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TUNAS AND BILLFISHES IN THE EASTERN PACIFIC OCEAN

INTRODUCTION

This report has been prepared for the 70th meeting of the Inter-American Tropical Tuna Commission in June 2003. It provides a summary of the fishery for tunas in the eastern Pacific Ocean (EPO), an assessment of the stocks of tunas and billfishes that are exploited in the fishery, and an evaluation of the pelagic ecosystem in the eastern Pacific.

The report is based on data available to the IATTC staff in April 2003.

All weights of catches and discards are in metric tons (T). The following abbreviations are used:

Species:	
ALB	Albacore tuna (*Thunnus alalunga*)
BEP	Bonito (*Sarda orientalis*)
BET	Bigeye tuna (*Thunnus obesus*)
BUM	Blue marlin (*Makaira nigricans*)
MLS	Striped marlin (*Tetrapturus audax*)
PBF	Pacific bluefin tuna (*Thunnus orientalis*)
SKJ	Skipjack tuna (*Katsuwonus pelamis*)
SWO	Swordfish (*Xiphias gladius*)
YFT	Yellowfin tuna (*Thunnus albacares*)

Fishing gears:	
LL	Longline
LP	Pole-and-line
PS	Purse seine

Ocean areas:	
EPO	Eastern Pacific Ocean
WCPO	Western and Central Pacific Ocean

Flags:	
BLZ	Belize
BOL	Bolivia
COL	Colombia
CHN	People's Republic of China
CRI	Costa Rica
ECU	Ecuador
ESP	Spain
GTM	Guatemala
HND	Honduras
JPN	Japan
KOR	Republic of Korea
MEX	Mexico
NIC	Nicaragua
PER	Peru
PYF	French Polynesia
SLV	El Salvador
TWN	Taiwan
USA	United States of America
VEN	Venezuela
VUT	Vanuatu

A. THE FISHERY FOR TUNAS AND BILLFISHES IN THE EASTERN PACIFIC OCEAN IN 2002

1. THE SURFACE FLEET, AND CATCHES AND LANDINGS OF TUNAS AND BILLFISHES

1.1. The surface fleet

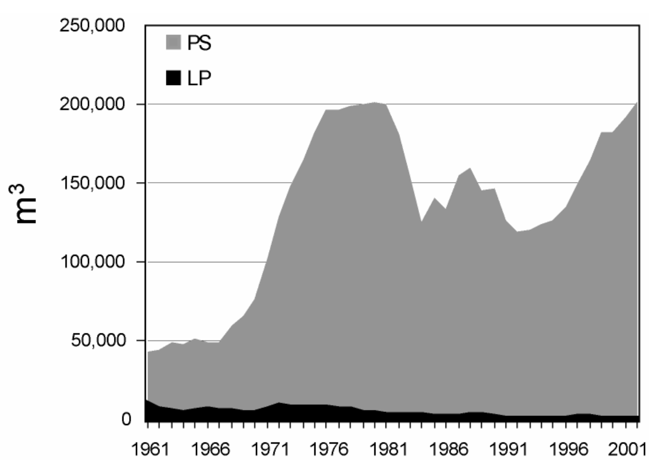
The IATTC maintains detailed records of gear, flag, and fish-carrying capacity for most of the vessels that fish with surface gear for yellowfin (*Thunnus albacares*), skipjack (*Katsuwonus pelamis*), bigeye (*Thunnus obesus*), and/or Pacific bluefin (*T. orientalis*) tuna in the eastern Pacific Ocean (EPO). Historically, detailed records have not been maintained for most longline vessels, nor for sport-fishing vessels and small craft such as canoes and launches, although recently the staff has begun compiling and maintaining these records, and will continue to do so in the future. The fleet described here includes purse seiners and pole-and-line vessels (hereafter referred to as surface gear) that have fished all or part of the year in the EPO for 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. The vessels were grouped, by carrying capacity, originally in short tons and later in metric tons, into six size classes.

During the past several years the IATTC staff has used well volume, in cubic meters, instead of weight, in metric tons, 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 size classes and well volumes are as follows:

Volume (cubic meters)	<53	53-106	107-212	213-319	320-425	>425
Class	1	2	3	4	5	6

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, a factor of 1.17 is used to convert the estimated capacity in metric tons to cubic meters. This conversion factor is consistent with the density at which the fish were packed into the wells of the vessels at the time that the size classification was developed. This conversion factor was also applied to all capacity data for 1961-1998 to facilitate comparisons among years, shown in the figure below.



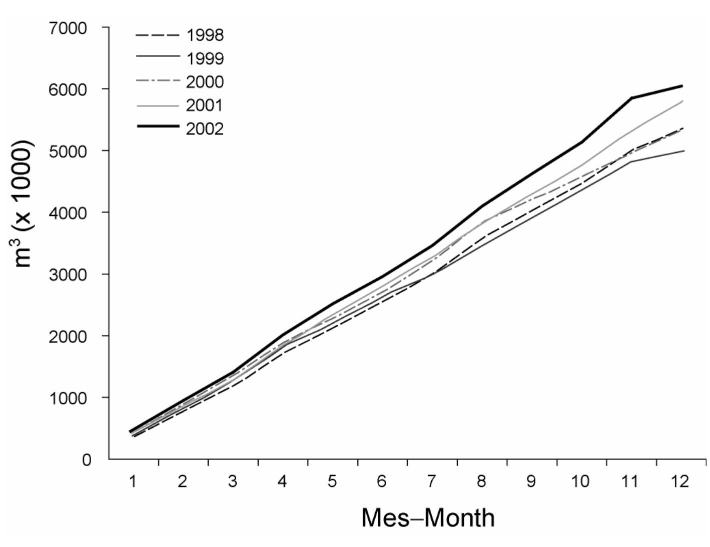
Carrying capacity, in cubic meters of well volume, of the surface fleet in the EPO, 1961-2002.

Until about 1960 fishing for tunas in the EPO was dominated by pole-and-line vessels operating in the more 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 surface fleet was dominated by these vessels. From 1961 to 2001 the number of pole-and-line vessels decreased from 93 to 10, and their total well volume from about 11 to 1 thousand cubic meters (m^3). During the same period the number of purse seiners increased from 125 to 205, and their total well volume from about 32 thousand to 190 thousand m^3, an average of about 926 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 196 thousand m^3, an average of about 693 m^3 per vessel.

The construction of new purse seiners, which began during the mid-1960s, resulted in an increase in the total well volume of the surface fleet from about 49 thousand m^3 in 1966 to about 196 thousand m^3 in 1976. From 1976 to1981 the total well volume increased slightly. The construction of new vessels continued, but this was mostly offset by losses due to sinkings and vessels leaving the fishery. 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 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 125 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 119 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 2002 was 201 thousand m^3.

The 2001 and preliminary 2002 data for numbers and total well volumes of purse seiners and pole-and-line vessels that fished for tunas in the EPO are shown in Tables 1a and 1b. The fleet was dominated by vessels operating under the Mexican and Ecuadorian flags during 2002. The Mexican fleet, which has been the largest fleet since 1987, had about 24% of the total well volume during 2002, while vessels registered in Ecuador, Venezuela, the United States, Spain, and Panama comprised about 24, 15, 7, 6, and 6% of the total well volume, respectively.

Class-6 purse seiners made up about 90% of the total well volume of the surface gear operating in the EPO during 2002, The cumulative capacity during 2002 is compared to the previous 4 years in the figure.



Cumulative capacity of the surface fleet at sea, by month, 1998-2002

1.2. Catches and landings

1.2.1. Tunas

1.2.1.a Surface catches

Estimates of the catches and landings of tunas come from several sources, including logbooks kept by the fishermen, data recorded by observers aboard the vessels, unloading data provided by canneries and other processors, and export and import records. All data for 2002 are provisional. Estimating the total catch for a fishery is difficult, due to the lack of information on fish that are caught, but, for various reasons, discarded at sea. Data on fish discarded at sea by Class-6 vessels have been collected by observers since 1993. This information allows for better estimation of the total amounts of fish caught by the surface fleet. Estimates of the total amount of catch that is landed (hereafter referred to as retained catch) are based principally on data from unloadings. Annual estimates of the retained and discarded catches of the various species of tunas captured by vessels of the EPO surface fleet are shown in Table 2, which also includes catch data for U.S.-flag sport-fishing vessels and other miscellaneous types of surface gear. In the case of bluefin, the recreational catches have become an increasingly important component of the total catch in recent years.

The average annual retained catch of yellowfin in the EPO by surface gear during 1987-2001 was 268 thousand T (range: 219 to 396 thousand T). The preliminary estimate of the retained catch of yellowfin in 2002, 419 thousand T, is the greatest on record, exceeding the average for 1987-2001 by 56%. The average amount of yellowfin discarded at sea by the surface fisheries during 1993-2002 was about 2.1% of the total surface catch (retained catch plus discards) of yellowfin (range: 0.9 to 2.6%).

An estimated 158 thousand T of skipjack were caught in 2002, which is 32% greater than the average for 1987-2001 (120 thousand T, range: 62 to 266 thousand T). The average amount of skipjack discarded at sea during 1993-2002 was about 11.8% of the total catch of skipjack (range: 7.5 to 18.2%).

Prior to 1994 the average annual retained catch of bigeye in the EPO by surface gear was about 5 thousand T (range: <1 to 15 thousand T). 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 29 thousand T in 1994 to 35 to 52 thousand T during 1995-1999, to a record high of 70 thousand T in 2000. The catch of bigeye decreased to 43 thousand T in 2001, and the preliminary estimate of the retained catch in the EPO in 2002 is 35 thousand T. The average amount of bigeye discarded at sea by the surface fisheries during 1993-2002 was about 7.4% of the total surface catch of bigeye (range: 2.7 to 11.3%). It is difficult to distinguish small bigeye from small yellowfin. Therefore, since 2000 a species-composition sampling scheme has been used to improve estimates of the actual catches of small bigeye made by purse-seine vessels

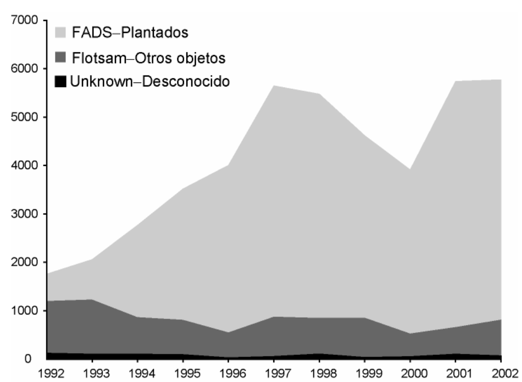
While yellowfin, skipjack, and bigeye comprise the most significant portion of the retained catches of the surface fleet in the EPO, bluefin, albacore (*Thunnus alalunga*), black skipjack (*Euthynnus lineatus)*, bonito (*Sarda orientalis*), and other species contribute to the overall harvest in this area. The total retained catch of these other species by these fisheries was about 4 thousand T in 2002, which is well below the 1987-2001 annual average retained catch of about 8 thousand T (range: 2 to 17 thousand T). The estimated retained and discarded catches of these species for the 1970-2002 period are presented in Table 2.

The retained catches in the EPO during 2001, by flag, and the landings of EPO-caught tunas taken by surface gear in the EPO, by country, are given in Table 3a, and preliminary estimates of the equivalent data for 2002 are given in Table 3b. The estimated retained catch of all species in the EPO during 2002 was about 616 thousand T, which was about 5% greater than that for 2001, 588 thousand T, and much greater than the average for 1987-2001 of 421 thousand T. Ecuadorian-, Mexican-, and Venezuelan-flag vessels harvested about 26, 22, and 20%, respectively, of the retained catches of all species made in 2002. Other countries with significant catches were Colombia, Panama, and Spain (5% each).

The landings are fish unloaded from fishing vessels during a calendar year, regardless of the year of catch. The country of landing is that in which the fish were unloaded or, in the case of transshipments, the country that received the transshipped fish. Preliminary landings data (Table 3b) indicate that, of the 632 thousand T of tunas landed in 2002, 41% was landed in Ecuador and 25% in Mexico. Other countries with significant landings of tunas caught in the EPO included Costa Rica (6%) and Colombia and Venezuela (5% each). It is important to note that when final information is available the landings currently assigned to various countries may change due to exports from storage facilities to processors in other nations.

Tunas are caught by surface gear in three types of schools, associated with dolphins, associated with floating objects, such as flotsam or FADs, and associated only with other fish (unassociated schools). Estimates of the numbers of purse-seine sets of each type in the EPO during the 1978-2002 period, and the retained catches of these sets, are listed in Table 4. The estimates for Class-1 to -5 vessels were calculated from logbook data in the IATTC statistical data base, and those for Class-6 vessels were calculated from logbook data and from the observer data bases of the IATTC and the observer programs of Ecuador, the European Union, Mexico, the United States, and Venezuela. The greatest numbers of sets on schools associated with floating objects and on unassociated schools of tuna were made during the period 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 made on fish associated with dolphins decreased only moderately during the mid-1990s, and in 2002 were the greatest since 1990.

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 in use for only a few years, but their importance has increased during that period, while that of flotsam has decreased, as shown by the figure below.



Number of sets on floating objects by Class-6 vessels, 1993-2002

The average annual distributions of the logged catches of yellowfin, skipjack, and bigeye, by set type, by purse seiners in the EPO during 1987-2001 (1994-2001 for bigeye), are shown in Figures 1a, 2a, and 3a, and preliminary estimates for 2002 are shown in Figures 1b, 2b, and 3b. The distributions of the catches of yellowfin and skipjack during 2002 were similar to those of 1987-2001, although some differences are evident. Bigeye are not often caught by surface gear north of about 7°N. The distribution of the catch of bigeye during 2002 was similar to those of 1994-2001. With the development of the fishery for tunas associated with FADs described above, the relative importance of the nearshore areas has decreased, while that of the offshore areas has increased, as is apparent in Figure 3b.

1.2.1.b Longline catches

The distribution of catches of bigeye in the Pacific Ocean during 1990-2000, by gear (longline, purse-seine and other), is shown in Figure 4.

Data on the retained catches for most of the larger longline vessels operating in the EPO, and for an increasing portion of the smaller ones, are obtained from various sources. These vessels, particularly the larger ones, direct their effort primarily at bigeye and yellowfin tuna. The annual retained catches of yellowfin, skipjack, bigeye, and bluefin by these fisheries are shown in Tables 5a, 5b, 5c, and 5d, respectively and the fishing effort and total catch by the principal fleets is shown in Table 6. The data for 1999-2002 are preliminary. During 1985-1999 the retained catches of yellowfin remained relatively stable, averaging about 20 thousand T (range: 13 to 34 thousand T) per year, or about 7.5% of the total retained catches of yellowfin. The size distribution of yellowfin in the Japanese longline catch are shown in Figure 5. Prior to 1986 the retained longline catches of bigeye averaged about 50 thousand T (range: 29 to 73 thousand T); in about 1986 they increased significantly, to approximately 100 thousand T, and remained high during 1986-1994, averaging about 85 thousand T (range: 72 to 102 thousand T). The size distribution of bigeye in the Japanese longline catch are shown in Figure 6. During 1970-1993, prior to the increased use of FADs and resultant greater catches of bigeye by purse-seine vessels, the longline fisheries, on average, accounted for 93% of the retained catches of this species from the EPO. During 1995-1999 the annual retained catches of bigeye by the longline fisheries ranged from about 33 to 49 thousand T (average: 43 thousand T), which is well within the pre-1986 historical range, but significantly less than the retained catches during 1986-1994. Small amounts of skipjack are caught by longline vessels, as shown in Table 5b. The catches of Pacific bluefin in the entire Pacific Ocean are shown in Table 5d. These data were compiled during the Second Meeting of the Pacific Bluefin Tuna Working Group of the Interium Scientific Committee on Tunas and Tuna-like Species in the North Pacific (ISC).

1.2.2. Billfishes

Swordfish (*Xiphias gladius*) are fished in the EPO with longline gear and gillnets, and occasionally with recreational gear. Most of those caught with commercial gear are retained. Blue marlin (*Makaira nigricans*), black marlin (*M. indica*), striped marlin (*Tetrapturus audax*), shortbill spearfish (*T. angustirostris*), and sailfish (*Istiophorus platypterus*) are fished with longline and recreational gear, and they are occasionally caught by purse-seine vessels. Most of the longline-caught marlins, spearfish, and sailfish are retained, and most of those caught with commercial surface gear are discarded at sea. Information on the commercial catches and bycatches of billfishes in the EPO is given in Table 7.

2. SIZE COMPOSITIONS OF THE SURFACE CATCHES OF TUNAS

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 population for various purposes, including age-structured population modeling. The results of age-structured population modeling can be used to estimate recruitment, which can be compared to spawning biomass and oceanographic conditions. Also, the estimates of mortality obtained from age-structured population modeling can be used, in conjunction with growth estimates, for yield-per-recruit modeling. The results of such studies have been described in several IATTC Bulletins, in all of its Annual Reports since that for 1954, and in its Stock Assessment Reports.

Length-frequency samples of yellowfin, skipjack, bigeye, Pacific bluefin, and occasionally black skipjack from purse-seine, pole-and-line vessels, and recreational catches made in the EPO are collected by IATTC personnel at ports of landing in Ecuador, Mexico, Panama, the USA (California and Puerto Rico), 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. Briefly, the fish in a well of a purse seiner 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 7), based on the staff's most recent stock assessments.

Data for fish caught during the 1997-2002 period are presented in this report. With the exception of bluefin, two length-frequency histograms are presented for each species: the first shows the data by stratum (gear type, set type, and area) for 2002, and the second shows the catch for the current year and the previous five years. For bluefin, the histogram shows the 1997-2002 catches by commercial and recreational gear, combined. Samples from 916 wells (including those from recreational vessels) were taken during 2002.

There are ten yellowfin surface fisheries defined for stock assessments: four floating-object, two unassociated school, three dolphin, and one pole-and-line (Figure 7). Of the 916 wells sampled, 796 contained yellowfin. The estimated size compositions of the fish caught during 2002 are shown in Figure 8a. The majority of the yellowfin catch was taken by dolphin sets in the North and Inshore areas, but the largest fish, on average, were caught in dolphin sets in the Southern area. The average weights of yellowfin caught in unassociated school sets in the Southern area and by floating-object sets in the Inshore area in 2001 and 2002 were greater than those of the previous five years. The bimodal distribution that is evident in some of the fisheries is most apparent in the unassociated fisheries and the North and Inshore dolphin fisheries.

The estimated size compositions of the yellowfin caught by all fisheries combined during 1997-2002 are shown in Figure 8b. The size ranges of yellowfin are generally consistent over time (40-160 cm), but the size distributions differ among quarters and among years. The average weights of yellowfin caught were greater during 2001 and 2002 than during 1997-2000, probably due to catches of large fish in the Southern areas. The bimodal distribution mentioned above is evident in the graph for 2002.

There are eight skipjack fisheries defined for stock assessments: four floating-object, two unassociated school, one dolphin, and one pole-and-line. The last two fisheries include all 13 sampling areas. Of the 916 wells sampled, 434 contained skipjack. The estimated size compositions of the fish caught during 2002 are shown in Figure 9a. The majority of the fish was taken in floating-object sets, particularly in the Southern area. The average weight of skipjack caught in floating-object sets during 2002 was less than that of 2001, especially in the Northern and Southern areas. Negligible amounts of skipjack were caught in dolphin sets and by pole-and-line vessels.

The estimated size compositions of the skipjack caught by all fisheries combined during 1997-2002 are shown in Figure 9b. The average weight of the fish caught during 2002 was the lowest since 1997-1998. A distinct mode of smaller fish between 40 and 50 cm is apparent in the graphs for 1997, 1998, and 2002.

There are seven bigeye surface fisheries defined for stock assessments: four floating-object, one unassociated school, one dolphin, and one pole-and-line. The last three fisheries include all 13 sampling areas. Of the 916 wells sampled, 197 contained bigeye. The estimated size compositions of the fish caught during 2002 are shown in Figure 10a. In 2001 and 2002, the majority of the bigeye was caught in sets on floating objects in the Southern area, whereas in 2000 the majority of the catch was made by floating-objects sets in the Equatorial area. A small amount of bigeye was caught in unassociated school sets and in floating-object sets in the Inshore area. As was the case for skipjack, the average weight of bigeye taken in floating-object sets was less in 2002. A mode of smaller fish between 40 and 80 cm is present throughout the floating-object fishery, but especially in the northern and southern areas. Negligible amounts of bigeye were taken in unassociated sets or in floating-object sets in the inshore area. There were no recorded catches of bigeye in dolphin sets or by pole-and-line vessels.

The estimated size compositions of the bigeye caught by all fisheries combined during 1997-2002 are shown in Figure 10b. The average weight of the fish has decreased steadily since 2000, when the largest recorded catch of bigeye was taken.

Pacific bluefin are caught by surface gear by both commercial and sport-fishing vessels off California and Baja California from about 23°N to 35°N, with most of the catch being taken during May through October. During 2002 bluefin were caught between 25°N and 37°N from May through October. The majority of the catch of bluefin by commercial vessels was taken during July, September, and October, and most of the catches by sport-fishing vessels were taken in August. In the past, commercial and recreational catches have been reported separately. In 2002, however, 45 samples were taken from recreational vessels and only one from a commercial vessel, making it infeasible to estimate the catches and size compositions separately. Therefore, the commercial and recreational catches of bluefin were combined for the 1997-2002 period. The estimated size compositions are shown in Figure 11.

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 catch is discarded at sea, but small amounts, mixed with the more desirable species, are sometimes retained. Because only two samples of black skipjack were taken from the 916 wells sampled during 2002, length-frequency histograms for this species are not presented in this report.

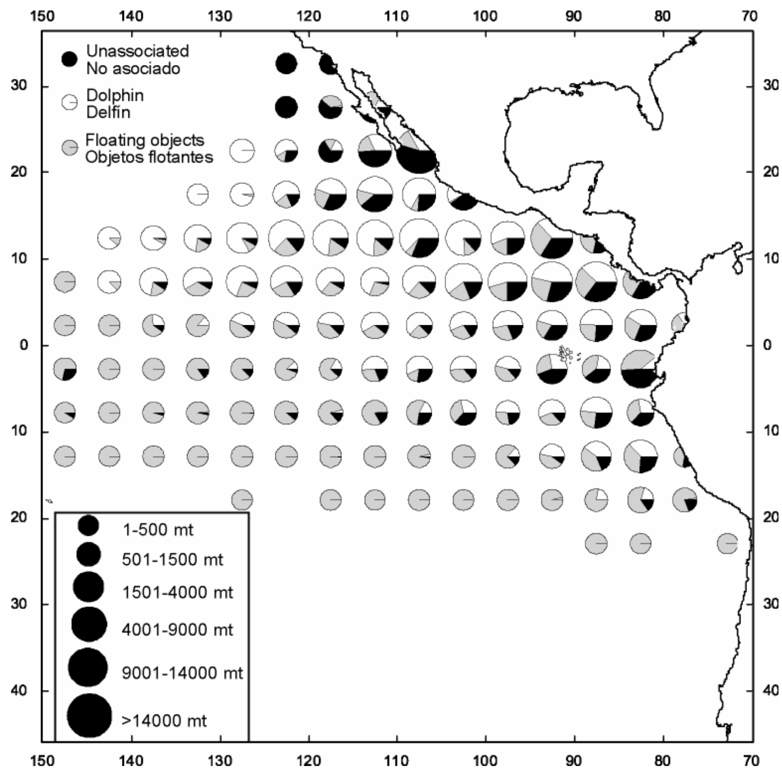


FIGURE 1a. Average annual distributions of the logged purse-seine catches of yellowfin, by set type, 1987-2001.

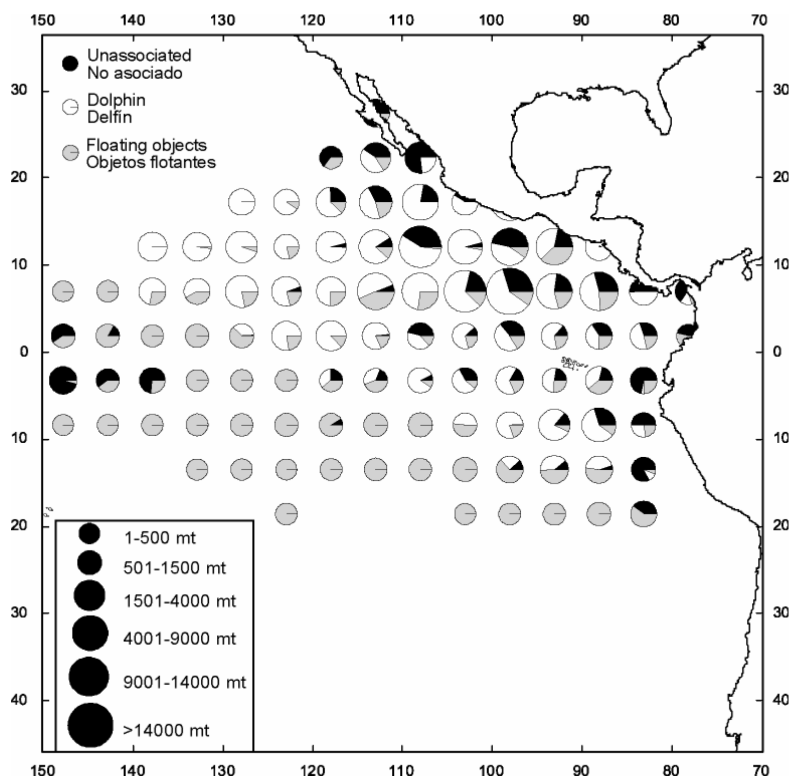


FIGURE 1b. Average annual distributions of the logged purse-seine catches of yellowfin, by set type, 2002 (preliminary).

