USA	VEN	VUT	C + OTR[1]	Total
1980	-	1,941	5,760	C	19,753	-	4,784	443	-	91,081	6,450	-	12,830	143,042
1981	-	2,632	7,004	6,651	41,147	-	7,202	C	C	91,611	6,269	-	5,718	168,234
1982	-	122	5,511	934	18,785	-	8,487	C	C	72,082	4,057	-	4,777	114,755
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	13,174	-	35,814	4,842	99,208	C	4,414	-	-	3,341	70,108	11,588	12,742	255,231
2001	21,793	-	55,191	9,580	129,381	C	10,577	-	C	4,836	111,030	9,678	30,636	382,702
2002	29,683	-	30,965	4,965	153,172	C	19,961	C	3,095	8,404	122,821	5,466	33,975	412,507
2003	17,638	-	33,027	3,737	172,164	-	24,888	C	C	906	95,168	2,925	30,654	381,107
2004	C	-	40,839	C	90,902	C	31,236	-	C	2,523	54,095	1,621	48,381	269,597
2005	C	-	40,754	C	111,458	6,912	29,897	-	6,905	C	41,604	C	30,069	267,599
2006	C	-	25,544	C	67,958	7,201	23,516	-	C	C	17,916	C	24,195	166,330
2007	C	-	19,741	C	64,940	5,449	28,853	-	C	C	23,992	C	27,289	170,264
2008	C	-	18,472	C	84,456	5,723	26,853	C	C	C	21,704	C	27,879	185,087
2009	C	-	18,095	C	101,276	8,305	36,402	C	C	C	29,797	C	42,015	235,890

[1] Includes—Incluye: BLZ, BMU, BOL, CAN, CHN, COG, CYM, CYP, GTM, HND, KOR, LBR, NLD, NZL, PRT, RUS, SEN, VCT, UNK

TABLE A-3b. Annual catches of yellowfin tuna by longline vessels, and totals for all gears, in the EPO, by vessel flag, 1980-2009. The data for 2008-2009 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, 1980-2009. Los datos de 2008-2009 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]
1980	-	-	-	11,549	1,892	-	-	36	-	-	*	13,477	156,519	2,343
1981	-	-	-	7,090	753	-	-	156	-	-	*	7,999	176,233	2,277
1982	-	-	-	9,826	1,054	-	-	81	-	-	*	10,961	125,716	1,818
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	279,086	3,540
2001	942	1,133	846	14,808	5,230	29	732	3,928	29	13	1,918	29,608	412,310	4,436
2002	1,457	1,563	278	8,513	3,626	4	907	7,360	5	290	1,528	25,531	438,038	1,501
2003	2,739	1,418	462	9,125	4,911	365	C	3,477	5	699	1,973	25,174	406,281	1,615
2004	798	1,701	767	7,338	2,997	32	2,802	1,824	6	171	343	18,779	288,376	2,511
2005	682	1,791	530	3,966	532	1	1,782	2,422	7	-	182	11,895	279,494	3,673
2006	246	1,402	537	2,968	-	0	2,164	1,671	21	-	108	9,117	175,447	2,144
2007	224	1,204	408	4,582	353	8	-	745	11	-	90	7,625	177,889	2,161
2008	469	154	335	5,312	129	2	-	247	31	-	43	6,722	191,809	1,723
2009	*	*	*	4,227	*	*	*	636	*	*	*	4,863	240,753	1,069

[1] Includes—Incluye: BLZ, CHL, ECU, GTM, HND, NIC, SLV

[2] Includes gillnets, pole-and-line, recreational, 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, 1980-2009. 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, 1980-2009. 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+
	COL	CRI	ECU	ESP	MEX	NIC	PAN	PER	SLV	USA	VEN	VUT	C+OTR[1]	Total	OTR[2]
1980	-	2,142	5,085	C	11,451	-	3,773	172	-	92,408	3,471	-	12,410	130,912	7,190
1981	-	1,047	8,213	2,642	24,081	-	4,230	C	C	71,237	3,562	-	4,153	119,165	6,836
1982	-	226	13,590	1,609	14,598	-	5,814	C	C	58,647	2,382	-	3,633	100,499	4,170
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	6,380	-	103,348	16,541	16,309	C	12,402	-	-	10,777	4,697	11,191	22,662	204,307	366
2001	2,623	-	65,579	22,598	8,850	C	6,141	-	C	4,355	1,161	8,110	24,144	143,561	1,696
2002	2,324	-	81,144	20,365	6,309	C	7,092	C	5,954	3,372	2,665	6,271	17,807	153,303	996
2003	5,862	-	139,232	28,778	8,793	-	13,554	C	C	8,242	7,883	21,182	41,003	274,529	4,049
2004	C	-	89,120	C	24,968	C	20,184	-	C	5,071	12,942	8,313	38,066	198,664	2,346
2005	C	-	138,609	C	31,685	2,469	28,055	-	5,258	C	14,015	C	41,689	261,780	3,311
2006	C	-	140,610	C	18,220	4,886	44,013	-	C	C	23,804	C	65,875	297,408	1,645
2007	C	-	93,510	C	21,694	2,964	23,052	-	C	C	21,604	C	45,466	208,290	1,170
2008	C	-	143,501	C	21,636	6,081	42,930	C	C	C	27,055	C	55,445	296,648	1,717
2009	C	-	130,850	C	6,528	3,980	24,581	C	C	C	17,732	C	45,997	229,668	308

[1] Includes—Incluye: BLZ, BMU, BOL, CAN, CHN, COG, CYM, CYP, ECU, GTM, HND, KOR, LBR, NLD, NZL, PRT, RUS, SEN, VCT, UNK

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

TABLE A-3d. Catches of bigeye tuna by purse-seine vessels in the EPO, by vessel flag, 1980-2009. 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, 1980-2009. 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	ESP	MEX	NIC	PAN	PER	SLV	USA	VEN	VUT	C + OTR[1]	Total
1980	-	-	3,191	C	59	-	2,000	*	-	11,291	1,715	-	3,682	21,938
1981	-	119	1,268	805	52	-	1,113	-	C	8,267	2,766	-	531	14,921
1982	-	-	105	41	16	-	1,039	*	*	4,548	1,190	-	*	6,939
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	1,279	-	37,264	21,815	222	C	5,795	*	-	2,598	51	7,974	17,642	94,640
2001	235	-	25,142	9,203	20	C	3,246	*	C	3,242	0	5,483	14,585	61,156
2002	299	-	27,035	8,080	2	C	2,457	C	6,819	2,610	0	2,851	7,287	57,440
2003	258	-	24,711	7,895	8	-	4,621	C	C	2,779	438	6,510	6,954	54,174
2004	C	-	31,368	C	0	C	11,261	*	C	3,689	1,040	5,096	15,138	67,592
2005	C	-	32,680	C	0	33	13,026	*	989	C	116	C	22,982	69,826
2006	C	-	38,597	C	59	2,486	13,247	*	C	C	3,729	C	25,860	83,978
2007	C	-	40,424	C	0	503	8,855	*	C	C	1,193	C	12,099	63,074
2008	C	-	41,197	C	328	855	11,723	C	C	C	2,196	C	18,741	75,040
2009	C	-	35,652	C	1,262	1,615	13,404	C	C	C	3,554	C	21,026	76,513

[1] Includes—Incluye: BLZ, BMU, BOL, CAN, CHN, CYM, CYP, GTM, HND, KOR, LBR, NLD, NZL, PRT, SEN, VCT, UNK

TABLE A-3e. Annual catches of bigeye tuna by longline vessels, and totals for all gears, in the EPO, by vessel flag, 1980-2009. The data for 2008-2009 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, 1980-2009. Los datos de 2008-2009 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]
1980	-	-	-	61,951	2,189	-	-	195	-	-	*	64,335	86,273	130
1981	-	-	-	49,970	2,966	-	-	480	-	-	*	53,416	68,337	7
1982	-	-	-	50,199	2,969	-	-	197	-	-	*	53,365	60,304	45
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	142,245	253
2001	2,639	28	684	38,048	12,576	1	80	9,285	147	3,277	1,990	68,755	129,911	19
2002	7,614	19	388	34,193	10,358	-	6	17,253	132	2,995	1,466	74,424	131,864	12
2003	10,066	18	346	24,888	10,272	-	C	12,016	232	1,258	680	59,776	113,950	21
2004	2,645	21	405	21,236	10,729	-	48	7,384	149	407	459	43,483	111,075	194
2005	2,104	23	398	19,113	11,580	-	30	6,441	536	1,056	151	41,432	111,258	25
2006	709	18	388	16,235	8,694	-	37	6,412	85	935	195	33,708	117,686	40
2007	2,324	15	361	13,977	5,611	-	-	6,057	417	1,073	93	29,928	93,002	44
2008	2,379	2	367	14,785	4,150	-	-	1,852	1,253	747	89	25,624	100,664	28
2009	2,481	*	*	14,911	6,034	-	-	3,396	*	1,113	*	27,395	104,448	*

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

[2] Includes gillnets, pole-and-line, troll, recreational, and unknown gears—Incluye red de transmalle, caña, curricán, 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 2008 and 2009, 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 2008 y 2009, 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	%
2008	**Retained catches–Capturas retenidas**									
ECU	18,472	143,501	41,197	*	*	154	23	89	203,436	35.4
MEX	85,268	22,135	328	4,407	10	3,366	6,969	40	122,523	21.3
NIC	5,723	6,081	855	*	*	3	*	*	12,662	2.2
PAN	26,853	42,930	11,723	*	*	47	66	4	81,623	14.2
VEN	21,704	27,055	2,196	*	*	52	9	3	51,019	8.9
OTR[1]	28,092	55,458	18,741	103	387	2	328	*	103,111	18.0
Total	186,112	297,160	75,040	4,510	397	3,624	7,395	136	574,374	
2009	**Retained catches–Capturas retenidas**									
ECU	18,095	130,850	35,652	*	3	109	*	146	184,855	33.0
MEX	101,985	6,679	1,262	3,019	17	3,742	7,885	2	124,591	22.2
NIC	8,305	3,980	1,615	*	*	*	*	*	13,900	2.5
PAN	36,402	24,581	13,404	*	*	133	*	*	74,520	13.3
VEN	29,797	17,732	3,554	*	*	8	*	1	51,092	9.1
OTR[1]	42,375	46,021	21,026	530	39	*	1,922	9	111,922	20.0
Total	236,959	229,843	76,513	3,549	59	3,992	9,807	158	560,880	

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

[1] Incluye Bolivia, Colombia, El Salvador, España, Estados Unidos, Guatemala, Honduras, Perú, 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 2008 and 2009 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 2008 y 2009 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			
1980	11,327	1,392	851	6,005	-	-	-	114	5	19,693	582	-	2,327	31	2,940	-	22,634
1981	25,422	754	619	6,559	-	-	-	179	-	33,532	218	-	867	23	1,109	-	34,641
1982	19,234	1,777	738	4,240	31	-	-	207	2	26,228	506	-	2,639	13	3,159	-	29,387
1983	14,774	356	225	4,117	13	-	9	175	2	19,670	214	-	629	44	887	-	20,557
1984	4,433	587	164	4,976	4	-	5	477	8	10,655	166	-	673	78	917	-	11,573
1985	4,154	1,817	114	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	3,523	89	-	21	365	14	14,474	119	-	861	54	1,033	-	15,507
1988	3,605	907	187	2,465	32	-	197	108	62	7,562	447	1	923	56	1,427	-	8,989
1989	6,190	754	241	1,934	71	-	259	205	54	9,707	57	-	1,046	133	1,236	-	10,943
1990	2,989	536	336	2,421	132	-	149	189	315	7,067	50	-	1,380	157	1,587	2	8,653
1991	9,808	286	238	4,204	265	-	-	342	119	15,262	9	-	410	98	517	-	15,781
1992	7,162	166	529	3,204	288	-	73	464	8	11,896	-	-	1,928	171	2,099	6	13,995
1993	6,600	129	822	1,759	40	-	1	471	3	9,825	-	-	580	401	981	2	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	7,223	821	-	-	335	2	28,248	11	-	657	307	975	4	29,225
1996	7,644	94	910	5,359	102	-	-	956	-	15,066	3,700	-	4,639	110	8,449	14	23,519
1997	13,152	34	1,312	4,354	1,054	-	-	1,814	-	21,720	367	-	2,240	289	2,897	20	24,632
1998	5,391	85	1,265	4,439	188	-	-	1,910	-	13,277	1	-	1,771	694	2,466	21	15,763
1999	16,173	35	1,174	5,193	256	-	-	3,089	-	25,919	2,369	35	184	625	3,213	21	29,153
2000	16,486	102	960	6,935	1,976	-	-	2,780	2	29,240	3,019	99	693	403	4,214	50	33,475
2001	7,620	180	797	5,477	968	10	-	1,839	4	16,895	863	-	292	404	1,559	65	18,504
2002	9,273	99	846	4,158	767	1	-	1,523	4	16,672	1,708	2	50	666	2,427	60	19,164
2003	6,432	44	1,249	3,124	2,141	-	-	1,863	21	14,874	3,211	43	22	412	3,689	77	18,622
2004	7,421	132	1,856	3,592	636	-	-	1,714	3	15,353	8,880	14	-	60	8,954	27	24,384
2005	11,451	549	1,939	6,136	1,085	-	-	1,368	-	22,527	4,542	-	201	86	4,830	24	27,384
2006	7,234	108	1,132	3,742	949	-	-	1,149	-	14,314	9,806	-	-	98	9,904	24	24,242
2007	5,899	236	2,317	5,097	1,054	-	-	1,401	-	16,004	4,147	-	42	16	4,205	24	20,233
2008	9,253	64	1,503	6,317	1,536	-	-	979	-	19,652	4,392	15	-	94	4,501	24	24,177
2009	7,424	50	1,052	4,795	794	-	-	892	-	15,008	3,019	-	410	156	3,585	*	18,617

[1] Source: International Scientific Committee, 10th Plenary Meeting, PBFWG workshop report on Pacific Bluefin Tuna, July 2010—Fuente: Comité Científico Internacional, 10ª Reunión Plenaria, Taller PBFWG sobre Atún Aleta Azul del Pacífico, julio de 2010

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 2008 and 2009 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 2008 y 2009 son preliminares.

ALB (N)	Eastern Pacific Ocean Océano Pacífico oriental						Western and central Pacific Ocean Océano Pacífico occidental y central					Total
	LL	LP	LTL	PS	OTR	Subtotal	LL	LP	LTL	OTR	Subtotal	
1980	1,268	407	5,421	194	168	7,458	14,367	46,717	2,347	4,345	67,776	75,234
1981	2,040	608	12,039	99	227	15,013	16,849	27,566	798	11,200	56,413	71,426
1982	1,971	198	3,303	355	257	6,084	16,398	29,841	3,410	13,351	63,000	69,084
1983	1,572	449	7,751	7	87	9,866	15,020	21,256	1,833	7,582	45,691	55,557
1984	2,592	1,441	8,343	3,910	1,427	17,713	13,543	25,602	1,011	13,333	53,489	71,202
1985	1,313	877	5,308	42	1,176	8,716	13,468	21,335	1,163	13,729	49,695	58,411
1986	698	86	4,282	47	196	5,309	12,442	16,442	456	10,695	40,035	45,344
1987	1,114	320	2,300	1	171	3,906	14,433	18,920	570	11,337	45,260	49,166
1988	899	271	4,202	17	64	5,453	15,020	6,543	165	18,887	40,615	46,068
1989	952	21	1,852	1	160	2,986	13,856	8,662	148	19,825	42,491	45,477
1990	1,143	170	2,440	39	24	3,816	15,647	8,477	465	26,096	50,685	54,501
1991	1,514	834	1,783	-	6	4,137	16,848	6,269	201	10,792	34,110	38,247
1992	1,635	255	4,515	-	2	6,407	18,688	13,633	419	16,578	49,318	55,725
1993	1,772	1	4,331	-	25	6,129	29,812	12,796	2,417	4,087	49,112	55,241
1994	2,356	85	9,581	-	106	12,128	29,016	26,304	3,553	3,380	62,253	74,381
1995	1,380	465	7,308	-	102	9,255	32,456	20,596	3,450	1,623	58,125	67,380
1996	1,675	72	8,195	11	88	10,041	38,896	20,224	13,654	971	73,745	83,786
1997	1,365	59	6,056	1	1,018	8,499	48,645	32,252	12,618	1,717	95,232	103,731
1998	1,730	81	11,938	42	1,208	14,999	47,442	22,924	8,136	1,987	80,489	95,488
1999	2,701	227	10,801	47	3,621	17,397	45,607	50,202	3,052	7,487	106,348	123,745
2000	1,880	86	10,874	71	1,798	14,709	41,027	21,533	4,371	3,116	70,047	84,756
2001	1,822	157	11,570	3	1,635	15,187	36,596	29,412	5,168	1,364	72,540	87,727
2002	1,227	381	11,905	31	2,357	15,901	32,657	48,451	4,418	3,831	89,357	105,258
2003	1,126	59	17,749	32	2,228	21,194	31,874	36,114	4,137	924	73,049	94,243
2004	854	126	20,162	105	1,518	22,765	28,786	32,254	2,093	7,354	70,487	93,252
2005	582	66	13,722	2	1,739	16,111	32,146	16,133	345	1,442	50,066	66,177
2006	3,797	1	18,500	109	299	22,706	29,720	15,422	431	729	46,302	69,008
2007	2,979	21	17,962	187	1,229	22,378	29,091	37,768	708	5,022	72,589	94,967
2008	916	6	15,732	10	383	17,047	27,149	19,060	1,112	2,532	49,853	66,900
2009	532	8	5,685	48	*	6,273	22,918	32,419	11,401	2,877	69,615	75,888

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 2008 and 2009 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 2008 y 2009 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	
1980	4,051	-	60	4,111	26,921	101	1,468	-	28,490	32,601
1981	5,235	-	35	5,270	27,459	-	2,085	-	29,544	34,814
1982	6,436	-	2	6,438	21,911	1	2,434	4	24,350	30,788
1983	5,861	-	2	5,863	18,448	-	744	37	19,229	25,092
1984	4,120	-	24	4,144	16,220	2	2,773	1,565	20,560	24,704
1985	5,955	-	170	6,125	21,183	-	3,253	1,767	26,203	32,328
1986	5,752	74	149	5,975	26,889	-	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	-	10,317	19,253	-	3,014	5,283	27,550	37,867
1989	5,832	593	90	6,515	12,906	-	7,777	21,878	42,561	49,076
1990	5,393	1,336	306	7,035	13,975	245	5,639	7,232	27,091	34,126
1991	6,379	795	170	7,344	17,006	14	7,010	1,319	25,349	32,693
1992	15,445	1,205	18	16,668	15,147	11	5,373	47	20,578	37,246
1993	9,422	35	19	9,476	20,807	74	4,261	51	25,193	34,669
1994	8,034	446	22	8,502	26,084	67	6,718	67	32,936	41,438
1995	4,805	2	15	4,822	24,527	139	7,714	89	32,469	37,291
1996	5,956	94	21	6,071	17,860	30	7,285	135	25,310	31,381
1997	8,313	466	-	8,779	18,790	21	4,213	133	23,157	31,936
1998	10,905	12	-	10,917	26,886	36	6,268	85	33,275	44,192
1999	8,932	81	7	9,020	22,977	138	3,338	67	26,520	35,540
2000	7,783	778	3	8,564	26,185	102	5,491	136	31,914	40,478
2001	17,588	516	5	18,109	31,050	37	4,626	194	35,907	54,016
2002	14,062	131	40	14,233	46,528	18	4,443	110	51,099	65,332
2003	23,775	419	3	24,197	32,994	12	5,193	127	38,326	62,523
2004	17,590	331	-	17,921	40,197	110	4,200	116	44,623	62,544
2005	8,279	181	7	8,467	49,318	28	3,270	122	52,738	61,205
2006	6,815	48	119	6,982	55,883	29	2,835	69	58,816	65,798
2007	5,955	19	87	6,061	50,830	20	2,063	50	52,963	59,024
2008	5,082	*	159	5,241	41,224	20	3,502	*	44,746	49,987
2009	3,476	*	*	3,476	55,772	*	2,027	*	57,799	61,275

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 2009 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 2009 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**					
1994	5	7,804	7,809	125,000	1,105	1
1995	0	7,185	7,185	132,561	2,546	1
1996	14	7,472	7,486	138,295	1,760	57
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	147,671	537	15
2001	0	9,876	9,876	237,862	1,807	6
2002	0	12,290	12,290	301,260	3,175	2
2003	0	13,760	13,760	264,007	13,359	1
2004	0	11,783	11,783	175,533	10,775	3
2005	0	12,173	12,173	165,900	12,060	2
2006	0	8,923	8,923	91,812	4,805	0
2007	0	8,871	8,871	97,174	3,277	7
2008	0	9,246	9,246	122,125	8,390	5
2009	0	10,910	10,910	178,284	2,758	1
OBJ	**Sets on fish associated with floating objects Lances sobre peces asociados con objetos flotantes**					
1994	668	2,770	3,438	21,389	51,145	33,965
1995	707	3,519	4,226	21,364	80,052	41,875
1996	1,230	3,965	5,195	28,102	69,637	58,376
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	42,853	120,929	92,339
2001	827	5,674	6,501	66,984	122,702	60,378
2002	867	5,771	6,638	38,077	116,608	55,919
2003	706	5,457	6,163	30,136	181,585	52,381
2004	615	4,986	5,601	28,032	117,710	66,079
2005	639	4,992	5,631	26,077	132,774	68,141
2006	1,158	6,862	8,020	34,251	191,829	82,273
2007	1,383	5,857	7,240	29,662	122,283	61,821
2008	1,815	6,655	8,470	34,825	157,226	73,867
2009	1,723	7,077	8,800	36,147	156,879	75,392

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					
1994	5,440	4,835	10,275	62,019	17,876	933
1995	6,120	4,782	10,902	61,509	44,449	3,445
1996	5,807	5,118	10,925	72,210	32,576	2,878
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	64,707	82,841	2,286
2001	4,022	3,024	7,046	77,856	19,052	772
2002	4,938	3,442	8,380	73,170	33,520	1,519
2003	7,274	5,131	12,405	86,964	79,585	1,792
2004	4,969	5,696	10,665	66,032	70,179	1,510
2005	6,109	7,816	13,925	75,622	116,946	1,683
2006	6,189	8,443	14,632	40,267	100,774	1,705
2007	4,842	7,211	12,053	43,428	82,730	1,246
2008	4,769	6,210	10,979	28,137	131,032	1,168
2009	3,169	4,109	7,278	21,459	70,031	1,120
ALL	Sets on all types of schools Lances sobre todos tipos de cardumen					
1994	6,113	15,409	21,522	208,408	70,126	34,899
1995	6,827	15,486	22,313	215,434	127,047	45,321
1996	7,051	16,555	23,606	238,607	103,973	61,311
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	255,231	204,307	94,640
2001	4,849	18,574	23,423	382,702	143,561	61,156
2002	5,805	21,503	27,308	412,507	153,303	57,440
2003	7,980	24,348	32,328	381,107	274,529	54,174
2004	5,584	22,465	28,049	269,597	198,664	67,592
2005	6,748	24,981	31,729	267,599	261,780	69,826
2006	7,347	24,228	31,575	166,330	297,408	83,978
2007	6,225	21,939	28,164	170,264	208,290	63,074
2008	6,584	22,111	28,695	185,087	296,648	75,040
2009	4,892	22,096	26,988	235,890	229,668	76,513

TABLE A-8. Types of floating objects on which sets were made. The 2009 data are preliminary.
TABLA A-8. Tipos de objetos flotantes sobre los que se hicieron lances. Los datos de 2009 son preliminares.

OBJ	Flotsam Naturales		FADs Plantados		Unknown Desconocido		Total
	No.	%	No.	%	No.	%	
1994	773	27.9	1,899	68.6	98	3.5	2,770
1995	728	20.7	2,714	77.1	77	2.2	3,519
1996	538	13.6	3,405	85.9	22	0.6	3,965
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	320	4.5	6,750	95.4	7	0.1	7,077

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
1980	-	-	138,143	75,639	11,787	5,907	-	-	3000	1611	-	-	-
1981	-	-	131,254	59,226	19,727	6,540	-	-	5952	2948	-	-	-
1982	-	-	116,210	61,369	18,608	7,489	-	-	8117	3910	-	-	-
1983	-	-	127,177	69,563	14,680	6,478	-	-	4850	2311	-	-	49
1984	-	-	119,628	57,262	11,770	4,490	-	-	3730	1734	-	-	-
1985	-	-	106,761	74,347	19,799	10,508	-	-	3126	1979	-	-	2
1986	-	-	160,572	111,673	30,778	17,432	-	-	4874	2569	-	-	68
1987	-	-	188,386	104,053	36,436	19,405	-	-	12267	5335	-	-	273
1988	-	-	182,709	82,384	43,056	10,172	-	-	9567	4590	-	-	234
1989	-	-	170,370	84,961	43,365	4,879	-	-	16360	4962	-	-	9
1990	-	-	178,414	117,923	47,167	17,415	-	-	12543	4755	-	-	-
1991	-	-	200,374	112,337	65,024	24,644	-	-	17969	5862	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	41,926	20,060	1,438	238	15,614
2002	34,894	10,398	103,912	45,401	96,273	14,370	943	3,238	78,024	31,773	611	138	10,258
2003	43,290	14,548	101,236	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	49,981	19,535	1,047	166	9,194
2005	16,895	3,681	65,085	25,712	15,798	12,284	13,356	2,514	38,542	12,229	2,579	557	5,442
2006	*	969	56,525	21,432	*	8,752	11,786	3,220	38,139	12,375	234	121	6,792
2007	12,229	2,624	45,970	20,515	10,548	6,037	9,672	3,753	22,243	9,498	2,686	436	3,731
2008	11,519	2,984	44,534	21,182	4,394	4,302	10,255	3,017	13,319	4,198	6,314	1,347	1,369

[1] Includes the catches of—Incluye las capturas de: Belize, Chile, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, México, Nicaragua, Panamá, Vanuatú

TABLE A-10. Numbers and well volumes, in cubic meters, of purse-seine and pole-and line vessels of the EPO tuna fleet, 1977-2009. The data for 2009 are preliminary.
TABLA A-10. Número y volumen de bodega, en metros cúbicos, de buques cerqueros y cañeros de la flota atunera del OPO, 1977-2009. Los datos de 2009 son preliminares.