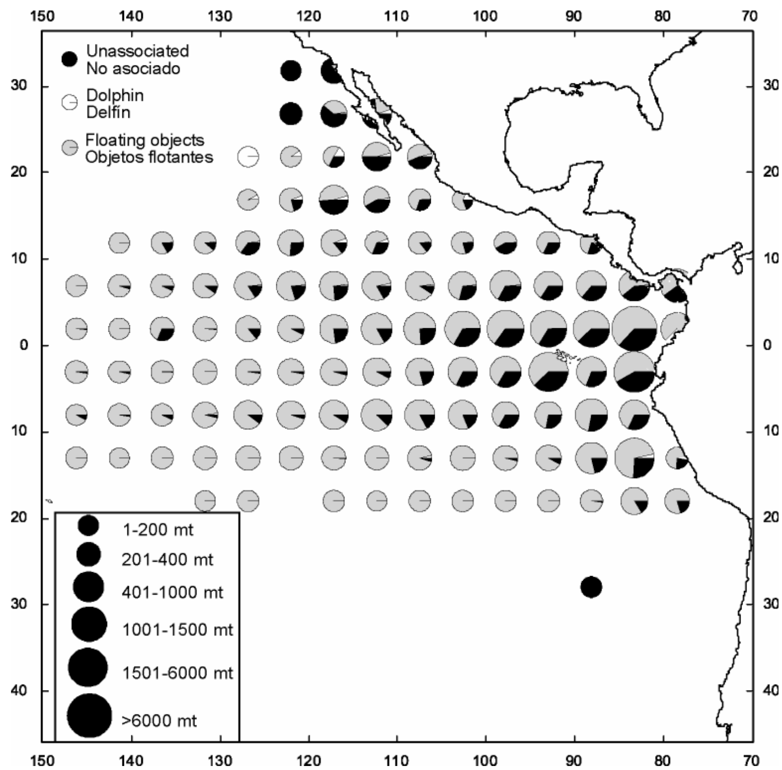


FIGURE 2a. Average annual distributions of the logged purse-seine catches of skipjack, by set type, 1987-2001.

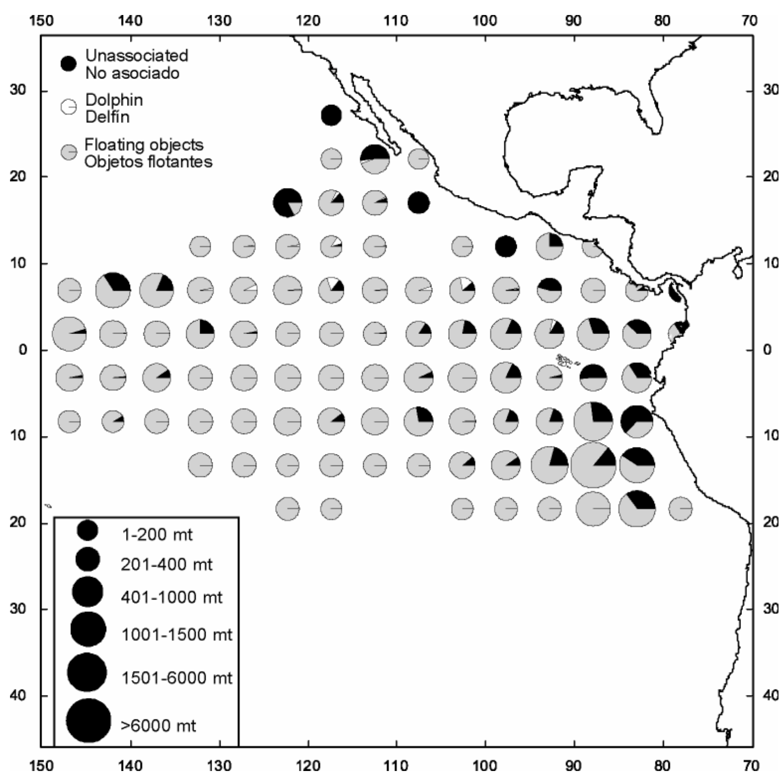


FIGURE 2b. Average annual distributions of the logged purse-seine catches of skipjack, by set type, 2002 (preliminary).

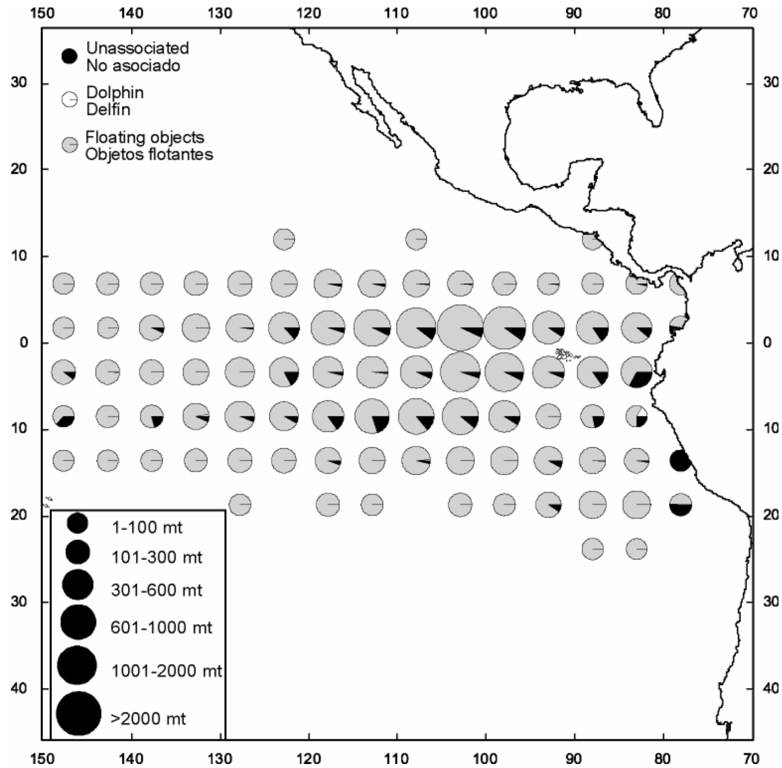


FIGURE 3a. Average annual distributions of the logged purse-seine catches of bigeye, by set type, 1994-2001.

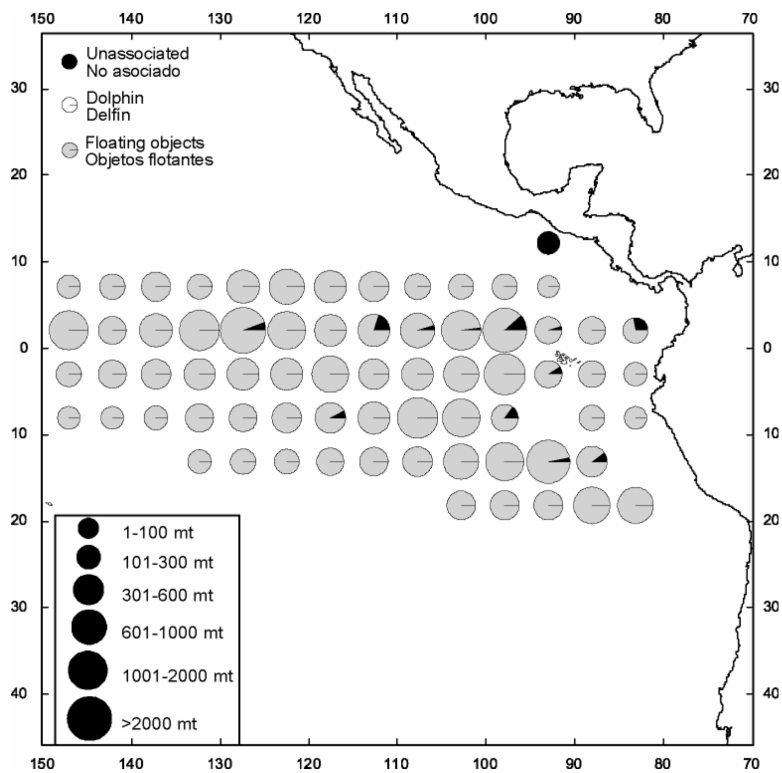


FIGURE 3b. Average annual distributions of the logged purse-seine catches of bigeye, by set type, 2002 (preliminary).

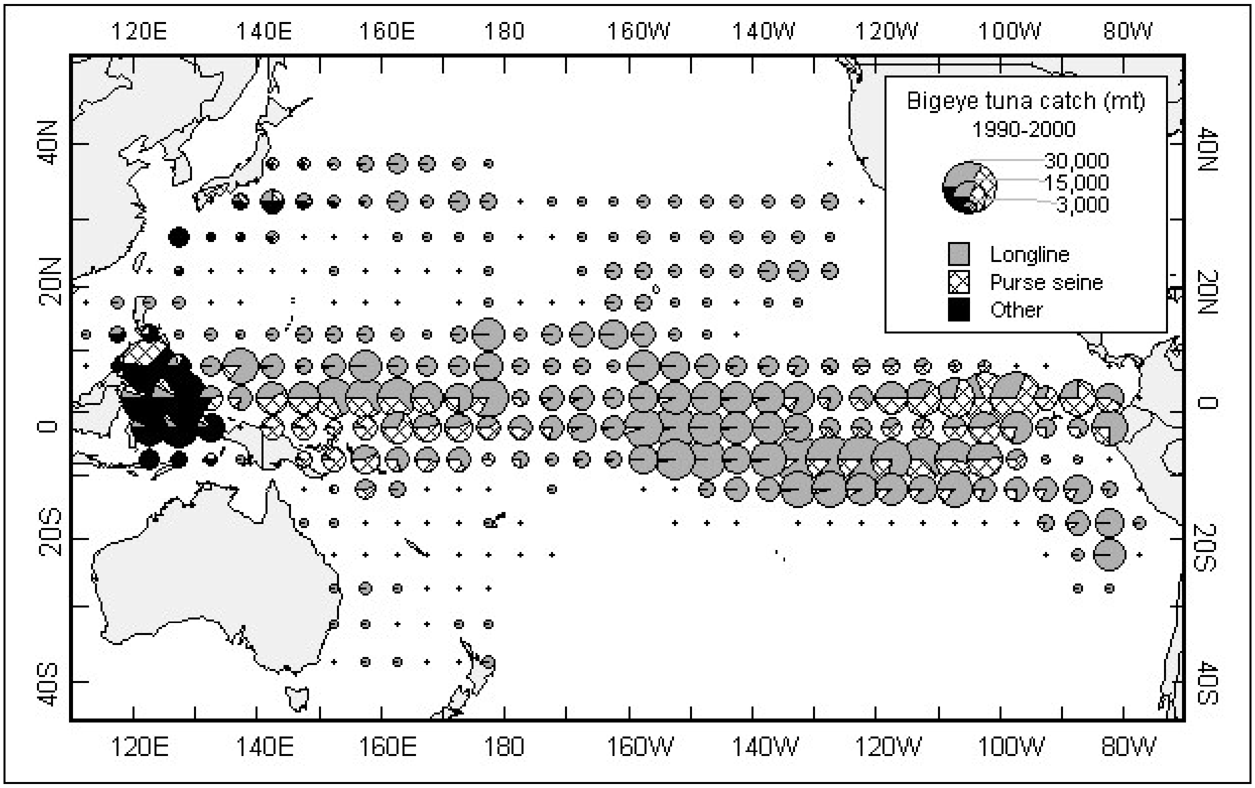


FIGURE 4. Distribution of catches of bigeye tuna in the Pacific Ocean, 1990–2000. (Adapted from Figure 37, Hampton and Williams. 2003. The western and central Pacific Tuna Fishery 2001. Secretariat of the Pacific Community).

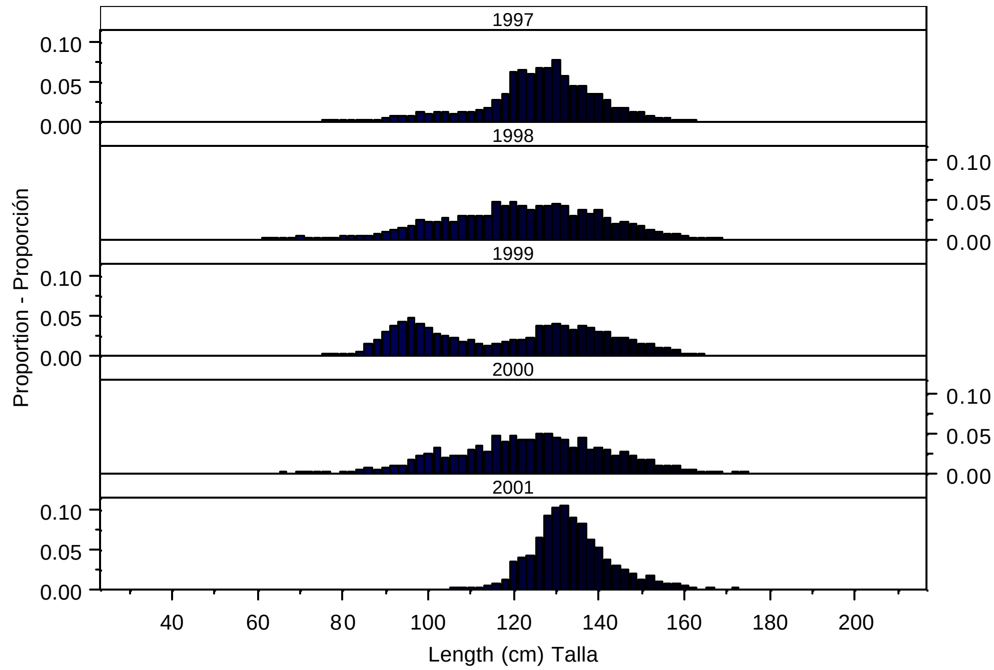


FIGURE 5. Estimated size compositions of the catch of yellowfin tuna by the Japanese longline fishery in the EPO, 1997-2001.

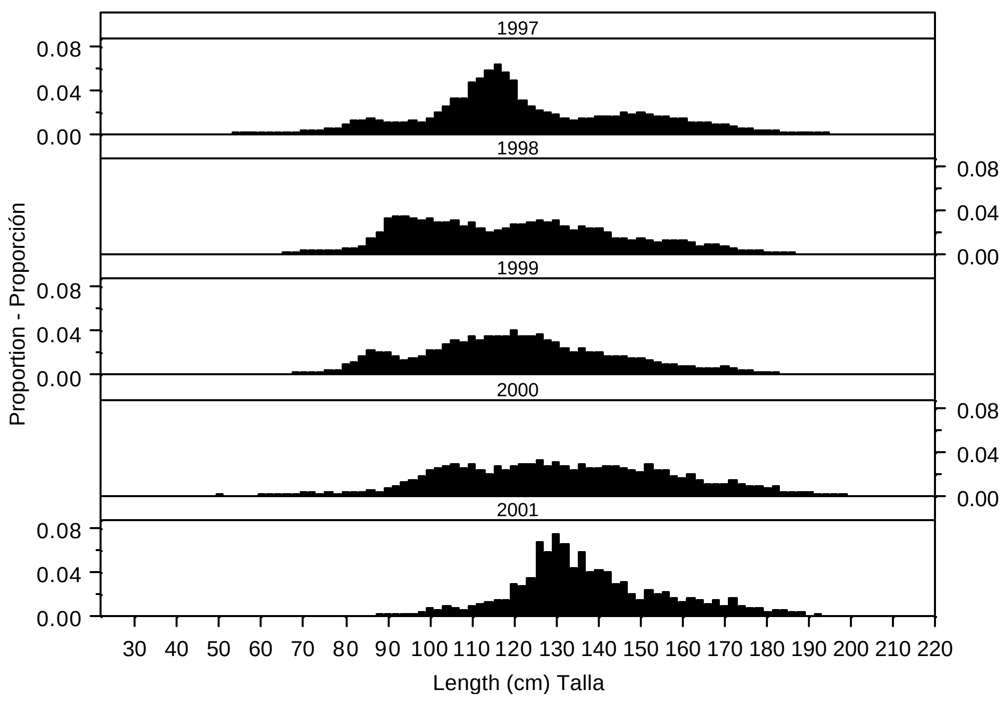


FIGURE 6. Estimated size compositions of the catch of bigeye tuna by the Japanese longline fishery in the EPO, 1997-2001.

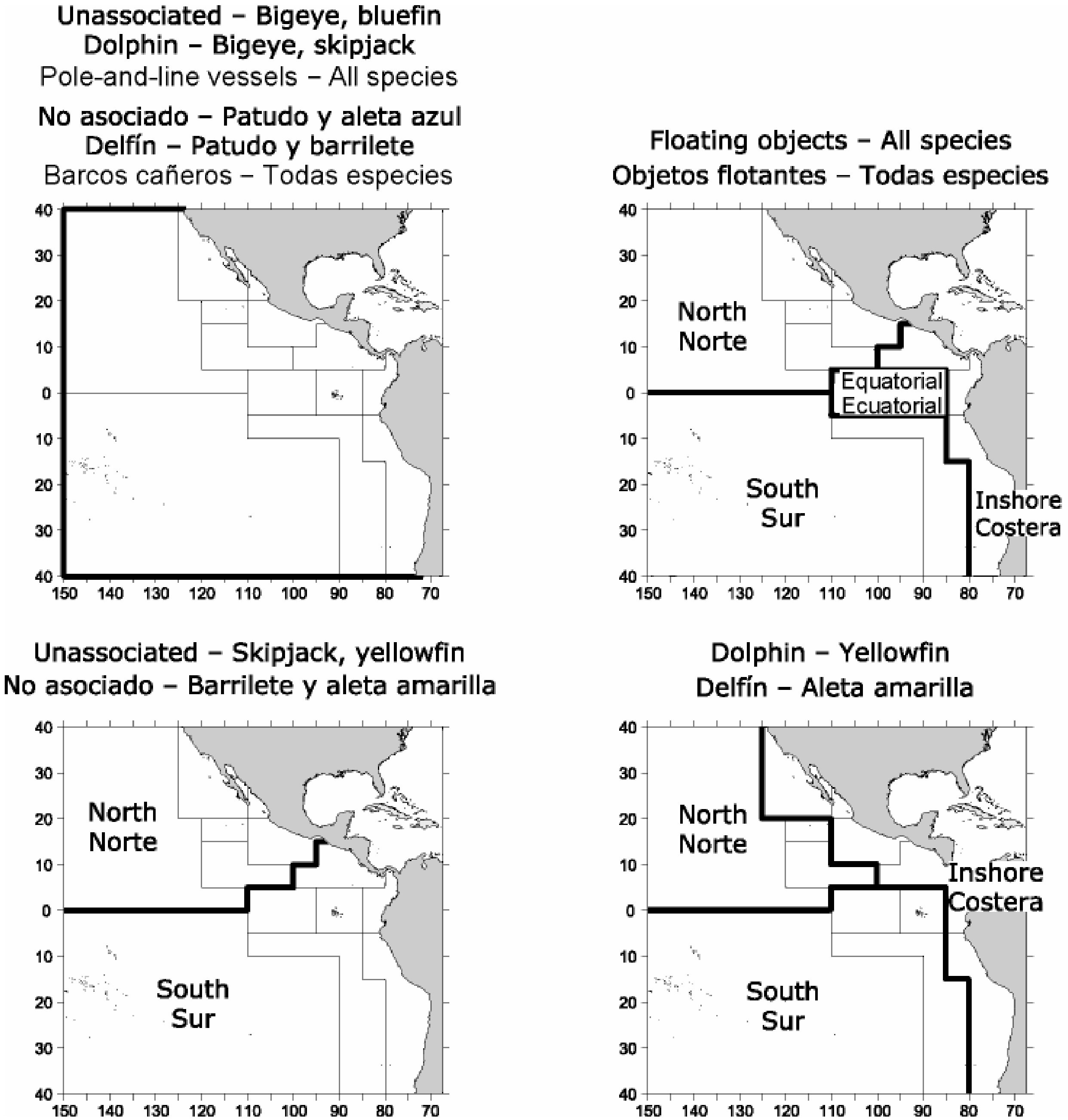
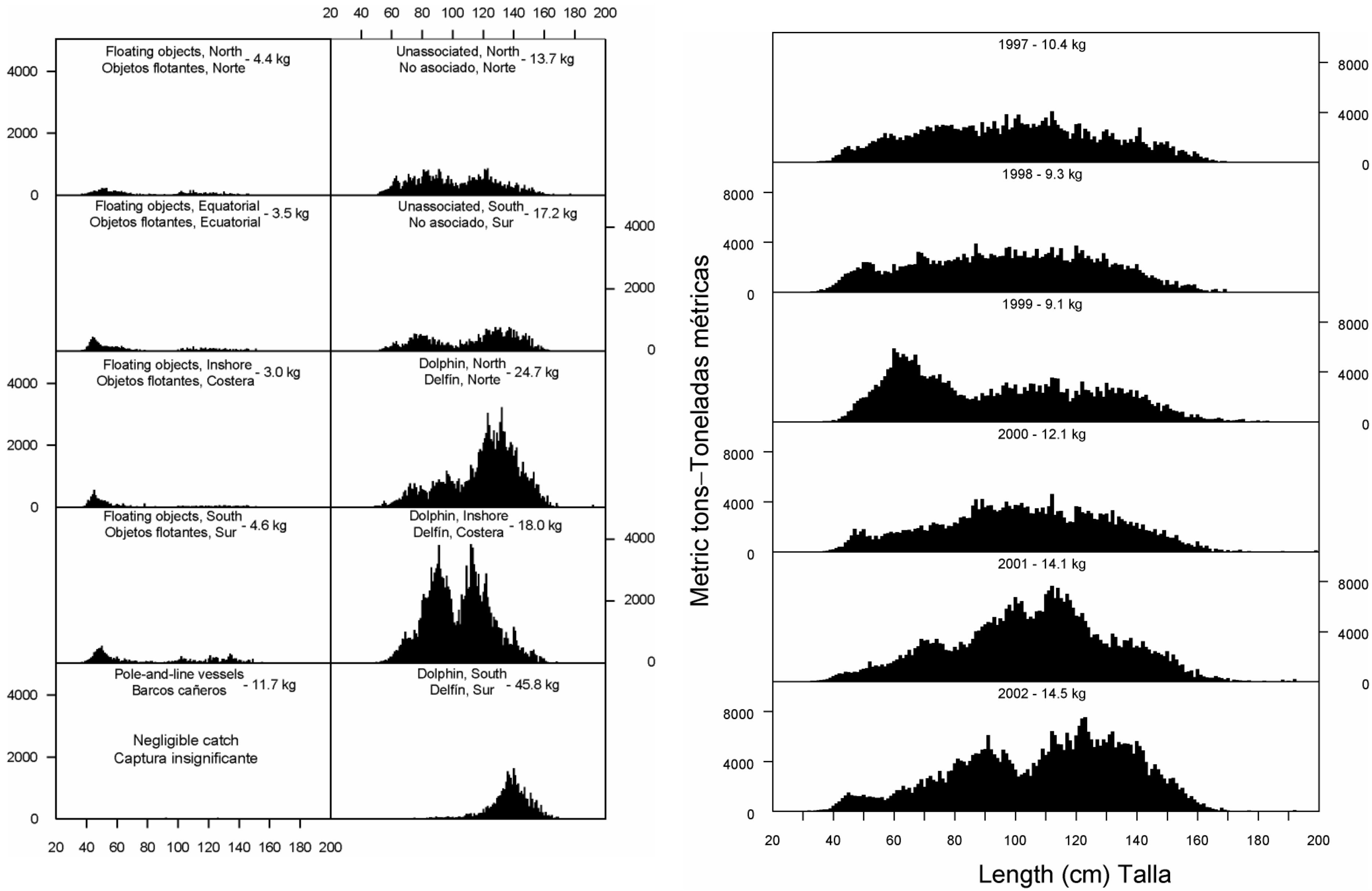
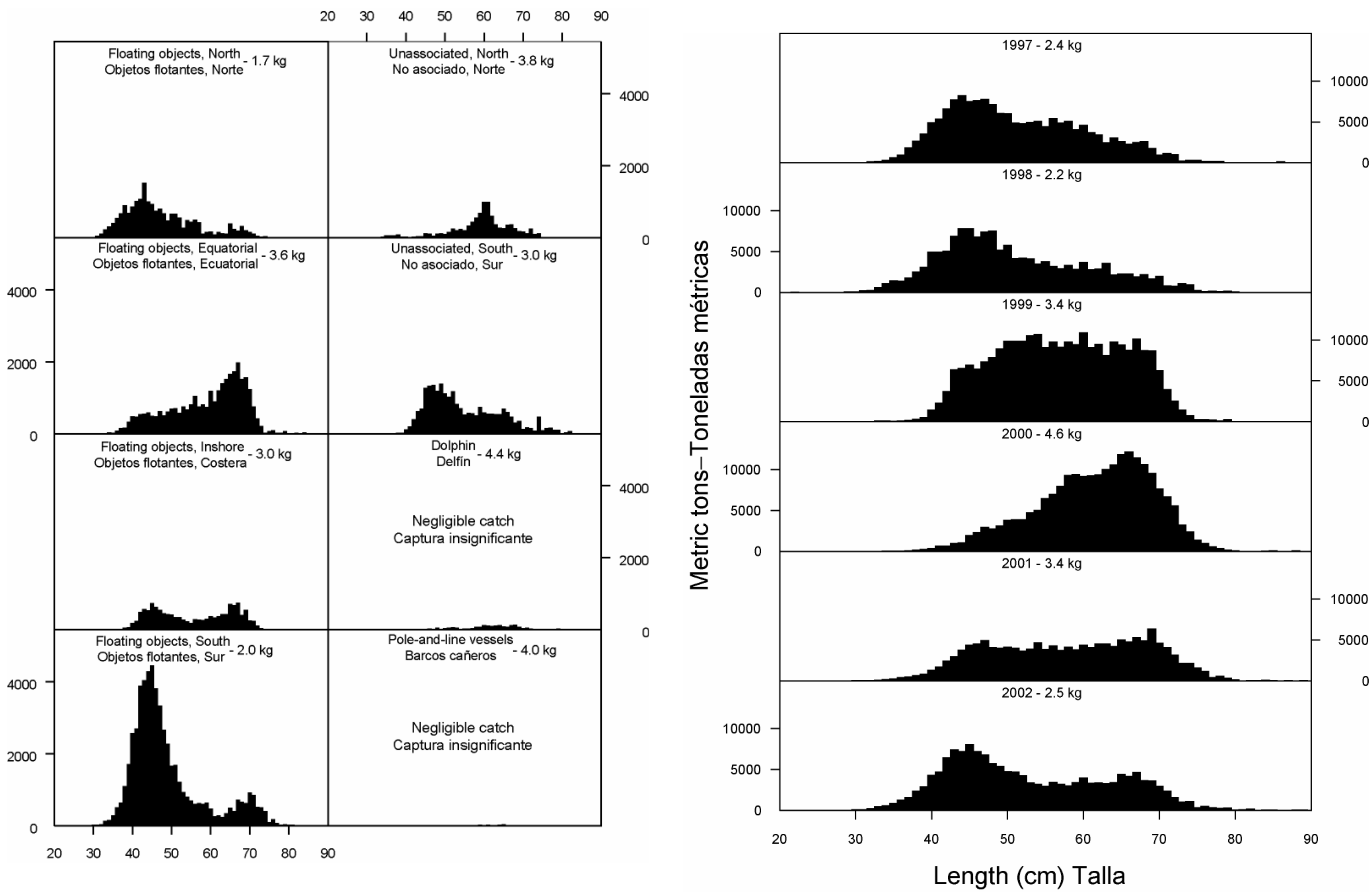