	PS		LP		Total	
	No.	**Vol. (m^3)**	**No.**	**Vol. (m^3)**	**No.**	**Vol. (m^3)**
1977	253	189,967	116	6,780	369	196,746
1978	271	192,259	118	6,736	389	198,995
1979	282	195,494	50	4,341	332	199,835
1980	270	196,476	50	4,186	320	200,662
1981	251	196,484	41	3,308	292	199,792
1982	223	178,234	40	3,016	263	181,250
1983	215	149,404	60	3,940	275	153,344
1984	175	121,650	40	3,245	215	124,895
1985	178	137,814	25	2,574	203	140,387
1986	166	131,806	17	2,060	183	133,867
1987	177	152,351	29	2,376	206	154,727
1988	189	156,636	36	3,274	225	159,910
1989	178	141,956	30	3,135	208	145,091
1990	172	143,946	23	2,044	195	145,990
1991	155	124,501	19	1,629	174	126,131
1992	160	117,017	19	1,612	179	118,629
1993	152	118,730	15	1,543	167	120,272
1994	167	122,214	20	1,725	187	123,939
1995	175	124,096	20	1,784	195	125,880
1996	183	132,731	17	1,639	200	134,370
1997	194	146,533	23	2,105	217	148,637
1998	203	161,560	22	2,217	225	163,777
1999	208	180,652	14	1,656	222	182,308
2000	205	180,679	13	1,310	218	181,989
2001	205	189,897	10	1,259	215	191,156
2002	218	199,870	6	921	224	200,791
2003	215	202,755	3	338	218	203,093
2004	218	206,473	3	338	221	206,811
2005	222	213,286	4	498	226	213,784
2006	226	225,950	4	498	230	226,448
2007	229	226,985	4	380	233	227,365
2008	220	225,030	4	380	224	225,410
2009	214	223,995	4	380	218	224,375

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 2008, 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 2008, 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	3	2	7	3	-	15	15,110
ECU	PS	35	20	16	4	9	84	60,519
ESP	PS	-	-	-	-	4	4	10,116
GTM	PS	-	-	-	2	-	2	3,056
HND	PS	-	1	1	-	-	2	1,559
MEX	PS	7	7	21	16	-	51	52,920
	LP	4	-	-	-	-	4	380
NIC	PS	-	-	5	-	-	5	6,023
PAN	PS	-	4	9	10	4	27	36,711
PER	PS	-	2	-	-	-	2	1,000
SLV	PS	-	-	1	-	3	4	7,415
USA	PS	2	-	-	-	-	2	292
VEN	PS	-	-	10	8	2	20	28,309
VUT	PS	-	-	1	2	-	3	3,609
Grand total—Total general	PS	47	36	71	44	22	220	
	LP	4	-	-	-	-	4	
	PS + LP	51	36	71	44	22	224	
		Well volume—Volumen de bodega (m^3)						
Grand total—Total general	PS	12,102	20,556	79,357	64,580	48,435		225,030
	LP	380	-	-	-	-		380
	PS + LP	12,482	20,556	79,357	64,580	48,435		225,410

- : 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 2009 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 2009, 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	23	13	4	9	85	60,096
ESP	PS	-	-	-	-	4	4	10,116
GTM	PS	-	-	-	1	1	2	3,575
HND	PS	-	1	1	-	-	2	1,559
MEX	PS	5	5	20	16	-	46	50,254
	LP	4	-	-	-	-	4	380
NIC	PS	-	-	4	1	-	5	6,353
PAN	PS	-	4	8	10	2	24	31,225
PER	PS	-	2	-	-	-	2	1,000
SLV	PS	-	-	1	-	3	4	7,415
USA	PS	-	-	1	-	2	3	5,315
VEN	PS	-	-	11	8	2	21	29,403
VUT	PS	-	-	1	2	-	3	3,609
Grand total—Total general	PS	44	35	67	45	23	214	
	LP	4	-	-	-	-	4	
	PS + LP	48	35	67	45	23	218	
		Well volume—Volumen de bodega (m^3)						
Grand total—Total general	PS	11,591	20,517	75,251	66,101	50,535		223,995
	LP	380	-	-	-	-		380
	PS + LP	11,971	20,517	75,251	66,101	50,535		224,375

- : 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 l999-2008 and in 2009, 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 1999-2008 y en 2009 por mes.

Month Mes	1999-2008			2009
	Min	Max	Ave.-Prom.	
1	125.6	100.9	157.7	117.7
2	137.5	104.3	175.3	156.7
3	131.1	101.2	159.9	142.2
4	134.6	108.9	164.2	165.0
5	131.7	95.2	164.4	159.3
6	135.6	106.2	175.0	160.9
7	139.7	87.6	170.4	164.7
8	107.5	62.2	140.2	108.4
9	119.1	92.9	137.7	114.8
10	140.8	93.6	172.2	165.5
11	125.2	77.3	150.8	124.0
12	71.9	33.1	116.4	64.6
Ave.-Prom.	125.0	88.6	157.0	137.0

B. YELLOWFIN TUNA

This section presents the most current stock assessment of yellowfin tuna (*Thunnus albacares*) in the eastern Pacific Ocean (EPO). An integrated statistical age-structured stock assessment model (Stock Synthesis Version 3) 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. 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. 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, and stock structure. The assessment for 2009 is identical to that of 2008 except for updated and new data. The catch data for the surface fisheries have been updated and new data added for 2009. New or updated longline catch data are available for China (2008), Chinese Taipei (2006-2009), French Polynesia (2008), Korea (2007-2008) and the United States (2007-2008). New surface fishery size composition data for 2009 were added. Surface fishery CPUE data were updated, and new CPUE data added for 2009. No new longline length composition or CPUE data were added.

In general, the recruitment of yellowfin to the fisheries in the EPO is variable, with a seasonal component (Figure B-1). This analysis and previous analyses have indicated that the yellowfin population has experienced two, or possibly three, different recruitment productivity regimes (1975-1982, 1983-2002, and 2003-2008). The productivity regimes correspond to regimes in biomass, 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 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 do the northern and coastal dolphin-associated fisheries.

Significant levels of fishing mortality have been estimated for the yellowfin fishery in the EPO (Figure B-2). These levels are highest for middle-aged yellowfin. All three purse-seine set types have had moderate impacts on the spawning biomass of yellowfin, while longline catches and discards of small yellowfin tuna in the purse-seine fishery on floating objects have had minor impacts (Figure B-3).

There is a large retrospective pattern of overestimating recent recruitment, due to the size-composition data for the floating-object fishery. This retrospective pattern, in combination with the wide confidence intervals for estimates of recent recruitment, indicate that estimates of recent recruitment and recent biomass are uncertain. The results of the assessment are also particularly sensitive to the level of natural mortality assumed for adult yellowfin.

Historically, the spawning biomass ratio (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 1975-1983 corresponding to the low productivity regime, but above that level for most of the following years, except for the recent period (2004-2007) (Figure B-4). 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 two different productivity regimes may support two different MSY levels and associated SBR levels. The SBR at the start of 2010 is estimated to be above the level corresponding to the MSY. The effort levels are estimated to be less than those that would support the MSY (based on the current distribution of effort among the different fisheries) (Figure B-5), and recent catches are below MSY (Table B-1).

It is important to note that the curve relating the average sustainable yield to the long-term fishing mortality is very flat around the MSY level (Figure B-6). Therefore, 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 level at MSY would provide 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 (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 was no relationship (Figure B-6).

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 (Figure B-7), 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 level corresponding to MSY.

If a stock-recruitment relationship is assumed, the outlook is more pessimistic, and current biomass is estimated to be below the level corresponding to the MSY. The status of the stock is sensitive to the value of adult natural mortality and the assumed length of the oldest age modeled (29 quarters).

Under recent levels of fishing mortality (2007-2009), the spawning biomass is predicted to slightly decrease below the level corresponding to MSY, but then increase above it. Fishing at the level of fishing mortality corresponding to MSY (F_{MSY}) is predicted to produce slightly higher catches (Figure B-8).

Key Results

1. There is uncertainty about recent and future recruitment and biomass levels, and there are retrospective patterns of overestimating recent recruitment.
2. The recent fishing mortality rates are lower than those corresponding to the MSY.
3. Increasing the average weight of the yellowfin caught could increase the MSY.
4. There have been two, and possibly three, different productivity regimes, and the levels of MSY and the biomasses corresponding to the MSY may differ among the regimes. The population may have recently switched from the high to an intermediate productivity regime.
5. The results are more pessimistic if a stock-recruitment relationship is assumed.
6. The results are sensitive to the natural mortality assumed for adult yellowfin and the length assumed for the oldest fish.

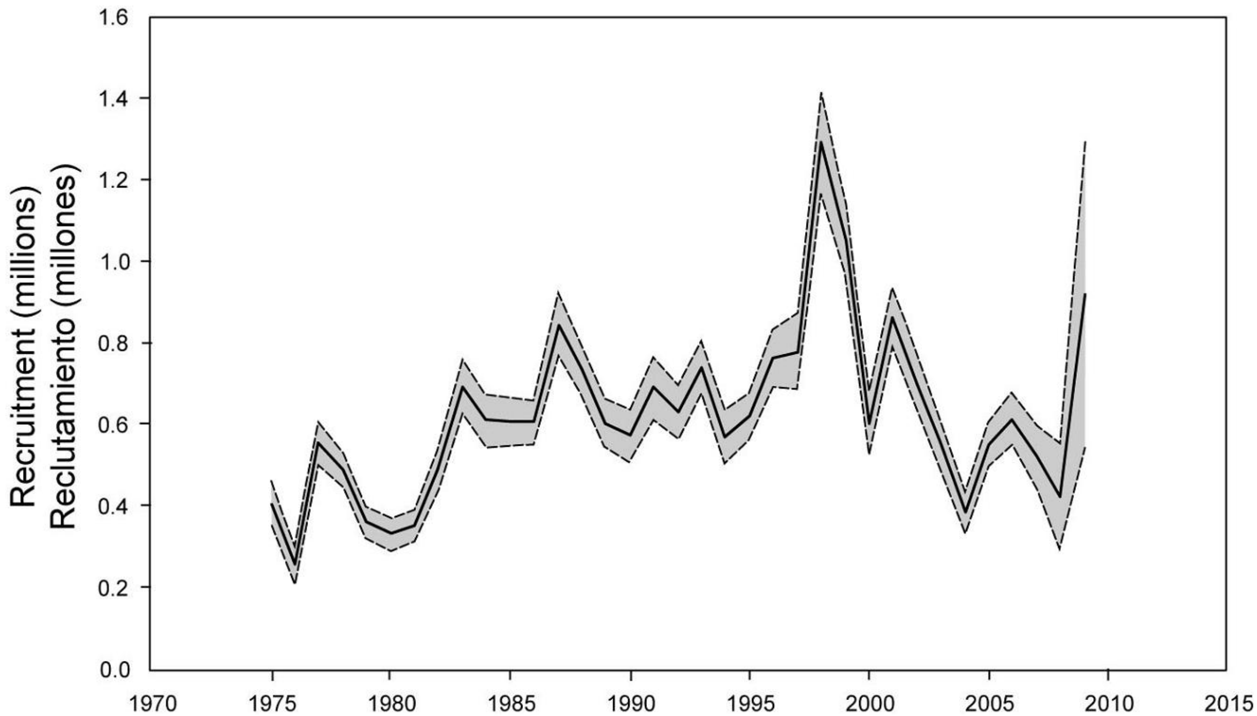


FIGURE B-1. Estimated annual recruitment at age zero of yellowfin tuna to the fisheries of the EPO. The solid line illustrates the maximum likelihood estimates of recruitment, and the dashed lines indicate the approximate 95% confidence intervals around those estimates. The solid line illustrates the maximum likelihood estimates of recruitment, and the dashed lines the approximate 95% confidence intervals around those estimates.

FIGURA B-1. Reclutamiento anual estimado a edad cero del atún aleta amarilla a las pesquerías del OPO. La línea sólida indica las estimaciones de verosimilitud máxima del reclutamiento, y las líneas de trazos los límites de confianza de 95% aproximados de las estimaciones. La línea sólida indica las estimaciones de verosimilitud máxima del reclutamiento, y las líneas de trazos los límites de confianza de 95% aproximados de las estimaciones.

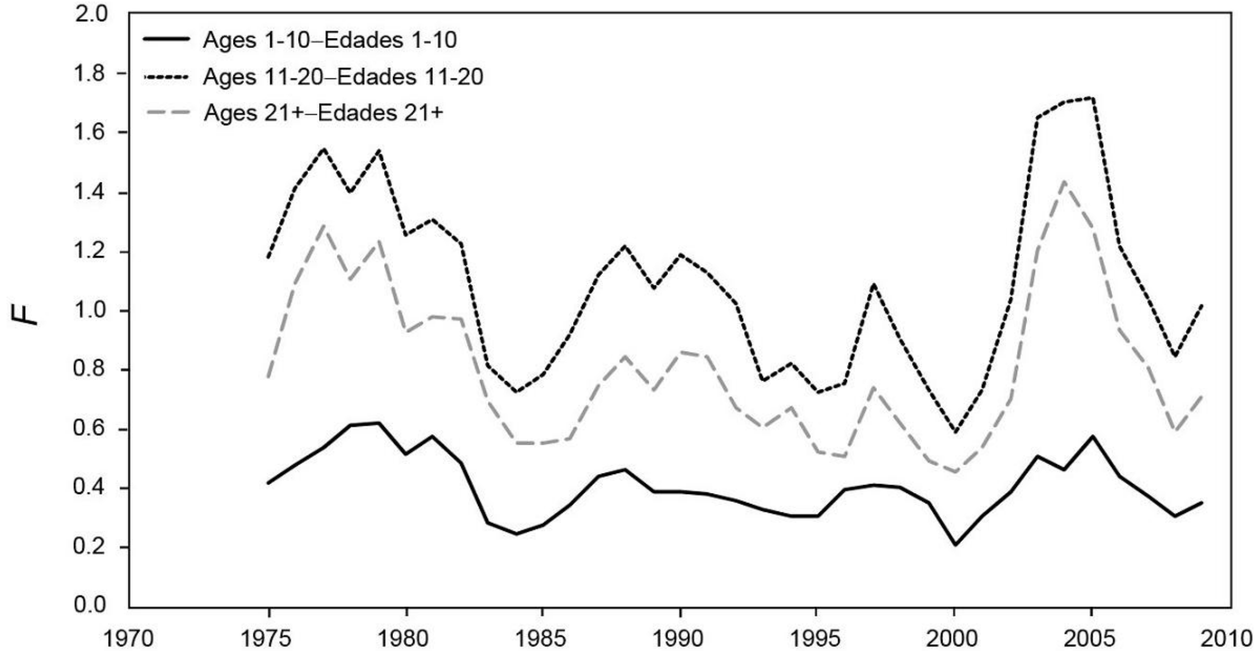


FIGURE B-2. Average annual fishing mortality (*F*) by age groups, by all gears, of yellowfin tuna recruited to the fisheries of the EPO. The age groups are defined by age in quarters.

FIGURA B-2. 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.

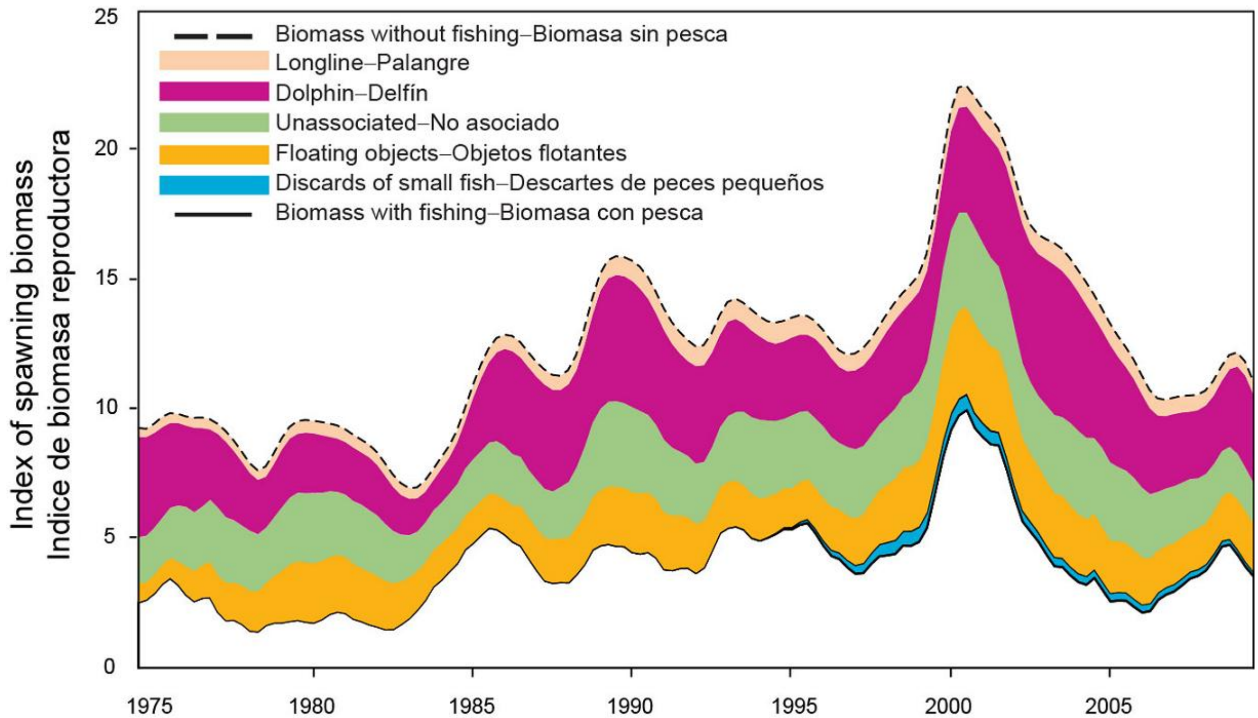


FIGURE B-3. Biomass trajectory of a simulated population of yellowfin tuna that was never exploited (dashed line) and that predicted by the stock assessment model (solid line). The shaded areas between the two lines show the portions of the fishery impact attributed to each fishing method.

FIGURA B-3. Trayectoria de la biomasa de una población simulada de atún aleta amarilla que nunca fue explotada (línea de trazos) y aquélla 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.

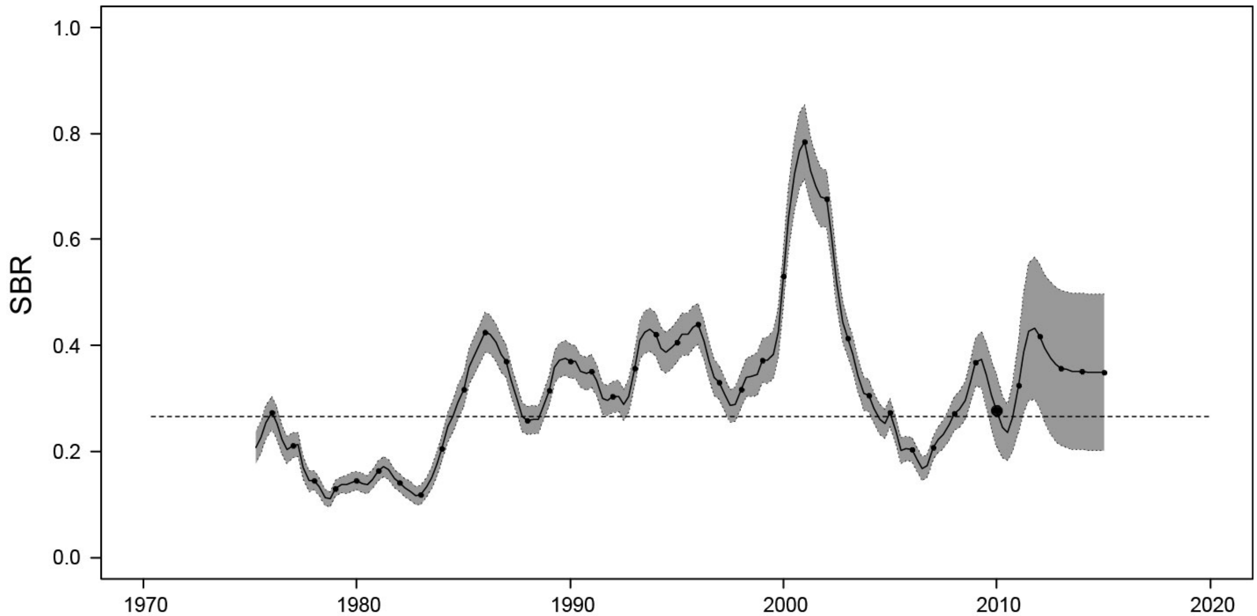


FIGURE B-4. Spawning biomass ratios (SBRs) for 1975-2009 and SBRs projected during 2010-2013 for yellowfin tuna in the EPO. The dashed horizontal line identifies SBR_{MSY}, and the thin dashed lines represent the 95% confidence intervals of the estimates. The estimates after 2009 indicate the SBR predicted if the fishing mortality continues at the average of that observed during 2007-2009, and average environmental conditions occur during the next 5 years.

FIGURA B-4. Cocientes de biomasa reproductora **(**SBR) de 1975-2009 y SBR proyectados durante 2010-2013 para el atún aleta amarilla en el OPO. La línea de trazos horizontal identifica el SBR_{RMS}, y las líneas delgadas de trazos representan los intervalos de confianza de 95% de las estimaciones. Las estimaciones a partir de 2009 señalan el SBR predicho si la mortalidad por pesca continúa en el nivel medio observado durante 2007-2009 y con condiciones ambientales promedio en los 5 años próximos.

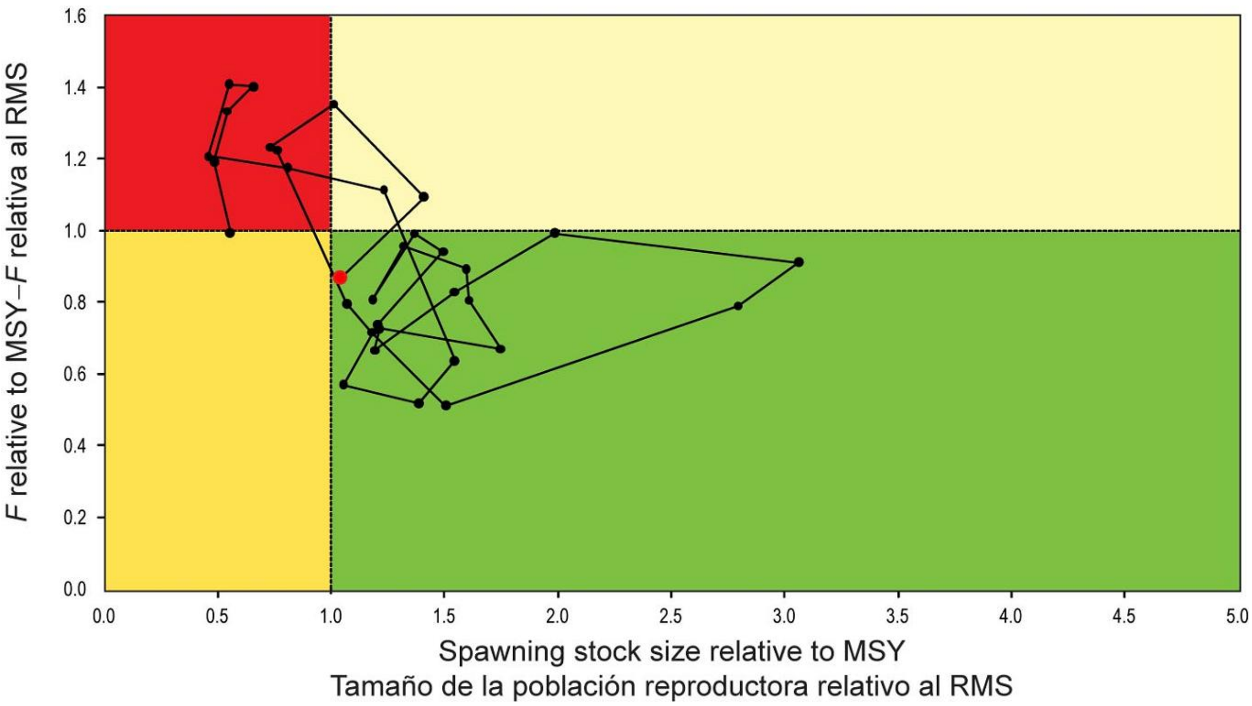


FIGURE B-5. Phase plot of the time series of estimates for stock size and fishing mortality relative to their MSY reference points. Each dot is based on the average exploitation rate over three years; the large red dot indicates the most recent estimate.

FIGURA B-5. Gráfica de fase de la serie de tiempo de las estimaciones del tamaño de la población y la mortalidad por pesca en relación con sus puntos de referencia de RMS. Cada punto se basa en la tasa de explotación media de tres años; el punto rojo grande indica la estimación valor más reciente.

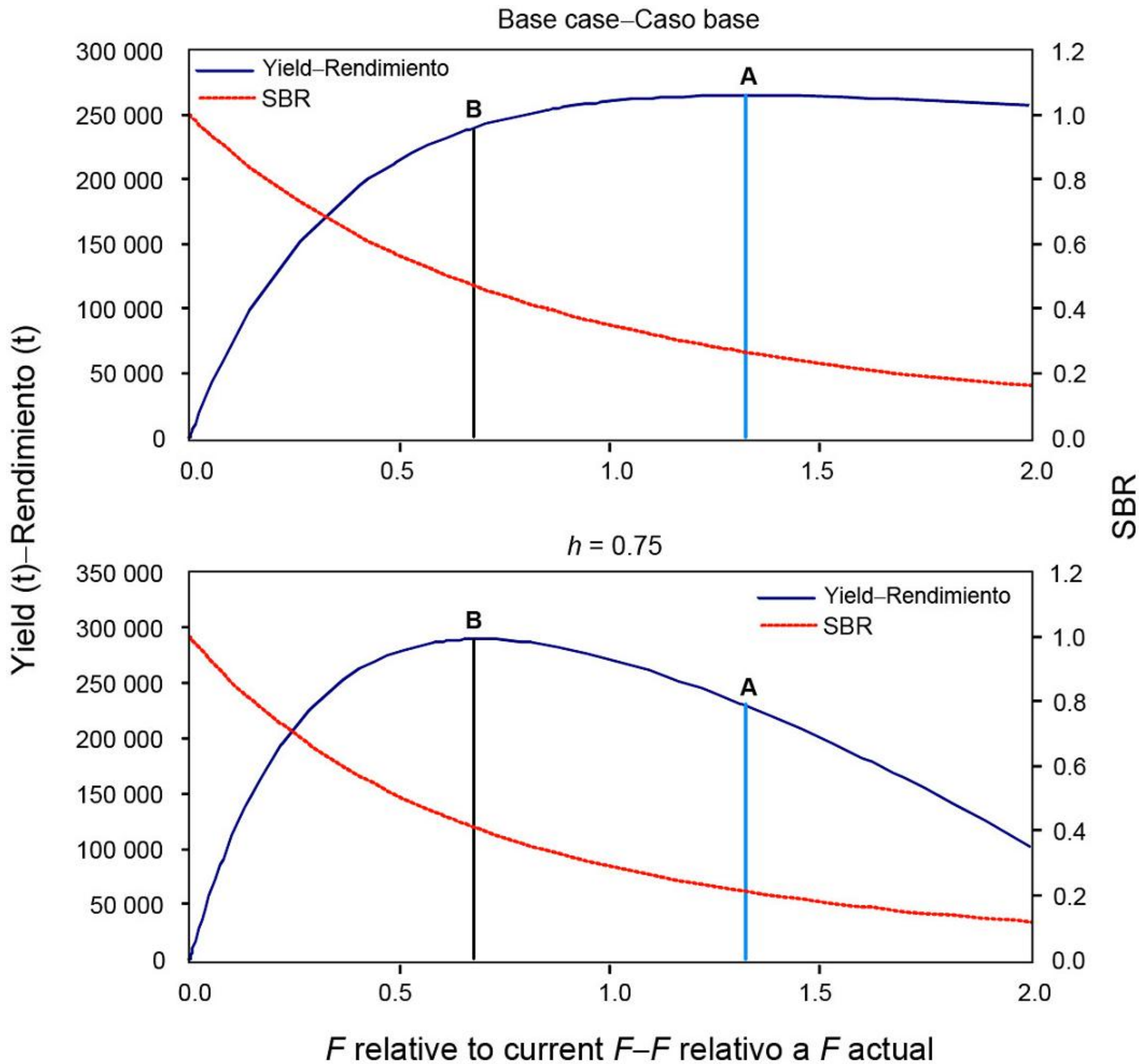


FIGURE B-6. Yield and spawning biomass ratio (SBR) as a function of fishing mortality relative to the current fishing mortality. The vertical lines represent the fishing mortality corresponding to MSY for the base case and the sensitivity analysis that uses a stock-recruitment relationship (h = 0.75). The vertical lines a and b represent the fishing mortality corresponding to MSY for the base case and h = 0.75, respectively.

FIGURA B-6. 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 el análisis de sensibilidad que usa 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 = 0.5, respectivamente.