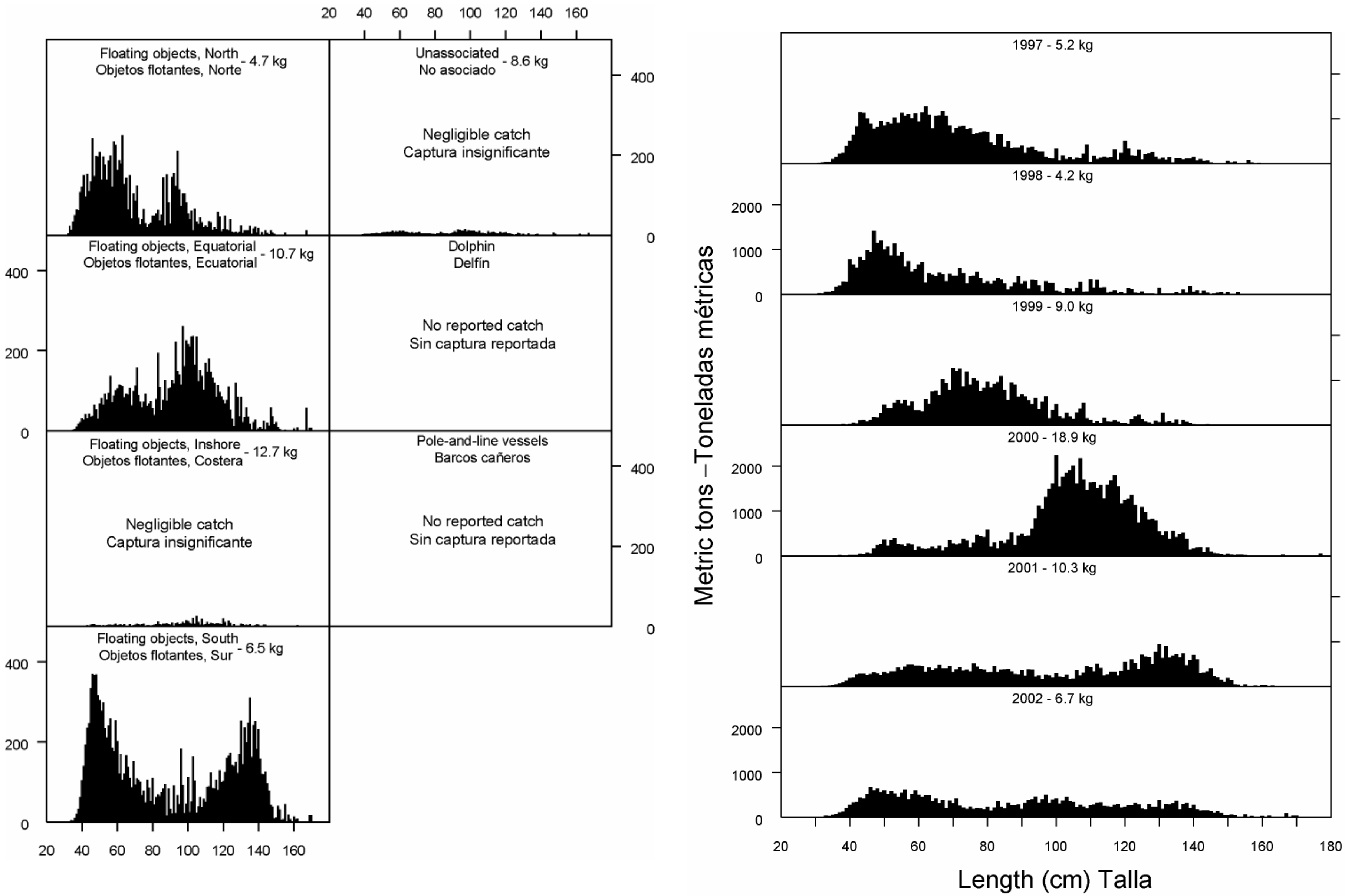
FIGURE 7. The fisheries defined by the IATTC staff for stock assessment of yellowfin, skipjack, and bigeye in the EPO. The thin lines indicate the boundaries of the 13 length-frequency sampling areas, and the bold lines the boundaries of the fisheries.



FIGURES 8a and 8b. Estimated size compositions of the yellowfin caught in each fishery of the EPO in 2002 (8a, left) and in the entire EPO in 1997-2002 (8b, right). The average weights of the fish in the samples are given at the tops of the panels.



FIGURES 9a and 9b. Estimated size compositions of the skipjack caught in each fishery of the EPO in 2002 (9a, left) and in the entire EPO in 1997-2002 (9b, right). The average weights of the fish in the samples are given at the tops of the panels.



FIGURES 10a and 10b. Estimated size compositions of the bigeye caught in each fishery of the EPO in 2002 (10a, left) and in the entire EPO in 1997-2002 (10b, right). The average weights of the fish in the samples are given at the tops of the panels.

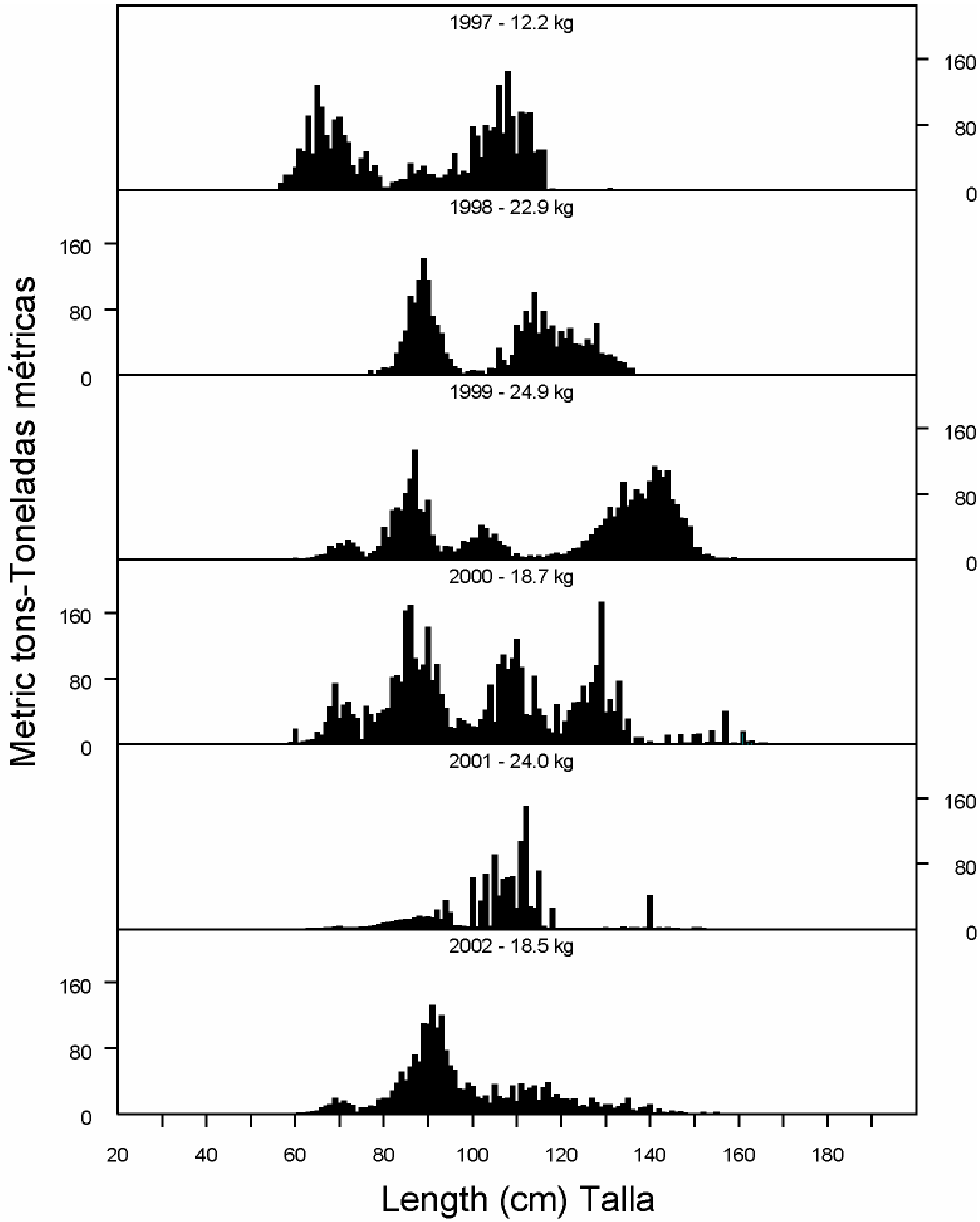


FIGURE 11. Estimated size compositions of the Pacific bluefin caught in the entire EPO in 1997-2002. The average weights of the fish in the samples are given at the tops of the panels.

TABLE 1a. Estimates of the numbers and well volumes, in cubic meters, of the purse seiners and pole-and-line vessels of the EPO tuna fleet in 2001, by flag, gear, and size class. Each vessel is included in the totals for each flag under which it fished during the year, but is included only once in "Grand total." Therefore the grand totals may not equal the sums of the individual flag entries. PS = purse seiner; LP = pole-and-line vessel.

TABLA 1a. Estimaciones del número y volumen de bodega, en metros cúbicos, de los buques cerqueros y cañeros de la flota atunera en el OPO en 2001, por bandera, arte de pesca, y clase de arqueo. 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. PS = cerquero; LP = cañero.

Flag	Gear	Size class—Clase de arqueo							Well volume
Bandera	Arte	1	2	3	4	5	6	Total	Volumen de bodega
					Number—Número				
BLZ	PS	-	-	-	-	-	2	2	1,822
BOL	PS	-	-	2	-	-	5	7	6,190
COL	PS	-	-	2	1	2	5	10	7,397
ECU	PS	-	5	12	11	7	38	73	48,310
ESP	PS	-	-	-	-	-	5	5	12,177
GTM	PS	-	-	-	-	-	4	4	7,640
HND	PS	-	-	-	-	-	3	3	2,254
MEX	PS	-	-	4	4	9	37	54	47,145
	LP	1	3	6	-	-		10	1,271
NIC	PS	-	-	-	-	-	1	1	1,229
PAN	PS	-	-	2	-	-	6	8	9,157
SLV	PS	-	-	-	-	-	2	2	4,469
USA	PS	-	-	2	-	2	5	9	7,415
VEN	PS	-	-	-	-	-	25	25	31,687
VUT	PS	-	-	-	-	-	6	6	7,819
		-	-	-	-	-			
Grand total	PS	-	5	22	18	20	140	205	
Total general	LP	1	3	6	-	-	-	10	
	PS+LP	1	8	28	18	20	140	215	
					Well volume—Volumen de bodega				
Grand total	PS	-	453	3,970	5,207	9,156	171,079	189,865	
Total general	LP	53	293	-	-	-	913	1,259	
	PS+LP	53	746	3,970	5,207	9,156	171,992	191,124	

TABLE 1b. Preliminary estimates of the numbers and well volumes, in cubic meters, of the purse seiners and pole-and-line vessels of the EPO tuna fleet in 2002, by flag, gear, and size class. Each vessel is included in the totals for each flag under which it fished during the year, but is included only once in "Grand total." Therefore the grand totals may not equal the sums of the individual flag entries. PS = purse seiner; LP = pole-and-line vessel.

TABLA 1b. Estimaciones preliminares del número y volumen de bodega, en metros cúbicos, de buques cerqueros y cañeros de la flota atunera en el OPO en 2002, por bandera, arte de pesca, y clase de arqueo. 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. PS = cerquero; LP = cañero.

Flag	**Gear**	**Size class—Clase de arqueo**							**Well volume**
Bandera	**Arte**	**1**	**2**	**3**	**4**	**5**	**6**	**Total**	**Volumen de bodega**
				Number—Número					
BLZ	PS	-	-	1	-	-	1	2	1,018
BOL	PS	-	-	2	1	-	7	10	7,910
COL	PS	-	-	2	1	2	5	10	7,397
ECU	PS	-	7	12	12	8	37	76	47,609
ESP	PS	-	-	-	-	-	5	5	12,177
GTM	PS	-	-	-	-	-	4	4	7,640
HND	PS	-	-	-	-	-	2	2	1,798
MEX	PS	-	-	5	4	11	36	56	47,832
	LP			6	-	-	-	6	925
NIC	PS	-	-	-	-	-	1	1	1,229
PAN	PS	-	-	-	2	-	8	10	11,706
PER	PS	-	-	-	-	-	1	1	1,022
SLV	PS	-	-	-	-	-	3	3	5,686
USA	PS	-	-	2	-	-	9	11	13,339
VEN	PS	-	-	-	-	-	24	24	30,784
VUT	PS	-	-	-	-	1	4	5	4,024
Unknown Desconocido	PS	-	-	-	-	-	1	1	486
Grand total	PS	-	7	24	20	22	145	218	
Total general	LP	-	-	6	-	-	-	6	
	PS+LP	-	7	30	20	22	145	224	
				Well volume—Volumen de bodega					
Grand total	PS	-	758	4,397	5,622	9,333	179,832	199,942	
Total general	LP	-	-	925	-	-	-	925	
	PS+LP	-	756	5,322	5,622	9,333	179,832	200,867	

TABLE 2. Estimated retained and discarded catches by surface gear, in metric tons, of the EPO tuna fleet. "Others" includes sharks, other tunas, and miscellaneous fishes. The 2001 and 2002 data are preliminary. Additional information concerning this table is given in the text.

TABLA 2. Estimaciones de capturas retenidas y descartadas, en toneladas métricas, por artes de superficie de la flota atunera del OPO. "Otros" incluye tiburones, otros atunes, y peces diversos. Los datos de 2001 y 2002 son preliminares. En el texto se presenta información adicional sobre esta tabla.

	Yellowfin			**Skipjack**			**Bigeye**			**Bluefin**		
	Retained	**Discarded**	**Total**	**Retained**	**Discarded**	**Total**	**Retained**	**Discarded**	**Total**	**Retained**	**Discarded**	**Total**
	Aleta amarilla			**Barrilete**			**Patudo**			**Aleta azul**		
	Retenido	**Descartado**	**Total**	**Retenido**	**Descartado**	**Total**	**Retenido**	**Descartado**	**Total**	**Retenido**	**Descartado**	**Total**
1970	155,626		155,626	56,020		56,020	1,332		1,332	3,966		3,966
1971	122,839		122,839	104,721		104,721	2,566		2,566	8,360		8,360
1972	177,127		177,127	33,409		33,409	2,238		2,238	13,347		13,347
1973	205,253		205,253	43,954		43,954	1,979		1,979	10,744		10,744
1974	210,364		210,364	78,803		78,803	890		890	5,617		5,617
1975	202,142		202,142	123,868		123,868	3,723		3,723	9,583		9,583
1976	236,347		236,347	126,287		126,287	10,243		10,243	10,645		10,645
1977	198,816		198,816	86,337		86,337	7,055		7,055	5,473		5,473
1978	180,594		180,594	169,895		169,895	11,759		11,759	5,397		5,397
1979	189,674		189,674	132,024		132,024	7,532		7,532	6,117		6,117
1980	159,425		159,425	130,671		130,671	15,421		15,421	2,939		2,939
1981	181,813		181,813	119,606		119,606	10,091		10,091	1,089		1,089
1982	125,084		125,084	98,757		98,757	4,102		4,102	3,150		3,150
1983	94,256		94,256	58,142		58,142	3,260		3,260	853		853
1984	145,061		145,061	60,551		60,551	5,936		5,936	881		881
1985	216,992		216,992	49,460		49,460	4,532		4,532	4,055		4,055
1986	268,274		268,274	63,552		63,552	1,939		1,939	5,085		5,085
1987	272,247		272,247	62,345		62,345	776		776	1,005		1,005
1988	288,403		288,403	85,326		85,326	1,053		1,053	1,424		1,424
1989	289,375		289,375	92,374		92,374	1,470		1,470	1,170		1,170
1990	273,329		273,329	72,575		72,575	4,712		4,712	1,542		1,542
1991	239,121		239,121	63,260		63,260	3,740		3,740	461		461
1992	239,849		239,849	83,964		83,964	5,497		5,497	1,999		1,999
1993	232,071	5,040	237,111	87,357	10,589	97,946	8,069	585	8,654	879	0	879
1994	219,261	4,614	223,875	74,534	10,314	84,848	29,375	2,305	31,680	1,062	0	1,062
1995	223,776	5,345	229,121	138,239	16,621	154,860	37,328	3,262	40,590	874	0	874
1996	250,170	6,660	256,830	112,205	24,970	137,175	51,353	5,786	57,139	8,259	0	8,259
1997	258,042	5,631	263,673	161,888	31,867	193,755	51,627	5,627	57,254	2,807	3	2,810
1998	265,781	4,718	270,499	145,115	22,856	167,971	35,154	2,853	38,007	2,223	0	2,223
1999	296,677	6,628	302,305	266,182	26,813	292,995	40,610	5,166	45,776	3,092	54	3,146
2000	273,245	6,815	280,060	211,252	26,364	237,616	70,153	5,624	75,777	4,127	0	4,127
2001	396,122	7,921	403,043	145,626	13,516	159,142	42,846	1,261	44,107	1,309	4	1,313
2002	418,967	3,956	422,923	158,043	12,793	170,836	35,201	977	36,178	2,121	6	2,127

TABLE 2. (continued)
TABLA 2. (continuación)

	Albacore			Bonito			Black skipjack			Others			All species combined		
	Retained	Discarded	Total	Retained	Discarded	Total	Retained	Discarded	Total	Retained	Discarded	Total	Retained	Discarded	Total
	Albacora			Bonito			Barrilete negro			Otros			Todas especies combinadas		
	Retenido	Descartado	Total	Retenido	Descartado	Total	Retenido	Descartado	Total	Retenido	Descartado	Total	Retenido	Descartado	Total
1970	4,476		4,476	4,738		4,738	0		0	27		27	226,185		226,185
1971	2,490		2,490	9,600		9,600	6		6	61		61	250,643		250,643
1972	4,832		4,832	8,872		8,872	601		601	367		367	240,793		240,793
1973	2,316		2,316	7,864		7,864	1,674		1,674	355		355	274,139		274,139
1974	4,783		4,783	4,436		4,436	3,742		3742	985		985	309,620		309,620
1975	3,332		3,332	16,838		16,838	511		511	277		277	360,274		360,274
1976	3,733		3,733	4,370		4,370	1,526		1,526	1,327		1,327	394,478		394,478
1977	1,963		1,963	11,275		11,275	1,458		1,458	1,950		1,950	314,327		314,327
1978	1,745		1,745	4,837		4,837	2,162		2,162	806		806	377,195		377,195
1979	327		327	1,805		1,805	1,366		1,366	1,249		1,249	340,094		340,094
1980	601		601	6,110		6,110	3,680		3,680	953		953	319,800		319,800
1981	739		739	5,918		5,918	1,911		1,911	1,010		1,010	322,177		322,177
1982	553		553	2,121		2,121	1,338		1,338	783		783	235,888		235,888
1983	456		456	3,829		3,829	1,236		1,236	1,709		1,709	163,741		163,741
1984	5,351		5,351	3,514		3,514	666		666	987		987	222,947		222,947
1985	919		919	3,604		3,604	296		296	536		536	280,394		280,394
1986	133		133	490		490	595		595	1,140		1,140	341,208		341,208
1987	417		417	3,326		3,326	557		557	1,612		1,612	342,285		342,285
1988	288		288	9,550		9,550	1,267		1,267	1,297		1,297	388,608		388,608
1989	1		1	12,095		12,095	783		783	1,072		1,072	398,340		398,340
1990	184		184	13,856		13,856	792		792	944		944	367,934		367,934
1991	834		834	1,288		1,288	446		446	649		649	309,799		309,799
1992	255		255	978		978	104		104	762		762	333,408		333,408
1993	1	0	1	599	12	611	104	3,950	4,054	314	1,981	2,295	329,394	22,157	351,551
1994	85	0	85	8,692	145	8,837	188	805	993	419	522	941	333,616	18,705	352,321
1995	465	2	467	8,009	55	8,064	187	1,415	1,602	172	668	840	409,050	27,368	436,418
1996	83	0	83	655	1	656	704	2,417	3,121	219	1,052	1,271	423,648	40,886	464,534
1997	60	0	60	1,104	5	1,109	101	2,582	2,683	148	3,407	3,555	475,777	49,122	524,899
1998	124	0	124	1,337	5	1,342	528	1,857	2,385	168	1,233	1,401	450,430	33,522	483,952
1999	274	0	274	1,710	0	1,710	178	3,412	3,590	218	3,096	3,314	607,941	45,169	653,110
2000	149	0	149	615	0	615	293	1,885	2,178	364	1,496	1,860	560,198	42,184	602,382
2001	20	0	20	18	0	18	1,961	1,261	3,222	441	766	1,207	588,343	24,729	613,072
2002	33	0	33	0	0	0	1,202	1,939	3,141	1,039	1,828	2,867	616,606	21,499	638,105

TABLE 3a. Estimates of the retained catches and landings, in metric tons, of tunas caught by surface gear in the EPO in 2001, by species and vessel flag (upper panel) and location where processed (lower panel). Misc. = other species, including sharks, other tunas, and miscellaneous fishes.

TABLA 3a. Estimaciones de las capturas retenidas y descargas de atún capturado con artes de superficie en el OPO en 2001, por especie y bandera del buque (panel superior) y localidad donde fue procesado (panel inferior), en toneladas métricas. Misc. = otras especies, incluyendo tiburones, otros túnidos, y peces diversos.

Flag Bandera	YFT	SKJ	BET	PBF	ALB	BEP	BSJ	Misc.	Total	Percent of total Porcentaje del total
					Retained catches—Capturas retenidas					
Colombia	24,871	2,523	150	0	0	0	79	12	27,635	4.7
Ecuador	54,661	70,388	19,878	0	0	0	1,802	426	147,155	25.0
España—Spain	10,967	21,564	6,724	0	0	0	0	0	39,255	6.7
México	134,401	8,123	91	863	18	18	0	0	143,514	24.4
Panamá	12,223	5,843	1,708	0	0	0	0	0	19,774	3.4
U.S.A.—EE.UU.	5,420	4,226	2,226	446	0	2	72	0	12,392	2.1
Venezuela	109,707	2,178	3	0	0	0	0	0	111,888	19.0
Vanuatu	10,654	8,047	3,785	0	0	0	0	0	22,486	3.8
Other—Otros[1]	33,218	22,734	8,281	0	0	0	8	3	64,244	10.9
Total	396,122	145,626	42,846	1,309	18	20	1,961	441	588,343	
					Landings—Descargas					
Colombia	38,918	6,662	2,017	0	0	0	8	0	47,605	8.1
Costa Rica	26,232	2,031	548	0	0	0	0	0	28,811	4.9
Ecuador	101,514	94,796	31,010	0	0	0	1,881	441	229,642	38.8
España—Spain	12,058	9,665	3,411	0	0	17	0	0	25,151	4.3
México	128,406	7,758	90	853	17	0	0	0	137,124	23.2
Peru	1,729	1,370	0	0	0	0	0	0	3,099	0.5
Venezuela	32,384	714	0	0	0	0	0	0	33,098	5.6
Other-Otros[2]	57,071	22,526	6,187	456	0	2	72	0	86,314	14.6
Total	398,312	145,522	43,263	1,309	17	19	1,961	441	590,844	

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

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

[2] Includes Guatemala, Panama, Thailand, U.S.A., and unidentified. This category is used to avoid revealing the operations of individual vessels or companies.