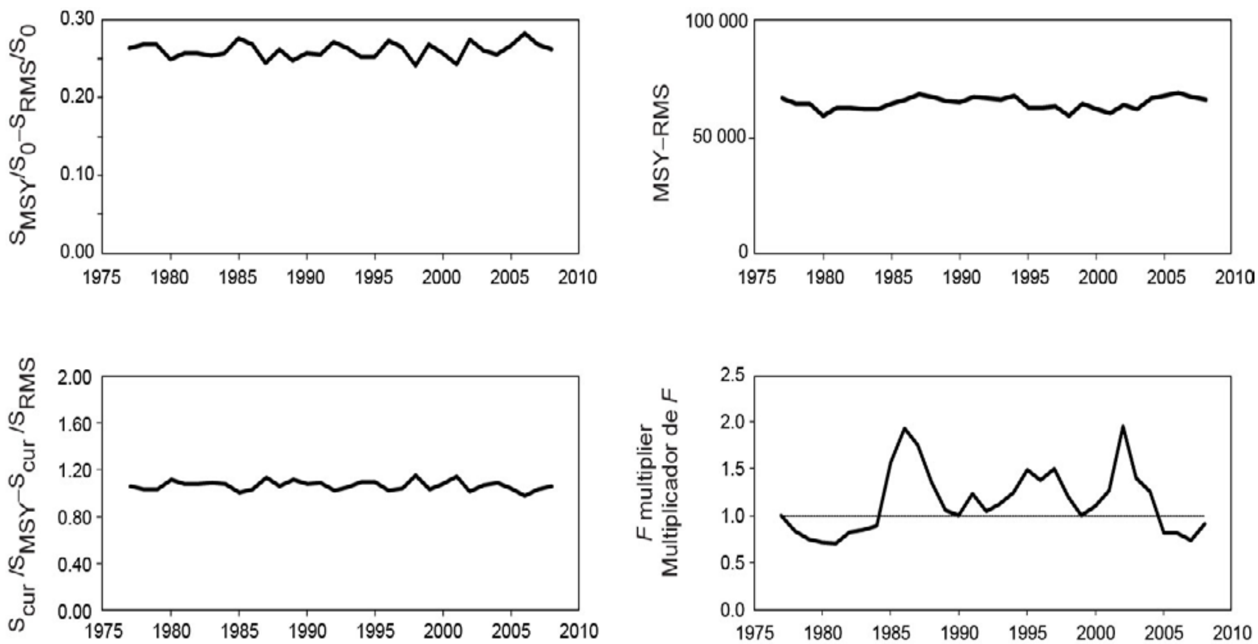


FIGURE B-7. Estimates of MSY-related quantities calculated using the average age-specific fishing mortality for each year (*i.e.* the values for 2006 are calculated using the average age-specific fishing mortality in 2006 scaled by the quantity *F*scale, which maximizes the equilibrium yield). (S_{cur} is the index of spawning biomass at the end of the last year in the assessment). See the text for definitions.

FIGURA B-7. Estimaciones de cantidades relacionadas con el RMS calculadas a partir de la mortalidad por pesca media por edad para cada año (o sea, se calculan los valores de 2006 usando la mortalidad por pesca media por edad escalada por la cantidad *F*scale, que maximiza el rendimiento de equilibrio). (S_{cur} es el índice de la biomasa reproductora al fin del último año en la evaluación). Ver definiciones en el texto.

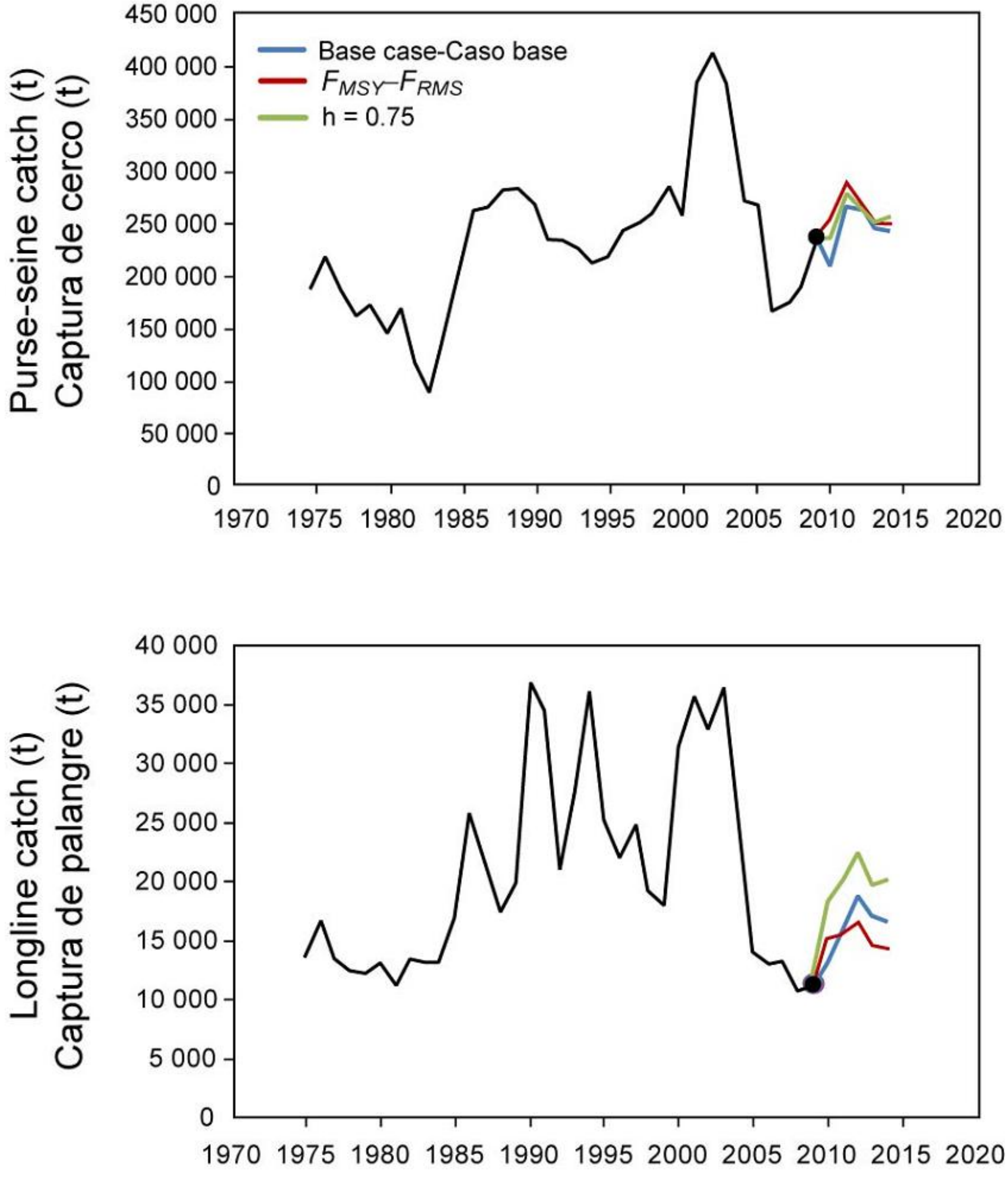


FIGURE B-8. Historic and projected purse-seine and longline catch from the base case while fishing with the current effort, the base case while fishing at the fishing mortality corresponding to MSY (F_{MSY}), and the analysis of sensitivity to steepness (labeled h75) of the stock-recruitment relationship while fishing with the current effort.

FIGURA B-8. Capturas de cerco y de palangre históricas y proyectadas 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 de la relación población-reclutamiento al pescar con el esfuerzo actual.

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 2007-2009. The quantities are also given based on average *F* for 2007-2009. 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 2010 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 2009.

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 2007-2009. Se presentan también las cantidades basadas en la *F* media de 2007-2009. 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 2010 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 2009.

	Base case – Caso base	***h* = 0.75**
MSY–RMS	264,967	289,896
B_{MSY} –B_{RMS}	357,780	555,182
S_{MSY} —S_{RMS}	3,367	5,974
C_{recent}/MSY—$C_{reciente}$/RMS	0.94	0.86
B_{recent}/B_{MSY} –$B_{reciente}/B_{RMS}$	1.10	0.71
S_{recent}/S_{MSY} –$S_{reciente}/S_{RMS}$	1.05	0.59
$S_{MSY}/S_{F=0}$ –$S_{RMS}/S_{F=0}$	0.27	0.35
F multiplier—Multiplicador de *F*	1.33	0.69

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.

The catches used in the assessment 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 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. Except for a large peak in 1999, the floating-object CPUE has generally fluctuated around an average level since 1990. The unassociated CPUE has been higher than average since about 2003 and was at its highest level in 2008. The standardized effort indicator of exploitation rate has been increasing since about 1991 and has been above the upper reference level in recent years, but dropped below it in 2009. The average weight of skipjack has been declining since 2000, and in 2009 was below the lower reference level. Ignoring the peak in 2000, average length has been declining since 1985. The biomass, recruitment, and exploitation rate have been increasing over the past 20 years, and have fluctuated at high levels since 2003.

The main concern with the skipjack stock is the constantly increasing exploitation rate. However, the data- and model-based indicators have yet to detect any adverse consequence of this increase. The average weight is below its lower reference level, which can be a consequence of overexploitation, but it can also be caused by recent recruitments being greater than past recruitments. The 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.

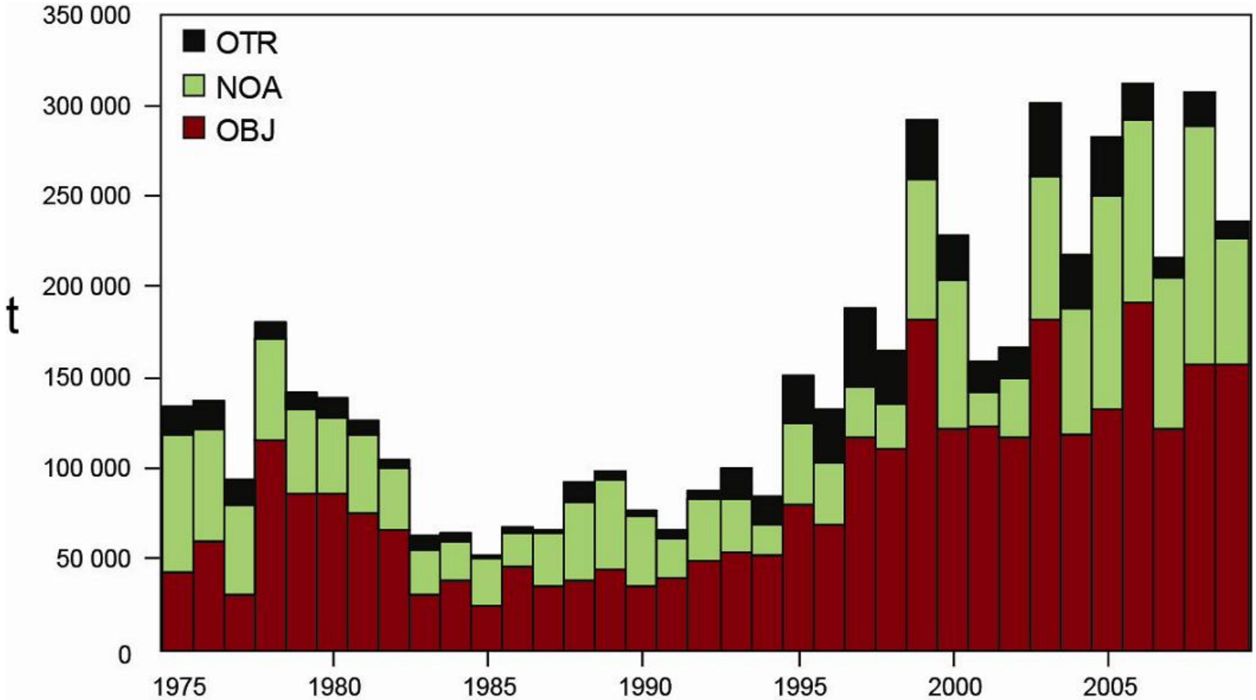


FIGURE C-1. Total catches (retained catches plus discards) of skipjack tuna by the purse-seine fisheries on floating objects and unassociated schools, and by other fisheries combined, in the eastern Pacific Ocean. The purse-seine catches are adjusted to the species composition estimate obtained from sampling the catches. The 2009 catch data are provisional.

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 2009 son provisionales.

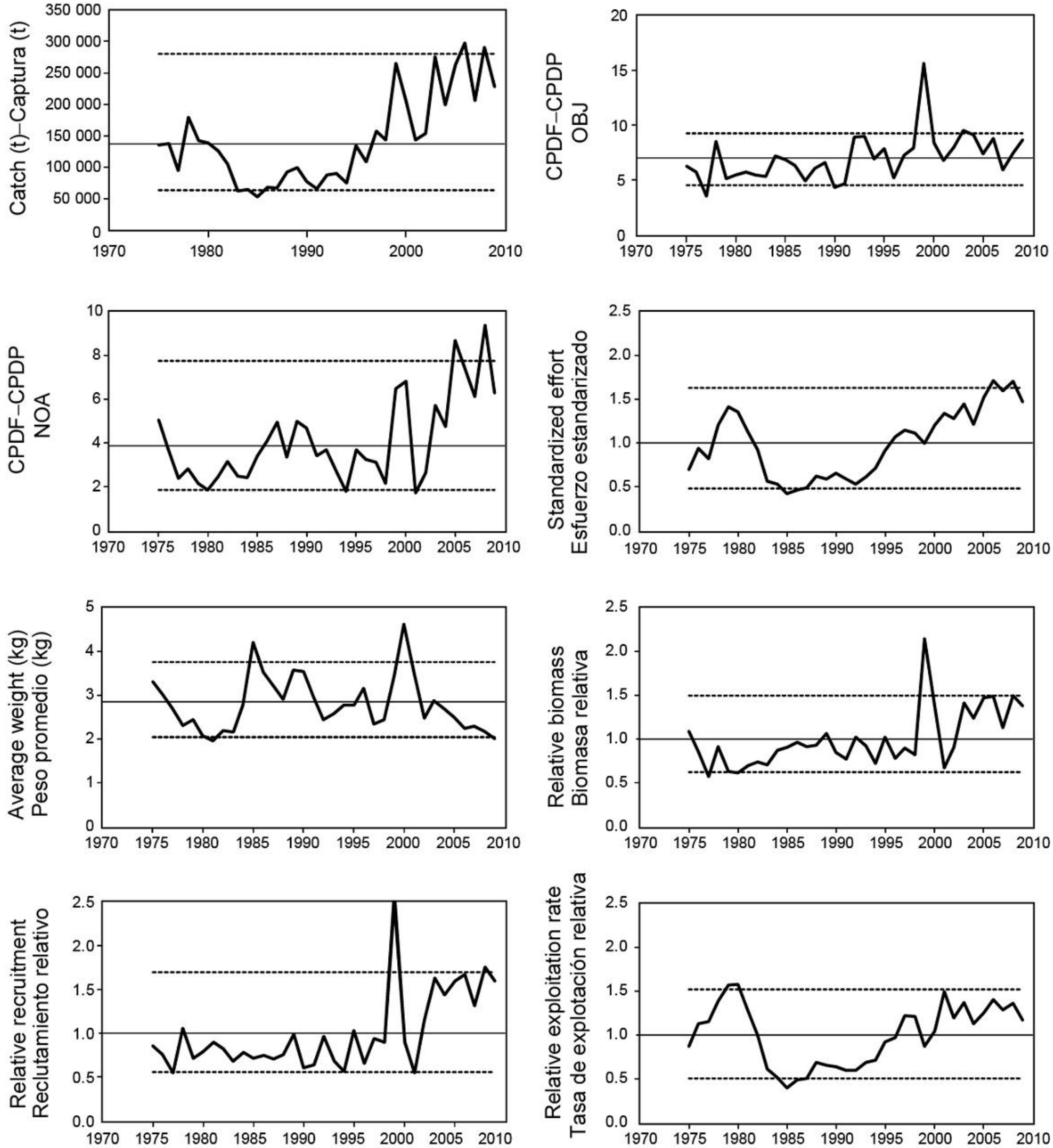


FIGURE C-2. Indicators of the stock status of skipjack tuna based on data and/or a simple stock assessment model. CPDF: catch per day fished.

FIGURA C-2. Indicadores de la condición de la población de atún barrilete basados en datos y/o en un modelo sencillo de evaluación de población. CPDF: captura por día de pesca

D. BIGEYE TUNA

This section presents the current stock assessment of bigeye tuna (*Thunnus obesus*) in the eastern Pacific Ocean (EPO), which was conducted using Stock Synthesis (Version 3).

Bigeye 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 (Figure A-3), but a substantial portion of the longline catches of bigeye in the EPO is made north of that parallel (Figure A-4). Bigeye tuna do not move long distances (95% of tagged bigeye showed net movements of less than 1000 nautical miles), and current information indicates minimal net movement between the EPO and the western and central Pacific Ocean (Figure D-1). 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 local levels. The assessment is conducted as if there were a single stock in the EPO, and there is limited exchange of fish between the EPO and the western and central Pacific Ocean. Its results are consistent with results of other analyses of bigeye tuna on a Pacific-wide basis. In addition, analyses have shown that the results are insensitive to the spatial structure of the analysis. Currently, there are not enough tagging data to provide adequate estimates of movement between the EPO and the western Pacific Ocean.

The assessment assumptions have been modified from the previous assessment based on extensive investigatory analysis and a series of recommendations of the external review of the IATTC staff's assessment of bigeye tuna, held in May 2010. The spatial definitions of the longline fisheries have been re-evaluated and four, rather than two, longline fisheries are assumed in this assessment. With respect to data weighting, the observation error coefficient of variation for the southern longline fishery was pre-specified at a fixed value, rather than being treated as an estimated parameter. Changes to the growth modeling consisted of assuming a Richards model instead of the less flexible von Bertalanffy curve. In addition, the parameters which determine the variance of the length-at-age were estimated rather than fixed, while the average size of the oldest fish (L_2 parameter) was pre-specified at a fixed value, as in previous assessments. Changes in the modeling of catchability and selectivity have also been made. In order to reduce the residual patterns of the model fit to the catch length-frequency data of the longline fishery, the assumption of logistic selectivity for the southern longline fishery throughout the entire time period of the assessment was relaxed. In particular, all longline fisheries were split into two periods at 1990, each with its independent catch rate time series, and estimated catchability and selectivity parameters. The size selectivity curves of the pre-1990 longline fisheries were assumed to be dome-shaped, rather than asymptotic as in previous assessments. Dome-shaped size selectivity curves have also been assumed for two of the four longline fisheries during the late period (post-1990).

The stock assessment requires a substantial amount of information. Data on retained catch, discards, catch per unit of effort (CPUE), and age-at-length data 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 for the surface fisheries have been updated to include new data for 2009. New or updated longline catch data are available for China (2008), Chinese Taipei (2006-2009), French Polynesia (2008), Japan (2006-2009), Korea (2008) and the United States (2007-2008). New purse-seine length-frequency data are available for 2009. New or updated length-frequency data are available for the Japanese longline fleet (2006-2008). Analyses were carried out to assess the sensitivity of results to: 1) a stock-recruitment relationship with various different assumed values for the steepness parameter; 2) assuming different values for the average size of the oldest fish in the Richards growth curve; 3) assuming lower and higher rates of natural mortality (M) for adult bigeye; and 4) using data only from the late period of the fishery (1995-2009), which best reflects the current mix of tuna fisheries operating in the EPO.

There have been substantial changes in the bigeye tuna fishery in the EPO. Initially, the majority of the bigeye catch was taken by longline vessels, but with the expansion of the fishery on fish associated with fish-aggregating devices (FADs) since 1993, the purse-seine fishery has taken an increasing proportion of the catch (Figure D-2). The FAD fishery captures smaller bigeye, and has therefore resulted in 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 increased to a much lesser extent (Figure D-3). Fishing mortality of fish more than 20 quarters old has also increased significantly since the early 1990s, as larger bigeye became vulnerable to the longline fisheries.

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.

There are several important features in the estimated time series of bigeye recruitment (Figure D-4). First, estimates of recruitment before 1993 are very uncertain, as the floating-object fisheries were not catching significant amounts of small bigeye. There was a period of above-average annual recruitment in 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 high in 2005 and 2006. The 2007 recruitment was below average, but the recruitment in 2008 appears to have been particularly high. The most recent annual recruitment estimate (2009) is slightly below average levels. However, this recent estimate is very uncertain and should be regarded with caution, due to the fact that recently-recruited bigeye are represented in only a few length-frequency samples.

The biomass of 3+-quarter-old bigeye increased during 1983-1985, and reached its peak level of about 845 thousand metric tons (t) in 1986, after which it decreased to a historic low of about 347 thousand t at the beginning of 2004. Since then, the biomass of 3+-quarter-old bigeye has shown an increasing trend in the EPO. Spawning biomass has generally followed a trend similar to that for the biomass of 3+-quarter-olds, but with a lag of 1-2 years. There is uncertainty in the estimated biomasses of both 3+-quarter-old bigeye and spawners. Nevertheless, it is apparent that fishing has reduced the total biomass of bigeye in the EPO. The biomasses of both 3+quarter-old fish and spawners are estimated to have been increasing over the last five years. This increasing trend may be partly attributed to the effect of IATTC tuna conservation resolutions during 2004-2009, above-average recruitments, and reduced longline fishing effort in the EPO in recent years.

The estimated trajectory of the spawning biomass that would have occurred without fishing and that projected by the assessment model, together with an estimate of the impacts attributed to each fishing gear, are shown in Figure D-5.

The estimates of summary biomass are moderately sensitive to the steepness of the stock-recruitment relationship. Specifically, the estimates of biomass are greater than those estimated in the base case assessment, but the trends are similar. The trends in recruitment are similar to those of the base case. The estimated biomass and recruitment time series are very sensitive to the assumed value of the average size of the oldest fish – the L_2 parameter – in the growth function. Biomass and recruitment estimates are greater for a lesser value of that parameter. The estimated biomass and recruitment time series are very sensitive to the assumed rate of adult natural mortality for bigeye. Biomass and recruitment estimates increase with higher levels of adult natural mortality.

When data from only the late period of the fishery (1995-2009) are used in the bigeye assessment, and no stock-recruitment relationship is assumed (steepness = 1), the summary biomass estimates are lower than the base case estimates. When a stock-recruitment relationship is assumed (steepness = 0.75), the summary biomass estimates are slightly higher than the base case estimates. These results are partially explained by differences in absolute recruitment, but the relative recruitment trends are very similar.

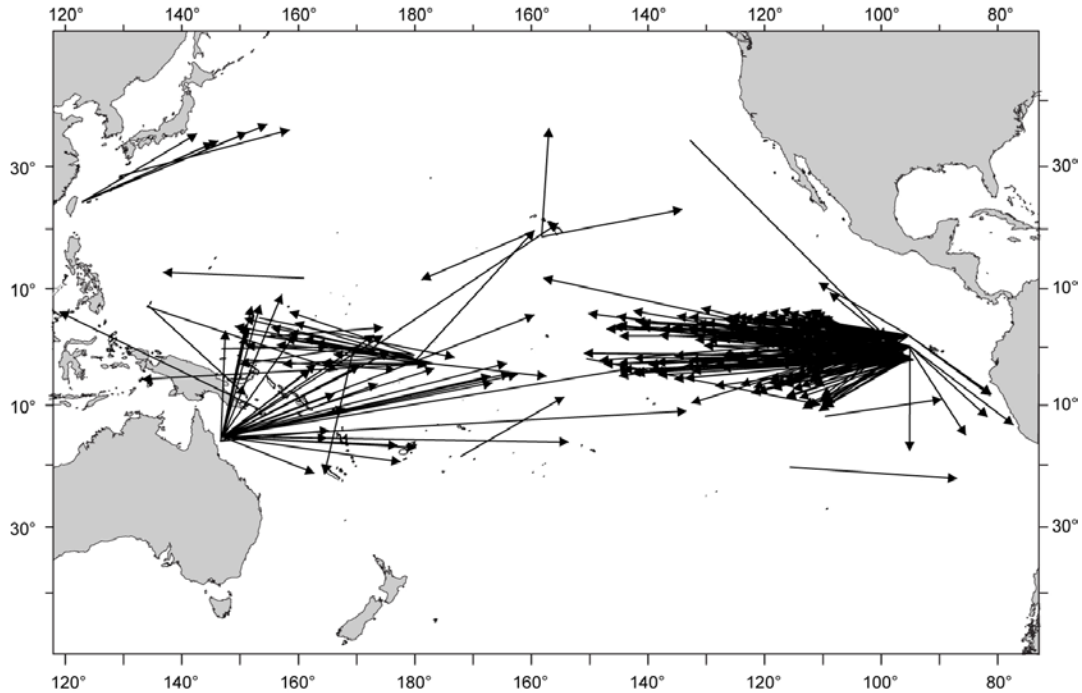
At the beginning of January 2010, the spawning biomass ratio (the ratio of the spawning biomass at that time to that of the unfished stock; SBR) of bigeye tuna in the EPO had recovered from its historic low level of 0.17 at the start of 2005 to 0.26 (Figure D.6). This most recent SBR estimate is about 37% higher than the SBR level corresponding to the maximum sustainable yield (MSY). Recent spikes in recruitment are predicted to sustain, in the short term, the recent increasing trend observed for SBR since 2004 (Figure D.6) and increase longline catches for the next few years (Figure D-7). However, high levels of fishing mortality are expected to subsequently reduce and then stabilize SBR under average recruitment conditions. Under current effort levels, the base case assessment estimates that the population is likely to remain above the level corresponding to MSY. These simulations are based on the assumption that selectivity and catchability patterns will not change in the future. Changes in targeting practices or increasing catchability of bigeye as abundance declines (*e.g*. density-dependent catchability) could result in differences from the outcomes predicted here.

Recent catches are estimated to have been 17% greater than those corresponding to the MSY levels (Table D-1). If fishing mortality (*F*) is proportional to fishing effort, and the current patterns of age-specific selectivity are maintained, the level of fishing effort corresponding to the MSY is about 13% higher than the current (2007-2009) level of effort. 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 less than F_{MSY} (Figure D-8).

All sensitivity analyses indicate that, at the beginning of 2005, the bigeye spawning biomass (*S*) had initiated a recovery trend. Although the results from the base case model show that, at the beginning of 2010, the spawning biomass was higher than S_{MSY} (stock not overfished), and the fishing mortality rate was below that corresponding to F_{MSY} (overfishing not occurring) (Figure D-9), this interpretation is subject to uncertainty and mainly dependent upon the assumptions made on three key biological parameters: the steepness of the stock recruitment relationship, the average size of the older fish in the population, and the levels of adult natural mortality. It also depends on the historic period of the bigeye exploitation used in the assessment.

Key results

1. The results of this assessment indicate a recent recovery trend for bigeye tuna in the EPO (2005-2009), subsequent to IATTC tuna conservation resolutions initiated in 2004;
2. There is uncertainty about recent and future recruitment and biomass levels;
3. The recent fishing mortality rates are estimated to be below the level corresponding to MSY, and the recent levels of spawning biomass are estimated to be above that level. However, 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, the assumed levels of natural mortality for adult bigeye, and the historic period of the bigeye exploitation used in the assessment. 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, if lower rates of natural mortality are assumed for adult bigeye, and if only the late period of the fishery (1995-2009) is included in the assessment;
4. The results are more optimistic if a lower value is assumed for the average size of the older fish, and if higher levels of natural mortality are assumed for adult bigeye.



5.

FIGURE D-1. Movements of more than 1000 nm by tagged bigeye tuna in the Pacific Ocean.
FIGURA D-1. Desplazamientos de más de 1000 mn de atunes patudo marcados en el Océano Pacífico.

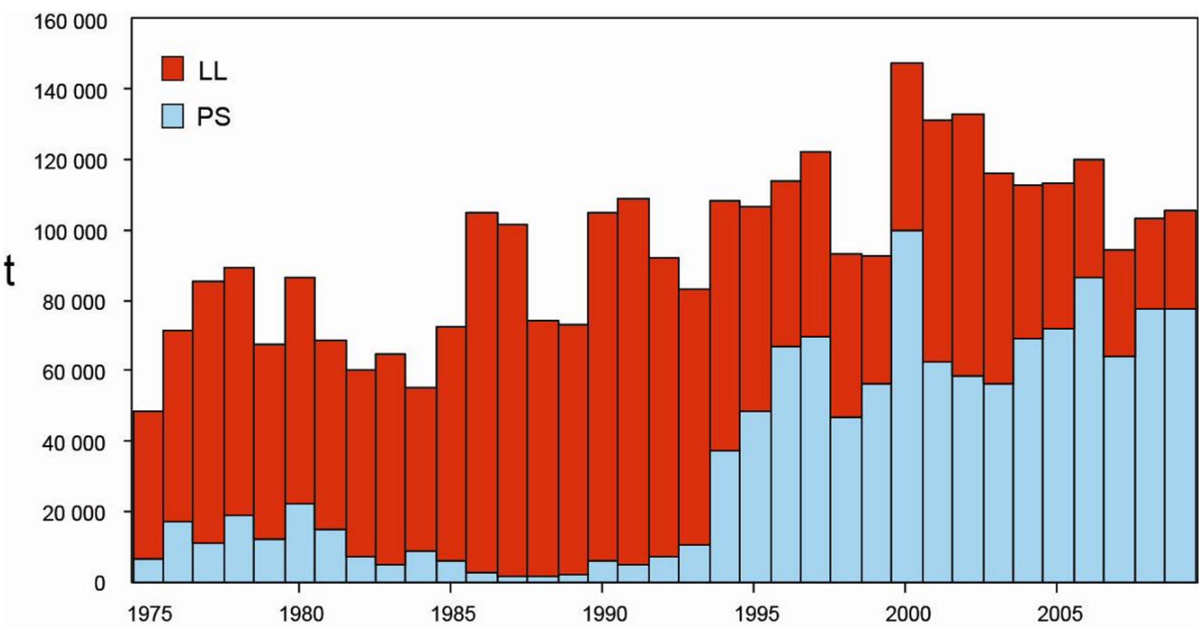


FIGURE D-2. Total catches (retained catches plus discards) of bigeye tuna by the purse-seine fisheries, and retained catches for the longline fisheries, in the eastern Pacific Ocean. The purse-seine catches are adjusted to the species composition estimate obtained from sampling the catches. The 2009 catch data are provisional.

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 2009 son provisionales.

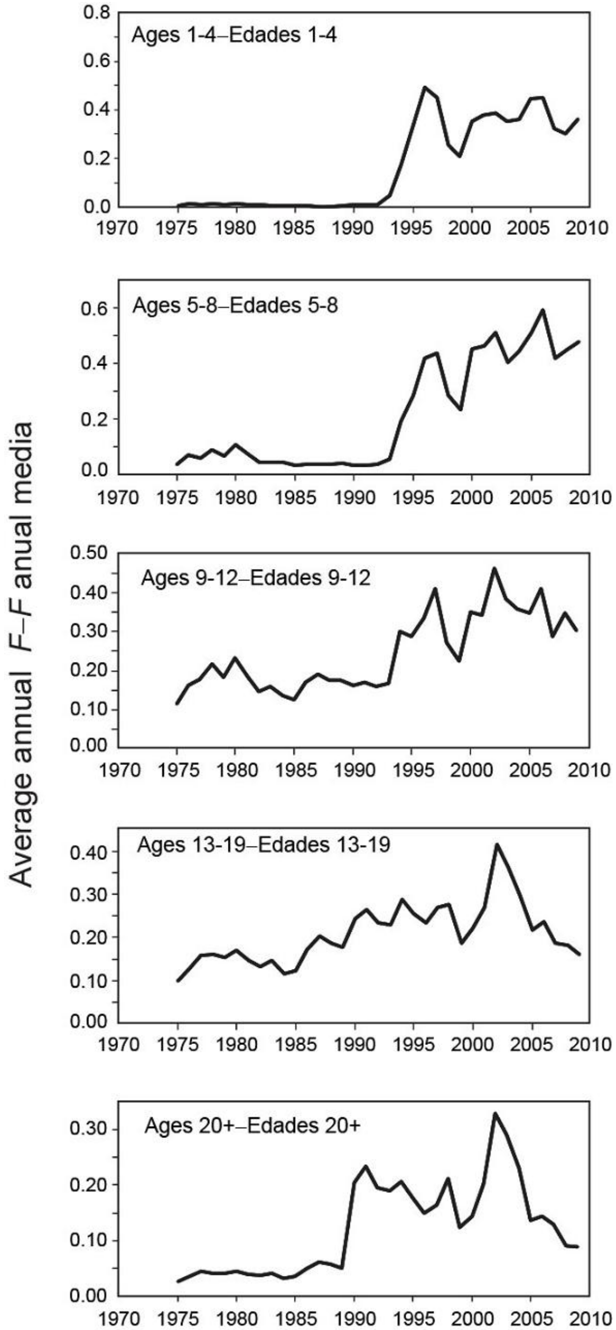


FIGURE D-3. Average annual fishing mortality, by all gears, of bigeye tuna recruited to the fisheries of the EPO. Each panel illustrates an average of four annual fishing mortality vectors that affected the fish in the range of ages indicated in the title of each panel. For example, the trend illustrated in the upper left panel is an average of the fishing mortalities that affected 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 un promedio de cuatro vectores anuales de mortalidad por pesca que afectaron los peces de la edad indicada en el título de cada recuadro. Por ejemplo, la tendencia ilustrada en el recuadro superior izquierdo es un promedio de las mortalidades por pesca que afectaron a peces de entre 1-4 trimestres de edad.

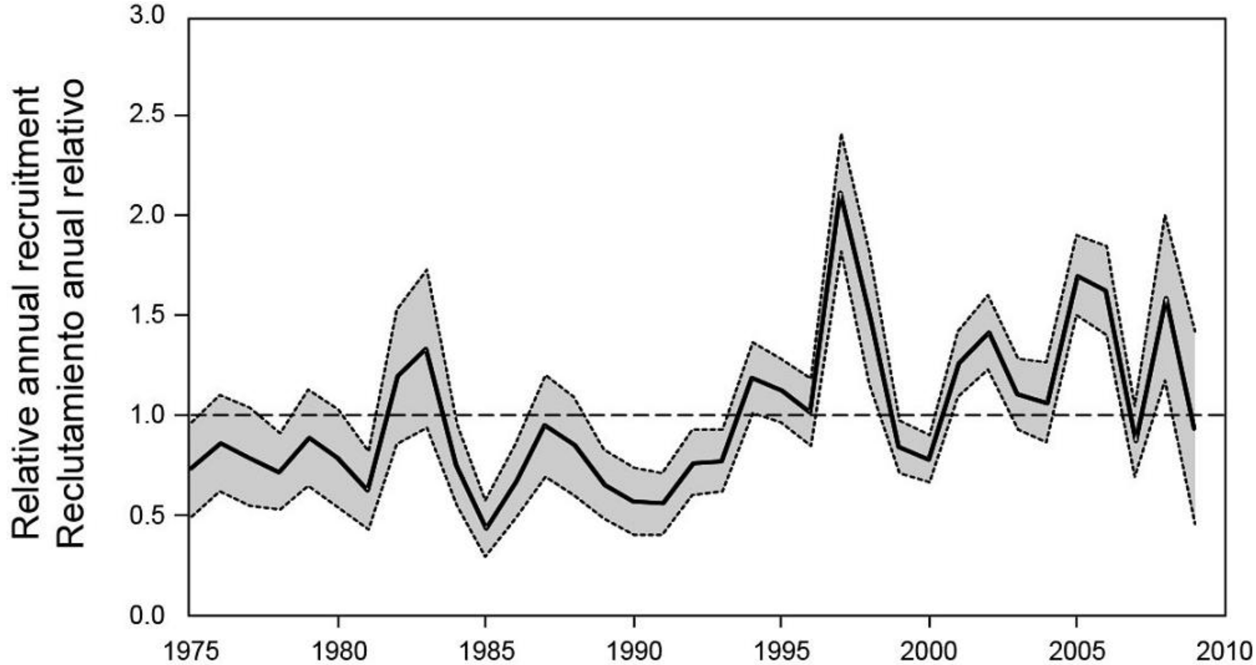


FIGURE D-4. Estimated recruitment of bigeye tuna to the fisheries of the EPO. The estimates are scaled so that the estimate of virgin recruitment is equal to 1.0. The solid line shows the maximum likelihood estimates of recruitment, and the shaded area indicates the approximate 95% confidence intervals around those estimates.

FIGURA D-4. 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. 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.

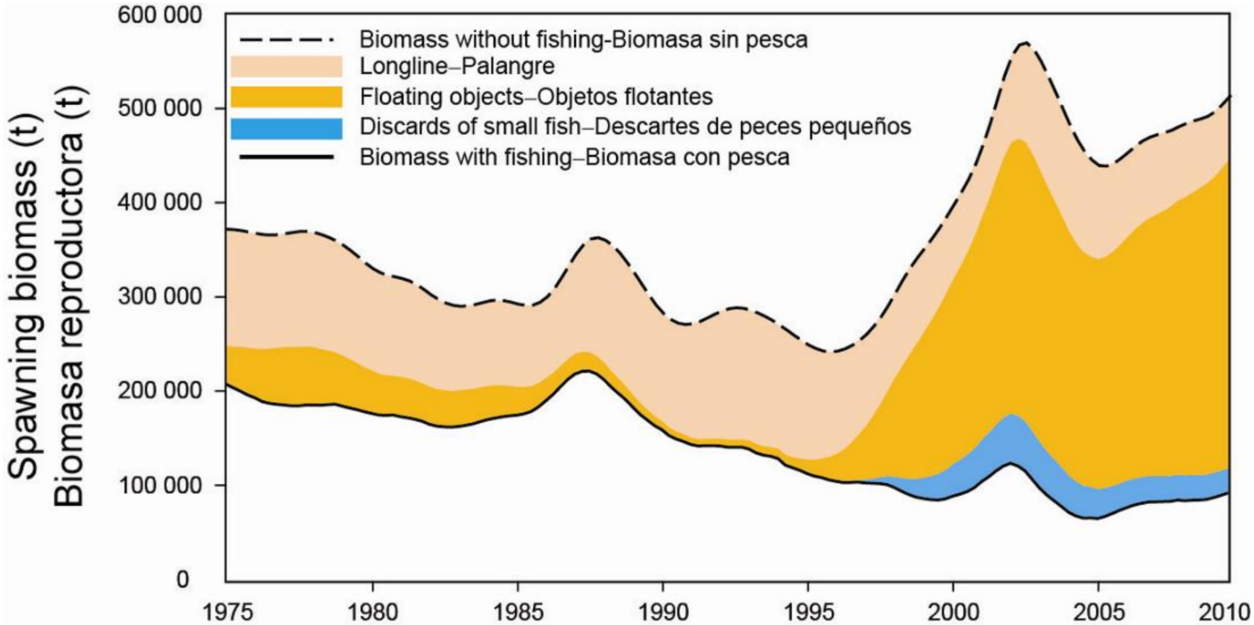


FIGURE D-5. Trajectory of the spawning biomass of a simulated population of bigeye tuna that was not exploited (dashed line) and that predicted by the stock assessment model (solid line). The shaded areas between the two lines show the portions of the fishery impact attributed to each fishery.

FIGURA D-5. Trayectoria de la biomasa reproductora de una población simulada de atún patudo no explotada (línea de trazos) y la que predice el modelo de evaluación (línea sólida). Las áreas sombreadas entre las dos líneas señalan la porción del impacto de la pesca atribuida a cada método de pesca.

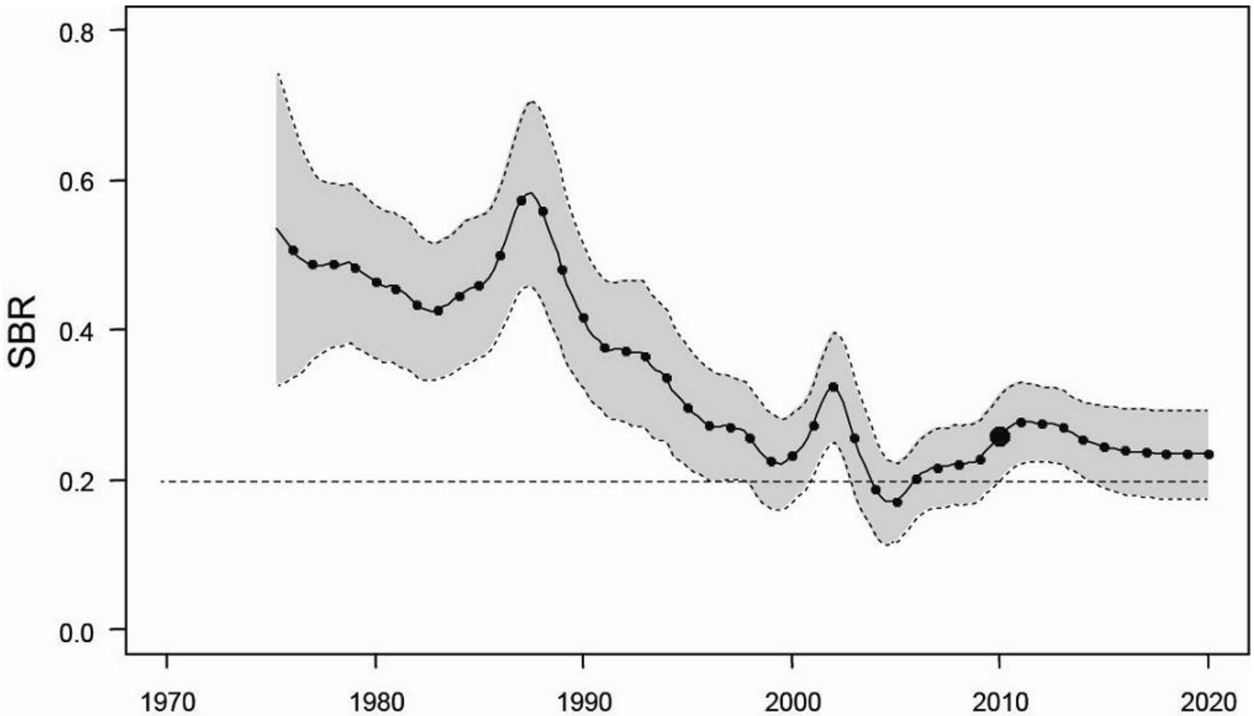


FIGURE D-6. Estimated spawning biomass ratios (SBRs) for bigeye tuna in the EPO. The dashed horizontal line (at about 0.19) identifies the SBR at MSY. The solid curve illustrates the maximum likelihood estimates, and the estimates after 2009 (the large dot) indicate the SBR predicted to occur if fishing mortality rates continue at the average of that observed during 2006-2008. The dashed lines are the 95-percent confidence intervals around these estimates.

FIGURA D-6. Cocientes de biomasa reproductora (SBR) estimados del atún patudo en el OPO. La línea de trazos horizontal (en aproximadamente 0.19) identifica el SBR en RMS. La línea sólida ilustra las estimaciones de verosimilitud máxima, y las estimaciones a partir de 2009 (el punto grande) señalan el SBR predicho si las tasas de mortalidad por pesca continúan en el promedio observado durante 2006-2008. Las líneas de trazos representan los límites de confianza de 95% de las estimaciones.

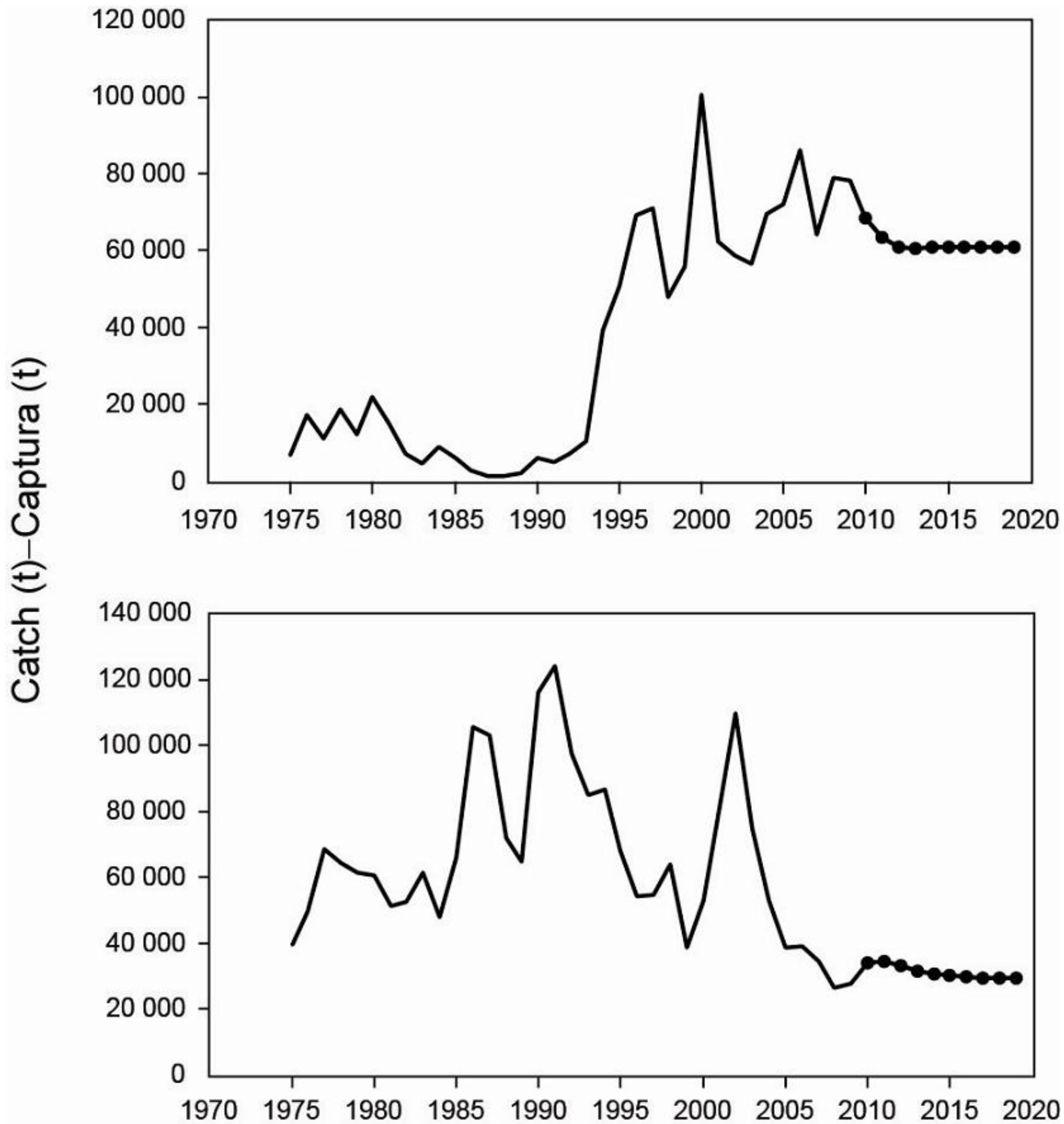


FIGURE D-7. Catches for 1975-2008, and predicted catches for 2009-2018, of bigeye tuna by the purse-seine and pole-and-line (upper panel) and longline (lower panel) fisheries. The predicted catches are based on average fishing mortality during 2006-2008.

FIGURA D-7. Capturas de atún patudo durante 1975-2008, y predichas para 2009-2018, por las pesquerías de cerco y de caña (recuadro superior) y de palangre (recuadro inferior). Las capturas predichas se basan en la mortalida por pesca promedio durante 2006-2008.

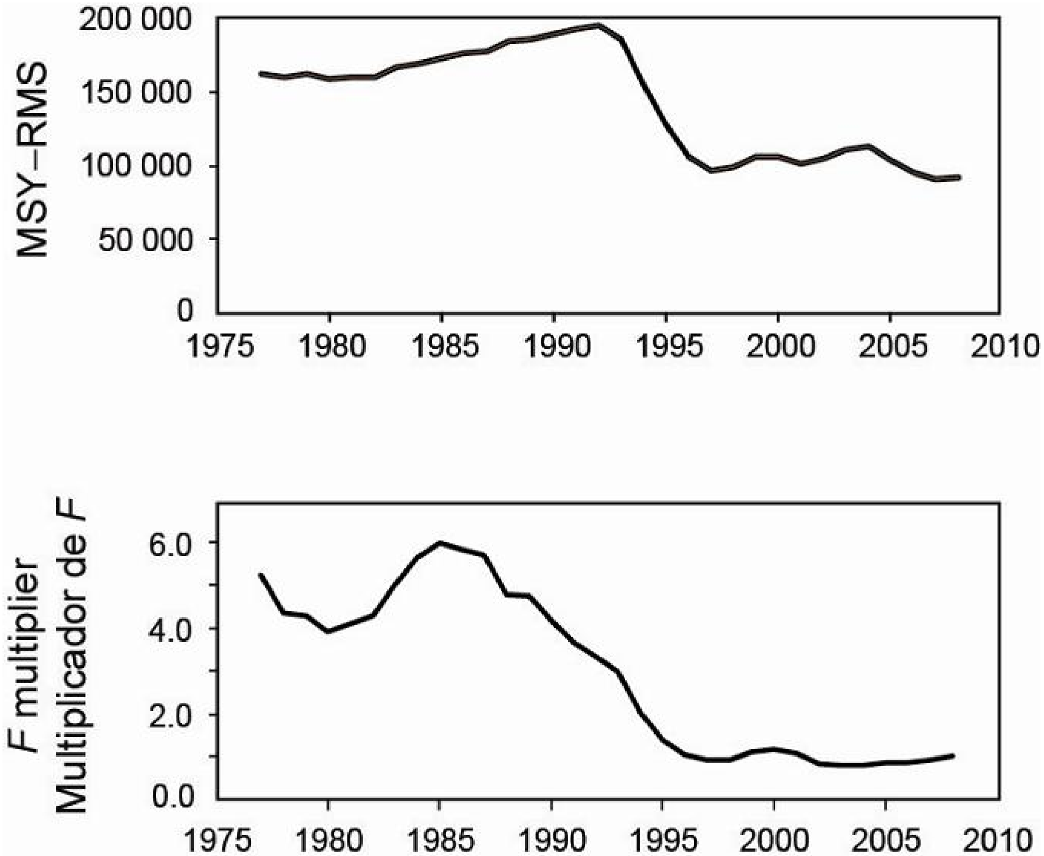


FIGURE D-8. MSY (upper panel) and the change (increase or reduction) in the effort required to produce the MSY (lower panel) for bigeye tuna, estimated separately for each year, using the average age-specific fishing mortality for that year.

FIGURA D-8. RMS (recuadro superior) y cambio (aumento o reducción) del esfuerzo necesario para producir el RMS (recuadro inferior), de atún patudo, estimado por separado para cada año, usando la mortalidad por pesca promedio por edad de ese año.

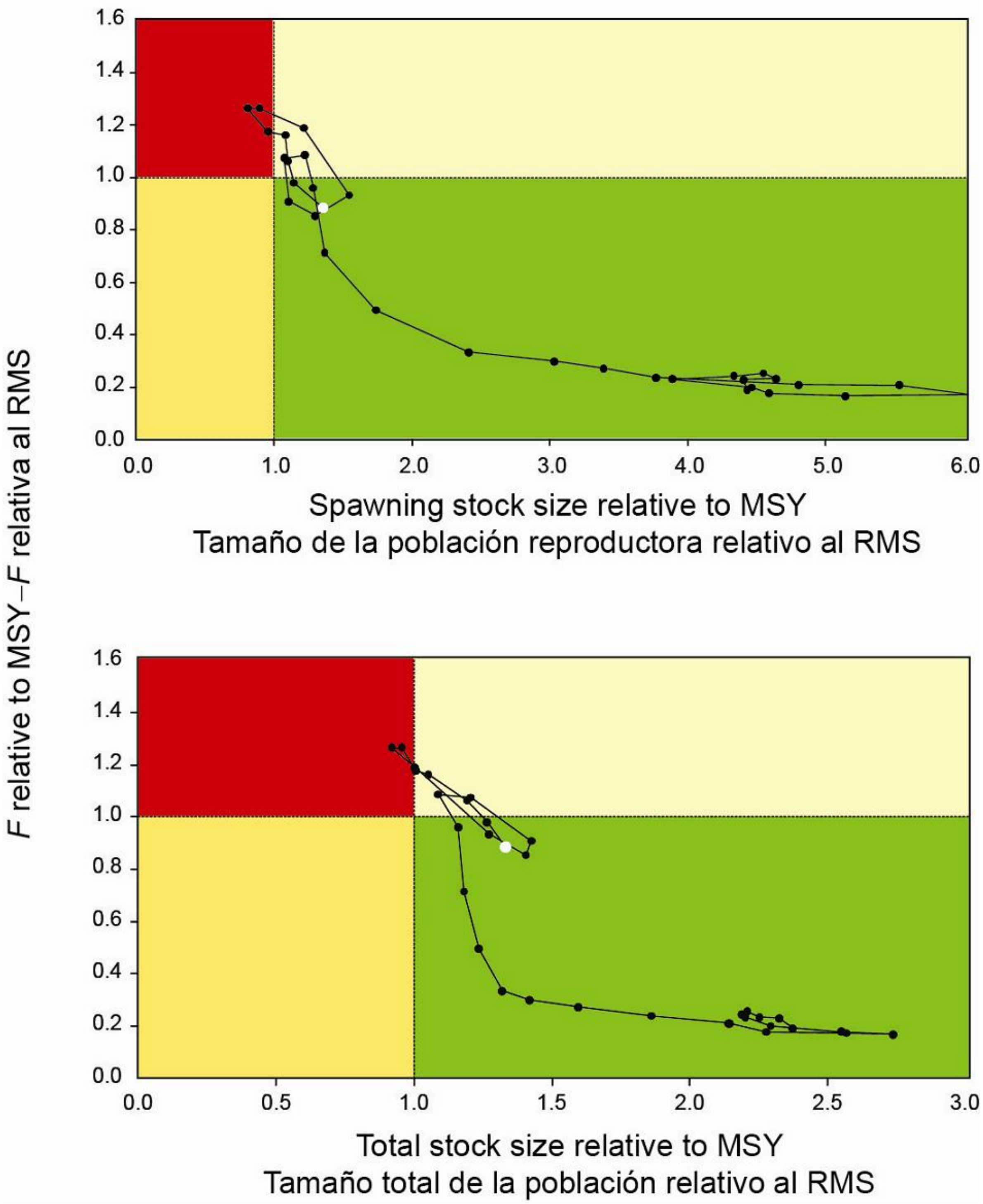


FIGURE D-9. Phase plot of the time series of estimates of stock size (top: spawning biomass, *S*; bottom: total biomass, *B*) and fishing mortality (*F*) of bigeye relative to their MSY reference points. Each dot is based on the average exploitation rate over three years; the large dot indicates the most recent estimate.

FIGURA D-9. Gráfica de fase de la serie de tiempo de las estimaciones del tamaño de la población (arriba: biomasa reproductora, *S*; abajo: biomasa total, *B*) y la mortalidad por pesca (*F*) de atún patudo en relación con sus puntos de referencia de RMS. Cada punto se basa en la tasa de explotación media de tres años. El punto grande indica la estimación más reciente.

TABLE 5.1. 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 2007-2009. B_{recent} and B_{MSY} are defined as the biomass of fish 3+ quarters old (in metric tons) at the beginning of 2010 and at MSY, respectively. S_{recent} and S_{MSY} are in metric tons. C_{recent} is the estimated total catch in 2009. 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 2007-2009.

TABLA 5.1. 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 2007-2009. Se definen B_{recent} y B_{RMS} como la biomasa de peces de 3+ trimestres de edad (en toneladas métricas) al principio de 2010 y en RMS, respectivamente. Se expresan S_{recent} y S_{MSY} en toneladas métricas. C_{recent} es la captura total estimada en 2009. 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 2007-2009.