[2] Incluye EE.UU., Guatemala, Panamá, Tailandia, y no identificados. Se usa esta categoría para no revelar información sobre las actividades de buques o empresas individuales.

TABLE 3b. Preliminary estimates of the retained catches and landings, in metric tons, of tunas caught by surface gear in the EPO in 2002, by species and vessel flag (upper panel) and location where processed (lower panel). Misc. = other species, including sharks, other tunas, and miscellaneous fishes.

TABLA 3b. Estimaciones preliminares de las capturas retenidas y descargas de atún capturado con artes de superficie en el OPO en 2002, por especie y bandera del buque (panel superior) y localidad donde fue procesado (panel inferior), en toneladas métricas. Misc. = otras especies, incluyendo tiburones, otros túnidos, y peces diversos.

Flag Bandera	YFT	SKJ	BET	PBF	ALB	BEP	BSJ	Misc.	Total	Percent of total Porcentaje del total
Retained catches—Capturas retenidas										
Colombia	30,291	2,299	151	0	0	0	0	329	33,070	5.4
Ecuador	38,710	77,285	18,185	0	0	0	588	632	135,400	22.0
España—Spain	5,199	22,076	4,606	0	0	0	0	0	31,881	5.2
México	151,969	8,822	3	1,727	0	30	390	0	162,941	26.4
Panamá	20,017	7,468	1,299	0	0	0	0	0	28,784	4.7
U.S.A.—EE.UU.	8,650	3,759	1,717	394	0	3	224	64	14,811	2.4
Venezuela	119,858	3,888	293	0	0	0	0	0	124,039	20.1
Vanuatu	5,717	6,792	1,912	0	0	0	0	0	14,421	2.3
Other—Otros[1]	38,556	25,654	7,035	0	0	0	0	14	71,259	11.6
Total	418,967	158,043	35,201	2,121	0	33	1,202	1,039	616,606	
Landings—Descargas										
Colombia	29,181	2,700	1,012	0	0	0	0	0	32,893	5.2
Costa Rica	36,435	2,566	354	0	0	0	0	0	39,355	6.2
Ecuador	99,627	126,597	30,794	0	0	0	588	976	258,582	40.9
España—Spain	8,467	5,497	463	0	0	0	0	0	14,427	2.3
México	148,684	8,736	3	1,727	0	29	389	0	159,568	25.2
U.S.A.—EE.UU.	6,424	1,318	64	394	0	3	224	64	8,491	1.3
Venezuela	29,966	350	0	0	0	0	0	0	30,316	4.8
Other-Otros[2]	66,955	16,851	4,692	0	0	0	0	0	88,498	14.0
Total	425,739	164,615	37,382	2,121	0	32	1,201	1,040	632,130	

1 Includes Belize, Bolivia, El Salvador, Guatemala, Honduras, Nicaragua, Peru,, and unidentified. This category is used to avoid revealing the operations of individual vessels or companies.

1 Incluye Belice, Bolivia, El Salvador, Guatemala, Honduras, Nicaragua, Perú, y no identificados. Se usa esta categoría para no revelar información sobre las actividades de buques o empresas individuales.

1 Includes Canada, El Salvador, French Polynesia, Guatemala, Panama, Peru, and unidentified. This category is used to avoid revealing the operations of individual vessels or companies.

1 Incluye Canadá, El Salvador, Guatemala, Panamá, Perú, Polinesia Francesa, y no identificados. Se usa esta categoría para no revelar información sobre las actividades de buques o empresas individuales.

TABLE 4. Estimated numbers of sets by set type and vessel size class, and estimated retained catches, in metric tons, for yellowfin, skipjack, and bigeye tuna in the EPO, by purse-seine vessels. The data for 2002 are preliminary.

TABLA 4. Números estimados de lances, por tipo de lance y clase de arqueo de los buques, y capturas retenidas estimadas, en toneladas métricas, de atunes aleta amarilla, barrilete, y patudo en el OPO. Los datos de 2002 son preliminares.

	Sets on fish associated with dolphins					
	Number of sets			Retained catch		
	Classes 1-5	Class 6	Total	Yellowfin	Skipjack	Bigeye
	Lances sobre peces asociados con delfines					
	Número de lances			Captura retenida		
	Clases 1-5	Clase 6	Total	Aleta amarilla	Barrilete	Patudo
1987	57	13,286	13,343	190,432	332	20
1988	49	11,160	11,209	157,173	4,898	0
1989	33	12,827	12,860	194,846	1,447	0
1990	31	10,997	11,028	179,253	867	0
1991	0	9,661	9,661	159,255	786	38
1992	26	10,398	10,424	169,350	869	0
1993	34	6,953	6,987	110,045	714	97
1994	5	7,804	7,809	125,379	516	0
1995	0	7,185	7,185	131,932	1,032	0
1996	14	7,472	7,486	137,258	729	0
1997	43	8,977	9,020	156,163	6,004	35
1998	0	10,645	10,645	151,678	2,879	66
1999	0	8,648	8,648	143,503	1,214	0
2000	2	9,235	9,237	155,212	468	0
2001	6	9,847	9,853	240,873	1,289	10
2002	0	12,433	12,433	297,147	2,153	0

	Sets on fish associated with floating objects					
	Number of sets			Retained catch		
	Classes 1-5	Class 6	Total	Yellowfin	Skipjack	Bigeye
	Lances sobre peces asociados con objetos flotantes					
	Número de lances			Captura retenida		
	Clases 1-5	Clase 6	Total	Aleta amarilla	Barrilete	Patudo
1987	1,322	1,813	3,135	27,189	32,160	561
1988	823	2,281	3,104	23,933	35,949	569
1989	974	2,339	3,313	28,362	41,452	1,215
1990	719	2,558	3,277	34,247	34,980	3,359
1991	819	2,165	2,984	23,758	37,655	1,950
1992	868	1,763	2,631	13,057	45,556	1,154
1993	493	2,063	2,556	15,964	48,144	4,548
1994	668	2,770	3,438	17,362	47,992	27,472
1995	707	3,521	4,228	20,570	81,253	32,767
1996	1,230	4,007	5,237	31,073	74,260	48,251
1997	1,699	5,653	7,352	27,625	123,002	50,226
1998	1,198	5,481	6,679	31,271	115,370	31,332
1999	630	4,620	5,250	38,569	178,824	35,846
2000	494	3,916	4,410	43,116	123,857	67,514
2001	697	5,743	6,440	62,807	122,268	41,899
2002	778	5,775	6,553	37,159	121,891	34,541

TABLE 4. (continued)
TABLA 4. (continuación)

	Sets on fish in unassociated schools					
	Number of sets			Retained catch		
	Classes 1-5	Class 6	Total	Yellowfin	Skipjack	Bigeye
	Lances sobre peces en cardúmenes no asociados					
	Número de lances			Captura retenida		
	Clases 1-5	Clase 6	Total	Aleta amarilla	Barrilete	Patudo
1987	1,823	3,981	5,804	49,399	26,303	194
1988	4,147	7,536	11,683	102,042	39,535	481
1989	2,955	5,878	8,833	60,226	46,332	256
1990	3,683	5,397	9,080	56,551	35,788	1,351
1991	3,571	3,612	7,183	52,770	22,958	1,727
1992	4,010	4,079	8,089	53,507	35,333	4,343
1993	5,739	6,267	12,006	100,974	34,865	3,424
1994	5,440	5,064	10,504	72,765	22,916	1,902
1995	6,120	4,782	10,902	69,985	50,715	4,560
1996	5,807	5,118	10,925	77,343	34,635	3,102
1997	5,334	4,693	10,027	69,658	29,510	1,354
1998	5,700	4,631	10,331	77,642	25,108	3,757
1999	5,632	6,143	11,775	111,885	84,036	4,765
2000	6,119	5,482	11,601	72,487	86,695	2,641
2001	4,481	3,037	7,518	88,818	21,331	940
2002	5,008	3,405	8,413	83,764	33,404	658

	Sets on all types of schools					
	Number of sets			Retained catch		
	Classes 1-5	Class 6	Total	Yellowfin	Skipjack	Bigeye
	Lances sobre todos tipos de cardumen					
	Número de lances			Captura retenida		
	Clases 1-5	Clase 6	Total	Aleta amarilla	Barrilete	Patudo
1987	3,202	19,080	22,282	267,020	58,795	775
1988	5,019	20,977	25,996	283,148	80,382	1,050
1989	3,962	21,044	25,006	283,434	89,231	1,471
1990	4,433	18,952	23,385	270,051	71,635	4,710
1991	4,390	15,438	19,828	235,783	61,399	3,715
1992	4,904	16,240	21,144	235,914	81,758	5,497
1993	6,266	15,283	21,549	226,983	83,723	8,069
1994	6,113	15,638	21,751	215,506	71,424	29,374
1995	6,827	15,488	22,315	222,487	133,000	37,327
1996	7,051	16,597	23,648	245,674	109,624	51,353
1997	7,076	19,323	26,399	253,446	158,516	51,615
1998	6,898	20,757	27,655	260,591	143,357	35,155
1999	6,262	19,411	25,673	293,957	264,074	40,611
2000	6,615	18,633	25,248	270,815	211,020	70,155
2001	5,184	18,627	23,811	392,498	144,888	42,849
2002	5,786	21,613	27,399	418,070	157,448	35,199

TABLE 5a. Annual retained catches of yellowfin tuna by region, in metric tons. In some cases the data were converted from numbers of fish to weight in metric tons with average weight data estimated by the IATTC staff. "Other" includes China, Costa Rica, Ecuador, El Salvador, French Polynesia, Guatemala, Mexico, Nicaragua, and the USA. Data for 2000-2002 are preliminary.
TABLA 5a. Capturas retenidas anuales de atún aleta amarilla por región, en toneladas métricas. En algunos casos se convirtieron los datos de números de peces a peso en toneladas métricas usando datos de peso promedio estimados por el personal de la CIAT. "Otros" incluye China, Costa Rica, Ecuador, EE.UU., El Salvador, Guatemala, México, Nicaragua, y Polinesia Francesa. Los datos de 2000-2002 son preliminares.

	EPO – OPO							WCPO[3]	Total
	Surface--Superficie[1]	Longline – Palangre[2]					Subtotal EPO – OPO		
		JPN	KOR	TWN	Other – Otros	Subtotal			
1970	155,626	12,273	*	124	*	12,397	168,023	93,826	261,849
1971	122,839	7,368	*	276	*	7,644	130,483	94,392	224,875
1972	177,127	16,013	*	540	*	16,553	193,680	106,069	299,749
1973	205,253	11,413	*	344	*	11,757	217,010	122,911	339,921
1974	210,364	6,914	*	276	*	7,190	217,554	127,255	344,809
1975	202,142	10,299	138	313	*	10,749	212,891	132,100	344,992
1976	236,347	15,036	284	151	*	15,471	251,818	145,413	397,231
1977	198,816	11,222	558	104	*	11,884	210,700	176,832	387,532
1978	180,594	9,187	585	101	*	9,874	190,468	174,505	364,972
1979	189,674	10,909	312	141	*	11,362	201,036	194,150	395,186
1980	159,425	11,549	1,243	31	*	12,823	172,248	210,075	382,323
1981	181,813	7,090	680	165	*	7,935	189,748	225,309	415,057
1982	125,084	9,826	784	82	*	10,692	135,776	219,392	355,168
1983	94,256	9,404	1,057	65	49	10,575	104,831	253,793	358,623
1984	145,061	9,134	937	44	*	10,115	155,176	246,691	401,867
1985	216,992	10,633	1,995	50	2	12,680	229,672	258,160	487,832
1986	268,274	17,770	3,250	76	68	21,164	289,438	244,535	533,973
1987	272,247	13,484	3,103	113	272	16,972	289,219	301,926	591,145
1988	288,403	12,481	1,305	34	232	14,052	302,455	258,505	560,960
1989	289,375	15,335	811	689	9	16,844	306,219	312,038	618,257
1990	273,329	29,255	3,244	630	*	33,129	306,458	350,813	657,271
1991	239,121	23,721	4,796	1,301	171	29,989	269,110	384,243	653,353
1992	239,849	15,296	2,092	227	267	17,882	257,731	391,881	649,612
1993	232,071	20,339	2,441	93	874	23,747	255,818	392,400	648,218
1994	219,261	25,983	2,309	275	778	29,345	248,606	387,831	636,437
1995	223,776	17,042	2,014	42	763	19,861	243,637	379,289	622,926
1996	250,170	12,631	2,246	48	601	15,526	265,696	319,499	585,195
1997	258,042	16,218	2,840	151	1,042	20,251	278,293	458,251	736,544
1998	265,781	10,048	2,436	95	2,195	14,774	280,555	484,594	765,150
1999	295,677	7,186	1,941	43	3,134	12,304	307,981	437,720	745,701
2000	273,245	14,731	2,628	1,149	2,691	21,199	294,444	426,909	721,353
2001	396,122	14,781	3,669	4,814	2,958	26,222	422,344	382,948	805,292
2002	418,967	7,498	*	*	1,199	8,697	427,664	*	*

1 Source: Table 2—Fuente: Tabla 2

2 Sources: published and unpublished data from the National Research Institute of Far Seas Fisheries (NRIFSF), Shimizu, Japan, Institute of Oceanography, National Taiwan University, Taipei, Taiwan, Ministry of Agriculture, People's Republic of China, and National Fisheries Research and Development Agency, Republic of Korea.

2 Fuentes: datos publicados e inéditos del Instituto Nacional de Investigación de Pesquerías de Ultramar (NRIFSF) en Shimizu (Japón), el Instituto de Oceanografía de la Universidad Nacional de Taiwan en Taipei, Ministerio de Agricultura, República Popular de China, y la Agencia Nacional de Investigación y Desarrollo Pesquero de Corea.

3 Source—Fuente: Secretariat of the Pacific Community, Ocean Fisheries Programme

* not available—no disponible

TABLE 5b. Annual retained catches of skipjack tuna by region, in metric tons. In some cases the data were converted from numbers of fish to weight in metric tons with average weight data estimated by the IATTC staff. "Other" includes Costa Rica, French Polynesia, Mexico, and the USA. Data for 2000-2002 are preliminary.

TABLA 5b. Capturas retenidas anuales de atún barrilete por región, en toneladas métricas. En algunos casos los dates fueron convertidos de número de peces a peso en toneladas con datos de peso promedio estimados por el personal de la CIAT. "Otros" incluye Costa Rica, EE.UU., México, y Polinesia Francesa. Los datos de 2000-2002 son preliminares.

	EPO – OPO							WCPO[3]	Total
	Surface--Superficie[1]	Longline – Palangre[2]					Subtotal EPO – OPO		
		JPN	KOR	TWN	Other – Otros	Subtotal			
1970	56,020	*	*	4	*	4	56,024	242,082	298,106
1971	104,721	*	*	*	*	*	104,721	226,371	331,092
1972	33,409	*	*	*	*	*	33,409	235,712	269,121
1973	43,954	*	*	*	*	*	43,954	326,546	370,500
1974	78,803	*	*	*	*	*	78,803	355,361	434,164
1975	123,868	*	6	*	*	6	123,874	288,511	412,385
1976	126,287	*	7	*	*	7	126,294	357,899	484,193
1977	86,337	*	12	83	*	96	86,432	404,232	490,664
1978	169,895	*	10	7	*	17	169,912	450,473	620,385
1979	132,024	*	7	4	*	11	132,035	411,304	543,339
1980	130,671	*	5	-	*	5	130,676	458,419	589,095
1981	119,606	*	9	1	*	10	119,616	438,178	557,794
1982	98,757	*	9	1	*	10	98,767	491,053	589,820
1983	58,142	*	13	-	*	13	58,155	683,404	741,559
1984	60,551	*	9	-	*	9	60,560	751,612	812,172
1985	49,460	*	12	-	*	12	49,472	604,107	653,579
1986	63,552	*	21	2	*	23	63,575	756,819	820,394
1987	62,345	*	9	3	*	12	62,357	685,917	748,274
1988	85,326	*	5	6	*	11	85,337	836,160	921,497
1989	92,374	*	2	9	*	11	92,385	814,257	906,642
1990	72,575	*	6	-	*	6	72,581	890,699	963,280
1991	63,260	*	8	2	3	13	63,273	1,128,878	1,192,151
1992	83,964	*	4	-	*	4	83,968	1,007,830	1,091,798
1993	87,357	*	4	3	*	7	87,364	907,113	994,477
1994	74,534	*	2	10	3	15	74,549	991,279	1,065,828
1995	138,239	*	2	1	6	9	138,248	1,059,366	1,197,614
1996	112,205	*	5	5	24	34	112,239	1,029,964	1,142,203
1997	161,888	20	2	70	13	105	161,993	958,297	1,120,290
1998	145,115	44	2	18	31	95	145,210	1,306,771	1,451,981
1999	266,182	47	4	21	23	95	266,277	1,163,444	1,429,721
2000	211,252	23	3	8	49	83	211,335	1,163,517	1,374,852
2001	145,626	29	0	311	22	362	145,988	1,160,767	1,306,755
2002	158,043	*	*	*	38	38	158,081	*	*

1 Source: Table 2—Fuente: Tabla 2

2 Sources: published and unpublished data from the National Research Institute of Far Seas Fisheries (NRIFSF), Shimizu, Japan, Institute of Oceanography, National Taiwan University, Taipei, Taiwan, Ministry of Agriculture, People's Republic of China, and National Fisheries Research and Development Agency, Republic of Korea.

2 Fuentes: datos publicados e inéditos del Instituto Nacional de Investigación de Pesquerías de Ultramar (NRIFSF) en Shimizu (Japón), el Instituto de Oceanografía de la Universidad Nacional de Taiwan en Taipei, Ministerio de Agricultura, República Popular de China, y la Agencia Nacional de Investigación y Desarrollo Pesquero de Corea.

3 Source—Fuente: Secretariat of the Pacific Community, Ocean Fisheries Programme

* not available—no disponible

TABLE 5c. Annual retained catches of bigeye tuna by region, in metric tons. In some cases the data were converted from numbers of fish to weight in metric tons with average weight data estimated by the IATTC staff. “Other” includes China, Costa Rica, Ecuador, El Salvador, French Polynesia, Guatemala, Mexico, and the USA. Data for 2000-2002 are preliminary.

TABLA 5c. Capturas retenidas anuales de atún patudo por región, en toneladas métricas. En algunos casos se convirtieron los datos de números de peces a peso en toneladas métricas usando datos de peso promedio estimados por el personal de la CIAT “Otros” incluye China, Costa Rica, Ecuador, EE.UU., El Salvador, Guatemala, México, y Polinesia Francesa. Los datos de 2000-2002 son preliminares.

	EPO – OPO							WCPO[3]	Total
	Surface--Superficie[1]	Longline – Palangre[2]					Subtotal EPO – OPO		
		JPN	KOR	TWN	Other – Otros	Subtotal			
1970	1,332	32,521	*	392	*	32,913	34,245	50,246	84,491
1971	2,566	28,871	*	329	*	29,199	31,766	34,536	66,302
1972	2,238	35,113	*	831	*	35,944	38,182	49,960	88,142
1973	1,979	49,731	*	1,312	*	51,043	53,022	37,431	90,453
1974	890	36,013	*	576	*	36,589	37,479	50,583	88,062
1975	3,723	40,726	432	432	*	41,590	45,313	57,909	103,222
1976	10,243	52,827	807	217	*	53,852	64,094	65,052	129,146
1977	7,055	70,024	2,352	211	*	72,587	79,642	65,828	145,470
1978	11,759	67,214	2,090	156	*	69,460	81,219	40,767	121,986
1979	7,532	54,377	694	234	*	55,305	62,837	66,310	129,147
1980	15,421	61,951	1,453	108	*	63,512	78,933	52,434	131,367
1981	10,091	49,970	2,135	640	*	52,745	62,836	42,362	105,198
1982	4,102	50,199	2,300	144	*	52,643	56,745	52,758	109,503
1983	3,260	57,185	2,000	163	*	59,348	62,608	48,897	111,505
1984	5,936	44,587	1,362	153	*	46,102	52,038	51,908	103,946
1985	4,532	61,627	3,696	126	*	65,449	69,981	54,639	124,620
1986	1,939	91,981	7,570	146	0	99,697	101,636	48,957	150,593
1987	776	87,913	7,182	606	1	95,702	96,478	50,794	147,272
1988	1,053	66,015	4,219	665	1	70,900	71,953	46,745	118,698
1989	1,470	67,514	2,199	1,246	*	70,959	72,429	52,561	124,990
1990	4,712	86,148	8,122	715	*	94,985	99,697	61,820	161,517
1991	3,740	85,011	15,090	1,265	7	101,373	105,113	38,268	143,381
1992	5,497	74,466	6,720	727	114	82,027	87,524	70,503	158,027
1993	8,069	63,190	6,688	237	196	70,311	78,380	50,082	128,462
1994	29,375	61,471	7,290	367	128	69,256	98,631	43,069	141,700
1995	37,328	49,016	6,592	68	246	55,922	93,250	44,422	137,672
1996	51,353	36,685	6,423	103	170	43,381	94,734	35,337	130,071
1997	51,627	40,571	6,797	131	352	47,851	99,478	59,921	159,399
1998	35,154	35,752	6,534	149	1,064	43,499	78,653	83,984	162,637
1999	40,610	22,224	6,021	292	902	29,439	70,049	84,190	154,239
2000	70,153	27,865	6,779	3,869	989	39,502	109,655	71,442	181,097
2001	42,846	36,959	10,122	*	3,478	50,559	93,405	81,392	182,867[4]
2002	35,201	29,843	*	*	568	30,411	65,612	*	*

1 Source: Table 3—Fuente: Tabla 3

2 Sources: published and unpublished data from the National Research Institute of Far Seas Fisheries (NRIFSF), Shimizu, Japan, Institute of Oceanography, National Taiwan University, Taipei, Taiwan, Ministry of Agriculture, People's Republic of China, and National Fisheries Research and Development Agency, Republic of Korea.

2 Fuentes: datos publicados e inéditos del Instituto Nacional de Investigación de Pesquerías de Ultramar (NRIFSF) en Shimizu (Japón), el Instituto de Oceanografía de la Universidad Nacional de Taiwan en Taipei, Ministerio de Agricultura, República Popular de China, y la Agencia Nacional de Investigación y Desarrollo Pesquero de Corea.

3 Source-Fuente: Secretariat of the Pacific Community, Ocean Fisheries Programme

4 Includes 8070 T Pacific-wide Taiwanese catch—Incluye 8070 T captura taiwanesa del Pacífico entero

* not available—no disponible

TABLE 5d. Annual retained catches of Pacific bluefin tuna (metric tons).
TABLA 5d. Capturas retenidas anuales de aleta azul del Pacífico (toneladas métricas).

	Western Pacific nations[1]			Eastern Pacific nations				Total
				Surface[2]		Longline[3]	Subtotal	
	Surface	Longline	Subtotal	Commercial	Recreational			
	Naciones del Pacífico occidental[1]			Naciones del Pacífico oriental				Total
				Superficie[2]		Palangre[3]	Subtotal	
	Superficie	Palangre	Subtotal	Comercial	Deportiva			
1970	7,505	1,123	8,628	3,966	15	*	3,981	12,610
1971	8,673	757	9,430	8,348	6	*	8,354	17,784
1972	7,951	724	8,675	13,334	12	*	13,346	22,020
1973	8,798	1,158	9,956	10,743	44	*	10,787	20,743
1974	14,763	3,533	18,296	5,617	47	*	5,664	23,960
1975	10,770	1,558	12,328	9,582	27	*	9,609	21,937
1976	9,186	520	9,706	10,645	17	*	10,662	20,368
1977	12,617	712	13,329	5,473	15	*	5,488	18,817
1978	21,285	1,049	22,334	5,398	4	*	5,402	27,735
1979	25,311	1,223	26,534	6,112	9	*	6,121	32,655
1980	18,372	1,170	19,542	2,939	6	*	2,945	22,487
1981	29,576	975	30,551	1,126	6	*	1,132	31,683
1982	24,095	1,056	25,151	3,021	7	*	3,028	28,179
1983	18,046	864	18,910	1,037	21	*	1,058	19,968
1984	10,562	831	11,393	801	31	*	832	12,225
1985	11,985	706	12,691	3,929	55	*	3,984	16,675
1986	14,496	319	14,815	4,920	7	*	4,927	19,742
1987	13,314	711	14,025	942	21	*	963	14,988
1988	7,331	349	7,680	1,250	4	*	1,254	8,934
1989	9,099	645	9,744	1,076	70	*	1,146	10,890
1990	6,294	585	6,879	975	40	*	1,015	7,894
1991	14,084	627	14,711	113	57	*	170	14,881
1992	10,221	1,037	11,258	1,088	93	9	1,190	12,448
1993	7,818	1,328	9,146	527	114	45	686	9,832
1994	10,964	1,697	12,661	972	24	24	1,020	13,681
1995	22,768	1,104	23,872	718	166	27	911	24,783
1996	10,119	1,934	12,053	8,381	30	25	8,436	20,489
1997	14,757	3,197	17,954	2,575	90	25	2,690	20,644
1998	7,357	3,170	10,527	1,908	213	54	2,175	12,702
1999	16,863	4,244	21,107	2,463	397	89	2,949	24,056
2000	17,888	3,898	21,786	3,386	218	22	3,626	25,412
2001	995	2,429	3,424	1,006	303	7	1,316	4,740

1 Source: Report of the Second Meeting of the Pacific Bluefin Tuna Working Group of the ISC
1 Fuente: Informe de la Segunda Reunión del Grupo de Trabajo sobre Aleta Azul del Pacífico del ISC
2 Sources: 1970-1980 and 2001, IATTC; other years as in footnote 1
2 Fuentes: 1970-1980 y 2001, CIAT; otros años como en nota 1
3 Sources: As in footnote 2 and U.S. NMFS
3 Fuentes: Como en nota 2 y NMFS de EE.UU.
* not available—no disponible

TABLE 6. Nominal fishing effort (E; 1000 hooks) and estimated catch (C; metric tons) of yellowfin, skipjack, bigeye, bluefin, and albacore tunas, by flag, by the principal identified longline fishing fleets operating in the EPO, 1970-2001.

TABLA 6. Esfuerzo de pesca nominal (E; 1000 anzuelos) y captura estimada (C; toneladas métricas) de atunes aleta amarilla, barrilete, patudo, aleta azul, y albacora, por pabellón, de las principales flotas palangreras identificadas faenando en el OPO, 1970-2001.

	CHN		JPN		KOR		MEX		PYF		TWN	
	E	C	E	C	E	C	E	C	E	C	E	C
1970	-	-	83,400	47,300	-	-	-	-	-	-	5,250	5,200
1971	-	-	66,760	37,200	-	-	-	-	-	-	8,740	8,100
1972	-	-	78,240	52,000	-	-	-	-	-	-	7,630	6,800
1973	-	-	107,230	62,500	-	-	-	-	-	-	8,010	4,500
1974	-	-	89,210	43,500	-	-	-	-	-	-	10,260	5,200
1975	-	-	86,130	51,500	6,300	600	-	-	-	-	3,780	1,600
1976	-	-	117,300	68,800	17,100	1,520	-	-	-	-	2,200	1,500
1977	-	-	132,870	83,600	43,900	4,240	-	-	-	-	12,010	7,800
1978	-	-	140,010	79,300	35,800	5,800	-	-	-	-	8,710	6,500
1979	-	-	137,770	67,900	30,400	2,070	-	-	-	-	3,140	2,300
1980	-	-	138,140	75,600	61,500	4,520	10	0	-	-	2,830	1,500
1981	-	-	131,280	59,200	44,800	5,640	20	0	-	-	6,290	3,100
1982	-	-	116,200	61,300	44,300	6,550	50	0	-	-	8,020	3,900
1983	-	-	127,180	69,500	33,400	5,540	950	50	-	-	4,690	2,200
1984	-	-	119,640	57,200	44,200	4,020	-	-	-	-	3,620	1,700
1985	-	-	106,760	74,300	53,700	9,190	180	0	-	-	3,020	1,900
1986	-	-	160,550	111,600	48,800	13,220	2,670	70	-	-	4,580	2,400
1987	-	-	188,390	104,000	29,200	11,930	4,920	270	-	-	12,980	5,400
1988	-	-	182,690	82,400	21,500	6,970	4,160	230	-	-	9,710	4,600
1989	-	-	170,370	84,900	12,700	3,420	340	10	-	-	20,340	6,000
1990	-	-	178,420	117,900	32,300	11,670	-	-	-	-	12,930	5,000
1991	-	-	200,360	112,300	58,700	20,790	-	-	-	-	17,620	5,800
1992	-	-	191,280	93,000	29,800	9,570	-	-	500	200	32,150	13,800
1993	-	-	159,960	87,900	30,800	9,630	30	0	2,605	1,300	17,730	6,400
1994	-	-	163,980	92,500	28,700	10,090	170	30	3,410	1,000	12,930	5,000
1995	-	-	129,600	69,400	30,400	9,370	190	10	3,452	800	2,910	1,600
1996	-	-	103,650	52,300	31,400	9,090	40	0	4,219	1,700	5,860	3,600
1997	-	-	96,380	59,300	26,400	9,960	-	-	5,490	2,800	8,610	5,600
1998	-	-	106,570	50,200	26,200	10,130	150	20	6,415	3,700	9,120	4,500
1999	-	-	80,960	32,900	31,700	8,500	190	10	9,190	3,300	18,050	6,700
2000	-	-	76,700	43,800	29,100	9,580	990	20	10,230	4,800	27,120	11,700
2001	13,480	5,162	99,760	53,700	43,100	14,280	860	10	11,200	5,300	-	29,400

TABLE 7. Estimates of the commercial catches, in metric tons, of billfishes in the eastern Pacific Ocean. Most of the longline-caught fish were retained, and, with the exception of swordfish and blue marlin, most of those caught by surface gear were discarded.
TABLA 7. Estimaciones de las capturas comerciales, en toneladas métricas, de peces picudos en el Océano Pacífico oriental. La mayoría del pescado capturado con palangre fue retenida, y, a excepción de pez espada y marlín azul, la mayoría de la captura de superficie descartada.

	Swordfish		Blue marlin		Black marlin		Striped marlin		Shortbill spearfish		Sailfish	
	Longline	Surface	Longline	Surface	Longline	Surface	Longline	Surface	Longline	Surface	Longline	Surface
	Pez espada		Marlín azul		Marlín negro		Marlín rayado		Marlín trompa corta		Pez vela	
	Palangre	Superficie	Palangre	Superficie	Palangre	Superficie	Palangre	Superficie	Palangre	Superficie	Palangre	Superficie
1970	5,209	2,639	4,126		346		10,976					
1971	2,251	366	2,832		271		10,118					
1972	2,666	691	2,653		309		7,106					
1973	4,687	2,351	3,825		460		5,277					
1974	2,908	688	2,826		303		5,402					
1975	3,065	295	2,281		245		5,429				554	
1976	3,526	308	3,271		180		6,473				494	
1977	4,647	452	3,106		291		3,086				753	
1978	5,946	492	3,630		186		2,496				878	
1979	3,081	228	4,500		284		4,123				251	
1980	5,047	320	4,030		295		4,879				244	
1981	5,692	385	4,453		178		4,870				379	
1982	5,354	439	4,717		166		4,682				1,084	
1983	5,437	580	4,432		186		4,455				889	
1984	5,736	446	5,163		166		2,652				345	
1985	5,638	397	3,574		121		1,592				395	
1986	6,561	768	5,268		198		3,534		5		583	
1987	8,257	1,942	6,967		307		7,533		15		651	
1988	10,497	4,026	5,643		249		5,253		13		651	
1989	11,232	4,744	5,297		153		3,400		0		194	
1990	13,712	3,851	5,284		187		3,128		0		0	
1991	16,122	3,306	6,467	81	178	58	2,906	76	1	1	718	40
1992	15,682	2,821	6,411	59	188	95	2,855	69	1	1	1,354	41
1993	11,784	2,739	6,636	60	189	64	3,398	35	3	0.1	2,269	36
1994	9,942	2,555	9,436	80	240	118	3,333	34	143	0.3	1,803	29
1995	8,052	2,098	7,369	93	136	83	3,151	21	156	0.5	1,406	31
1996	8,882	636	3,606	97	113	92	2,933	22	127	0.5	745	25
1997	14,498	994	5,673	154	146	125	3,959	25	164	1	1,187	29
1998	15,308	1,950	5,302	148	158	113	3,323	18	135	0.4	1,367	49
1999	10,124	873	3,711	194	89	141	2,434	31	187	0.5	1,246	42
2000	13,958	905	3,374	141	96	97	1,533	17	184	0.5	1,300	58
2001	15,087	4	4,054	181	99	113	1,817	20	188	0.3	1,326	37

B. YELLOWFIN TUNA

An age-structured, catch-at-length analysis (A-SCALA) is used to assess yellowfin tuna in the EPO. The analysis method is described in IATTC Bulletin, Vol. 22, No. 4 (in press), and readers are referred to that document for technical details.

The stock assessment requires a substantial amount of information. Data on retained catch, discards, fishing effort, and the size compositions of the catches from several different fisheries have been analyzed. Several assumptions regarding processes such as growth, recruitment, movement, natural mortality, fishing mortality, and stock structure have also been made. The assessment for 2003 differs in several aspects from the assessment carried out in 2002. Catch, effort, and length-frequency data for the surface fisheries have been updated to include new data for 2002 and revised data for 2000 and 2001. Catch data for the Japanese longline fisheries have been updated to include new data for 2001 and updated data for 1998-2000. Catch data for the Taiwan longline fisheries have been updated for 1998, and new data for 1999 have been added. Longline effort data are based on neural-network-standardization of catch per unit of effort (CPUE). Longline catch-at-length data for 1975-1980 were included. Growth is constrained to equal the prior for more ages than in the 2002 assessment The smoothness penalties for selectivity were chosen by cross-validation. The years used to average catchability for the projections and management quantities were calculated by retrospective analysis. Iterative reweighting was used to determine the sample size for catch-at-length data in a sensitivity analysis. Diagnostics, including residual plots, correlation plots, and retrospective analysis, were carried out.

Significant levels of fishing mortality have been observed in the yellowfin tuna fishery in the EPO (Figure YFT1). These levels are highest for middle-aged yellowfin (except for the estimates for the oldest yellowfin, which is an artifact of the model). Both recruitment (Figure YFT2) and exploitation have had substantial impacts on the yellowfin biomass trajectory (Figure YFT3). It appears that the yellowfin population has experienced two different productivity regimes (1975-1983 and 1984-2001), with greater recruitment during the second than the first. The two recruitment regimes (Figure YFT2) correspond to two regimes in biomass (Figure YFT3), the high-recruitment regime producing greater biomasses. The spawning biomass ratio (the ratio of spawning biomass to that for the unfished stock; SBR) of yellowfin in the EPO was below the level that will support the average maximum sustainable yields (AMSYs) during the low-recruitment regime, but above that level during the high-recruitment regime (Figure YFT4). The two different productivity regimes may support two different levels of AMSY and associated SBRs, and the AMSY reported here is an average for the two regimes. The current SBR is slightly below the SBR level at AMSY (Figure YFT4). However, there is substantial uncertainty in the most recent estimate of SBR, and there is a similar probability that the current SBR is above the level which would produce AMSY as there is that the current SBR is below this level. The effort levels are estimated to be less than the levels that will support the AMSY (based on the current distribution of effort among the different fisheries). However, due to the large recruitment that entered the fishery in 1998, the catch levels are greater than the corresponding values at the AMSY (Table YFT1). Because of the flat yield curve, the current effort levels are estimated to produce, under average conditions, catch that is only slightly less than AMSY. Future projections under the current effort levels and average recruitment indicate that the population will increase to an SBR level more than the current level and above that which will support the AMSY (Figure YFT5). These simulations were carried out using the average recruitment for the 1975-2002 period. If they had been carried out using the average recruitment for the 1984-2002 period it is likely that the estimates of SBR and catches would be higher.

The analysis indicates that strong cohorts entered the fishery in 1998 through 2000 and that these cohorts increased the population biomass during 1999 and 2000. However, they have now moved through the population, so the biomass decreased in 2001 and 2002.

The overall average weights of yellowfin tuna that are caught have consistently been much less than the critical weight (36kg), indicating that, from the yield-per-recruit standpoint, the yellowfin in the EPO are not harvested at the optimal size. There is substantial variability in the average weights of the yellowfin taken by the different fisheries, however. In general, the floating-object (Fisheries 1-4), unassociated (Fisheries 5 and 6), and pole-and-line (Fishery 10) fisheries capture younger, smaller fish than do the dolphin-associated (Fisheries 7-9) and longline (Fisheries 11 and 12) fisheries. The longline fisheries and the purse-seine sets in the southern area on yellowfin associated with dolphins (Fishery 9) capture older, larger yellowfin than do the coastal (Fishery 8) and northern (Fishery 7) dolphin-associated fisheries. The AMSY calculations indicate that the yield levels could be greatly increased if the fishing effort were directed toward the fisheries that catch yellowfin closest to the critical weight (longlining and purse-seine sets on yellowfin associated with dolphins, particularly in the southern area). This would also increase the SBR levels.

Moderate changes in the level of surface fishing effort are predicted to affect the SBR, the total catch of the longline fleet, and the average weight of fish in the catch from all fisheries combined. These changes are larger than the changes caused by recent regulations. Increasing the level of surface fishing effort to 125% of its recent average is predicted to decrease the SBR, average weight of fish in the combined catch, and total catch taken by the longline fleet compared to predictions using average effort. Reducing the level of surface fishing effort to 75% of its recent average would have the opposite effects. The catch from surface fisheries would increase only slightly with a 25% increase in the level of surface fishing effort, but would decrease moderately with a 25% decrease in that level . Avoiding the capture of unmarketable yellowfin tuna around floating objects, particularly FADs, would not significantly affect the SBRs and catches, but would moderately increase the average weight of the fish caught. There is a large amount of uncertainty in the future predictions of catch and SBR.

A sensitivity analysis was carried out to determine the effect of a stock-recruitment relationship. The results suggest that the model with a stock-recruitment relationship fits the data slightly better than the base case. The results from the analysis with a stock-recruitment relationship are more pessimistic, suggesting that the effort level is greater than that which would produce AMSY (Table YFT1); however the yield at this effort level is only slightly less than AMSY. The biomass is estimated to have been less than the biomass that would give rise to AMSY for most of the modeling period, except for most of the 1999-2002 period.

The assessment results are very similar to those from the previous assessments. The major differences occur, as expected, in the most recent years. The current assessment and the 2002 assessment estimates that the biomass increased in 2000, whereas the earlier assessments estimated a decline. In addition, SBR and the SBR required to produce AMSY have increased compared to the earlier assessments because average recruitment has been calculated over a longer period, which includes more years from the low-recruitment regime, and due to changes in growth, fecundity, and current age-specific fishing mortality.

Summary

- The results are similar to those of the previous three assessments, except that SBR at SBR_{AMSY} is similar only to that of the last assessment;
- The biomass is estimated to have declined in 2002;
- There is uncertainty about recent and future recruitment and biomass levels;
- The current SBR is about equal to that required to produce AMSY;
- The current fishing mortality rates are less than those required to produce AMSY;
- The average weight of a yellowfin in the catch is much less than the critical weight, and increasing the average weight could substantially increase AMSY;
- There have been two different productivity regimes, and the levels of AMSY and the biomass required to produce AMSY may differ between the regimes;
- The results are sensitive to the assumption about the stock-recruitment relationship.

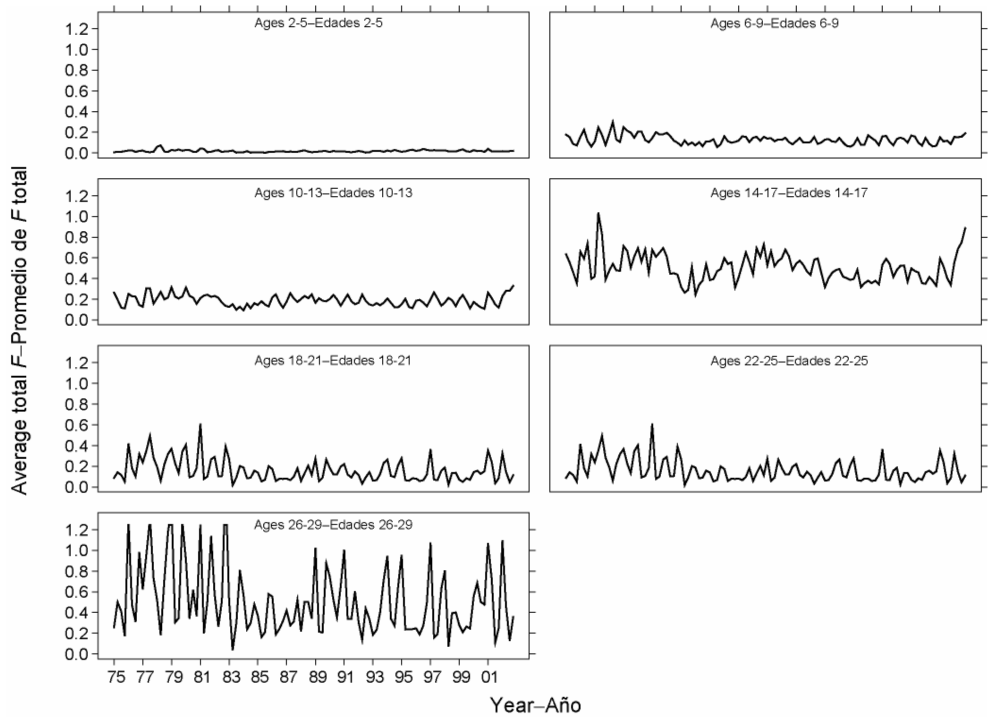


FIGURE YFT1. Time series of average total quarterly fishing mortality of yellowfin tuna recruited to the fisheries of the EPO. Each panel illustrates an average of four quarterly fishing mortality vectors that affected the fish of the age range indicated in the title of each panel. For example, the trend illustrated in the upper-left panel is an average of the fishing mortalities that affected fish that were 2-5 quarters old.

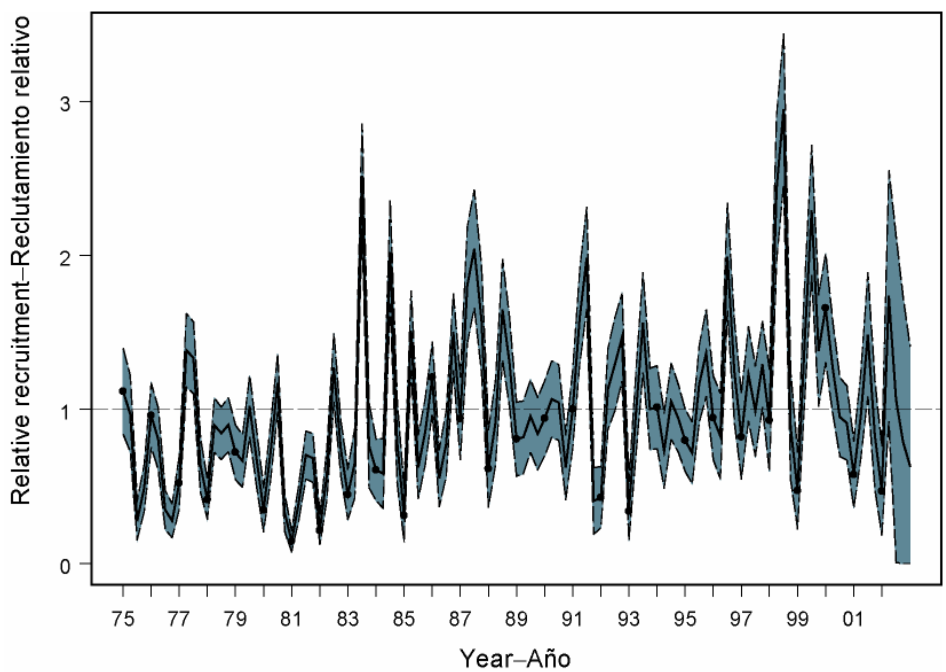


FIGURE YFT2. Estimated recruitment of yellowfin tuna to the fisheries of the EPO. The estimates are scaled so that the average recruitment is equal to 1.0. The bold line illustrates the maximum likelihood estimates of recruitment, and the thin lines indicate the approximate 95% confidence intervals around those estimates. The labels on the time axis are drawn at the start of each year, but, since the assessment model represents time on a quarterly basis, there are four estimates of recruitment for each year.

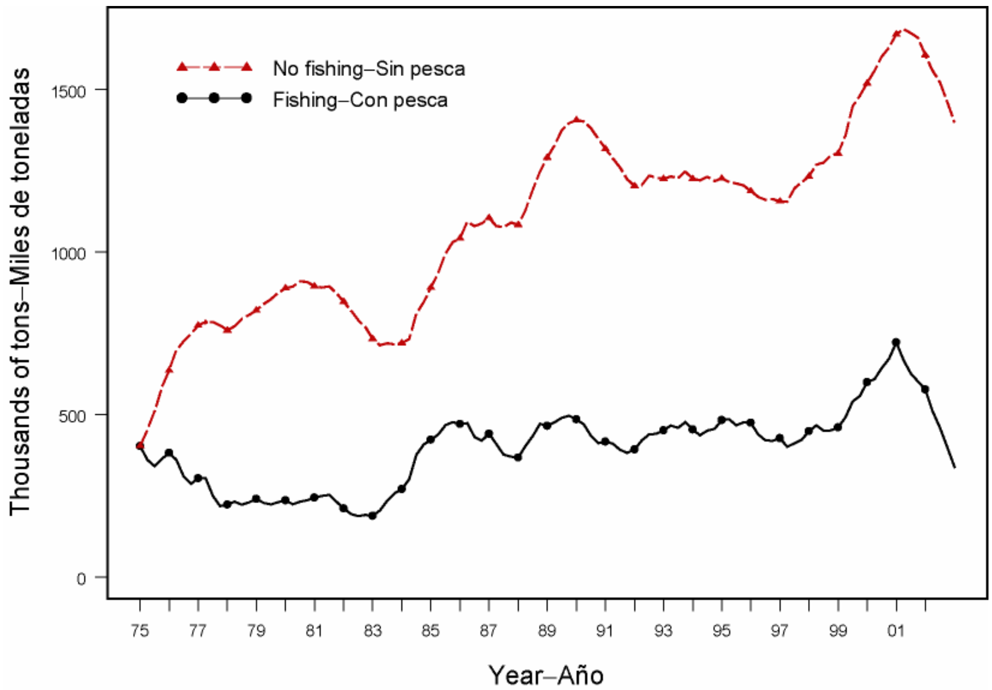


FIGURE YFT3. Biomass trajectory of a simulated population of yellowfin tuna that was not exploited during 1975-2002 (“no fishing”) and that predicted by the stock assessment model (“fishing”).

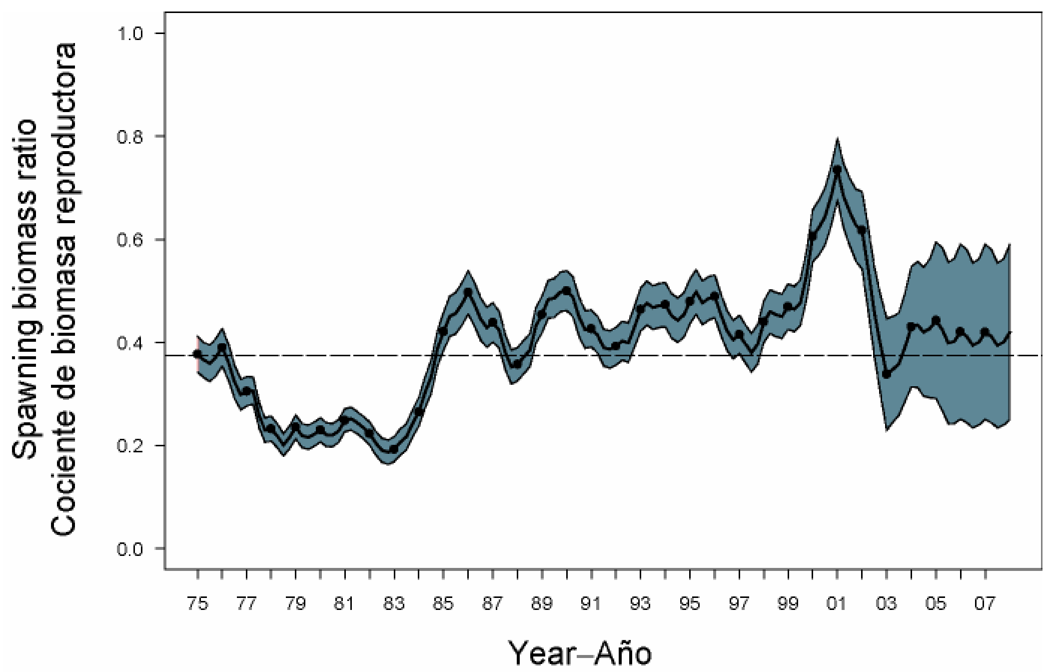


FIGURE YFT4. SBRs projected during 2003-2007 for yellowfin tuna in the EPO by the likelihood profile approximation method. The dashed horizontal line (at 0.37) identifies SBR_{AMSY}.