		Appendix-Anexo						
		A	B		C		D	
	Base case-Caso base	h = 0.75	L_2		Adult *M*-*M* adulto		Data-Datos 1995-2009	
			170 cm	200 cm	Sens *M*1	Sens *M*5	h=1	h=0.75
MSY-RMS	90,538	86,321	114,492	86,001	88,294	113,917	115,781	141,283
B_{MSY}- B_{RMS}	332,331	582,233	428,532	306,662	516,205	375,778	418,608	928,017
S_{MSY}- S_{RMS}	73,690	145,123	94,287	67,789	145,753	75,696	92,177	230,675
B_{MSY}/B_0- B_{RMS}/B_0	0.25	0.34	0.24	0.27	0.27	0.25	0.25	0.34
S_{MSY}/S_0- S_{RMS}/S_0	0.19	0.30	0.19	0.21	0.26	0.19	0.20	0.30
C_{recent}/MSY- C_{recent}/RMS	1.17	1.23	0.91	1.24	1.21	0.92	0.92	0.75
B_{recent}/B_{MSY}- B_{recent}/B_{RMS}	1.33	0.95	1.93	0.85	0.42	1.86	0.91	0.51
S_{recent}/S_{MSY}- S_{recent}/S_{RMS}	1.33	0.88	2.06	0.74	0.33	2.02	0.87	0.46
F multiplier- Multiplicador de *F*	1.13	0.83	1.87	0.73	0.45	1.79	1.00	0.73

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 WCPO but not in the EPO, so it is likely that there is a single stock of bluefin in the Pacific Ocean.

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 WCPO 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 WCPO, 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 WCPO.

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 WCPO 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 WCPO 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 WCPO.

An index of abundance for the predominantly young bluefin in the EPO has been calculated, based on standardization of catch per vessel day using a generalized linear model, and including the variables latitude, longitude, SST, SST^2, month, and vessel identification number. The index is highly variable, but shows a peak in the early 1960s, very low levels for a period in the early 1980s, and some increase since that time.

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 2008, and the group has subsequently conducted several workshops in 2009 and 2010, mainly to deal with data updates and modelling improvements. The assessment results were highly sensitive to the assumptions made about biological parameters, particularly natural mortality. A full stock assessment meeting is scheduled for mid-2012.

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 Pacific bluefin tuna 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 Pacific bluefin tuna. 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 the age structure of the fishing mortality into consideration. The indicator is based on calculating 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 calculated for Pacific bluefin tuna based on spawning biomass. The fisheries are grouped into those in the eastern Pacific Ocean (EPO) and those in the western and central Pacific Ocean (WCPO) because setting management guidelines for the EPO is the goal of this analysis. The base case assessment developed by the ISC 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 the respective fishery. This assumes that the impact is measured under the assumption that the impact of the other fisheries is not controlled.

The estimated impact of the fisheries on the Pacific bluefin population for the whole time period modeled (1952-2006) is substantial (Figure E-2). The impact is highly sensitive to the assumed values for natural mortality. The WCPO fisheries have had a greater impact than the EPO fisheries, and their rate of increase in recent years is higher. 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 lower during 1994-2007 than it was during 1970-1993, when the stocks were depleted to a much lower relative size; however, the impact has been increasing recently (Figure E-3). The estimated status of the stock is uncertain, and is sensitive to model assumptions. Catch levels should be set based on those years when the impact was low until the uncertainty in the assessment is reduced. This management measure should ensure that the fishery is sustainable as long as similar measures are taken in the WCPO.

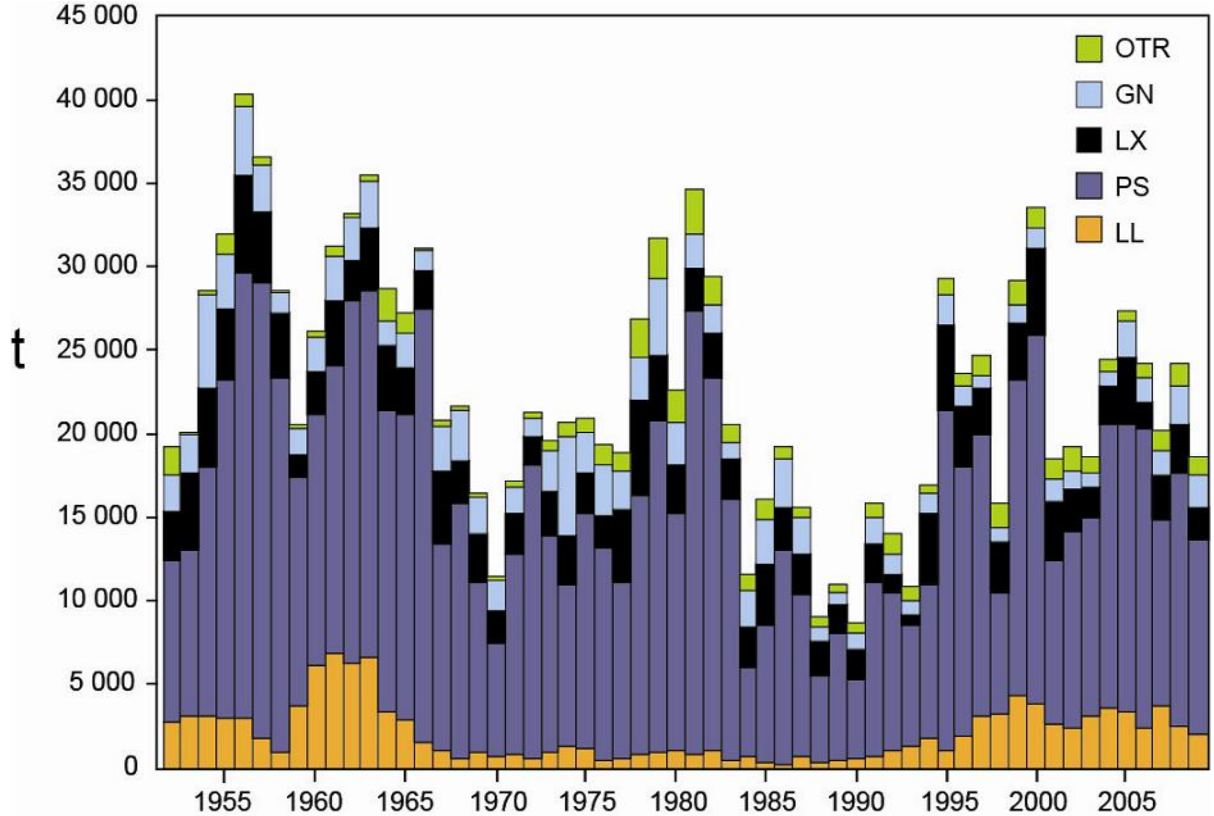


FIGURE E-1. Retained catches of Pacific bluefin.
FIGURA E-1. Capturas retenidas de aleta azul del Pacífico.

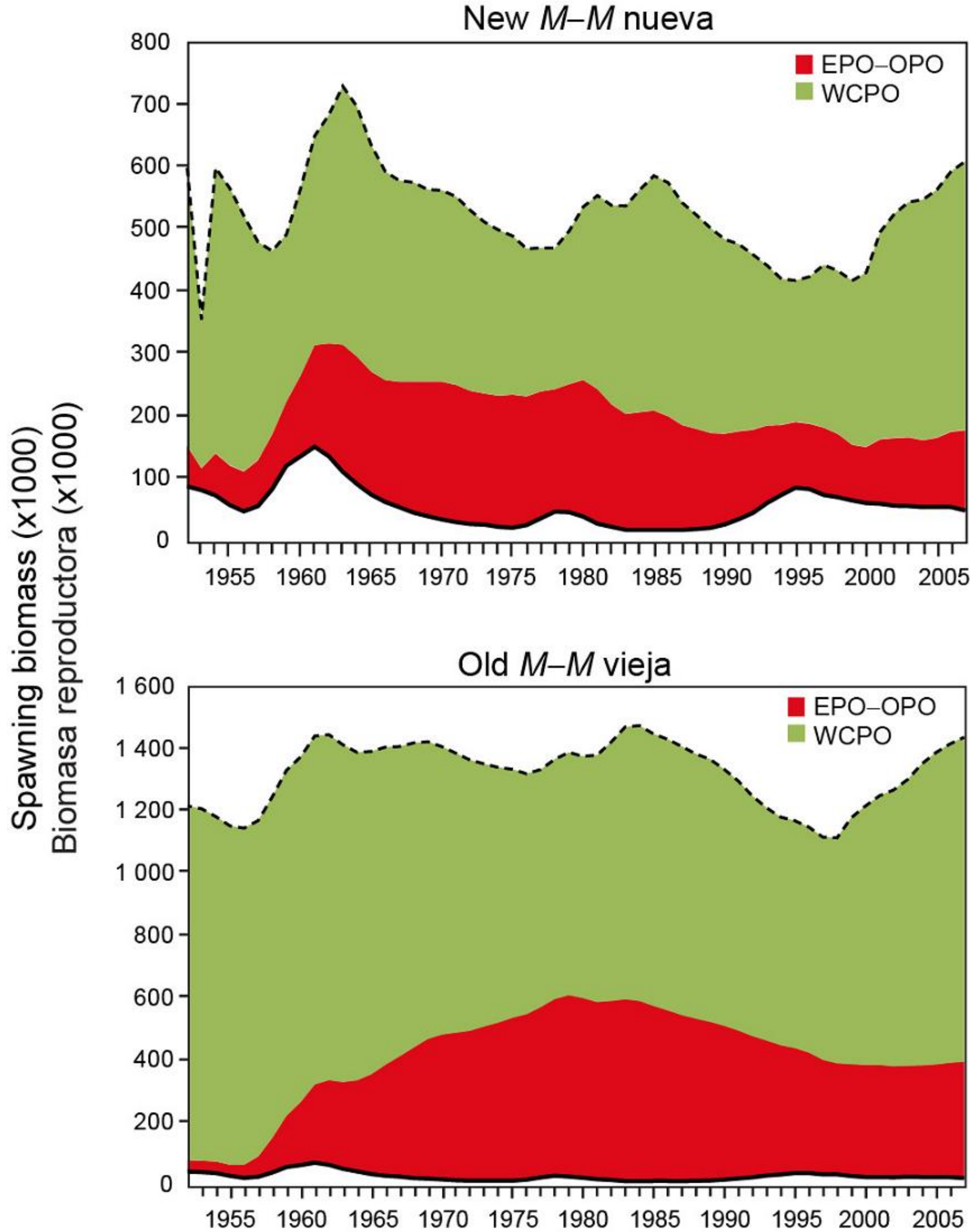


FIGURE E-2. Estimates of the impact on the Pacific bluefin tuna population of fisheries in the EPO and in the WCPO for the new (upper panel) and old (lower panel) values of natural mortality (*M*). The dashed line represents the estimated hypothetical unfished spawning biomass, and the solid line the estimated actual spawning biomass. New *M* = *M* assumed in the current assessment (Ichinokawa *et al*. 2010); 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 WCPO 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 (Ichinokawa *et al*. 2010); *M* vieja = *M* supuesta en la evaluación previa. Las áreas sombreadas indican el impacto atribuido a cada pesquería.

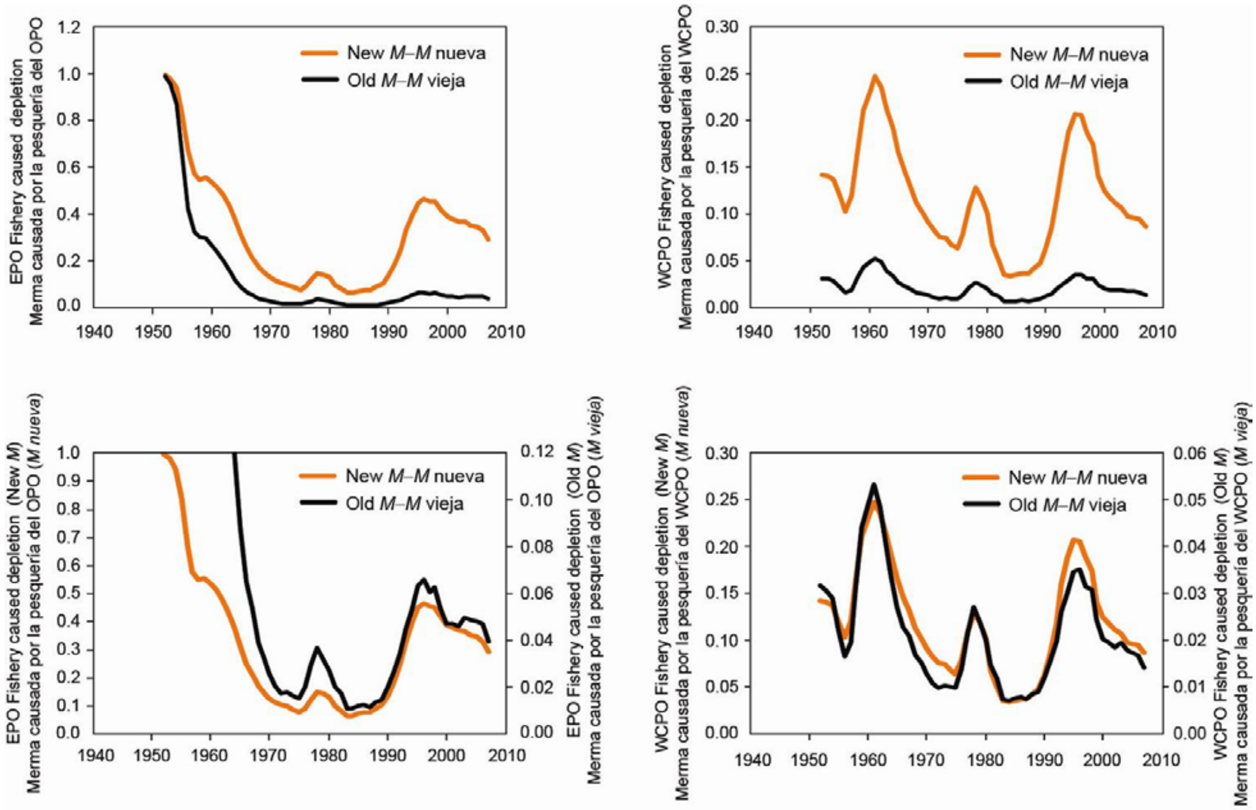


FIGURE E-3. Stock depletion (actual abundance as a fraction of the hypothetical abundance if the fishery were not operating) caused by the EPO fisheries (left) and WCPO fisheries (right) for the new and old values of *M*, on the same scale (top) and on different scales (bottom). Higher values correspond 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 WCPO (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 about38,000 t in1991, and then increased to about 126,000 t in 1999 (Figure F-1a). 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 55,000 to 70,000 t during 2001-2008 (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 2008 and 2006, respectively.

The assessment of South Pacific albacore, which was carried out with MULTIFAN-CL by scientists of the Secretariat of the Pacific Community, incorporated catch and effort, length-frequency, tagging data, and information on biological parameters. Although uncertainties were found to exist, it appeared reasonably certain that the stock was above the level corresponding to the average maximum sustainable yield (MSY), that the effort during 2004-2006 was less than that corresponding to the MSY, and that the spawning biomass was greater than that corresponding to the MSY. There currently appears 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 are recommended.

An assessment of North Pacific albacore 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 November-December 2006. The conclusions reached at that workshop were presented to the seventh plenary meeting of the ISC, held in July 2007. Among these were the following:

- The spawning stock biomass (SSB) in 2006 was estimated to be about 153 thousand t—53% above the long-term average (Figure F-2);
- Retrospective analysis revealed a tendency to overestimate the abundance of albacore;

- Recruitment had fluctuated about a long-term average of roughly 28 million fish during the 1990s and early 2000s;
- The current coefficient of fishing mortality (*F*), calculated as the geometric mean of the estimates for 2002-2004, was about 0.75, which is high relative to several biological reference points to which Working Group compared its estimate for albacore;
- The SSB was forecast to decline to an equilibrium level of about 92 thousand t by 2015;
- The substantial decline in total catch during recent years is cause for concern;
- In conclusion, the Working Group recommended that all nations participating in the fishery observe precautionary-based fishing practices.

Additional meetings of the Albacore Working Group took place in 2008, 2009, and 2010 These workshops were devoted mostly to discussion of data requirements and transition of assessments from Virtual Population Analysis to Stock Synthesis II. A full stock assessment meeting is scheduled for mid-2011.

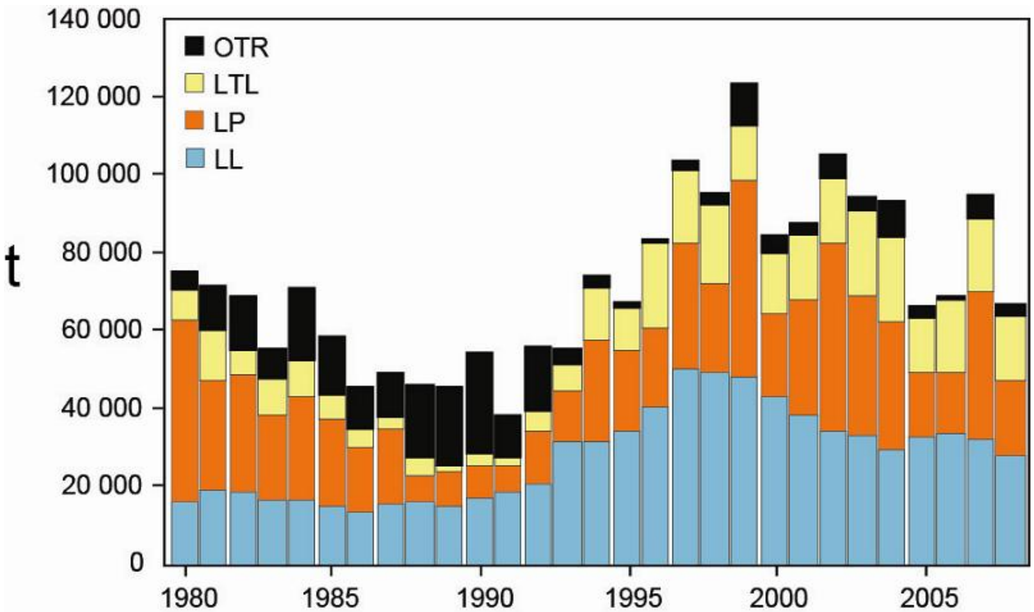


FIGURE F-1a. Retained catches of North Pacific albacore.
FIGURA F-1a. Capturas retenidas de albacora del Pacífico norte.

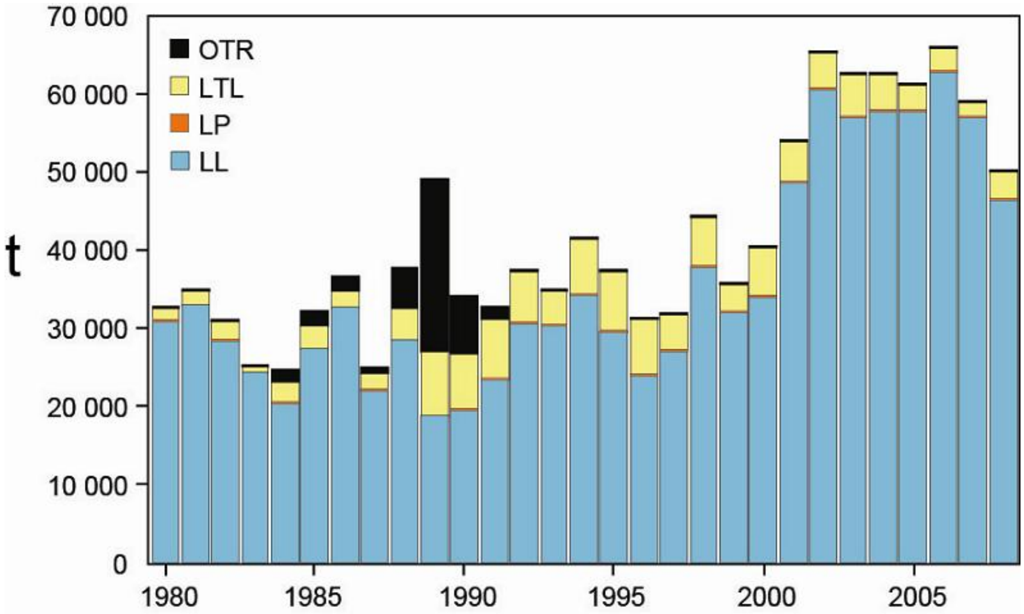


FIGURE F-1b. Retained catches of South Pacific albacore.
FIGURA F-1b. Capturas retenidas de albacora del Pacífico sur.

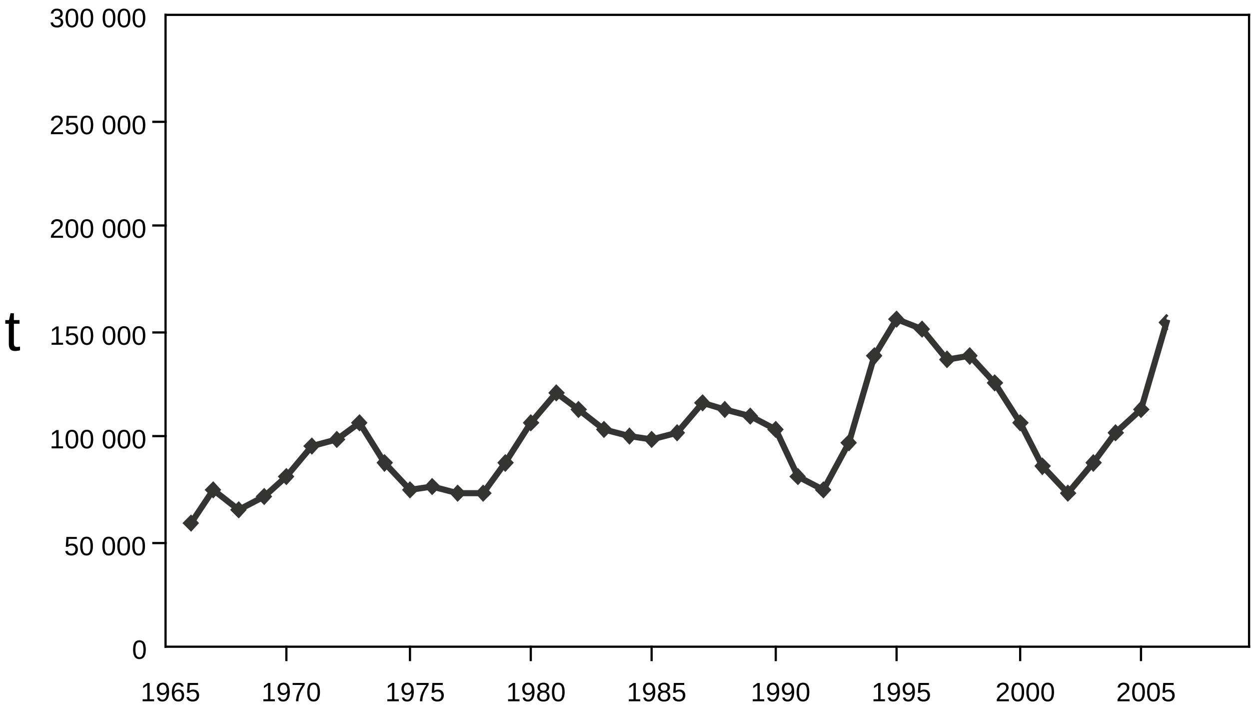


FIGURE F-2. Spawning stock biomass of North Pacific albacore tuna, from the North Pacific Albacore Workshop analysis of 2006
FIGURA F-2. Biomasa de la población reproductora del atún albacora del Pacífico Norte, de los análisis de la Reunión Técnica sobre el Albacora del Pacífico Norte de 2006.

G. SWORDFISH

Swordfish 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. During the 2005-2008 period the greatest catches in the EPO have been taken by vessels of Spain, Chile, and Japan, which together harvest about 70% of the total swordfish catch taken in the region. All three have fisheries that target swordfish, though much of the swordfish taken in the Japanese fishery are incidental catches of a fishery that targets predominantly bigeye tuna. Other nations with fisheries known to target swordfish are Mexico and the United States.

Swordfish reach maturity at about 5 to 6 years of age, when they are about 150 to 170 cm in length. They probably spawn more than once per season. Unequal sex ratios occur frequently. 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. Swordfish larvae have been found only at temperatures exceeding 24°C.

The best available scientific information from genetic and fishery data indicate that the swordfish of the northeastern Pacific Ocean and the southeastern Pacific Ocean (south of 5°S) constitute two distinct stocks. Also, there may be movement of a northwestern Pacific stock of swordfish into the EPO at various times.

The results of preliminary modeling with MULTIFAN-CL of a North Pacific swordfish stock in the area north of 10°N and west of 140°W indicate that, in recent years, 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 in the northern region (Figure G-1), it appears that swordfish are not overfished in the northern region of the EPO.

An assessment of the southern stock of swordfish in the EPO was carried out with Stock Synthesis II (SS2: Ver.1.23b) in 2006 and produced the following results. The population has undergone considerable changes in biomass and is currently at a moderate level of depletion. There was strong evidence of one or two large cohorts entering the fishery recently, but their strengths were uncertain. The trend in spawning biomass ratio (the ratio of the spawning biomass of the current stock to that of the unfished stock; SBR) for this stock was estimated to have been between about 0.5 and 0.9 during the entire period of monitoring (1945-2003), and to have decreased to its lowest levels during the mid-1960s and again during the mid-1990s.

The MSY for the southern EPO swordfish stock was estimated to be about 13,000-14,000 t, and the SBR at MSY to be about 0.26. The spawning biomass was estimated to be well above the biomass corresponding to the MSY.

The average annual catch from the this stock during 1993-2000 was about 7,000 t (range ~ 4,800-8,700 t). It rose to a peak of about 15,000 t in 2002, then declined to about 6,000 t (Figure G-1), which is less than the estimated MSY catch. It is not expected that catch levels on the order of those observed in the early 2000s would be sustainable.

No attempts have been made to estimate the level of MSY that could be obtained by each fishery operating exclusively. However, it is likely that the fisheries that capture younger fish (*e.g.* the longline fisheries of Chile, Japan, and Spain) are less efficient at maximizing yield.

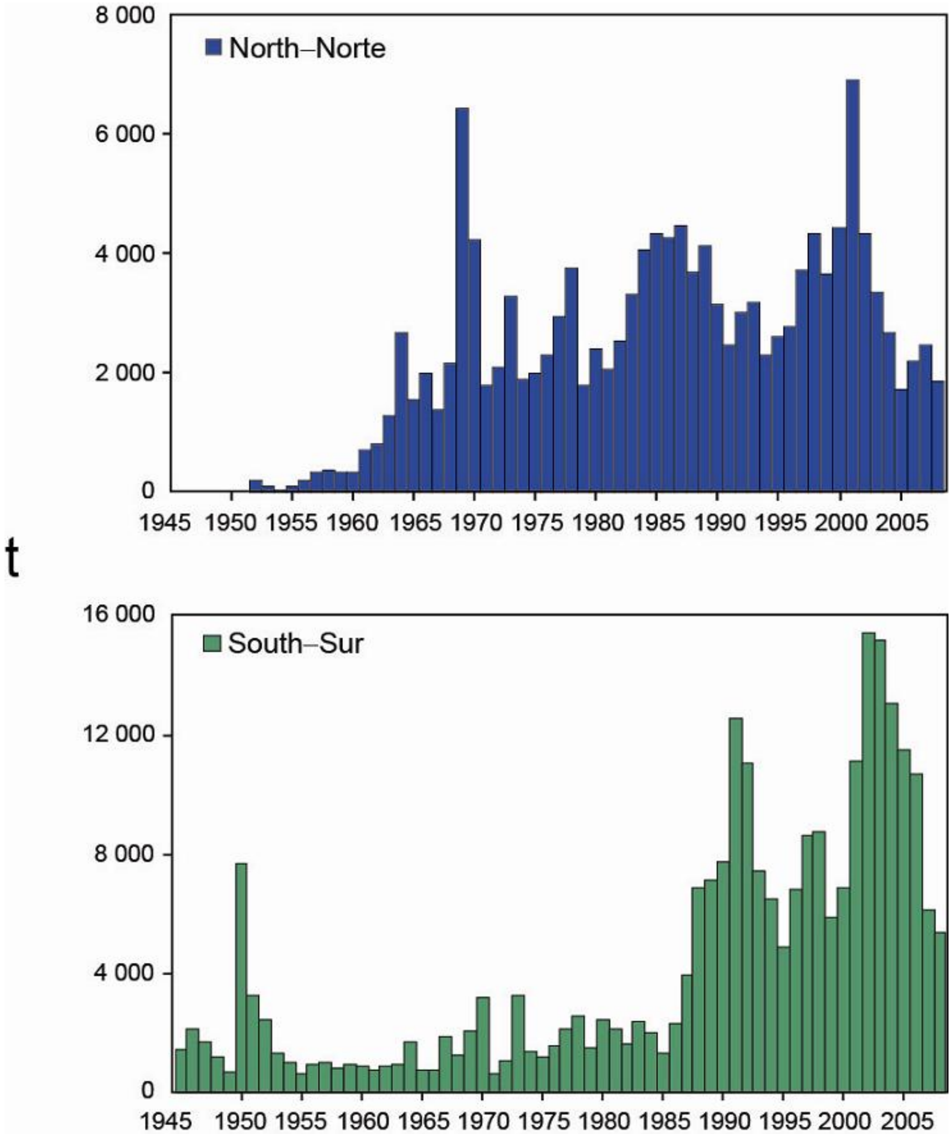


FIGURE G-1. Retained catches of swordfish in the eastern Pacific Ocean, by stock (north and south).
FIGURA G-1. Capturas retenidas de pez espada en el Océano Pacífico oriental, por población (norte y sur).

H. BLUE MARLIN

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

Blue marlin are taken mostly by longline vessels of many nations that fish for tunas and billfishes between about 50°N and 50°S. Lesser amounts are taken by recreational fisheries and by various other commercial fisheries.

Small numbers of blue marlin have been tagged, mostly by recreational fishermen, with conventional tags. A few of these fish have been recaptured long distances from the locations of release. In addition, blue marlin have been tagged with electronic tags and their activities monitored for short periods of time.

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.

It has been over a decade since the data for blue marlin were updated in order to conduct an assessment of the stock. The two most recent analyses of the status of blue marlin in the Pacific Ocean used the same data series, which included data through 1997. The first of these was an analysis using the Deriso-Schnute delay-difference population dynamics model, a form of production model. The data used for this assessment were the estimated annual total retained catches for 1951-1997 and the indices of catch-per-unit-of-fishing-effort for the Japanese longline fishery for 1955-1997. It was concluded that the levels of biomass and fishing effort were near those corresponding to the maximum sustainable yield (MSY).

The second analysis, which was presented in 2003, used data from the same years, but used the MULTIFAN-CL stock assessment model. The results indicated that there was considerable uncertainty regarding the levels of fishing effort that would produce the MSY. It was also estimated 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.

Even though blue marlin are a single stock in the Pacific Ocean, it is important to know how the catches in the eastern Pacific Ocean (Figure H-1) have varied over time. The fisheries in the eastern Pacific Ocean (EPO) have historically captured about 10 to 18% of the total harvest of blue marlin from the Pacific Ocean, with average annual catches since 2002 of about 3,600 t.

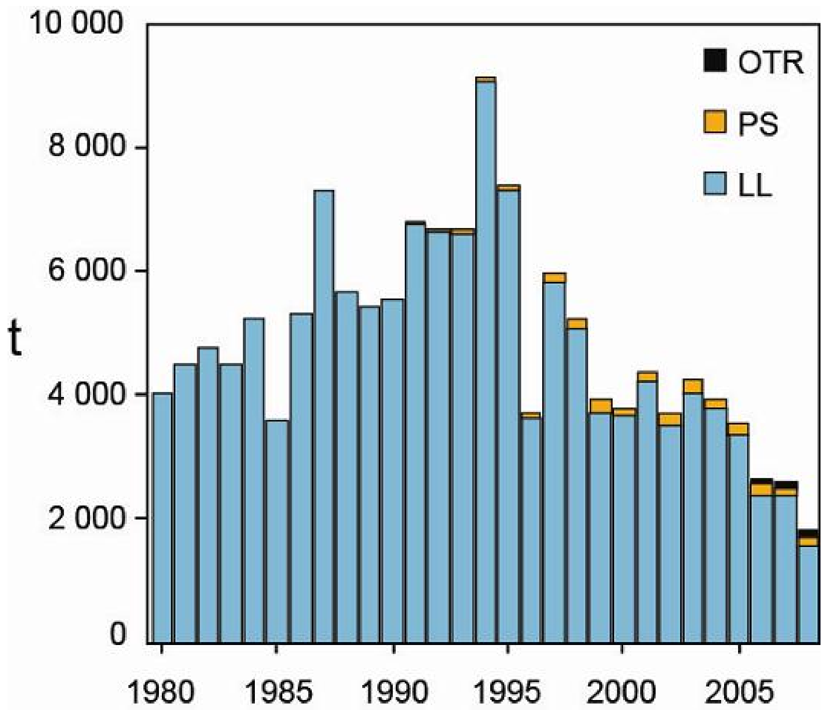


FIGURE H-1. Retained catches of blue marlin in the eastern Pacific Ocean, by gear type.
FIGURA H-1. Capturas retenidas de marlín azul en el Océano Pacífico oriental, por arte de pesca.

I. STRIPED MARLIN

This section presents information on the assessment of the stock of striped marlin in the eastern Pacific Ocean (EPO) north of 5°S (northern EPO), as well as general information on striped marlin. Data on catches (Figure I-1) made by longline and recreational fisheries were updated to 9 September 2010.

Striped marlin occur throughout the Pacific Ocean between about 45°N and 45°S. They are caught mostly by the longline fisheries of Far East and Western Hemisphere nations and by recreational fisheries. Lesser amounts are caught by gillnet and other fisheries. During recent years, the greatest commercial catches in the EPO have been taken by the fisheries of Chinese Taipei, French Polynesia, and Japan.

The principal recreational fishery for striped marlin in the EPO is that of Mexico, where commercial fishing for marlin and other billfish species is prohibited. These species are reserved for recreational fisheries within a zone extending up to 50 miles from the Pacific coast of Mexico. Most of the striped marlin caught in these fisheries are released, but some are landed, usually when a fisherman decides to take his catch home or when a fish dies during the capture process. Another category of landings occurs in catch-and-release recreational fisheries; these landings are the unobserved, or cryptic, mortalities that occur when a fish dies following its release. Results of tagging experiments using pop-up satellite tags suggest a mortality rate of about 25 percent for fish released in the recreational fishery.

In the case of the recreational fisheries of Mexico, the proportion of the catch that is released has increased over time. The recent release rate reported by the fishery is 93 percent, while the comparative rate from scientific sampling is 75 percent. The lowest release rate observed by sampling is about 72 percent, observed in 1999, the first year of sampling. Therefore, lacking data on release rates prior to 1999, it was assumed that the release rate for catches made during 1990-1998 was 70 percent. There are no data available on total catch or landings by the recreational fishery prior to 1990.

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-up satellite tags indicated that there is essentially no mixing of tagged fish among tagging areas, and that striped marlin maintain site fidelity.

Significant effort has been devoted to understanding the stock structure of striped marlin in the Pacific Ocean. It has been clear for some years that there are a number of stocks, and the 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.

This assessment is the first following stock-structure research that confirmed the presence and general distribution of this northern EPO stock. The base case is an age-structured assessment with catch in biomass (t) conducted using Stock Synthesis (Version 3.10.b), which allows integration of multiple categories of data from fisheries, *e.g*. catch, effort, and sampled distributions of the catch by size or age, as well as ancillary data which might affect population parameters and dynamics.

This assessment incorporates data on total landings by fishery, catch rates (CPUE: catch-per-unit-effort) from longline fisheries of Japan, and length measurements of fish taken by the longline and purse-seine fisheries of the northern EPO. Data on growth and age and weight at length were also used to convert lengths of fish to estimates of weight and age. The age selectivity and retention of each of the fisheries in the model for which length-frequency data are available is estimated as part of the fitting process, providing an indicator of the portion of the population exploited by age, gear, and area. The northern EPO was divided into three subareas for the assessment (Figure I-1), and a standardized CPUE, which provides an index of abundance, was determined for each, using data from Japanese longline fisheries. Six fisheries were defined in the model: F1, F2, and F3 are the longline fisheries of Japan in areas 1, 2, and 3; F4 is the other longline fisheries of the EPO; F5 is the recreational fishery of Mexico; and F6 is the EPO purse-seine fishery. Total catch was compiled for each of these fisheries (Figure I-2). When fitted, the model provides estimates of the selectivity of each of the fisheries based on the size- or age-frequency data. The estimated age selectivities for longline fisheries and the purse-seine fishery are shown in Figure I-3. Since detailed size-frequency data (the model incorporated length-frequency data in 2-cm intervals) were not available for the recreational fishery, in the base case the selectivity for that fishery was estimated using the selectivity of the longline fishery in Area 3.

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. The shifting patterns of areas fished and changes in the targeting practices of the fisheries increase the difficulties encountered when using fisheries data in analyses of stock status and trends, and these difficulties are intensified in analyses of species which are not principal targets of the fishery. The base case assessment for the northern EPO stock of striped marlin starts in 1975, after the full expansion of the longline fisheries and after the period of targeting in the northern EPO. However, sensitivity analyses were conducted in which the analyses were started in 1954, the first year of catch in the EPO.

A number of assumptions were necessary to the assessment. The model parameter steepness (h) describes the relationship between the expected level of recruitment from a spawning biomass that is 20 percent of the of the unexploited stock. Analyses of tunas and tuna-like species do not indicate that the level of recruitment is related to the level of spawning biomass, so it is normally assumed for these species that recruitment is independent of spawning biomass and that levels are primarily determined by the oceanic environment. This assumption (h = 1.0) was made in the base case model. The estimated annual recruitments from the base case are shown in Figure I-4.

The estimates of the fishing mortality rate (F) from the base case are shown in Figure I-5. These estimates may be influenced by assumptions about selectivity for fisheries for which size-frequency data are not available. In the base case, the selectivity of the recreational fishery was assumed to be the same as that of the longline fishery in the same area. However, the sizes of fish in the recreational fishery are on average somewhat greater than those in the longline fishery. An alternative assumption is that the selectivity of the recreational fishery is best estimated using that of the purse-seine fishery, which also tends to catch fish that are somewhat larger on average than those taken in both the longline and recreational fisheries. The sensitivity of estimates of annual F to assumptions about selectivity is shown in Figure I-5. It is clear from the quite different estimates that detailed size-frequency data for the recreational fisheries are vital to improving the assessment.

The total annual catch from this stock peaked at about 3,300 t in 1997, after which it declined to about 900 t in 2004. Subsequently it increased, averaging about 1,300 t since 2004. The estimated trajectory of the spawning biomass that would have occurred without fishing and that projected by the assessment model, together with an estimate of the impacts attributed to each fishing gear, are shown in Figure I-6. The spawning biomass generally decreased during 1975-2003, although peaks were observed in 1987 and 1997. The spawning biomass reached a low of about 915 t in 2003, and has increased since, with the base case estimate of spawning biomass in 2009 slightly over 1,500 t.

The spawning biomass ratio (SBR: the ratio of observed spawning biomass to spawning biomass in the unexploited stock) for the base case and for two sensitivity analyses with the model starting in 1954, as against 1975 in the base case, are shown in Figure I-7. The SBR had decreased to about 0.18 in 2003, and has since been increasing, to about 0.30 in 2009.

Key results from the base case assessment of striped marlin in the northern EPO

A summary of the estimates of management parameters from the base case, such as MSY, are given in Table I-1.

1. The striped marlin stock in the northern EPO is not overfished.
2. Overfishing is not occurring on the striped marlin stock in the northern EPO.

3. Spawning stock biomass has increased from a low of about 915 t in 2003 to about 1,500 t in 2009.
4. Catch in recent years has been on the order of 1,300 t, about 1,000 t less than the 2,300 t base case estimate of MSY.
5. The spawning biomass ratio (SBR) in 2003 is estimated to have been about 0.18. The SBR estimate for 2009 is about 0.29.
6. The estimated ratio of spawning biomass in 2009 (S_{2009}) to the spawning biomass expected on average to support annual catch at MSY levels (S_{MSY}) is 1.10.
7. The estimated fishing mortality multiplier (F_{mult}) [the factor by which the current level of *F* must be multiplied to bring fishing mortality to the level expected to provide annual harvests at the level of MSY] is 4.96, indicating that current *F* is significantly below the levels expected to produce MSY catch. However, estimates of current *F* are sensitive to assumptions about the selectivity of recreational fisheries. Detailed size-frequency data for recreational fisheries is vital to improving the assessment.
8. If fishing effort and harvests continue at levels near current observed levels, it is expected that the biomass of the stock will continue to increase over the near term.

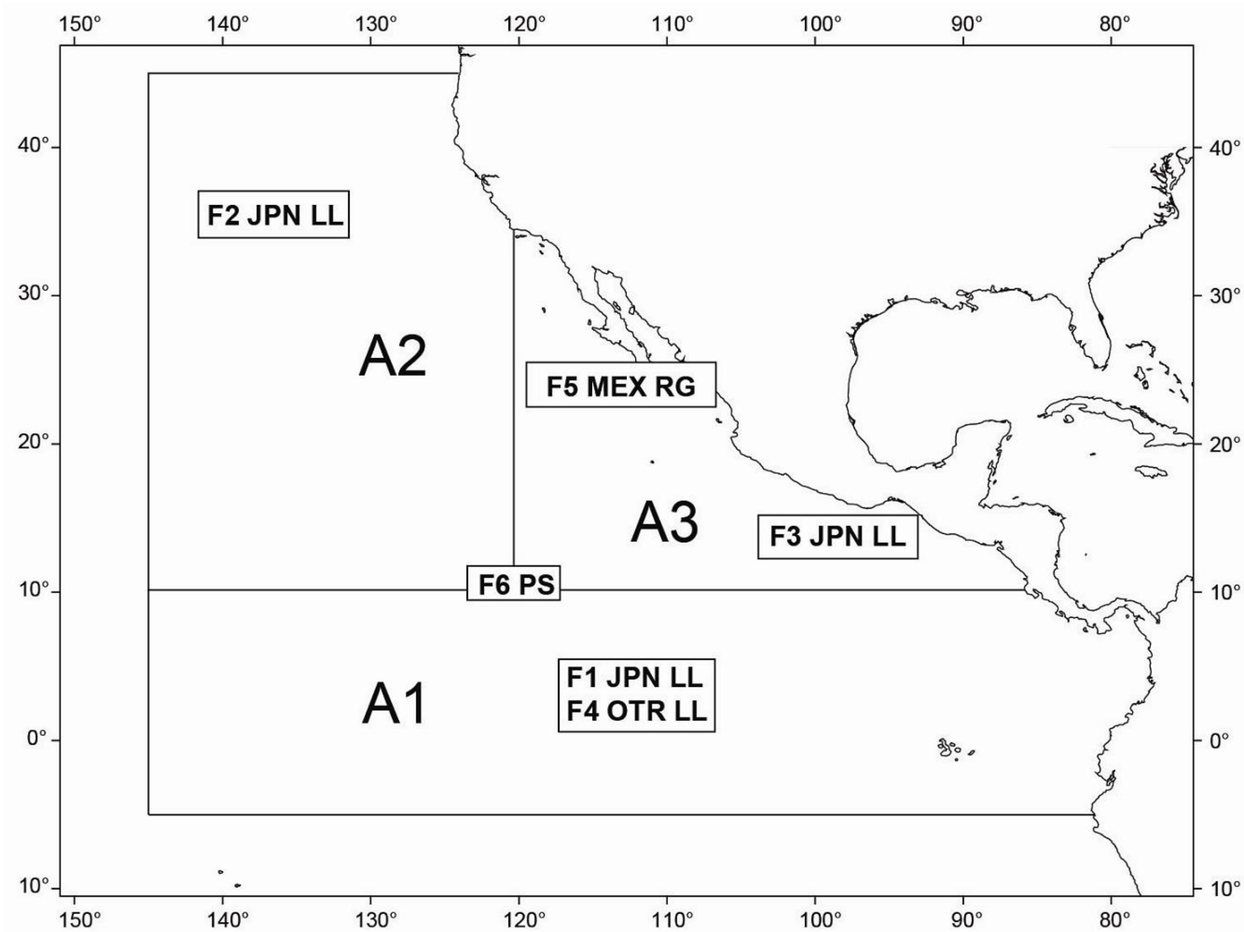


FIGURE I-1. Areas (A1-A3) and fisheries (F1-F6) defined for the base case assessment of striped marlin in the northern EPO. LL: longline; RG: recreational gear. JPN: Japan; MEX: Mexico; OTR: other.
FIGURA I-1. Áreas (A1-A3) y pesquerías (F1-F6) definidas para la evaluación de caso base del marlín rayado en el OPO norte. LL: palangre; RG: arte recreacional. JPN: Japón; MEX: México; OTR: otros.

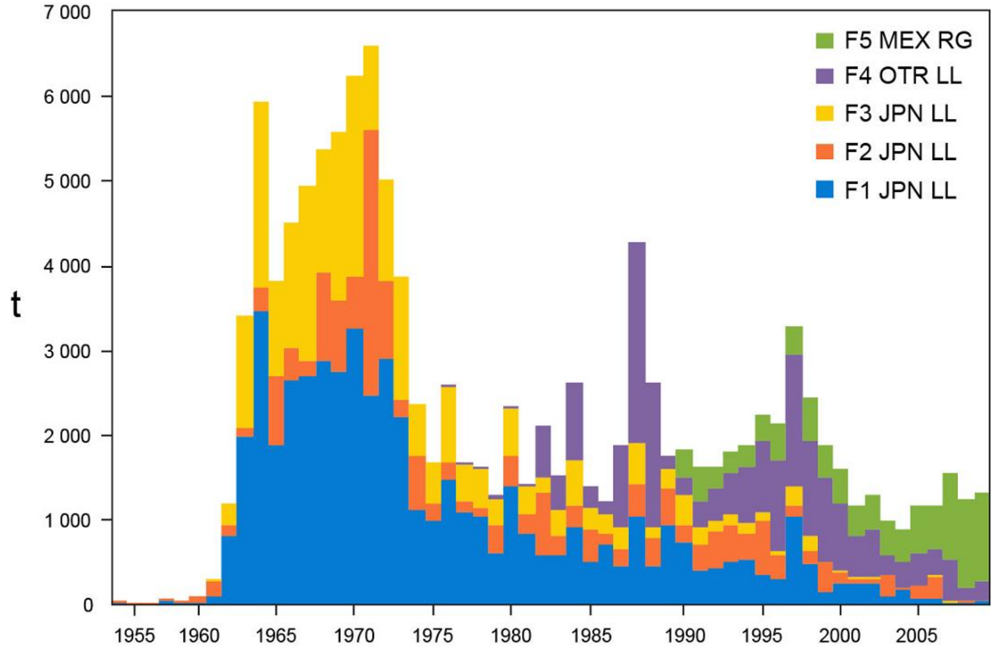


FIGURE I-2. Landings of striped marlin from the northern EPO by the fisheries defined for the base case assessment. LL: longline; RG: recreational gear. JPN: Japan; MEX: Mexico; OTR: other.
FIGURA I-2. Descargas de marlín rayado del OPO norte por las pesquerías definidas para la evaluación de caso base. LL: palangre; RG: arte recreacional. JPN: Japón; MEX: México; OTR: otros.

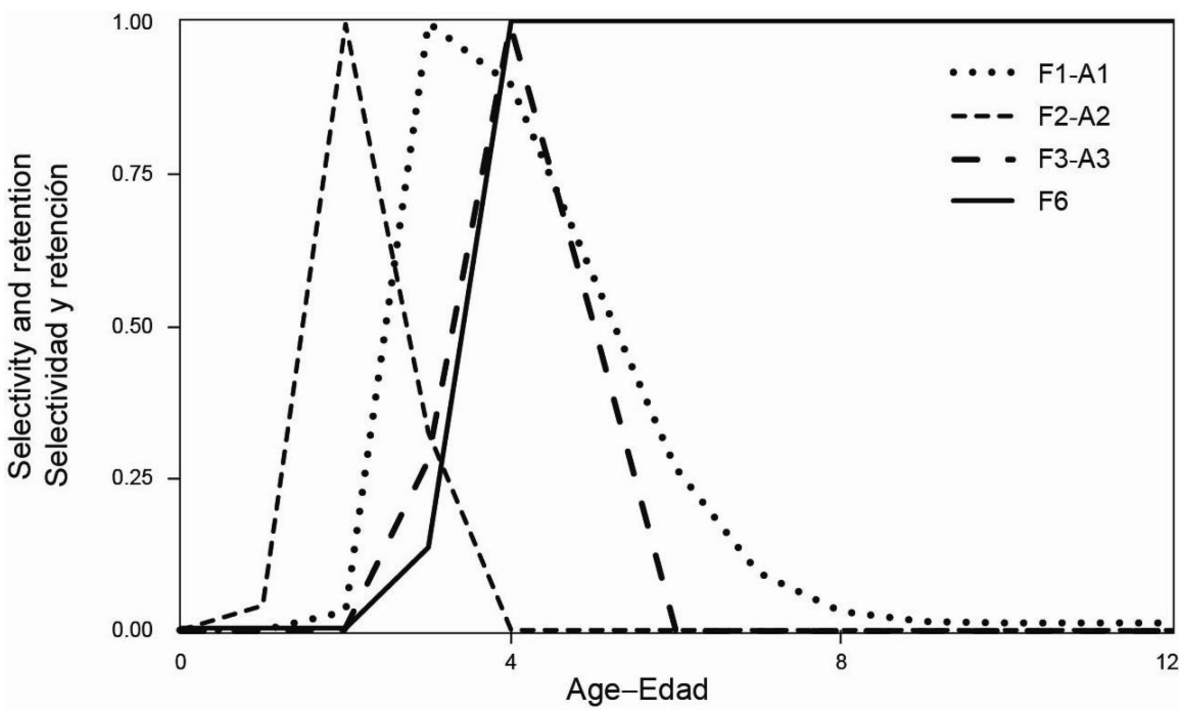


FIGURE I-3. Estimated age selectivity, by fishery, from the base case assessment of striped marlin in the northern EPO.
FIGURA I-3. Selectividad estimada por edad, por pesquería, de la evaluación de caso base del marlín rayado en el OPO norte.

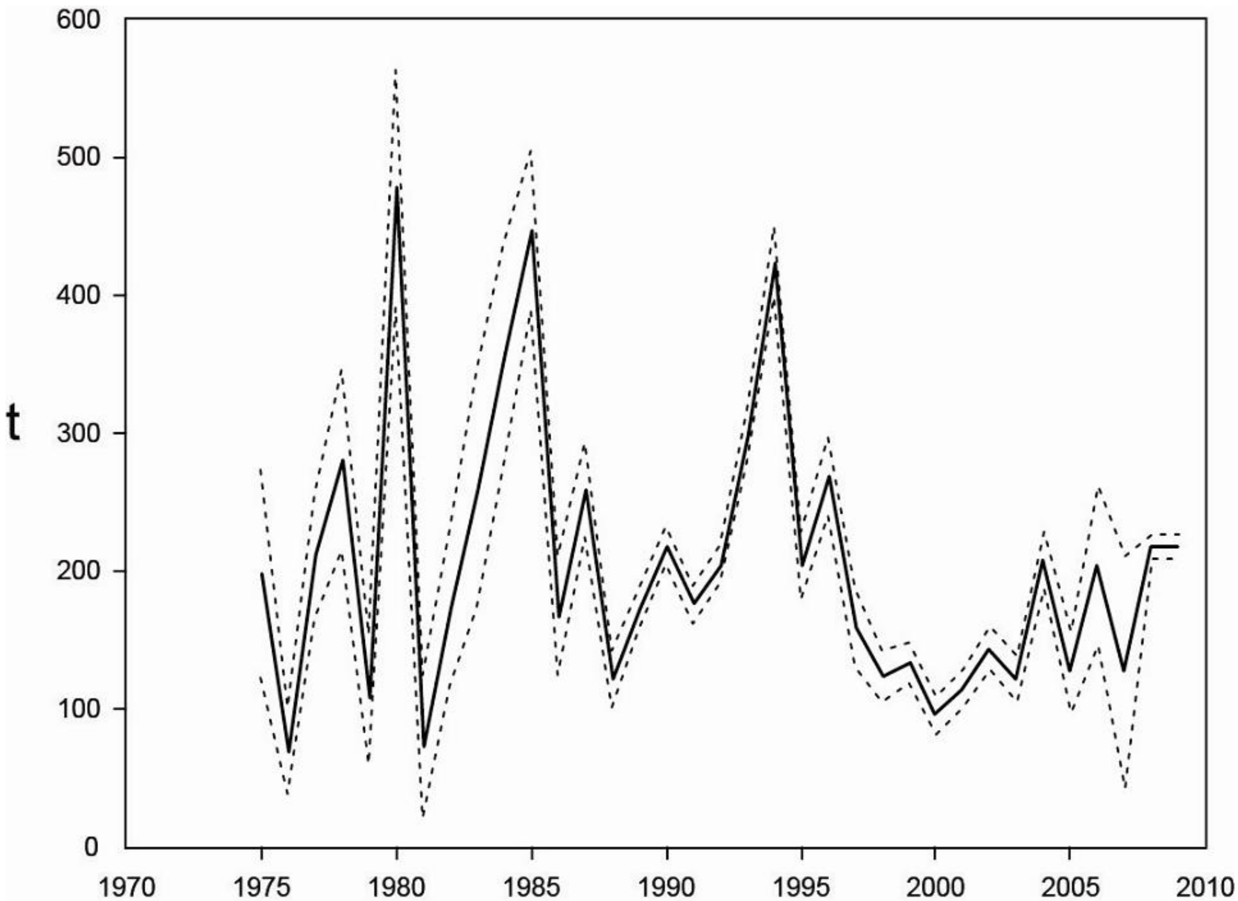


FIGURE I-4. Annual estimates of recruitment (solid line) and approximate 95-percent confidence limits (dashed lines) of striped marlin in the northern EPO, from the base case assessment.

FIGURA I-4. Estimaciones anuales del reclutamiento (línea sólida) y límites de confianza de 95% aproximados (líneas de trazos) de marlín rayado en el OPO norte, de la evaluación de caso base.