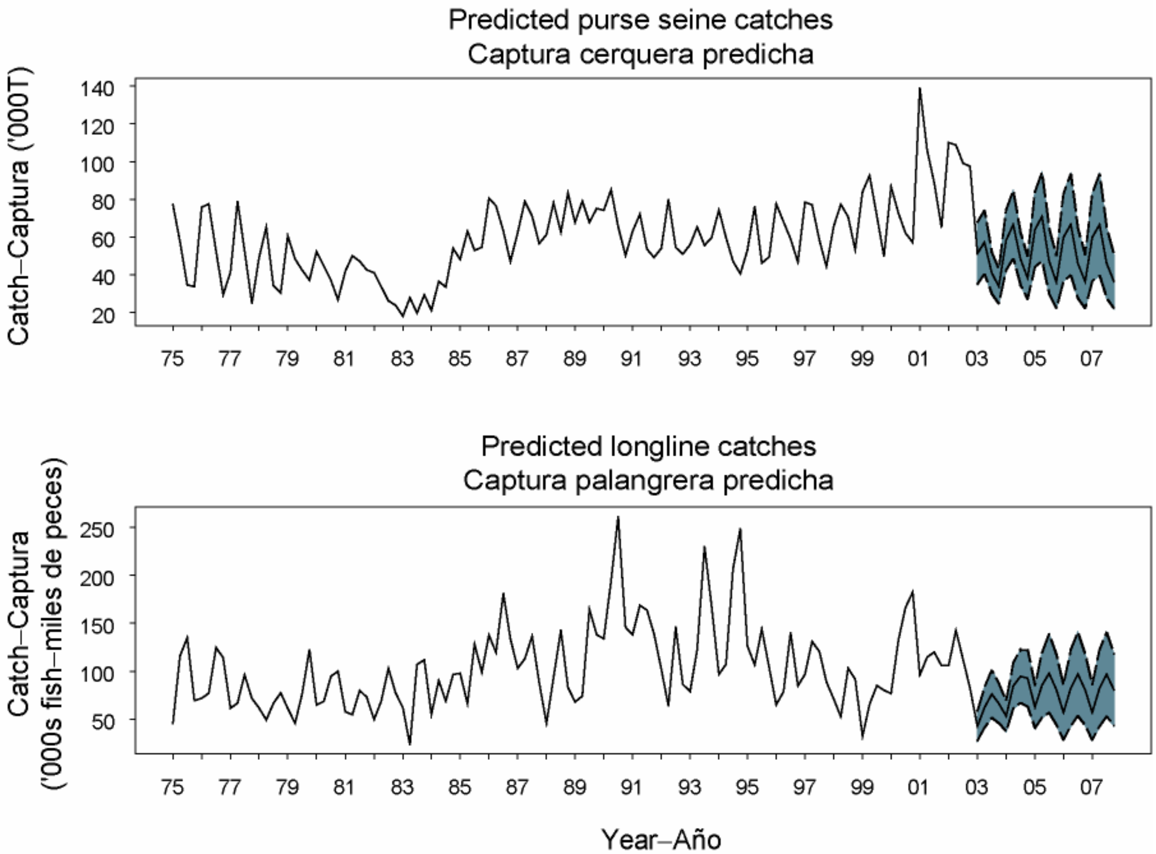


FIGURE YFT5. Simulated catches of yellowfin tuna taken by the primary surface fleet (Fisheries 1-10; top panel) and the the longline fleet (Fisheries 11 and 12, bottom panel) during 2003-2007 using the likelihood profile method.

TABLE YFT1. AMSY and related quantities for the base case and the stock-recruitment relationship sensitivity analysis.

	Basecase	**h = 0.75**	**Iterative reweighting**
AMSY–RPMS	254,723	266,371	250,750
B_{ms2}–B_{rm2}	381,775	502,129	377,686
S_{ms2}—S_{rm2}	6,010	7,946	5,990
C_{2002}/AMSY—C_{2002}/RPMS	1.72	1.64	1.76
B_{2003}/B_{AMSY}–B_{2003}/B_{RMS}	0.89	0.70	0.74
S_{2003}/S_{AMSY}–S_{2003}/S_{RMS}	0.89	0.70	0.74
$S_{AMSY}/S_{F=0}$–$S_{RPMS}/S_{F=0}$	0.37	0.41	0.38
F multiplier—Multiplicador de F	1.20	0.89	1.36

	2002 selectivity smoothness weighting factors	**Species composition based catches**
AMSY–RPMS	254,334	253,594
B_{ms2}–B_{rm2}	379,826	379,913
S_{ms2}—S_{rm2}	5,965	5,983
C_{2002}/AMSY—C_{2002}/RPMS	1.72	1.63
B_{2003}/B_{AMSY}–B_{2003}/B_{RMS}	0.86	0.87
S_{2003}/S_{AMSY}–S_{2003}/S_{RMS}	0.87	0.87
$S_{AMSY}/S_{F=0}$–$S_{RPMS}/S_{F=0}$	0.37	0.38
F multiplier—Multiplicador de F	1.18	1.20

C. SKIPJACK TUNA

An age-structured, catch-at-length analysis (A-SCALA) is used to assess skipjack tuna (*Katsuwonus pelamis*) in the EPO. The analysis method is described in IATTC Bulletin, Vol 22, No. 4 (in press), and readers are referred to that document for technical details. The assessment was carried out in 2002, and no new analysis was carried out in 2003. The stock assessment requires a substantial amount of information. Data on retained catch, discards, fishing effort, and the size compositions of the catches of several different fisheries have been analyzed. Several assumptions regarding processes such as growth, recruitment, movement, natural mortality, fishing mortality, and stock structure have also been made. Environmental influences on recruitment have been investigated. The assessment is still considered preliminary because 1) it is not known if catch –per –day oy fishing is proportional to abundance for the purse-seine fisheries, 2) it is possible that there is a population of large skipjack that is invulnerable to the fisheries, 3) stock structure in relation to the EPO and western and central Pacific stocks is uncertain, and 4) estimates of absolute biomass for 2002 differ by more than an order of magnitude from those of 2001.

Estimates from tagging data (Figure SKJ1) indicate that the rate of fishing mortality is about the same or less than the rate of natural mortality. The recruitment of skipjack tuna to the fisheries in the EPO is variable (Figure SKJ2). Biomass fluctuates mainly in response to the variations in recruitment, except for the low biomass levels in the early 1980s that were estimated to be a consequence of high fishing mortality rates (Figure SKJ3).

The analysis indicates that a group of very strong cohorts entered the fishery in 1998-1999, and that these cohorts increased the biomass and catches during 1999 and 2000 (Figure SKJ2). There is also an indication that the most recent recruitments have been low, which may lead to lower biomasses (Figure SKJ3) and catches. However, these estimates of low recruitment are based on limited information, and are therefore very uncertain.

There is considerable variation in spawning biomass ratio (the ratio of the spawning biomass to the spawning biomass of the unexploited stock; SBR) for skipjack tuna in the EPO (Figure SKJ4). In 2002 the SBR is at a low level (about 0.23). AMSY and yield-per-recruit calculations estimate that maximum yields are achieved with infinite fishing mortality because the critical weight is less than the average weight at recruitment to the main fisheries. However, this is uncertain because of uncertainties in the estimates of natural mortality and growth.

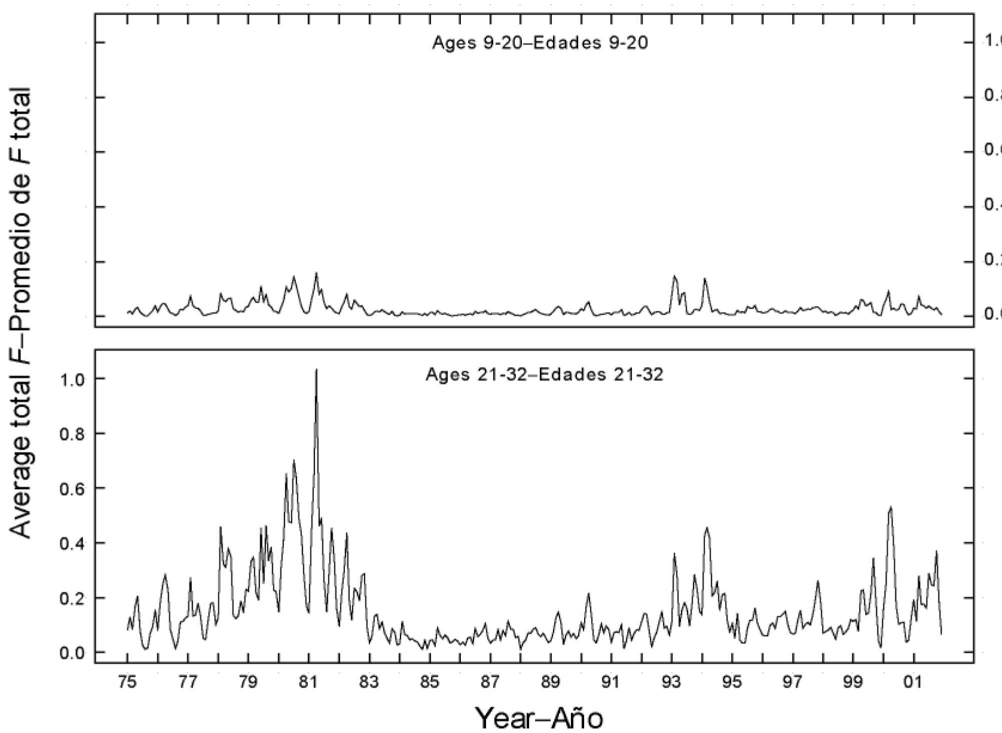


FIGURE SKJ1. Time series of average total monthly fishing mortality of skipjack tuna recruited to the fisheries of the EPO, from the monotonic selectivity assessment. Each panel illustrates an average of 12 monthly fishing mortality vectors that affected fish of the age range indicated in the title of each panel. For example, the trend illustrated in the upper panel is an average of the fishing mortalities that affected fish that were 9-20 months old.

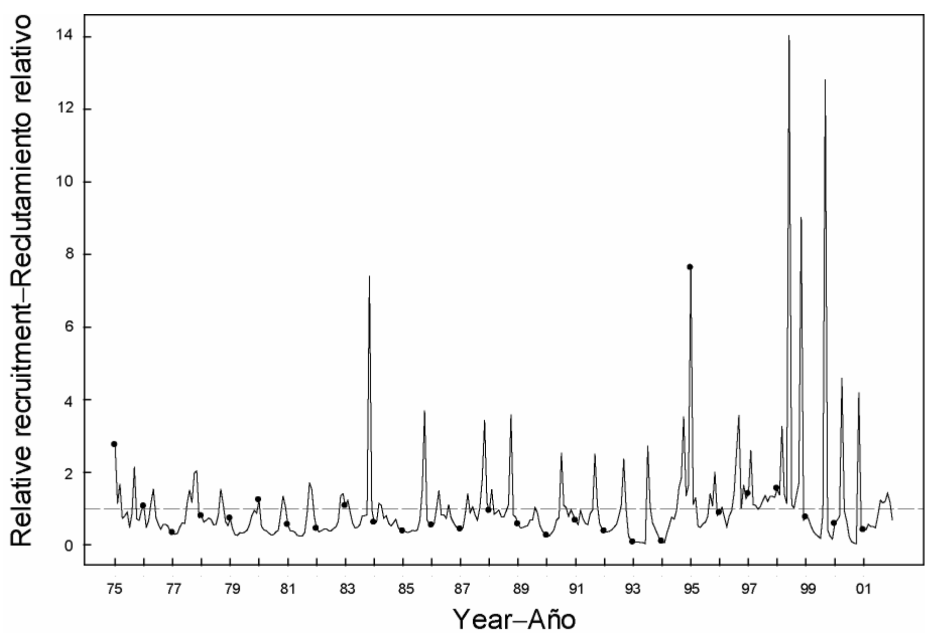


FIGURE SKJ2. Estimated recruitment of skipjack tuna to the fisheries of the EPO from the monotonic selectivity assessment. The estimates are scaled so that the average recruitment is equal to 1.0. The solid line illustrates the maximum-likelihood estimates of recruitment, and the dashed lines the 95% confidence intervals. The labels on the time axis are drawn at the start of each year, but, since the assessment model represents time on a monthly basis, there are 12 estimates of recruitment for each year.

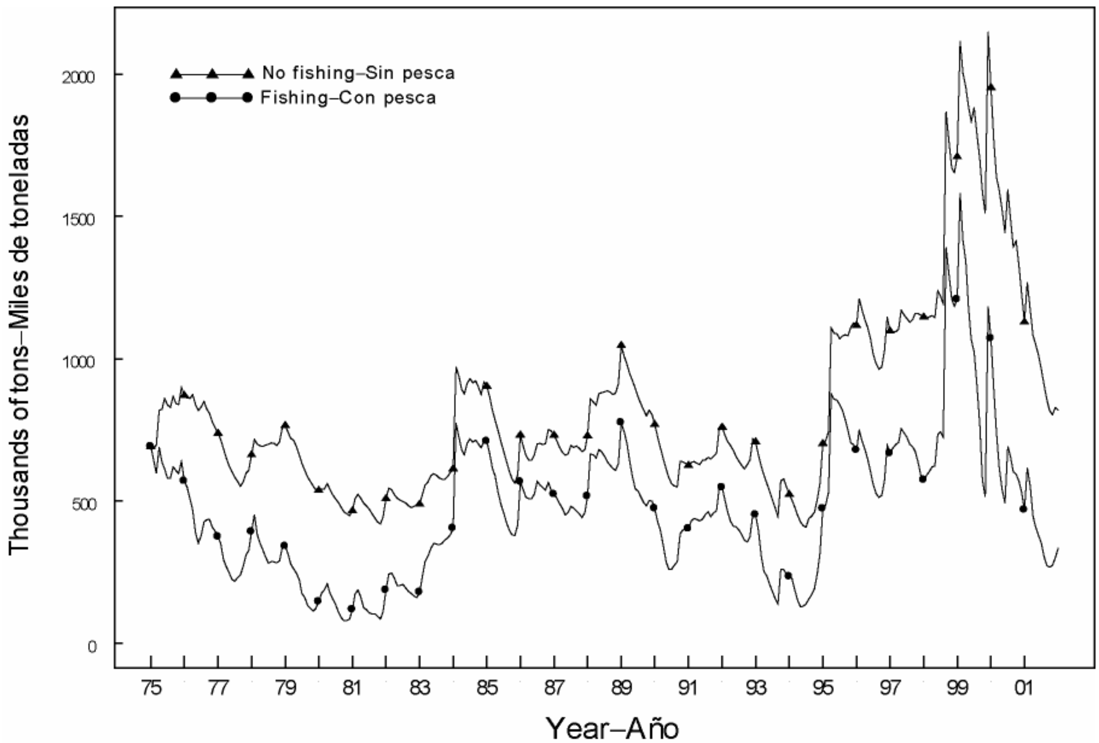


FIGURE SKJ3. Biomass trajectory of a simulated population of skipjack tuna that was not exploited during 1975-2002 ("no fishing") and that predicted by the stock assessment model ("fishing") from the monotonic selectivity stock assessment.

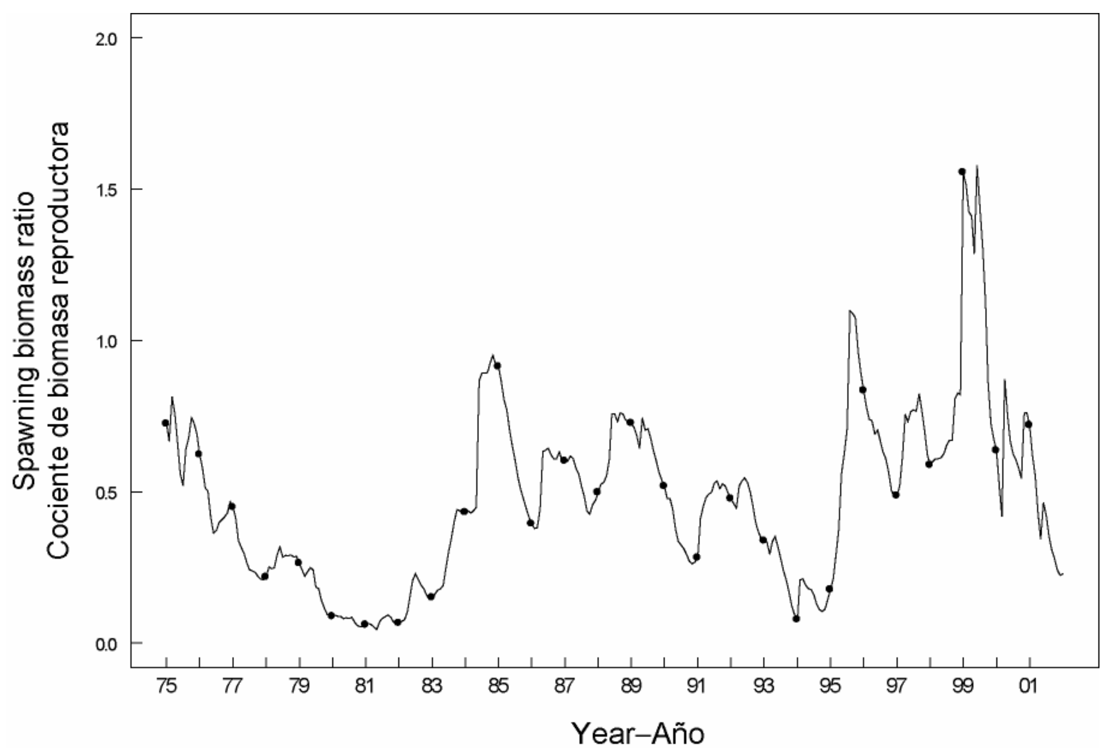


FIGURE SKJ4. Estimated time series of spawning biomass ratios (SBRs) for skipjack tuna in the EPO, from the monotonic selectivity assessment.

D. BIGEYE TUNA

An age-structured, catch-at-length analysis, A-SCALA, was used to assess bigeye tuna in the EPO. The analysis method is described in IATTC Bulletin, Vol 22, No. 4 (in press), and readers are referred to that document for technical details. The version of A-SCALA was similar to that used for the previous assessment with modifications to one of the assumptions. A-SCALA now allows missing values in environmental indices thought to be related to recruitment.

There are several other changes between this assessment and that for 2001, including: extending the model back to 1975, revising inputs for many biological parameters (*e.g.* maturity, natural mortality, fecundity, and sex ratios), using species composition estimates of catch from the purse-seine fisheries, incorporating new and updated data from the purse-seine fisheries, new and updated data for the longline fisheries of China, Japan,, Korea, and Taiwan, calculating standardized CPUE for longline fisheries using a neural network, changing the selectivity smoothness penalties, and changing the years assumed for catchability and fishing mortality for projections and yield calculations[1].

Various sensitivity analyses were performed, including the incorporation of a stock-recruitment relationship, replacing the species composition estimates of purse-seine catches with the unloading estimates used in previous assessments, replacing the neural network standardized CPUE with the habitat-standardized CPUE used in the previous assessment, and replacing the assumed sample sizes for the length-frequency data with estimates of the effective sample size calculated with an iterative procedure[2].

Two alternative scenarios were considered to assess the sensitivity of yield estimates and reference points to the period assumed to represent current (and future) fishing mortality and catchability. In the base case, estimates of fishing mortality and catchability (plus effort deviates) for 2000 and 2001 were used in projections and yield calculations. For sensitivity, fishing mortality and catchability from (1) 1999 and 2000, were compared with (2) 2001 and 2002.

There have been important changes in the amount of fishing mortality caused by the fisheries that catch bigeye tuna in the EPO. On average, the fishing mortality on bigeye less than about 20 quarters old has increased substantially since 1993, and that on fish more than about 24 quarters old has remained relatively constant (Figure BET1). The increase in average fishing mortality on the younger fish was caused by the expansion of the fisheries that catch bigeye in association with floating objects. The base case assessment suggests that (1) the use of fish-aggregating devices (FADs) has substantially increased the catchability of bigeye by fisheries that catch tunas associated with floating objects, and (2) that bigeye are substantially more catchable when they are associated with floating objects in offshore areas than in inshore areas.

Recruitment of bigeye tuna to the fisheries in the EPO is variable, and the mechanisms that explain variation in recruitment have not been identified. Nevertheless, the abundance of bigeye tuna being recruited to the fisheries in the EPO appears to be related to zonal-velocity anomalies at 240 m during the time that these fish were assumed to have hatched. 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 two important features in the estimated time series of bigeye recruitment. First, greater-than-average recruitments occurred in 1977, 1979, 1982-1983, 1992, 1994, and 1995-1997 (Figure BET2).

[1] The analyses described here were undertaken after the meeting of the Scientific Working Group in May 2003 as the data were not available before then. The group believed that it was necessary to undertake the analyses with these new data as they may impact the assessment.

[2] There was insufficient time to repeat this analysis with the revised longline data. However, this sensitivity was examined with the older data set. The results, which were somewhat more pessimistic than those of the base case, did not seem to be realistic, but warrant further examination in the future.

However, the lower confidence bounds of these estimates were only greater than the estimate of virgin recruitment for 1994 and 1997. An above-average cohort is estimated for the first quarter of 2001 but this estimate is uncertain. Second, recruitment has been much less than average for most of the recent period from the second quarter of 1998 to the end of 2000, and the upper confidence bounds of many of these recruitment estimates are below the virgin recruitment (Figure BET2). Evidence for these low recruitments comes from the decreased CPUEs achieved by some of the floating-object fisheries, discard records collected by observers, length-frequency data, and by poor environmental conditions for recruitment. The extended sequence of low recruitments is important because it is likely to produce a sequence of years in which the spawning biomass ratio (the ratio of spawning biomass to that for the unfished stock; SBR) will be below the level that would support the average maximum sustainable yield (AMSY).

Fishing has reduced the total biomass of bigeye present in the EPO, and it is predicted to be at its lowest level by the end of 2003 (Figure BET3). There has been an accelerated decline in biomass since the small peak in 2000.

The estimates of recruitment and biomass are sensitive both to the way in which the assessment model is parameterized and to the data that are included in the assessment. Including the unloading estimates of purse-seine catches reduced the estimates of biomass and recruitment. However, including a stock-recruitment relationship did not change the estimates of biomass or recruitment. Estimated biomass was greater when the habitat-standardized CPUE was included, but the biomass trajectories were generally similar. In general, the results of the sensitivity analysis and those of previous assessments support the view that the base case estimates of absolute biomass and recruitment are uncertain.

At the beginning of January 2003, the spawning biomass of bigeye tuna in the EPO was beginning to decline from a recent high level (Figure BET4). At that time the SBR was about 0.30, about 62% greater than the level that would be expected to produce the average maximum sustainable yield (AMSY), with lower and upper confidence limits (± 2 standard deviations) of about 0.19 and 0.40. The estimate of the lower confidence bound is above the estimate of SBR_{AMSY} (0.18), suggesting that, at the start of January 2003, the spawning biomass of bigeye in the EPO was greater than the level that is required to produce the AMSY.

Estimates of the average SBR projected to occur during 2003-2007 indicate that the SBR is likely to reach an historic low level in 2006, and remain below the level required to produce the AMSY until 2007, and probably after that (Figure BET4). This decline is likely to occur regardless of environmental conditions and the amounts of fishing that occur in the near future because the projected estimates of SBR are driven by the small cohorts that were produced during 1998-2000.

The average weight of fish in the catch of all fisheries combined has been below the critical weight (about 54.7 kg) since 1993, suggesting that the recent age-specific pattern of fishing mortality is not satisfactory from a yield-per-recruit perspective. The average weight of purse-seine-caught fish is about 17 kg, while the average weight of longline fish is about 55 kg.

The distribution of effort among fishing methods affects both the equilibrium yield per recruit and the equilibrium yield. When floating-object fisheries take a large proportion of the total catch, the maximum possible yield per recruit is less than that when longline catches are dominant. Also, if longline catches are dominant, the maximum yield per recruit (or a value close to it) can be obtained over a wide range of fishing effort. When floating-object fisheries take a large proportion of the total catch, a more narrow range of fishing effort provides a yield per recruit that is close to the maximum. When floating-object fisheries take a large proportion of the total catch and a stock-recruitment relationship exists, extremely large amounts of fishing effort would cause the population to crash. When longline catches are dominant, the population can sustain substantially greater fishing effort.

Recent catches are estimated to have been about 35% above the AMSY level (Table BET1). If fishing mortality is proportional to fishing effort, and the current patterns of age-specific selectivity are maintained, the level of fishing effort that is estimated to produce AMSY is about 84% of the current level of effort. Decreasing the effort to 84% of its present level would increase the long-term average yield by only 1%, but would increase the spawning potential of the stock by about 22%. The catch of bigeye by the surface fleet may be determined largely by the strength of cohorts recruited to the fishery. Thus, the catches of bigeye taken by the surface fleet will probably decline when the large cohorts recruited during 1995-1998 are no longer vulnerable to the surface fisheries. The AMSY of bigeye in the EPO could be maximized if the age-specific selectivity pattern were similar to that for the longline fishery that operates south of 15°N because it catches larger individuals close to the critical size.

With the exception of the sensitivity to steepness, analyses suggest that at the start of 2003 the spawning biomass was above the level that would be present if the stock were producing the AMSY (Table BET1). AMSY and the fishing mortality (F) multiplier are sensitive to how the assessment model is parameterized, the data that are included in the assessment, and the periods assumed to represent average fishing mortality.

The small cohorts of bigeye that were apparently recruited to the fisheries in the EPO during 1998-2000 should cause the SBR to decrease throughout 2003 and to be substantially less than SBR_{AMSY}. The spawning biomass of bigeye in the EPO should decline to historically low levels, and then continue to decline further. This decline is predicted to occur regardless of the amount of fishing effort and the environmental conditions that occur in the near future. The SBR is projected to further decrease during 2004-2006.

Preventing the discards of small bigeye from catches taken around floating objects (or ensuring that discarded fish survive) would increase the SBR, the yield per recruit, the catch taken by the surface fleet, and the catch taken by the longline fleet. Thus, any measure that effectively reduces the mortality of bigeye that are about 2-5 quarters old may help to achieve a variety of management objectives. Reducing future purse-seine effort by 25% is predicted to increase spawning biomass, mean weight of the catch, and longline catches, while only slightly reducing purse-seine catches. Conversely, increasing purse-seine effort by 25% will further decrease spawning biomass, mean weight of the catch, and longline catches. Reducing future longline effort by 25% is projected to have greater short-term (less than three years) benefits in increases in spawning biomass than reducing purse-seine effort, but by five years, the benefits of reducing purse-seine effort are three times those of reducing longline effort.

The sensitivity analysis indicates that, if fishing mortality rates continue at their recent (2001 and 2002) levels, longline catches and SBR will decrease to extremely low levels. As the base case does not include a stock-recruitment relationship, recruitment will not decline, so purse-seine catches are predicted to stay at moderate levels (Figure BET5).