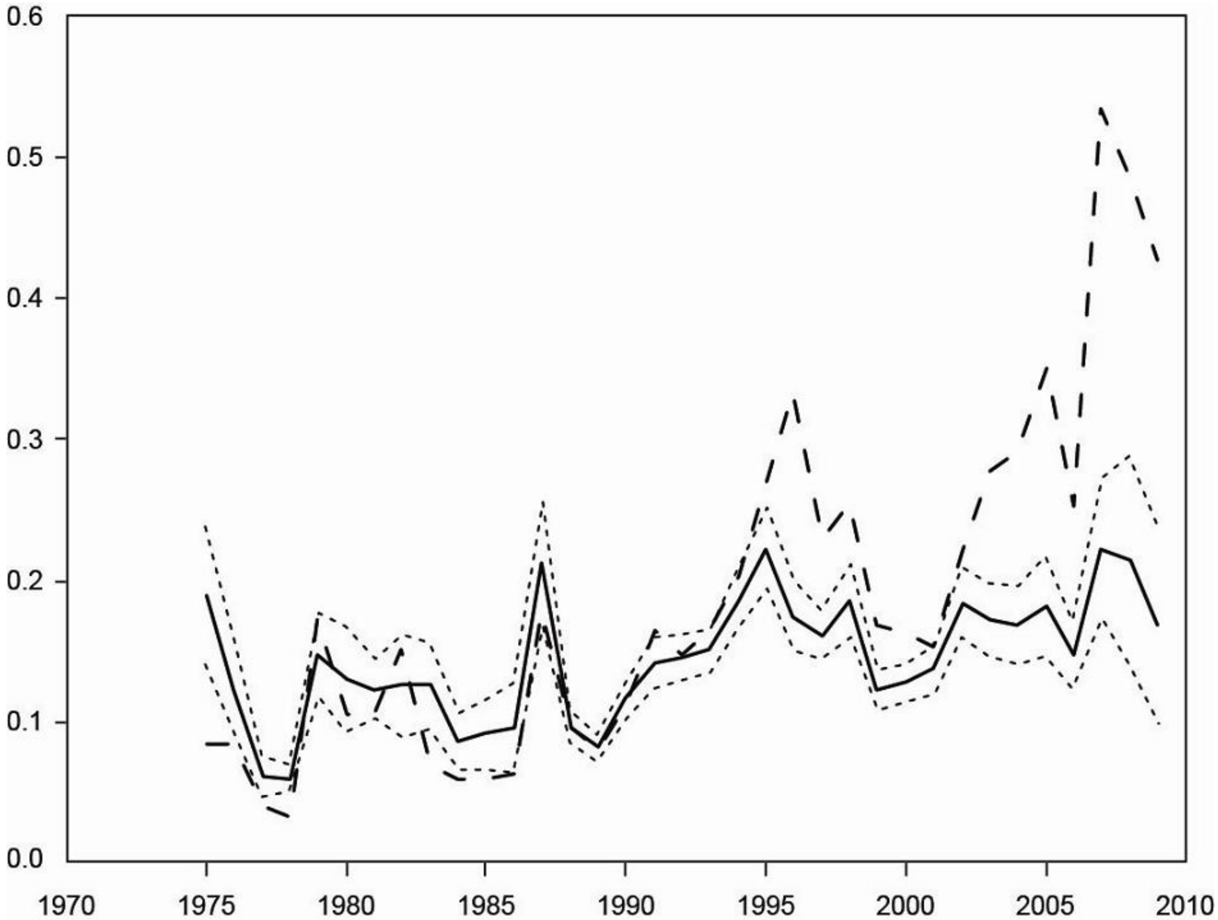


FIGURE I-5. Annual fishing mortality rate (*F*) estimates (solid line) for striped marlin in the northern EPO from the base case assessment, and approximate 95-percent confidence limits (dotted lines). The sensitivity of the assessment to assumptions about selectivity is illustrated by the annual estimates of *F* (dashed line) under the assumption that the selectivity of the recreational fishery is best approximated by that of the purse-seine fishery.

FIGURA I-5. Estimaciones de la tasa anual de mortalidad por pesca (*F*) (línea sólida) de marlín rayado en el OPO norte de la evaluación de caso base, y límites de confianza de 95% aproximados (líneas de trazos). La sensibilidad de la evaluación a los supuestos sobre la selectividad es ilustrada por las estimaciones de *F* (línea de trazos) bajo el supuesto que la mejor aproximación a la selectividad de la pesquería recreacional es aquélla de la pesquería de cerco.

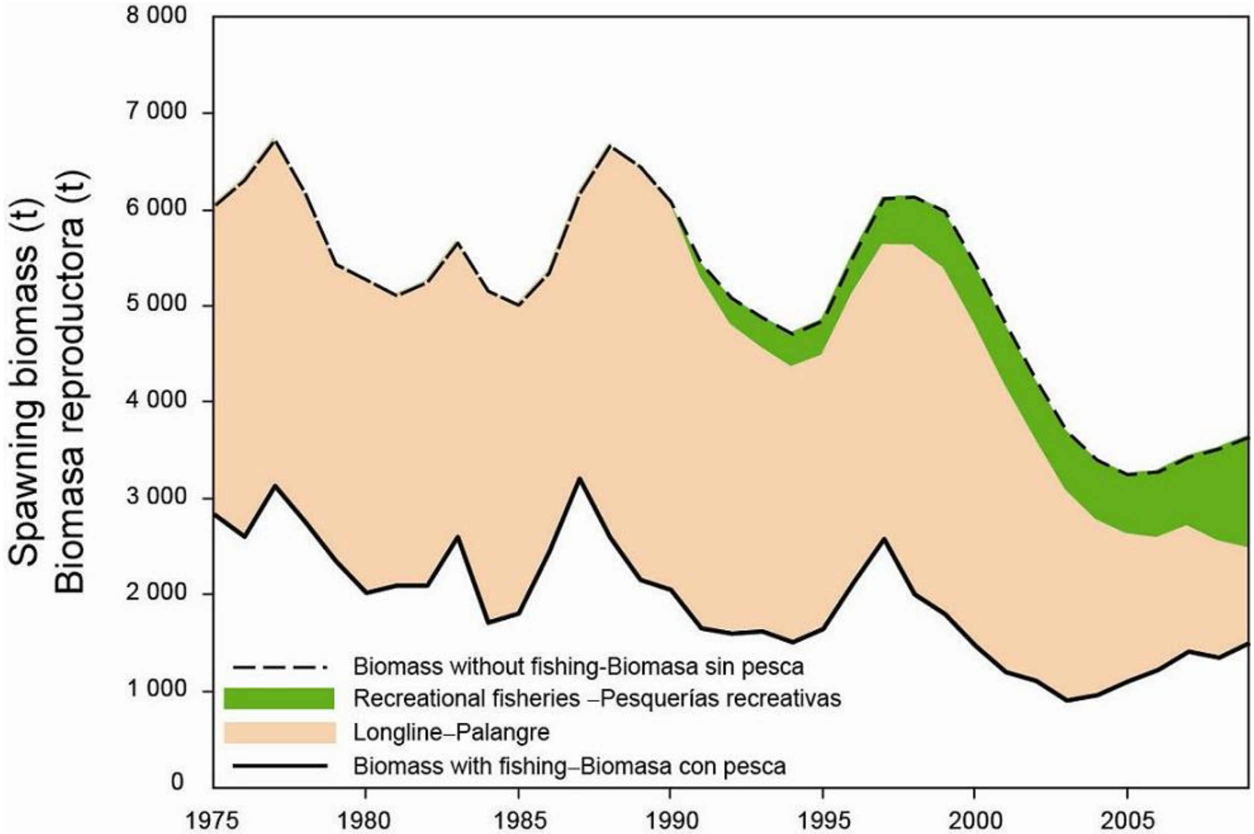


FIGURE I-6. Trajectory of the spawning biomass of a simulated population of striped marlin in the northern EPO that was not exploited (dashed line) and that predicted by the base case stock assessment model (solid line). The shaded areas between the two lines represent the portions of the fishery impact attributed to each fishery.

FIGURA I-6. Trayectoria de la biomasa reproductora de una población simulada de marlín rayado en el OPO norte no explotada (línea de trazos) y aquélla predicha por el modelo de evaluación de caso base (línea sólida). Las áreas sombreadas entre las dos líneas representan la porción del impacto de la pesca atribuida a cada método de pesca.

FIGURE I-7. Estimated spawning biomass ratio (SBR) from the base case assessment of the northern EPO stock of striped marlin from a model starting in 1954 (1954 A) with recruitment deviates starting in 1954, and from a model starting in 1954 (1954 B) with recruitment deviates starting in 1965, so that they start after the period of full expansion of the longline fisheries into the EPO, but before the period of high catches in the early 1970s.

FIGURA I-7. Cociente de biomasa reproductora (SBR) de la evaluación de caso base del marlín rayado en el OPO norte de un modelo que comienza en (1954 A) con desviaciones del reclutamiento que comienzan en 1954, y de un modelo que comienza en (1954 B) con desviaciones del reclutamiento que comienzan en 1965, para que comiencen después del período de expansión plena de las pesquerías de palangre al OPO, pero antes del período de capturas altas a principios de los años 1970.

TABLE I-1. Estimates of the MSY, in metric tons, of striped marlin, and associated management quantities, for the base case assessment (no stock-recruitment relationship, steepness [*h*] = 1). B_{recent} and B_{MSY} are the biomass of striped marlin 2+ years and older at the start of 2009 and at MSY, respectively, and S_{2009}, S_{MSY}, and $S_{F=0}$ are indices of spawning biomass at the start of 2009, at MSY and without fishing, respectively. C_{2009} is the estimated total catch in 2009.

TABLA I-1. Estimaciones del RMS, en toneladas métricas, del marlín rayado, y cantidades de ordenación asociadas, para la evaluación del caso base (sin relación población-reclutamiento, inclinación [*h*] = 1). $B_{reciente}$ y B_{RMS} son la biomasa de marlín rayado de 2+ años de edad al principio de 2009 y en RMS, respectivamente, y S_{2009}, S_{RMS}, y $S_{F=0}$ son índices de la biomasa reproductora al principio de 2009, en RMS y sin pesca, respectivamente. C_{2009} es la captura total estimada en 2009.

	Base case – Caso base
MSY–RMS	2,272
B_{MSY} –B_{RMS}	3,574
S_{MSY} —S_{RMS}	1,372
C_{2009}/MSY—C_{2009}/RMS	0.57
B_{recent}/B_{MSY} –$B_{reciente}/B_{RMS}$	0.96
S_{2009}/S_{MSY} –S_{2009}/S_{RMS}	1.10
$S_{MSY}/S_{F=0}$ –$S_{RMS}/S_{F=0}$	0.27
F multiplier—Multiplicador de *F*	4.96

J. 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.

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 other species that are normally 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 bycatches and discards is also available for large purse-seiners, and for some 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 other documents prepared for this meeting. An ecosystem perspective requires a focus on how the fishery may have altered the components of the ecosystem. The sections of this report noted in sections 2.2 and 2.3 below present 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, bigeye, and skipjack tunas is presented in Sections B-D of this report, and Pacific bluefin and albacore tunas are addressed in Sections E and F, respectively.

2.3. Billfishes

Information on the effects of the tuna fisheries on swordfish, blue marlin, and striped marlin is presented in Sections G-I of this report.

2.3.1. Black marlin, sailfish, 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 and billfishes during 2009 in the EPO are found in Tables A-2a and A-2b.

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 2009 are as follows:

Species and stock	Incidental mortality	
	Number	Metric tons
Offshore spotted dolphin		
Northeastern	264	17
Western-southern	254	17
Spinner dolphin		
Eastern	288	13
Whitebelly	222	13
Common dolphin		
Northern	109	8
Central	30	2
Southern	49	3
Other dolphins[1]	23	1
Total	**1,239**	**75**

[1] "Other dolphins" includes the following species and stocks, whose observed mortalities were as follows: Central American spinner dolphins (*Stenella longirostris centroamericana*) 9 (0.4 t); striped dolphins 24 (1.6 t); coastal spotted dolphins 4 (0.3 t); bottlenose dolphins 4 (0.4 t), unidentified dolphins 8 (0.4 t).

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, or whether either or both of them benefits from the interaction, remain critical pieces of information, given the large biomasses of both groups and their high rates of prey consumption. Diet and stable isotope analyses of yellowfin tuna and spotted and spinner dolphins caught in multispecies aggregations by purse-seine vessels in the EPO demonstrate significant differences in food habits and trophic position of the three species, suggesting that the tuna-dolphin association is probably not maintained by feeding advantages. This conclusion is supported by radio tracking studies of spotted dolphins outfitted with time-depth recorders, which indicate that the dolphins feed primarily at night on organisms associated with the deep scattering layer, while food habits studies of yellowfin tuna show primarily daytime feeding.

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. 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 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.

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. Striped dolphins (*Stenella coeruleoalba*) showed no clear trend in estimated abundance over time, and the estimates of abundance of sperm whales (*Physeter macrocephalus*) have tended to decrease in recent years.

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 8.2.

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. Only one mortality of a leatherback turtle has been recorded during the 10 years that IATTC observers have been recording this information. 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 2009, by set type (on floating objects (OBJ), unassociated schools (NOA), and dolphins (DEL)), are as follows:

	Set type			Total
	OBJ	**NOA**	**DEL**	
Olive Ridley	9	0	2	11
Eastern Pacific green	1	0	0	1
Loggerhead	0	0	0	0
Hawksbill	0	0	0	0
Leatherback	0	0	0	0
Unidentified	2	1	1	4
Total	12	1	3	16

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, and a Pacific-wide analysis of longline and purse-seine fishing is necessary to estimate the impact of fishing on the stock(s). Indices of relative abundance of silky sharks, based on data for purse-seine sets on floating objects, show a decreasing trend during 1994-2004; the trends in unstandardized bycatch per set are 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 show decreasing trends for all three set types during the same period. It is not known whether these decreasing trends are 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.

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 occur 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.

A sampling 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 is 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.

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 fishing mortality may be approaching the MSY level in the future.

Preliminary estimates of the catches (including purse-seine discards), in metric tons, of sharks and other large fishes in the EPO during 2009, other than those mentioned above, by large purse-seine vessels are as follows. Complete data are not available for small purse-seine, longline, and other types of vessels.

	Set type			
	OBJ	**NOA**	**DEL**	**Total**
Sharks	431	36	68	535
Rays (Mobulidae and Dasyatidae)	2	5	17	24
Dorado (*Coryphaena* spp.)	2,408	12	<1	2,421
Wahoo (*Acanthocybium solandri)*	653	<1	<1	654
Rainbow runner (*Elagatis bipinnulata*) and yellowtail (*Seriola lalandi*)	53	46	<1	99
Black skipjack	1,347	3,869	18	5,233
Bonito	21	9,556	0	9,576
Unidentified tunas	7,829	1,204	363	9,396
Unidentified billfishes	13	3	5	22
Other large fishes	301	100	24	426

Apart from blue sharks, there are no stock assessments available for these species in the EPO, and hence the impacts of the bycatches on the stocks are unknown.

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 1994-2009 are shown in Table A-7.

In October 2006, the NMFS hosted a workshop on bycatch reduction in the EPO purse-seine fishery. The attendees agreed to support a proposal for research on methods to reduce bycatches of sharks by attracting them away from floating objects prior to setting the purse seine. A feasibility study has been planned. The attendees 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 proposal, which was likewise supported by the attendees, involves using 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.

3. OTHER ECOSYSTEM COMPONENTS

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 (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 has identified areas of vulnerability to industrial longline fishing for several species of albatross and proposed mitigation measures. In an externally-funded study, the IATTC staff is currently investigating the population status of the black-footed albatross in the entire North Pacific Ocean, taking into account the effects of fisheries bycatch.

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 production 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. 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 capability of affecting 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. A sampling program by the IATTC staff, to examine possible changes in foraging behavior of yellowfin tuna, is described in Section 4.

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 7), 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 2009 are as follows:

	Set type			**Total**
	OBJ	**NOA**	**DEL**	
Triggerfishes (Balistidae) and filefishes (Monacanthidae)	36	<1	<1	36
Other small fishes	56	<1	<1	57
Frigate and bullet tunas (*Auxis* spp.)	312	169	1	482

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 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 depictions of 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. 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. The most common prey items of yellowfin tuna caught by purse seines offshore are frigate and bullet tunas, squids and argonauts (cephalopods), and flyingfishes and other 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 *Vinciguerria lucetia* appeared dominant in the diet during the early 1990s. Tunas that feed inshore utilize different prey than those caught offshore. For example, yellowfin and skipjack caught off Baja California feed heavily on red crabs, *Pleuroncodes planipes*. More recently, diet 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.

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 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 (AA-CSIA) of amino acids. 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 the base of the food web is not necessary. A recent 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. The diet data for the same yellowfin samples analyzed for isotope content showed comparable variability in the trophic position of yellowfin, but did not show an inshore-offshore gradient in trophic position.

A short-term study was conducted in 2006 to examine the stomach contents of recently-captured yellowfin tuna to detect possible changes in their foraging behavior relative to that of previous years. Single-species stock assessments are not designed to consider the effect of trophic interactions (*e.g.* predation, competition, and changes in trophic structure) on the stock in question. Prey populations that feed the apex predators also 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). Stomach samples of a ubiquitous predator, such as yellowfin tuna, compared with previous diet data, can be used to infer changes in prey populations by identifying changes in foraging behavior. Changes in foraging behavior could cause the tunas, for example, to alter the typical depth distributions while foraging, and this could affect their vulnerability to capture. Stomach samples of yellowfin tuna were collected from purse-seine sets made on fish associated with dolphins during the fourth quarter of 2006, and compared with samples from dolphin sets made during 2003-2005 in the same fishing area. Of special interest were the inter-annual differences in predation on the Humboldt squid because of recent changes in its abundance and geographical range (see 3.2 Forage). The amount of fresh squid tissue in the yellowfin stomachs was very low, and there were no differences in the diet proportions by weight from year to year. Cephalopod mandibles (or beaks), however, are retained in the stomachs, and the percent occurrence of Humboldt squid mandibles decreased by 21 percent between 2004 and 2006. Inter-annual differences in predation on other diet components were small. *Auxis* spp. were eaten in significantly greater quantities ($p<0.05$) in 2005 and 2006 compared to 2003 and 2004, and significantly more Pacific flatiron herring (*Harengula thrissina*) and chub mackerel (*Scomber japonicus*) were eaten in 2006 than in the previous three years. Overall, there is no convincing evidence of substantial changes in the trophic structure having taken place during 2003-2006, based on the food habits of yellowfin tuna caught in association with dolphins.

5. PHYSICAL ENVIRONMENT[2]

Environmental conditions affect marine ecosystems, the dynamics and catchability of tunas and billfishes, and the activities of the 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 often called the El Niño-Southern Oscillation (ENSO). The ENSO is an irregular fluctuation involving

[2] Much 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 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. The mild La Niña conditions that developed during the fourth quarter of 2008 continued into the first quarter of 2009. During the second quarter of 2009, the SSTs were mostly above normal and the depth of the thermocline increased. SSTs were all above normal during the third and fourth quarters of 2009. In December, 2009 the U.S. National Weather Service expected El Niño to "exert a significant influence on the global weather and climate in the coming months."

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.

There is evidence that the North Pacific Ocean is currently in a cool regime, while no such evidence is apparent for the equatorial Pacific.

Environmental variability in the tropical EPO is manifested differently in different regions in which tunas are caught. For example, SST anomalies in the tropical EPO warm pool (5° to 20°N, east of 120°W) have been about one-half the magnitude and several months later than those in the equatorial Pacific NIÑO3 area (5°S to 5°N, 90° to 150°W).

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.

New methods of ordination, developed by scientists at the Institute of Statistical Mathematics in Tokyo, Japan, have produced indices of association related to different groupings of catch and bycatch species for floating-object sets of the purse-seine fishery. The preliminary indices show clear large-scale spatial patterns, and relationships to environmental variables, such as SST, chlorophyll-a density, and mixed layer depth. Information on relationships between indices of species association and environmental characteristics may help to guide the development of approaches for bycatch reduction.

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 J-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 apex predators in the ecosystem. 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, TLs were estimated for a time series of annual catches and discards by species from 1993 to 2008 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 7), 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 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 J-2: Average PS+LP). A slight declining trend for the unassociated sets, amounting to 0.4 TL over the 16-year period, was statistically significant ($p<0.001$). It is not, however, considered an ecologically-detrimental trend because it was caused by increasing proportions of skipjack in the catch over time. The catches of large yellowfin (≥90 cm, TL 4.66), skipjack (TL 4.57), small yellowfin (<90 cm, TL 4.57), and large bigeye (≥80 cm, TL 5.17) contributed 36, 34, 19, and 6 percent, respectively, to the overall TL (4.63) during 1993-2008. The retained and discarded catches of all other species and groups contributed less than 5 percent of the overall TL of the catches, including small bigeye (4.7%, TL 4.53) and all the bycatch species. 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 J-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 ($p<0.001$) and negatively related to the percentage of the catch comprised of skipjack ($p<0.001$) (Figure J-3).

The TLs were also estimated separately for the time series of retained and discarded catches of the purse-seine fishery each year from 1993 to 2008 (Figure J-4). The discarded catches were much less than the retained catches, and thus the TL patterns of the total (retained plus discarded) catches (Figure J-2) were determined primarily by the TLs of the retained catches (Figure J-4). 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 TLs of the dolphin-set discards over the 16-year period (Figure J-4), is related to a reduction in dolphin mortalities and yellowfin tuna discards. For unassociated sets, the marked reduction in TL during 1997 was 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. From 1997 to 2001, the discarded catches of rays gradually declined in unassociated sets and those of large sharks and small yellowfin increased, resulting in a gradually increasing TL of the discarded catches over that interval. For floating-object sets, the discards of bigeye are related to higher TLs.

7. ECOLOGICAL RISK ASSESSMENT

Long-term ecological sustainability is a requirement of ecosystem-based fisheries management. Fishing impacts 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. For this analysis, vulnerability is defined 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.

A version of productivity and susceptibility analysis (PSA)[3], 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 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. Ten productivity and twelve susceptibility attributes were used in the recent PSA[3]. 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:

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

To examine the utility of productivity and susceptibility indices to assess vulnerability of fish, turtle, and

[3] 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.

mammal stocks to overfishing, a preliminary evaluation of three purse-seine "fisheries" in the EPO was made. The preliminary PSA was focused on 26 species (Table J-1) that comprised the majority of the biomass removed by the purse-seine vessels with carrying capacity greater than 363 metric tons during 2005-2009. Nine productivity and eight susceptibility attributes were based on the previous PSA, and some were modified for more consistency with the tuna fisheries in the EPO. The productivity and susceptibility attributes used in the IATTC's preliminary PSA are listed in Tables J-2 and J-3.

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 suit the distribution of life history characteristics observed in the species found in the EPO. Scoring thresholds for productivity attributes (Table J-2) were derived by dividing the compiled data into 1/3 percentiles. Scoring criteria for the susceptibility attributes (Table J-3) were taken from the previous PSA[3] and modified where appropriate to better suit the EPO fisheries. The scores for each index were then averaged. Scatter plots of averaged productivity and susceptibility scores for subsets of the 26 species caught by three purse-seine fisheries (on dolphins, unassociated tunas, and floating objects) are shown in Figures J-5 – J-7. The scale of the x-axis on the figures 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, the giant manta ray, and the dolphins had the lowest productivity scores. The tunas and some of the "large fishes" (Table J-1) scored the highest in productivity. The olive Ridley turtle, great hammerhead, and bigeye thresher shark in floating-object sets scored lowest in susceptibility, while bigeye trevally, yellowtail amberjack in unassociated sets, and black marlin in floating-object sets had the highest susceptibility scores. In terms of overall vulnerability to overfishing (equation above), some of the sharks and the giant manta scored the highest.

Caution is advised in interpretation of this preliminary PSA for silky and oceanic whitetip sharks. The analysis indicates that silky sharks are more vulnerable to overfishing in dolphin and unassociated sets (Figures J-5 and J-6), and oceanic whitetip sharks are more vulnerable in dolphin sets, than in floating-object sets (Figure J-7). This is due to higher susceptibility scores for those sharks in the index of areal overlap-geographical concentration and percent retention of the bycatch ("Desirability/value of catch," Table J-3) for dolphin sets than for the other fisheries. This is a misleading result because only 3% and 8% of the cumulative bycatch (in numbers of individuals) of silky and whitetip sharks, respectively, recorded during 2005-2009 was caught in dolphin sets (Table J-1). The floating-object sets, which produced 93% and 91% of the bycatch of silky and oceanic whitetip sharks, respectively, (Table J-1) clearly have the potential for producing the greatest impact on these sharks in the EPO.

The IATTC staff intends to continue ecological risk assessment for the EPO. PSA will be improved and expanded beyond the preliminary analysis described above, and will include more of the fisheries that operate in the EPO. In addition, other types of ecological risk assessment will be explored.

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 comes 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. Resolution C-05-01, adopted by the IATTC in June 2005, recommends that IATTC Parties and cooperating non-Parties, fishing entities, and regional economic integration organizations implement, if appropriate, the International Plan of Action for Reducing the Incidental Catch of Seabirds in Longline Fisheries; collect and provide information to the Commission on interactions with seabirds; and for the Working Group on Stock Assessment to present to the Commission an assessment of the impact of incidental catches of seabirds resulting from the activities of all the vessels fishing for tunas and tuna-like species in the EPO. This assessment should include identification of the geographic areas in which there could be interactions between longline fisheries and seabirds.

b. The sixth meeting of the IATTC Working Group on Bycatch recommended that the Stock Assessment Working Group suggest possible mitigation measures in areas in which seabird distributions and longline effort overlap, and that the IATTC consider mitigation measures at its June 2007 meeting. It also recommended that seabird bycatch data be collected from all tuna longliners in the EPO.

c. A population model for black-footed albatross is being developed to assess whether past and present levels of bycatch are likely to significantly affect their populations and to generate a protected species model that can be applied to multiple species and used to provide management advice. IATTC purse-seine observer data are being used also to plot seabird distributions.

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.

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.

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.

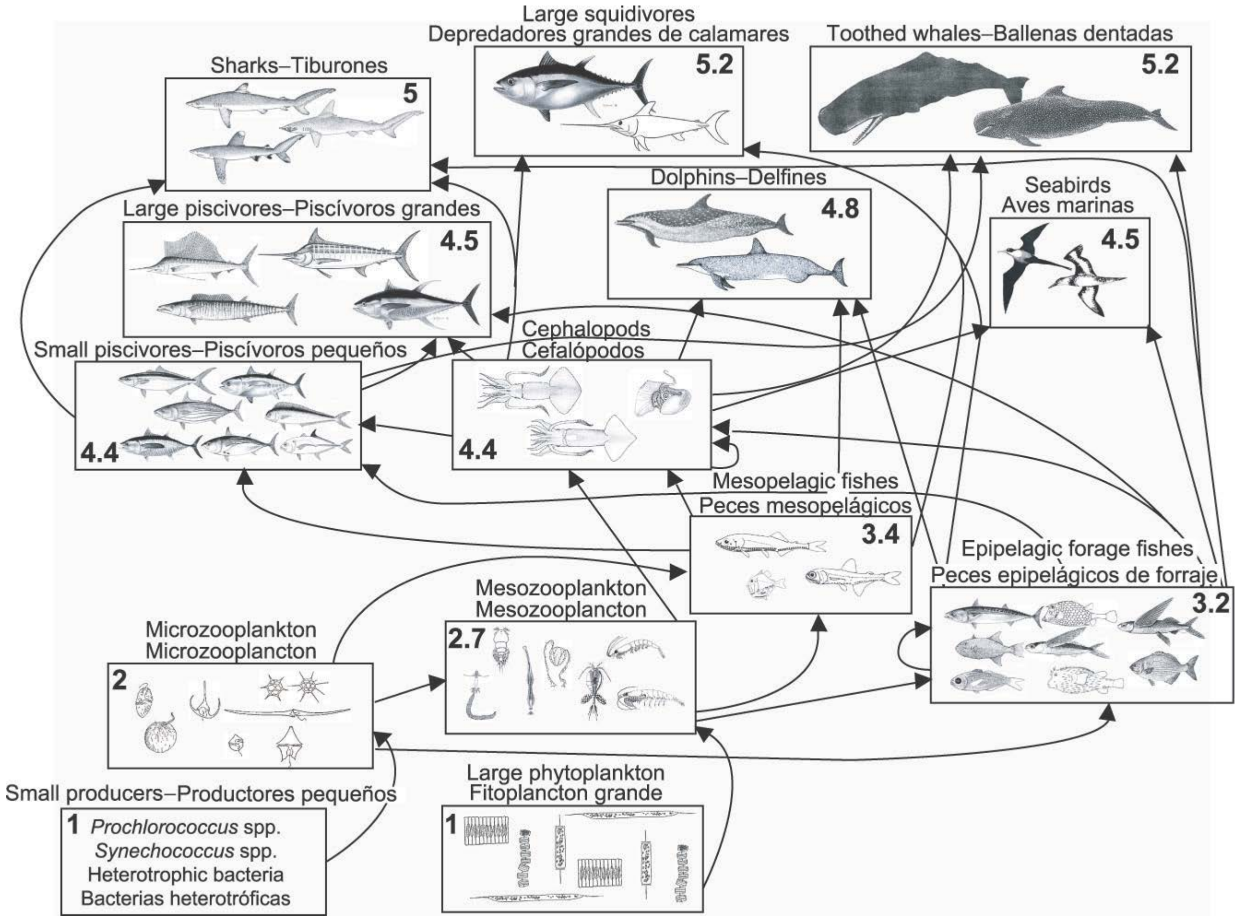


FIGURE J-1. Simplified food-web diagram of the pelagic ecosystem in the tropical EPO. The numbers inside the boxes indicate the approximate trophic levels of each group.
FIGURA J-1. Diagrama simplificado de la red trófica del ecosistema pelágico en el OPO tropical. Los números en los recuadros indican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

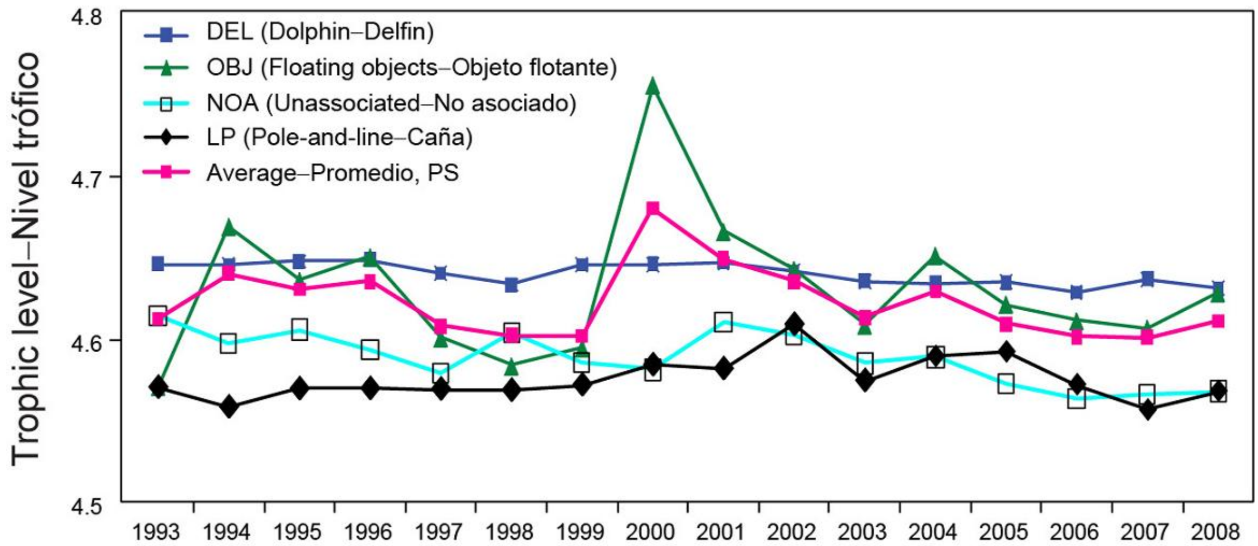


FIGURE J-2. Yearly trophic level estimates of the catches (retained and discarded) by the purse-seine and pole-and-line fisheries in the tropical EPO, 1993-2008.