Summary:

- Almost all cohorts since 1998 have been below average.
- As a consequence, total biomass and spawning biomass will decrease in the future below the lowest levels observed during the period modelled (1975-2003).
- The current status and future projections are more pessimistic if a stock-recruitment relationship (h = 0.75) exists.
- These conclusions are robust to alternative model and data formulations.

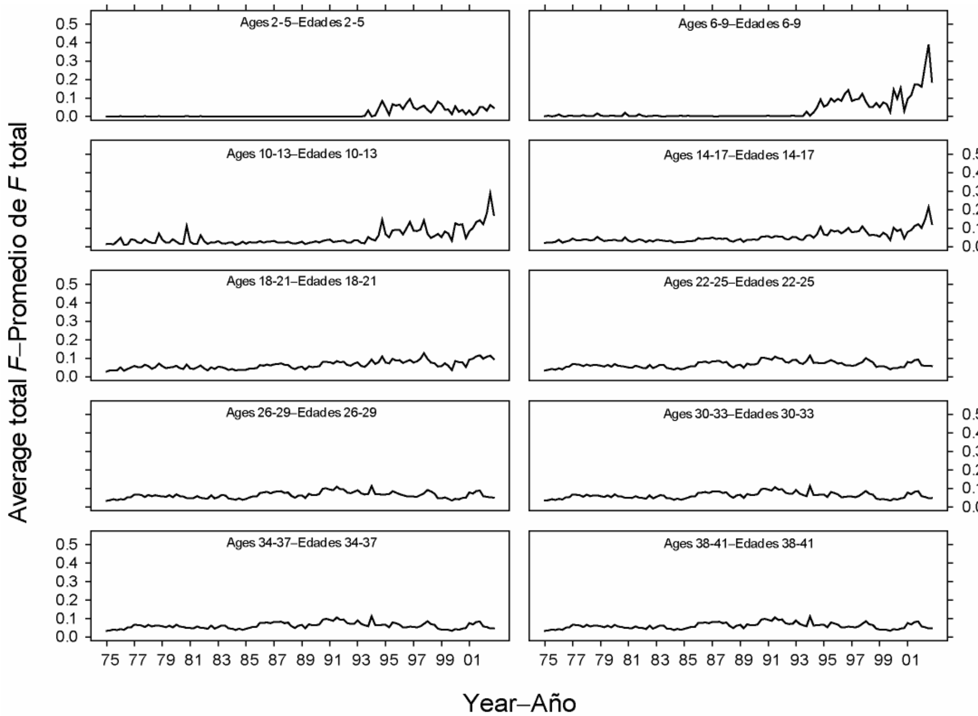


FIGURE BET1. Time series of average total quarterly fishing mortality on bigeye tuna recruited to the fisheries of the EPO. Each panel illustrates an average of four quarterly fishing mortality vectors that affected the fish in the age range indicated in the title of each panel. For example, the trend illustrated in the upper-left panel is an average of the fishing mortalities that affected fish that were 2-5 quarters old.

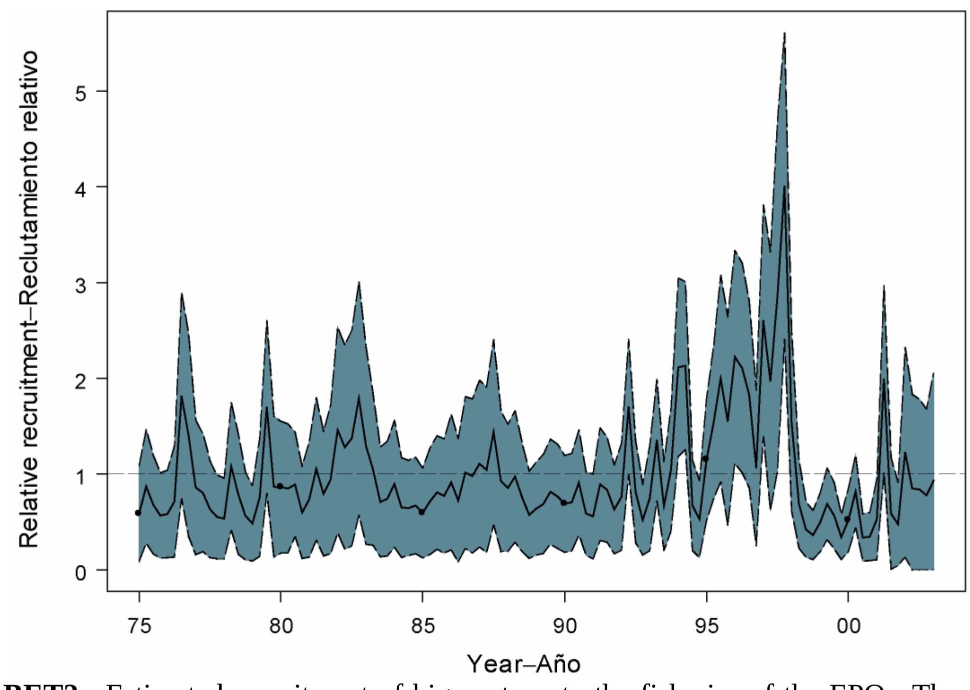


FIGURE BET2. Estimated recruitment of bigeye tuna to the fisheries of the EPO. The estimates are scaled so that the estimate of virgin recruitment is equal to 1.0. The bold line illustrates the maximum likelihood estimates of recruitment, and the thin lines are confidence intervals (±2 standard errors) around those estimates. The labels on the time axis are drawn at the start of each year, but, since the assessment model represents time on a quarterly basis, there are four estimates of recruitment for each year.

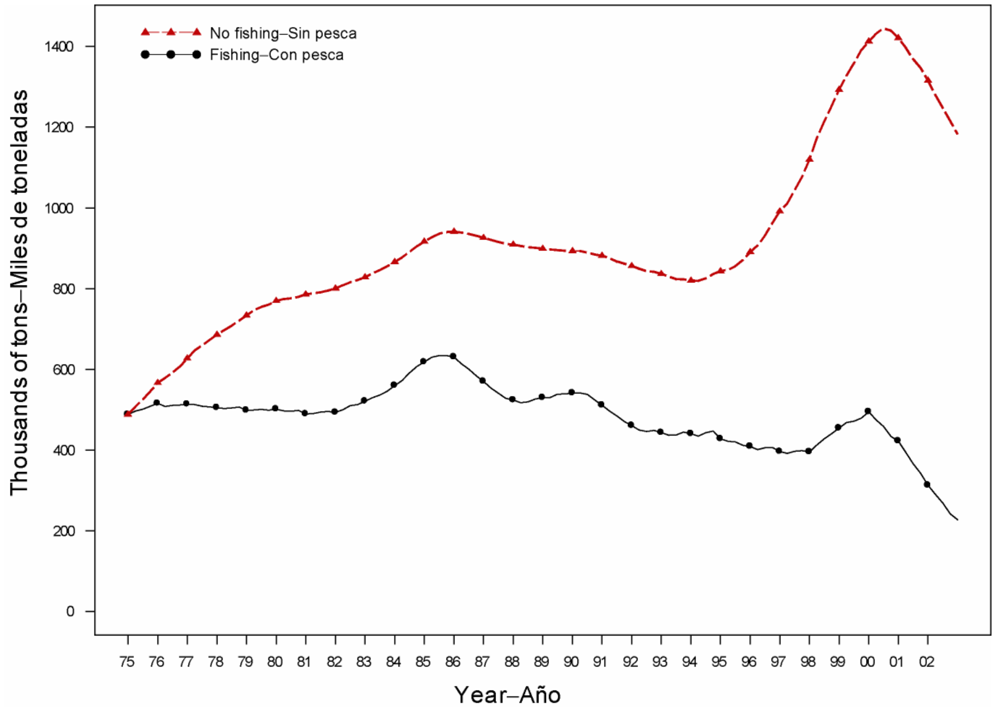


FIGURE BET3. Biomass trajectory of a simulated population of bigeye tuna that was not exploited during January 1975 through December 2002 ("no fishing") and that predicted by the stock assessment model ("fishing").

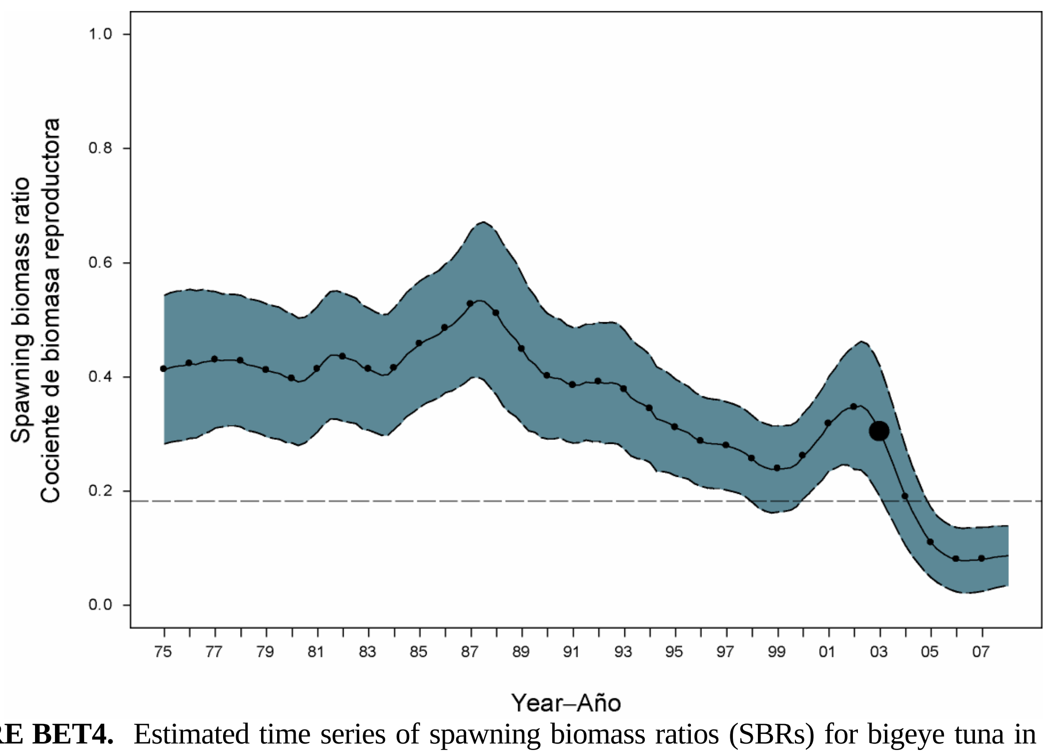


FIGURE BET4. Estimated time series of spawning biomass ratios (SBRs) for bigeye tuna in the EPO. The dashed horizontal line (at about 0.18) identifies the SBR at AMSY. The solid lines illustrate the maximum likelihood estimates, and the dashed lines are confidence intervals (±2 standard errors) around those estimates. The dashed line continuing the SBR trend indicates the SBR predicted to occur if effort continues at the average of that observed in 2001 and 2002, catchability (with effort deviates) continues at the average for 2000 and 2001, and average environmental conditions occur during the next five years.

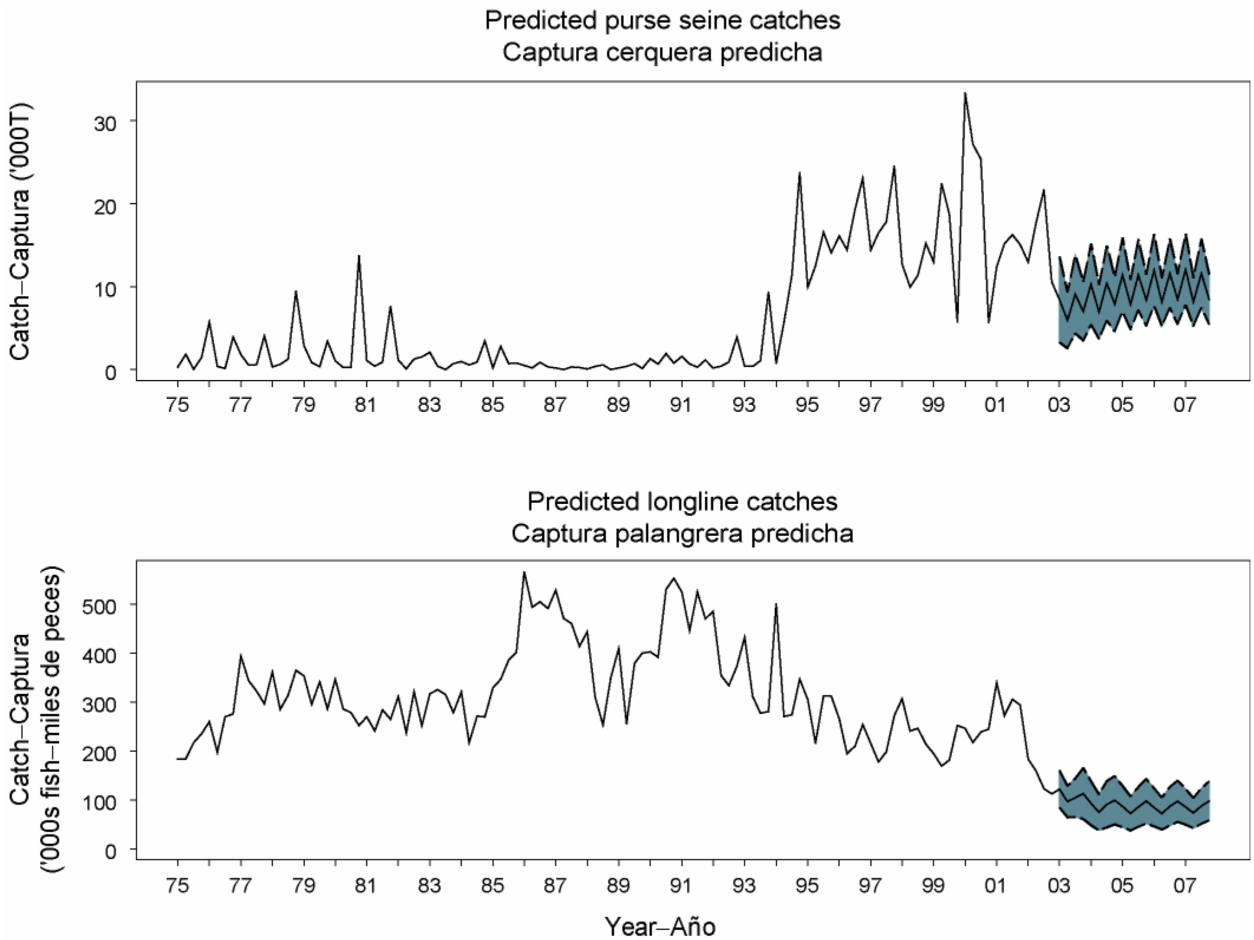


FIGURE BET5. Predicted catches for the surface (Fisheries 2, 3, 4, 5, and 7) and longline (Fisheries 8 and 9) fisheries based on average effort for 2002 and 2001 and average catchability for 2000 and 2001. Predictions were undertaken using the likelihood profile method. The shaded areas represent 95% confidence intervals for the predictions of future catches.

TABLE BET1. Estimates of the AMSY and its associated quantities for the basecase and sensitivity analyses. All analyses are based on average fishing mortality for 2000 and 2001. B_{recent} and B_{AMSY} are defined as the biomass of bigeye 1+ years old at the start of 2003 and at AMSY, respectively, and S_{recent} and S_{AMSY} are defined as indices of spawning biomass (therefore, they are not in metric tons). C_{recent} is the estimated total catch in 2002.

	Base case	Steepness = 0.75	Purse-seine unloading data	HBS CPUE
AMSY (T)—RMSP (tm)	77,199	72,928	71,690	77,463
B_{AMSY} (T)—B_{RMSP} (tm)	278,386	444,107	256,313	286,227
S_{AMSY}—S_{RMSP}	32,338	63,606	29,362	34,090
B_{AMSY}/B_0—B_{RMSP}/B_0	0.28	0.37	0.30	0.28
S_{AMSY}/S_0—S_{RMSP}/S_0	0.18	0.29	0.19	0.18
C_{recent}/AMSY—C_{recent}/RMSP	1.35	1.43	1.14	1.34
$B_{\text{recent}}/B_{\text{AMSY}}$—$B_{\text{recent}}/B_{\text{RMSP}}$	0.82	0.59	0.95	1.09
$S_{\text{recent}}/S_{\text{AMSY}}$—$S_{\text{recent}}/S_{\text{RMSP}}$	1.62	0.90	1.74	2.22
F multiplier—Multiplicador de F	0.84	0.54	0.91	0.98

E. PACIFIC BLUEFIN TUNA

Tagging studies have shown that there is exchange of bluefin, *Thunnus orientalis*, between the eastern and western Pacific Ocean. Larval, postlarval, and early juvenile bluefin have been caught in the western Pacific Ocean (WPO), but not the eastern Pacific Ocean (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 catch is made west of Baja California and California, within about 100 nautical miles of the coast, between about 23°N and 33°N. In recent years a considerable portion of the purse-seine catch of bluefin has been transported to holding pens, where the fish are held for fattening and later sale as sashimi-grade fish. Lesser amounts of bluefin are caught by recreational, gillnet, and longline gear. Bluefin have been caught during every month of the year, but most of the fish are taken during May through October.

Bluefin are exploited by various gears in the WPO from Taiwan to Hokkaido. Age-0 fish about 15 to 30 cm in length are caught by trolling during July-October south of Shikoku Island and south of Shizuoka Prefecture. During November-April age-0 fish about 35 to 60 cm in length are taken by trolling south and west of Kyushu Island. Age-1 and older fish are caught by purse seining, mostly during May-September, between about 30°-42°N and 140°-152°E. Bluefin of various sizes are also caught by traps, gillnets, and other gear, especially in the Sea of Japan. Small amounts of bluefin are also caught near the southeastern coast of Japan by longlining.

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. As stated above, it appears that spawning occurs only in the WPO. Some fish apparently remain their entire lives in the WPO, while others migrate to the EPO. These migrations begin mostly, or perhaps entirely, during the first and second years of life. The first- and second-year migrants are exposed to various fisheries before beginning their journey to the EPO. The migrants, after crossing the ocean, are exposed to commercial and recreational fisheries off California and Baja California. Eventually, the survivors return to the WPO.

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

Various indices of abundance of bluefin in the EPO have been calculated, but none of these is entirely satisfactory. The IATTC has calculated "habitat" and "bluefin-vessel" indices for the EPO routinely for several years.

A preliminary cohort analysis has indicated that the biomass of the spawning stock was relatively high during the 1960s, decreased during the 1970s and 1980s, and then increased during the 1990s. The recruitment was estimated to be highly variable, with four or five strong cohorts produced during the 1960-1998 period.

The total catches of bluefin have fluctuated considerably during the last 50 years (Figure PBF1). The presence of 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 recruitment. The results of yield-per-recruit and cohort analyses indicate that greater catches could be obtained if the catches of age-0 and age-1 fish were reduced or eliminated.

Spawner-recruit analyses do not indicate that the recruitment of Pacific bluefin could be increased by permitting more fish to spawn.

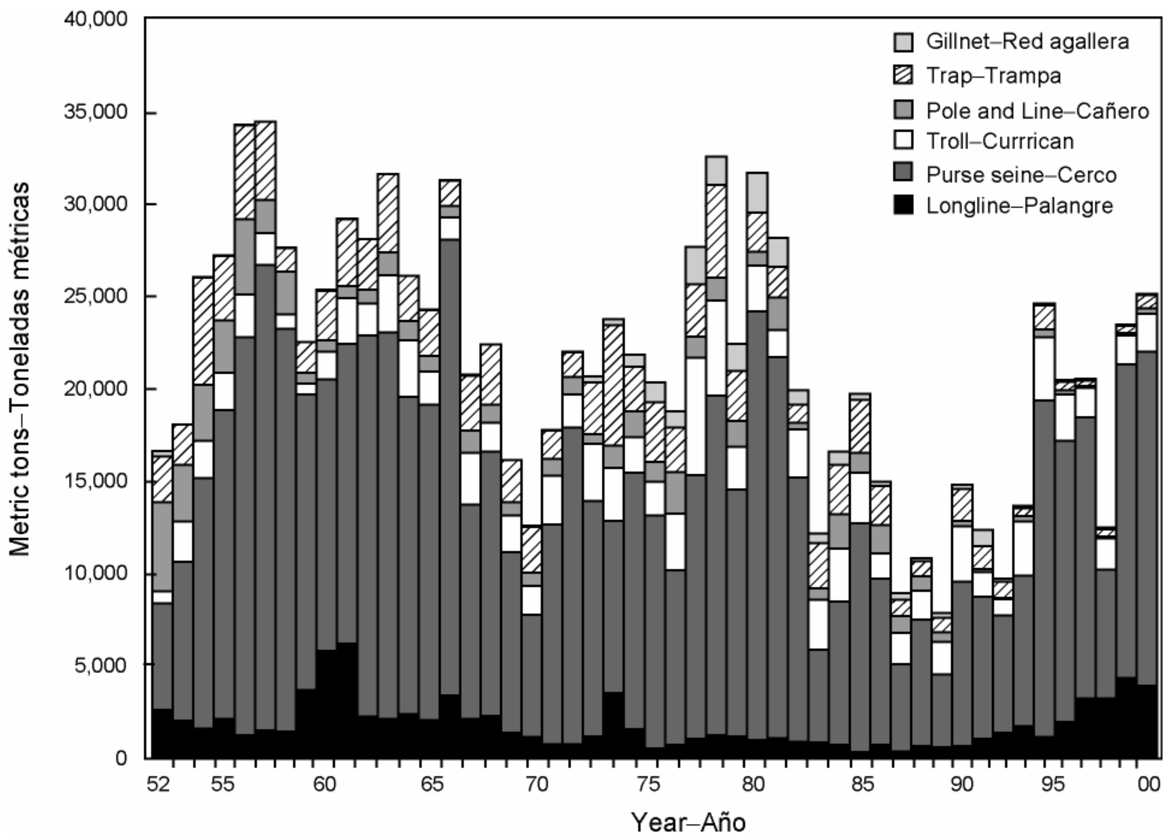


FIGURE PBF1. Retained catches of Pacific bluefin, 1952-2000.

F. ALBACORE TUNA

Most scientists who have studied albacore, *Thunnus alalunga*, in the Pacific Ocean have concluded that there are two stocks, one occurring in the northern hemisphere and the other in the southern hemisphere. Albacore are caught by longliners in most of the North and South Pacific, but not often between about 10°N and 5°S, by trollers in the eastern and central North Pacific and the central South Pacific, and by pole-and-line vessels in the western North Pacific. In the North Pacific about 55% of fish are taken in surface fisheries that catch smaller albacore, whereas only about 20% of the albacore caught in the South Pacific are taken by surface gear. Total catches of albacore from the North Pacific peaked in the early 1970s at over 100,000 T per year, and then declined. Catches recovered during the 1990s, and reached an all-time high of 127,800 T in 1999 (Figure ALB1a). In the South Pacific, catches have ranged between about 25,000 and 55,000 T during the 1980s and 1990s (Figure ALB1b).

The juveniles and adults are caught mostly in the Kuroshio Current, the North Pacific Transition Zone, and the California Current in the North Pacific and the Subtropical Convergence Zone in the South Pacific, but spawning occurs in tropical and subtropical waters.

There appear to be two subgroups of albacore in the North Pacific Ocean. The fish of the northern subgroup are found mostly north of 40°N when they are in the EPO. There is considerable exchange of fish of this subgroup between the troll fishery of the EPO and the pole-and-line and longline fisheries of the western Pacific Ocean. The fish of the southern subgroup occur mostly south of 40°N in the EPO, and relatively few of them are caught in the western Pacific. Fish that were tagged in offshore waters of the EPO and recaptured in the coastal fishery of the EPO exhibited different movements, depending on the latitude of release. Most of the recaptures of those released north of 35°N were made north of 40°N, and most of the recaptures of those released south of 35°N were made south of 40°N.

Much 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 the tropics, 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.

New age-structured stock assessments were presented for the North and South Pacific stocks of albacore in 2002. The South Pacific assessment, carried out with MULTIFAN-CL by the Secretariat for the Pacific Community, incorporated catch and effort, length-frequency, and tagging data. The stock was estimated to be well above the level that would produce the average maximum sustainable yield (AMSY), the current catches of around 40,000 T being much less than the estimated AMSY of 117,000 T. Although the recent recruitments are estimated to be slightly below average, there appears to be no need to restrict the fisheries for albacore in the South Pacific Ocean.

Virtual population analyses of the North Pacific stock of albacore were carried out during the 18th North Pacific albacore workshop. The estimated current biomass, 510,000 T, is almost 40% greater than that estimated for 1975, the first year of the period modeled. The estimated recruitments of the 1990s were greater than those of the 1980s, and the catches per unit effort for most of the surface fisheries have increased in recent years. The fishing mortality for juvenile fish is estimated to be relatively high. Projections, under different assumptions of future recruitment, suggest that the biomass will decline if the current levels of fishing mortality persist. F_{AMSY}, the fishing mortality corresponding to the AMSY, was not estimated, but a proxy for it suggested that the stock is currently being fished at a $F_{20\%}$ level. In the near future the North Pacific stock of albacore will be analyzed with MULTIFAN-CL, using data for years prior to 1975, in addition to those for more recent years.