FIGURA J-2. Estimaciones anuales del nivel trófico de las capturas (retenidas y descartadas) de las pesquerías cerquera y cañera en el OPO tropical, 1993-2008.

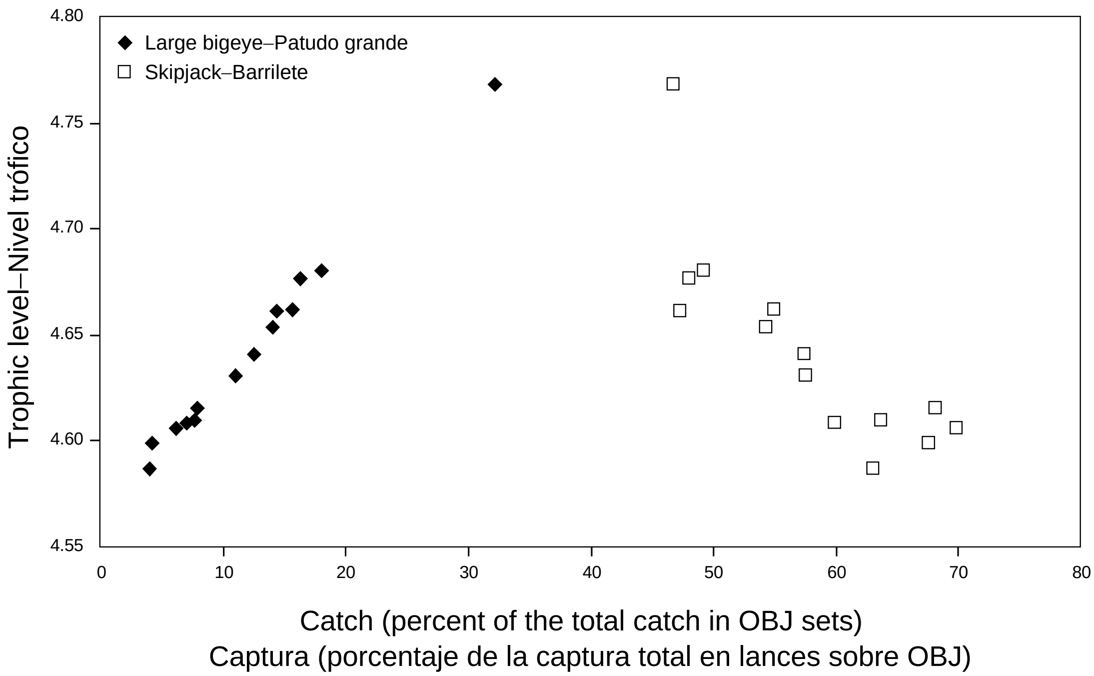


FIGURE J-3. Estimates of the trophic levels of the retained catches of large bigeye and of skipjack in floating-object sets (OBJ) in the tropical EPO, 1993-2006, versus the catches of large bigeye and of skipjack calculated as percentages of the total catches in floating-object sets each year.

FIGURA J-3. Estimaciones de los niveles tróficos de las capturas retenidas y descartadas en lances sobre objetos flotantes (OBJ) en el OPO tropical, 1993-2006, relativas a las capturas de patudo grande y barrilete, calculadas como porcentajes de las capturas totales en lances sobre objetos flotantes cada año.

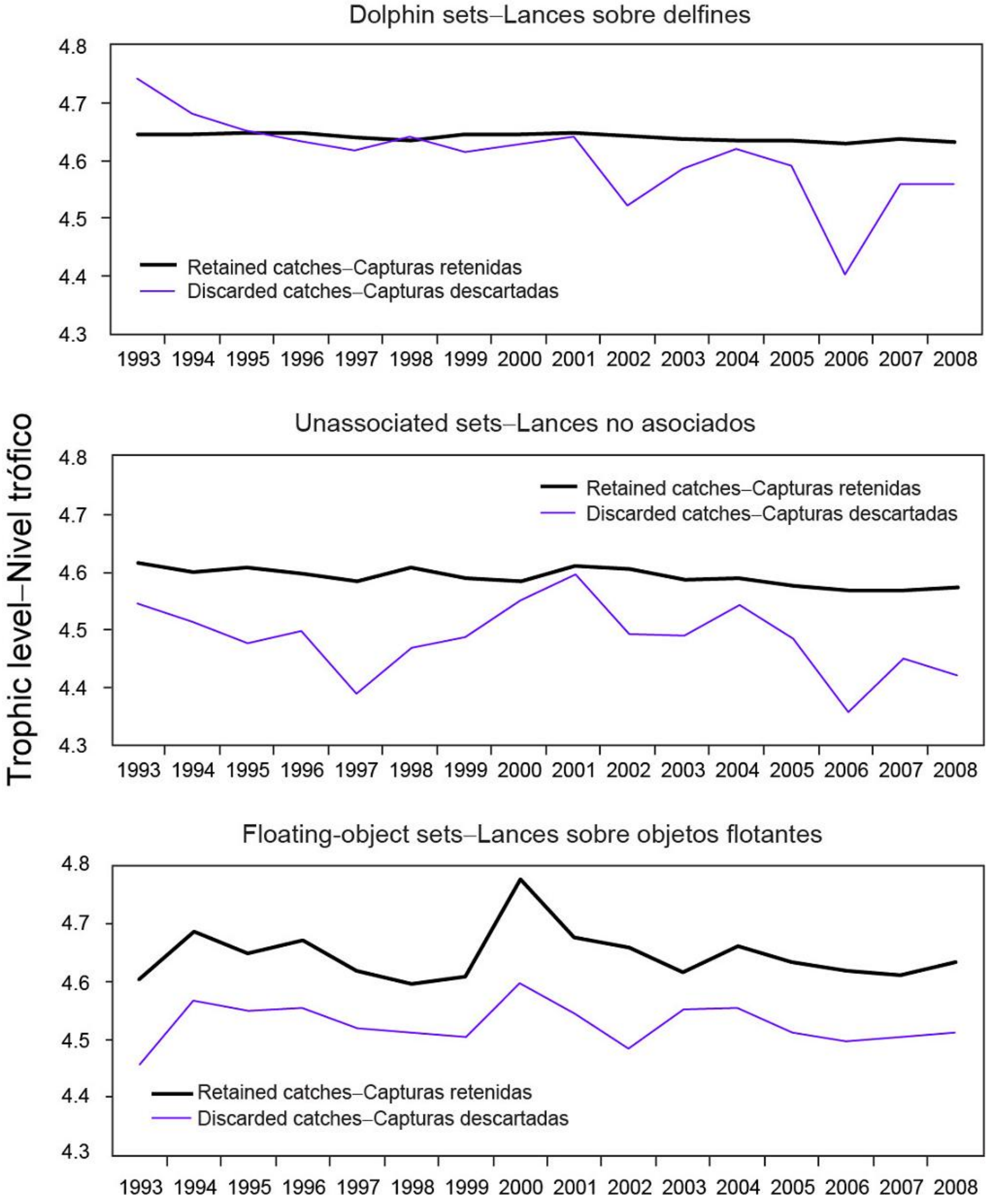


FIGURE J-4. Trophic level estimates of the retained catches and discarded catches by purse-seine fishing modes in the tropical EPO, 1993-2008.

FIGURA J-4. Estimaciones del nivel trófico de las capturas retenidas y descartadas por modalidad de pesca cerquera en el OPO tropical, 1993-2008.

Species codes used in Figures 5-7– Códigos de especies usados en las Figuras 5-7

	Grouping	Species	Grupo	Especie
YFT	Tunas	Yellowfin tuna	Atunes	Atún aleta amarilla
BET		Bigeye tuna		Atún patudo
SKJ		Skipjack tuna		Atún barrilete
BLM	Billfishes	Black marlin	Peces picudos	Marlín negro
BUM		Blue marlin		Marlín azul
MLS		Striped marlin		Marlín rayado
SFA		Indo-Pacific sailfish		Pez vela del Indo-Pacífico
DPN	Dolphins	Spotted dolphin	Delfines	Delfín manchado
DSI		Spinner dolphin		Delfín tornillo
DCO		Common dolphin		Delfín común
DOL	Large fishes	Dolphinfish	Peces grandes	Dorado
WAH		Wahoo		Peto
RRU		Rainbow runner		Salmón
CXS		Bigeye trevally		Jurel arco iris
YTC		Yellowtail amberjack		Medregal rabo amarillo
MOX		Ocean sunfish		Pez luna
RMB	Rays	Giant manta	Mantarrayas	Mantarraya gigante
FAL	Sharks	Silky shark	Tiburones	Tiburón jaquetón (sedoso)
OCS		Oceanic whitetip shark		Tiburón oceánico (punta blanca)
BTH		Bigeye thresher shark		Zorro ojón
PTH		Pelagic thresher shark		Zorro pelágico
SPL		Scalloped hammerhead shark		Cornuda común
SPK		Great hammerhead		Cornuda gigante
SPZ		Smooth hammerhead shark		Cornuda cruz
CNT	Small fishes	Ocean triggerfish	Peces pequeños	Pez ballesta oceánico
LKV	Turtles	Olive Ridley turtle	Tortugas	Tortuga golfina

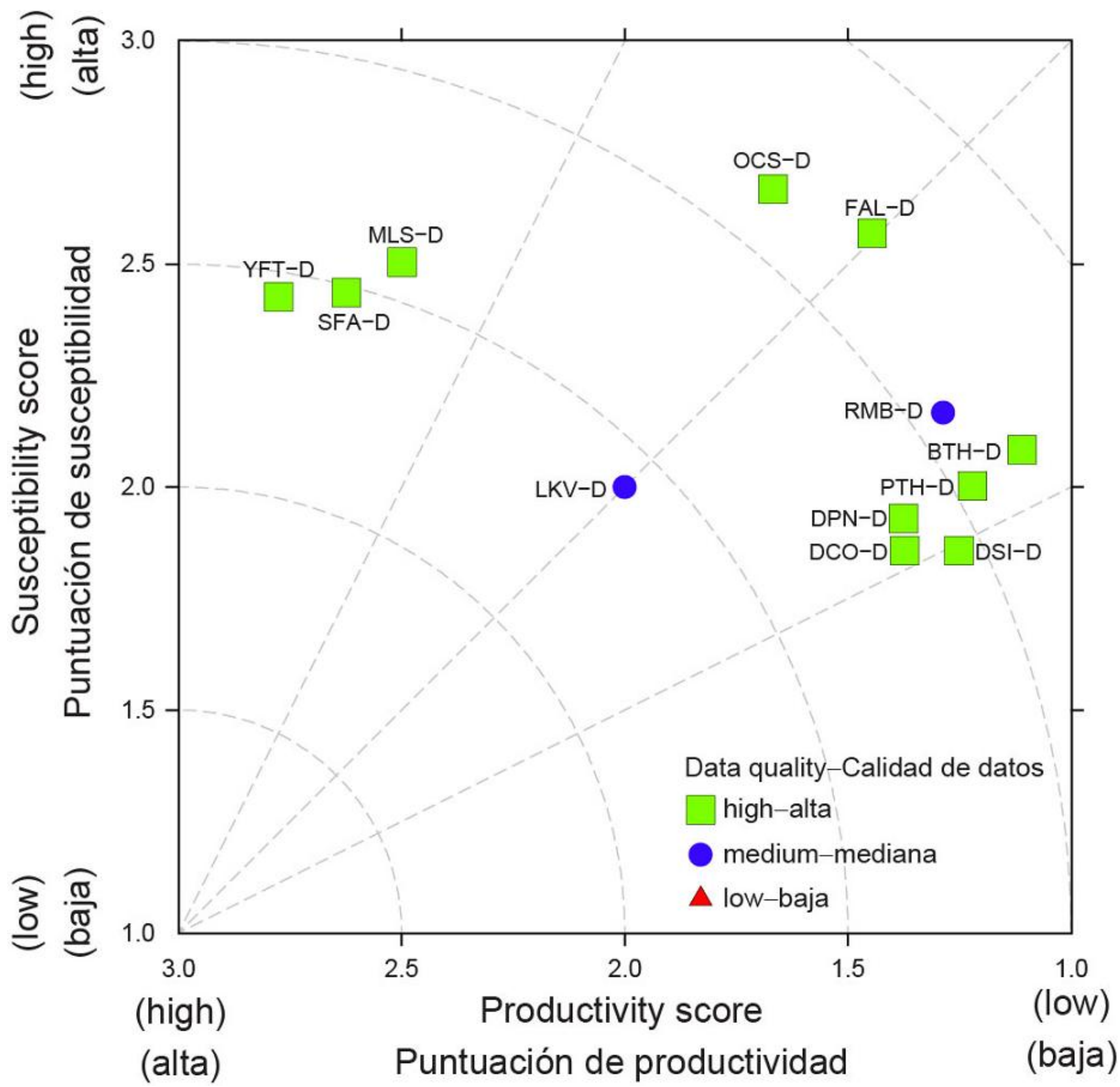


FIGURE J-5. Productivity and susceptibility x-y plot for target and bycatch species in dolphin sets in the purse-seine fishery of the eastern Pacific Ocean. 3-alpha species codes next to each point are defined on page 116; –D: dolphin sets.

FIGURA J-5. Gráfica x-y de productividad y susceptibilidad de especies objetivo y de captura incidental en lances sobre delfines en la pesquería de cerco en el Océano Pacífico oriental. Se definen los códigos de especies de tres letras en la página 116; –D: lances sobre delfines.

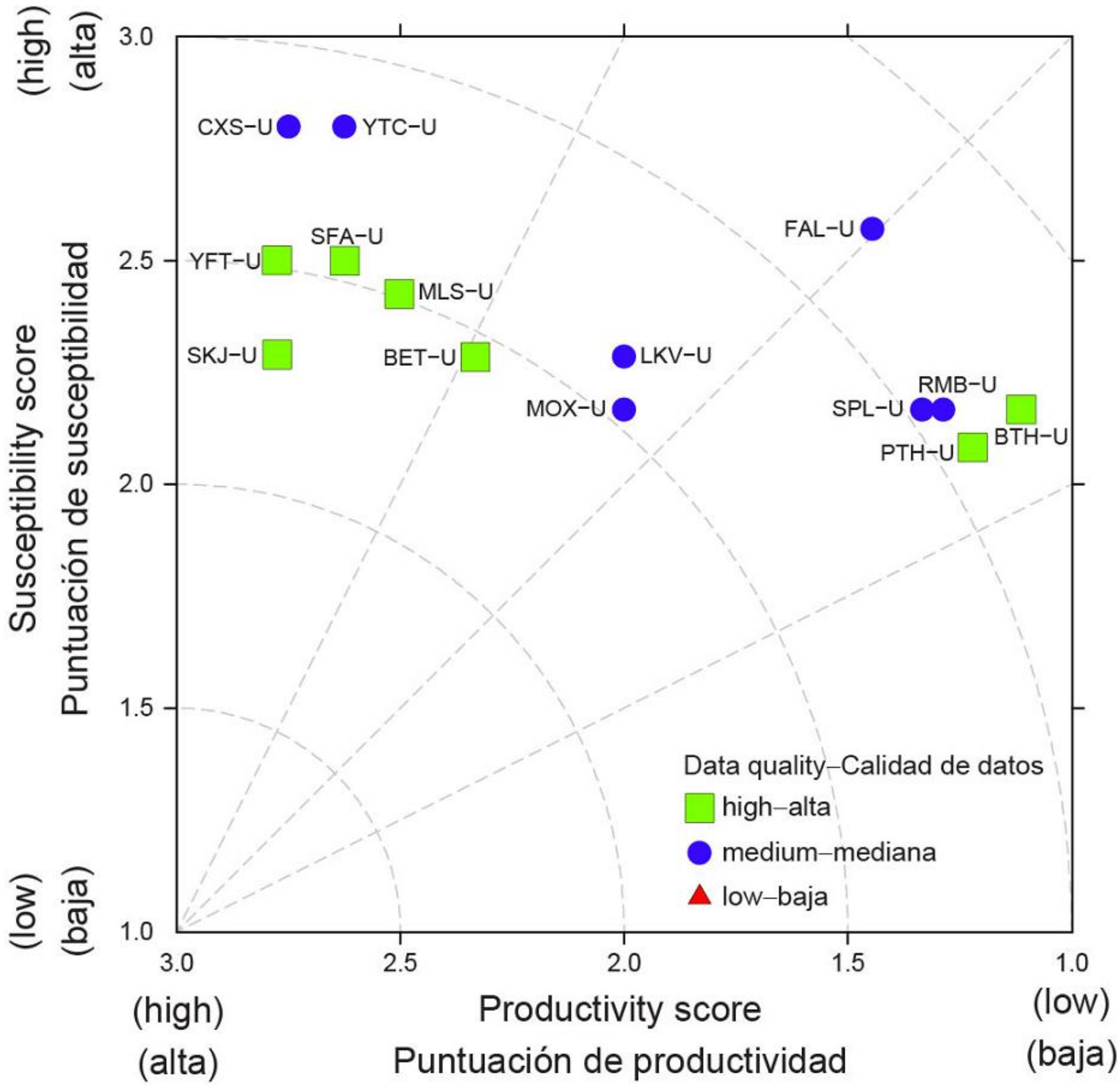


FIGURE J-6. Productivity and susceptibility x-y plot for target and bycatch species of unassociated sets in the purse-seine fishery of the eastern Pacific Ocean. 3-alpha species codes next to each point are defined on page 116; –U: unassociated sets.

FIGURA J-6. Gráfica x-y de productividad y susceptibilidad de especies objetivo y de captura incidental en lances no asociados en la pesquería de cerco en el Océano Pacífico oriental. Se definen los códigos de especies de tres letras en la página 116; –U: lances no asociados.

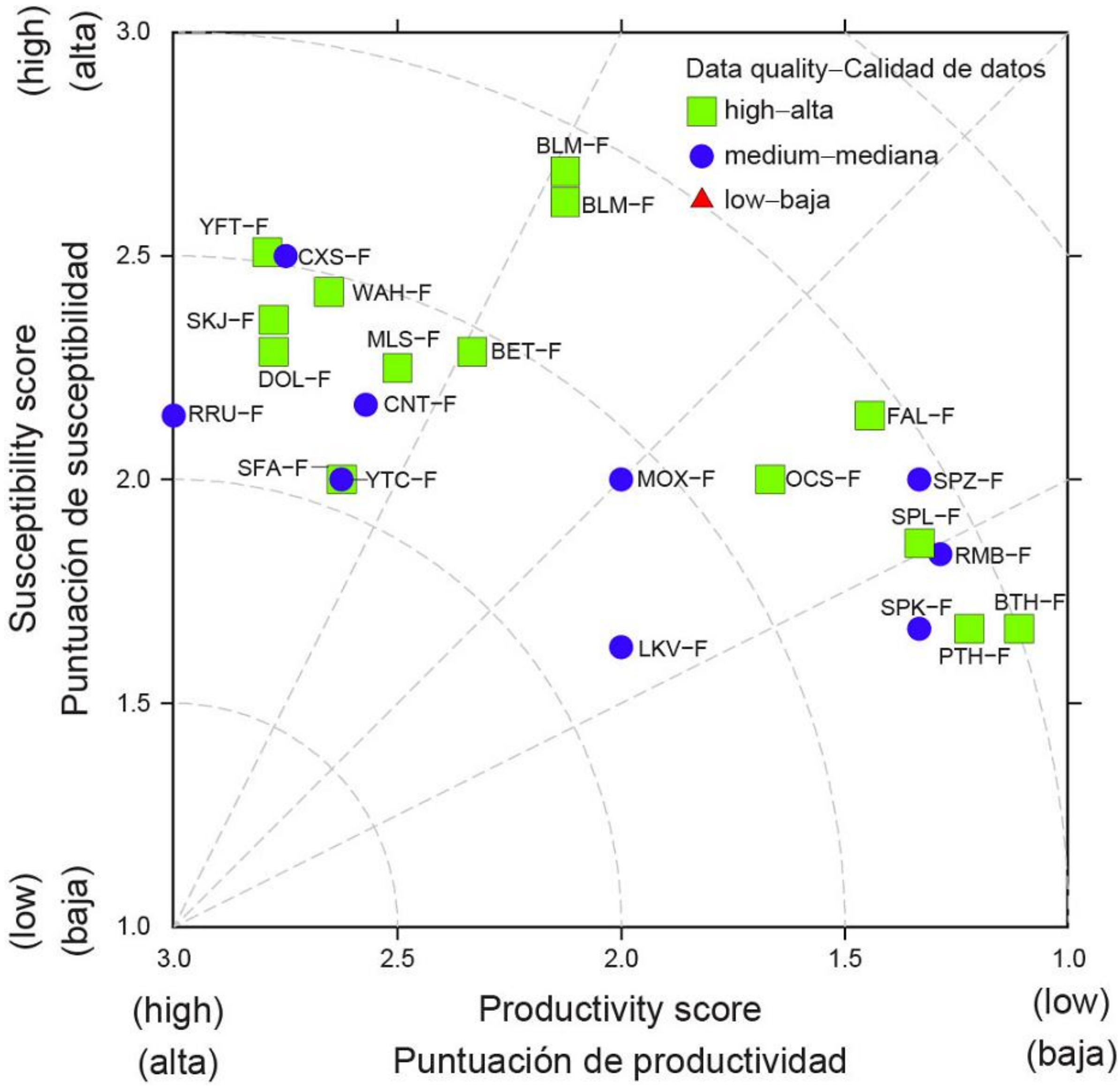


FIGURE J-7. Productivity and susceptibility x-y plot for target and bycatch species of floating-object sets in the purse-seine fishery of the eastern Pacific Ocean. 3-alpha species codes next to each point are defined on page 116; –F: floating-object sets.

FIGURA J-7. Gráfica x-y de productividad y susceptibilidad de especies objetivo y de captura incidental en lances sobre objetos flotantes en la pesquería de cerco en el Océano Pacífico oriental. Se definen los códigos de especies de tres letras en la página 116; –F: lances sobre objetos flotantes.

TABLE J-1. Target and bycatch species for which data were compiled to define scoring intervals of productivity and susceptibility attributes used in a preliminary PSA of the purse-seine fisheries (dolphin, unassociated, and floating-object sets) in the eastern Pacific Ocean. Bycatch percentages are for purse-seine vessels with carrying capacity greater than 363 metric tons during 2005-2009. "n/a" indicates the tuna species that were included in the analysis, but no percentages were given because tunas are not bycatches of these fisheries.

Species			Bycatch (percent by set type)		
Group	**Common name**	**Scientific name**	**Dolphin**	**Unassociated**	**Floating-object**
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*	--	--	85%
	Blue marlin	*Makaira nigricans*	--	--	89%
	Striped marlin	*Tetrapturus audax*	28%	24%	48%
	Indo-Pacific sailfish	*Istiophorus platypterus*	68%	17%	15%
Dolphins	Spotted dolphin	*Stenella attenuata*	100%	--	--
	Spinner dolphin	*Stenella longirostris*	100%	--	--
	Common dolphin	*Delphinus delphis*	100%	--	--
Large Fishes	Common dolphinfish	*Coryphaena hippurus*	--	--	98%
	Wahoo	*Acanthocybium solandri*	--	--	100%
	Rainbow runner	*Elagatis bipinnulata*	--	--	100%
	Bigeye trevally	*Caranx sexfasciatus*	--	52%	48%
	Yellowtail amberjack	*Seriola lalandi*	--	15%	85%
	Ocean sunfish	*Mola mola*	--	14%	79%
Rays	Giant manta	*Manta birostris*	61%	25%	13%
Sharks	Silky shark	*Carcharhinus falciformis*	3%	4%	93%
	Oceanic whitetip shark	*Carcharhinus longimanus*	8%	--	91%
	Bigeye thresher shark	*Alopias superciliosus*	35%	51%	14%
	Pelagic thresher shark	*Alopias pelagicus*	34%	43%	23%
	Scalloped hammerhead shark	*Sphyrna lewini*	--	18%	77%
	Great hammerhead	*Sphyrna mokarran*	--	--	93%
	Smooth hammerhead shark	*Sphyrna zygaena*	--	--	88%
Small Fishes	Ocean triggerfish	*Canthidermis maculatus*	--	--	100%
Turtles	Olive Ridley turtle	*Lepidochelys olivacea*	18%	13%	69%

TABLE J-2. Preliminary productivity attributes and proposed scoring thresholds used in the IATTC PSA.
TABLA J-2. Atributos de productividad preliminares y umbrales de puntuación propuestos usados en el PSA de la CIAT.

Productivity attribute Atributo de productividad	Ranking – Clasificación		
	Low – Bajo (1)	**Moderate – Moderado (2)**	**High – Alto (3)**
Intrinsic rate of population growth (*r*) Tasa intrínseca de crecimiento de la población (*r*)	> 1.3	> 0.1, ≤ 1.3	≤ 0.1
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)	> 200,000	10 – 200,000	< 10
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 J-3. Preliminary susceptibility attributes and proposed 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