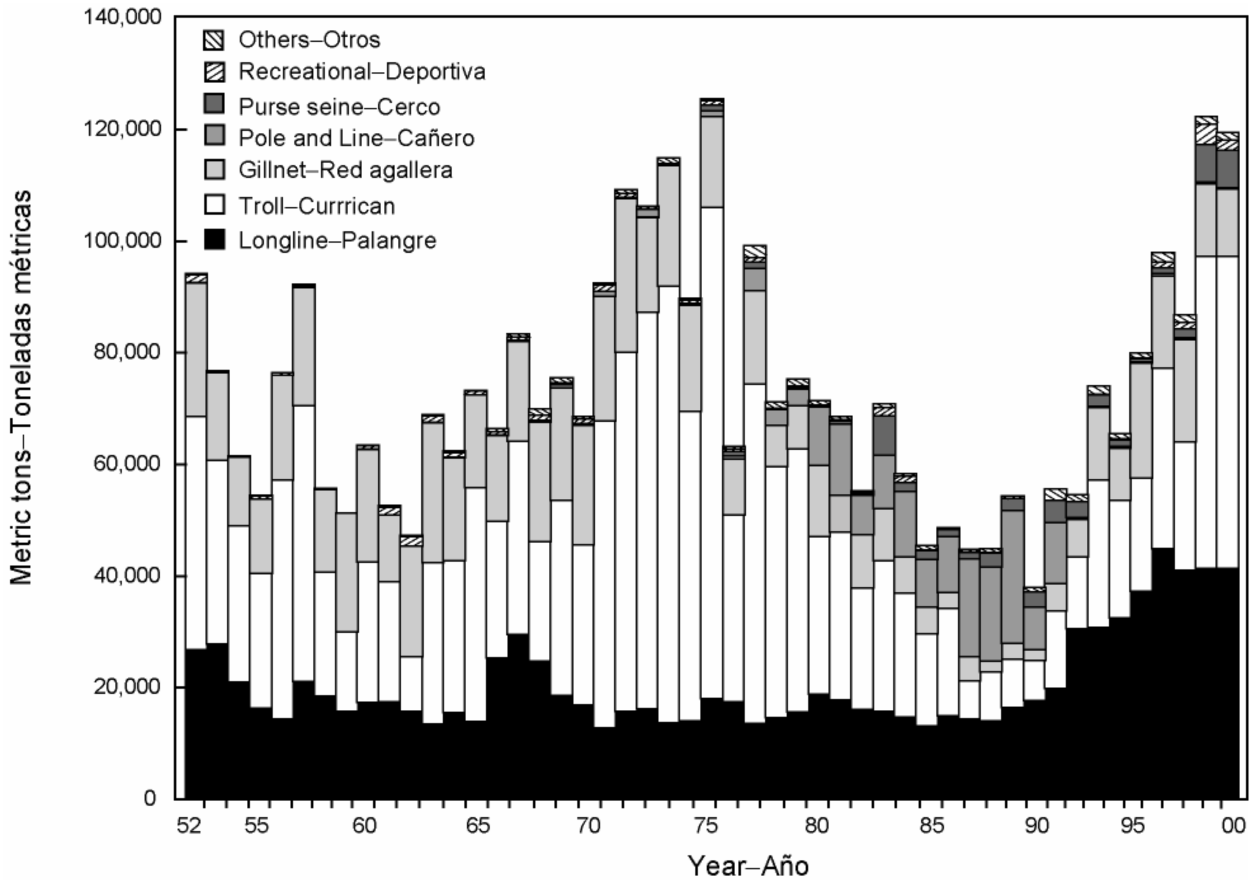


FIGURE ALB1a. Catches of North Pacific albacore, 1952-2000.

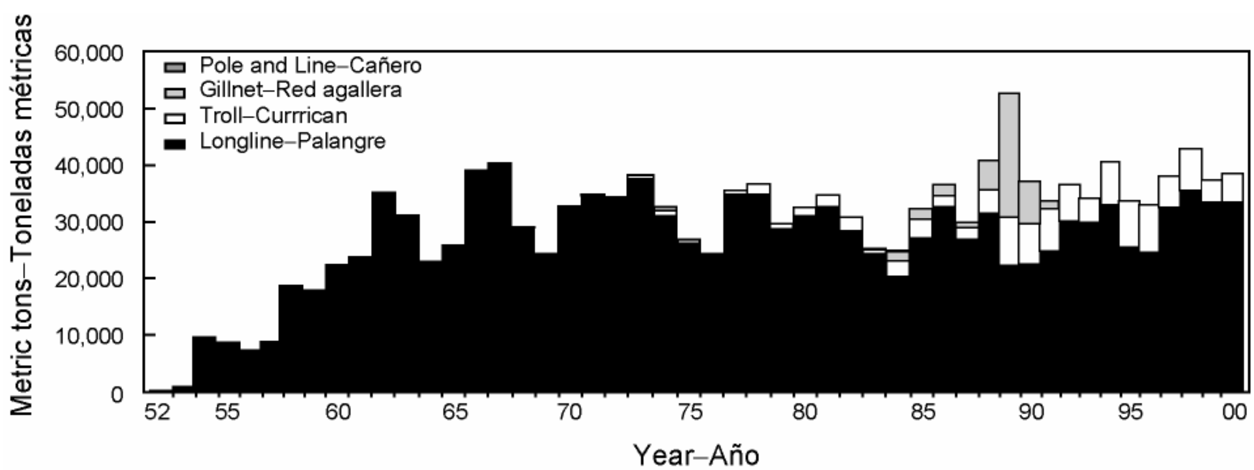


FIGURE ALB1b. Catches of South Pacific albacore, 1952-2000.

G. SWORDFISH

Swordfish, *Xiphias gladius*, occur throughout the Pacific Ocean between about 50°N and 50°S. They are caught mostly by the longline fisheries of Far East and Western Hemisphere nations (Figure SWO1). Lesser amounts are taken by gillnet and harpoon fisheries. They are seldom caught by recreational fishermen. During the most recent three-year period the greatest catches in the EPO have been taken by vessels of Chile, the United States, Japan and Spain.

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.

Only fragmentary data are available on the movements of swordfish. They tend to inhabit waters further below the surface during the day than at night.

Swordfish tend to inhabit frontal zones. Several of these occur in the 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.

There are probably one or two stocks of swordfish in the EPO, one with its center of distribution in the southeastern Pacific Ocean, and possibly another with its center of distribution off California and Baja California. As well, there may be movement of a northwestern Pacific stock of swordfish into the EPO at various times.

Production modeling indicates that the catches per unit of effort (CPUEs) of swordfish, although they have declined and then increased recently, are still greater than the CPUEs that correspond to the average maximum sustainable yield. This conclusion is tentative, due primarily to the current uncertainty regarding stock structure.

Results of preliminary modeling with MULTIFAN-CL of a north Pacific swordfish stock in areas north of 10°N indicate that in recent years the biomass level has been stable and well above 50% of the unexploited levels of stock biomass, implying that swordfish are not over-exploited at current levels of fishing effort.

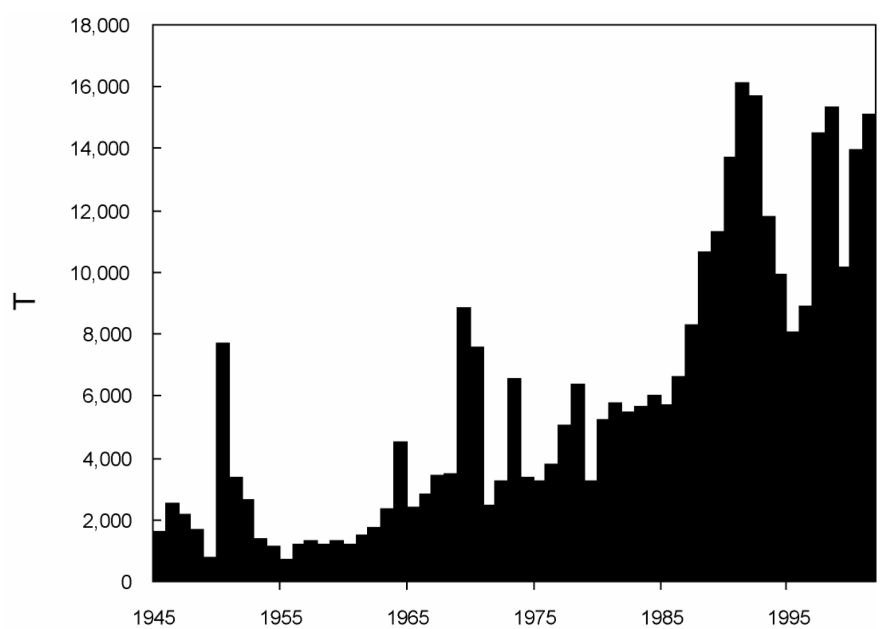


FIGURE SWO1. Retained catches of swordfish in the eastern Pacific Ocean, 1945-2001.

H. BLUE MARLIN

The best knowledge currently available indicates that blue marlin, *Makaira nigricans*, constitutes a single world-wide species and that there is a single stock of blue marlin in the Pacific Ocean. For this reason statistics on catches (Figure BUM1) are compiled, and analyses of stock status are made, for the entire Pacific Ocean, even though it is important to know how catches in the eastern Pacific Ocean (Figure BUM2) vary over time.

Blue marlin are taken 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 commercial surface 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 acoustic tags and their activities monitored for short periods.

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 in which the temperatures are within 1° to 2° of the SSTs.

The Deriso-Schnute delay-difference population dynamics model, a form of production model, was used to assess the status of the blue marlin stock in the Pacific Ocean. Data for the estimated annual total retained catches for 1951-1997 and standardized catch rates developed from catch and nominal fishing effort data for the Japanese longline fishery for 1955-1997 were used. It was concluded that the levels of biomass and fishing effort were near those required to maintain the average maximum sustainable yield (AMSY).

A more recent analysis, using MULTIFAN-CL, was conducted to assess the blue marlin stocks in the Pacific Ocean and to evaluate the efficacy of habitat-based standardization of longline effort. There is considerable uncertainty regarding the levels of fishing effort that would produce the AMSY. However, it was determined that blue marlin in the Pacific Ocean are close to fully exploited, *i.e*. that the population is somewhere near the top of the yield curve. It was also found that standardization of effort, using a habitat-based model, allowed estimation of parameters within reasonable bounds and with reduced confidence intervals about the estimates.

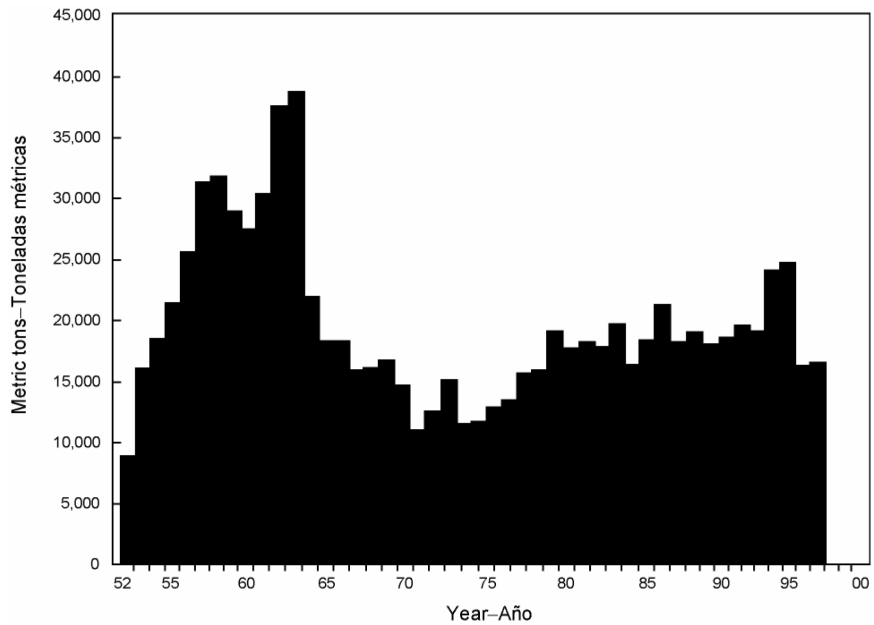


FIGURE BUM1. Retained catches of blue marlin in the Pacific Ocean, 1952-1998.

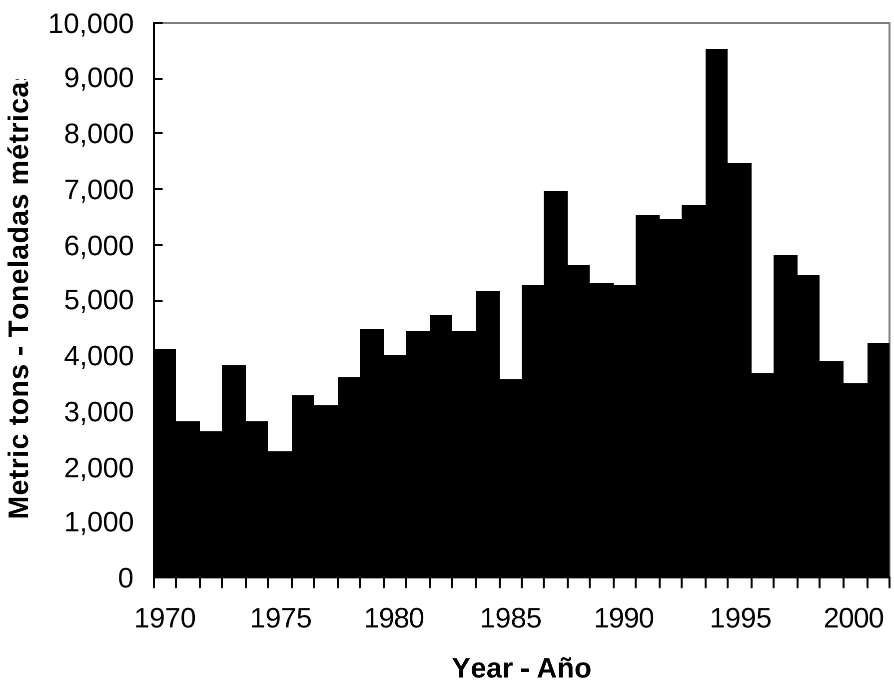


FIGURE BUM2 Retained catches of blue marlin in the eastern Pacific Ocean, 1970-2001.

I. STRIPED MARLIN

Striped marlin, *Tetrapturus audax*, 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. Lesser amounts are caught by recreational, gillnet and other fisheries. During recent years the greatest catches (Figure MLS1) in the eastern Pacific Ocean (EPO) have been taken by fisheries of Costa Rica, Japan, and the Republic of Korea.

Striped marlin reach maturity when they are about 140 cm long, and spawning occurs in widely-scattered areas of the Pacific Ocean.

The stock structure of striped marlin in the Pacific Ocean is not well known. There are indications that there is only limited exchange of striped marlin between the EPO and the central and western Pacific Ocean, so it is considered in this report that examinations of local depletions and independent assessments of the striped marlin of the EPO are meaningful. An analysis of trends in catch rates in subareas suggest that the fish in the EPO consist of one stock. Genetic studies have suggested that there are separate populations in the eastern and western south Pacific and that there may be a separate populations with centers of distribution in the regions proximate to Hawaii in the north-central Pacific and to Ecuador and to Mexico in the EPO. However, preliminary results of more recent analyses suggest that the fish in the Ecuador and Mexico region are from a single population.

Few tagging data are available for striped marlin. Most recaptures of tagged fish released off the tip of the Baja California peninsula generally have been made in the general area of release, but some have been recaptured around the Revillagigedo Islands, a few around Hawaii, and one near Norfolk Island.

Such being the case, the conclusions reached for a single-stock model, chosen on the basis of trends in catch rates, should be considered tentative, and efforts should be undertaken to resolve the question of stock structure of striped marlin in the EPO. To this end a collaborative study to investigate the stock structure and status of striped marlin in the Pacific has been undertaken.

Standardized catch rates were obtained from a general linear model and from the statistical habitat-based standardization method. Analyses of stock status made using two production models, taking into account the time period when billfish were targeted by longline fishing in the EPO, were considered the most plausible. A Pella-Tomlinson model yielded estimates of the average maximum sustained yield (AMSY) in the range of 3,700 to 4,100 T, with a current biomass to be about 47% of the unfished biomass. The current biomass is estimated to be greater than the biomass that would produce the AMSY. An analysis using the Deriso-Schnute delay difference model yielded estimates of AMSY in the range of 8,700 to 9,200 T, with current biomass greater than the biomass needed to produce the AMSY and about 70% of the size of the unexploited biomass.

Landings and standardized fishing effort for striped marlin decreased in the EPO from 1990-1991 through 1998, and this decline has continued, reaching new lows in preliminary estimates of retained catches in 2000 and 2001 of about 1,500 T, which are well below estimated AMSY harvest levels. This may result in a continued increase in the biomass of the stock in the EPO.

The stock(s) of striped marlin stocks in the EPO are apparently in good condition, with current and near-term anticipated fishing effort less than that required to produce the AMSY.

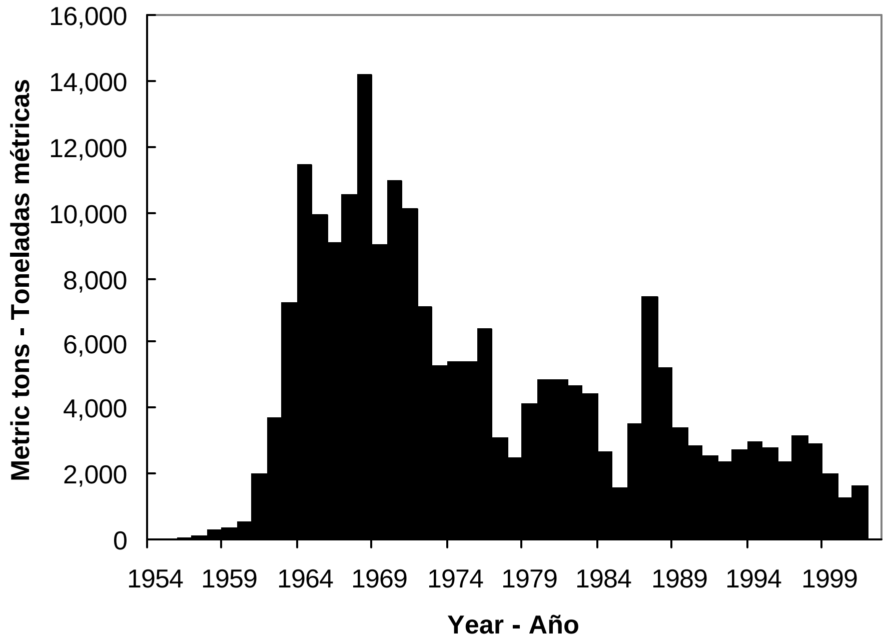


FIGURE MLS1. Retained catches of striped marlin in the eastern Pacific Ocean, 1954-2001.

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 ecosystem considerations into fisheries management.

The IATTC has taken account of ecosystem issues in many of its decisions, but it has not often focused its attention on the entire ecosystem in which the target species, the tunas and billfishes, reside. 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. The purpose is to provide the Commission the opportunity to consider the ecosystem as a whole as part of its consideration of the status of the tuna and billfish stocks and management measures.

This review does not suggest objectives for the incorporation of ecosystem considerations into the management of tuna or billfish fisheries or any new management measures. Rather, its prime purpose is to offer the Commission the opportunity to ensure that ecosystem considerations are clearly seen as part of its agenda.

It is important also to remember that the view that we have of the ecosystem is based on the recent past; we have no information about the ecosystem before exploitation began. Also, it is important to remember that the environment is subject to change on a variety of time scales, including the well-known El Niño-Southern Oscillation (ENSO) 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 report these bycatches are presented in the context of the effect of the fishery on the ecosystem. Unfortunately, information for the entire fishery is not available. Relatively good information is available for tunas and billfishes. The information is comprehensive for large purse seiners that carry AIDCP observers (Class 6 vessels), 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 Class 6 vessels and for some smaller purse seiners. There is little information on bycatches and discards for other fishing vessels.

2. ANALYSIS OF THE IMPACT OF CATCHES

2.1. Single-species assessments

This section provides a summary of current information on the effect of the tuna fisheries on stocks of single species in the EPO. It focuses on the current biomass of each stock considered compared to what it might have been in the absence of a fishery. The intention is to give a view of how the fishery may have altered the components of the ecosystem, rather than the detailed assessments, which can be found in other sections of this report or in other Commission documents. The section below frequently refers to comparisons with the unexploited stock size. There are no direct measurements of this, and in any case it would have varied from year to year. The term normally means the stock size that would be produced in the absence of a fishery with the average recruitment observed during the period in which the stock was assessed.

2.1.1. Tunas

2.1.1.a Yellowfin

Since 1984 the yellowfin stock has been at or above the level that will provide the average maximum sustainable yield. To meet this objective, the spawning stock size must be kept above 37% of its unexploited size with the current mix of fishing methods. One estimate of the effect of this reduced stock size is that the predation by yellowfin on other parts of the ecosystem is reduced to about 30% of what it was in the absence of a fishery.

2.1.1.b Skipjack

Skipjack assessments are far less certain than those for yellowfin and bigeye, in part because the fishery does not appear to be having much impact on the stock. However, it appears that fluctuations in recruitment cause large variations in stock size. In 2002, the biomass was estimated to be about 50% of the what it would have been in the absence of a fishery.

2.1.1.c Bigeye

Up to 1993 bigeye were taken mostly by longline fishing. By 1993 the stock size was estimated to be 42% of its unexploited size. After 1993, purse seining for tunas associated with fish-aggregating devices (FADs) took significant quantities of small and medium-sized bigeye. Currently, after several years of poor recruitment, the stock size is estimated to be at about 28% of its unexploited size. The biomass estimated for 2003 is the lowest since 1975, the first year included in the model.

2.1.1.d Albacore

It is generally considered that there are two stocks of albacore in the Pacific Ocean, one in the North Pacific and the other in the South Pacific. The South Pacific stock is thought to be at about 90% of its unexploited size, while that of the North Pacific appears to be at about 30% of its unexploited size.

2.1.2. Billfishes

2.1.2.a Swordfish

The variations in swordfish catch per unit of effort in the EPO show no trend, suggesting that catches to date have not affected the stock significantly. The stock size is likely to be near its unexploited size.

2.1.2.b Blue marlin

Recent stock assessments of blue marlin have suggested that the current stock size is between 50 and 90% of the unexploited stock size.

2.1.2.c Striped marlin

A recent stock assessment of striped marlin suggests that the current stock size is about 50 to 70% of the unexploited stock size.

2.1.2.d Black marlin and sailfish

No recent formal stock assessment has been made for these species, although there are some data presented in the IATTC Bulletin series published jointly by scientists of the National Research Institute of Far Seas Fisheries of Japan and the staff of the IATTC that show trends in catches, effort, and catches per unit of effort.

2.2. Dolphins

Table ECO1 shows the mortality in the fishery in 2002 and a published estimate of the abundances of the various stocks. Studies of the association of tunas with dolphins have been an important component of the staff's long-term approach to understanding key interactions of 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 to include in ecosystem models, given the large biomasses of both groups, and their high consumption of prey. Populations of dolphins involved in the purse-seine fishery were reduced from their unexploited levels during the 1960s and 1970s, but are now growing slowly and are expected to continue to do so.

2.3. Sea turtles

Olive Ridley turtles are, by far, the species of sea turtle taken most often by purse seiners. They are followed by the green sea turtle, and, very occasionally, by loggerhead and hawksbill turtles. Only one leatherback mortality has been recorded during the nine 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 FADs. The average annual mortalities of turtles caused by Class-6 purse-seine vessels during 1993-2002 were as follows:

	Set type		
	Floating object	**Unassociated**	**Dolphin**
Olive Ridley	51.6	19.9	11.4
Green	6.3	4.3	0.8
Loggerhead	0.6	1.3	0.1
Hawksbill	0.6	0.2	0.2
Leatherback	0.1	0.0	0.0
Unidentified	23.5	11.3	4.6
Average number of sets	4,379	4,932	8,877

The mortalities of sea turtles due to purse seining for tunas are probably less than those due to other types of human activity.

There is no comprehensive information available on bycatches of turtles by longliners. However, based on information from other parts of the world, the mortality rates due to longlining may be greater than those due to purse seining, particularly for shallow longlines targeting species such as 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 local longline vessels that fish for tunas and billfishes in the EPO.

The populations of olive Ridley, green, and loggerhead turtles of the EPO are designated as threatened, and those of the leatherback turtle as endangered, by the Convention on International Trade in Endangered Species of Wild Flora and Fauna. The lack of comprehensive information concerning the impact of the fishery on turtles is a serious weakness in understanding the effects of the fisheries for tunas and billfishes on the offshore pelagic ecosystem of the EPO.

2.4. Sharks and other large fishes

Sharks and other large fishes are taken by both purse-seine and longline vessels. The staff is analyzing the relative abundance of silky sharks, the most commonly caught species of shark in the purse-seine fishery. Preliminary estimates of relative abundance for the equatorial region, between about 8°N and 10°S, show a decreasing trend over time. It is not known whether this decreasing trend is due to the fishery, changes in the environment (perhaps associated with the 1997-1998 El Niño), or other processes.

The average annual discards (in numbers) of sharks and other large fish during 1993-2002 (other than those discussed above) by Class-6 purse-seine vessels are as follows:

	Set type		
	Floating object	**Unassociated**	**Dolphin**
Dorado	546,354	11,112	326
Wahoo	267,137	1,150	408
Yellowtail	40,551	18,780	1,309
Rainbow runner	60,396	1,275	11
Sharks and rays	38,699	10,024	4,869

There are no stock assessments available for these species in the EPO, and hence the impact of the bycatch on the stocks is unknown.

The catch rates of other species in the purse-seine fishery are different for each type of set. With a few exceptions, the bycatch rates are highest in sets on floating objects, followed by unassociated sets and, at a much lower level, dolphin sets. Dolphin bycatch rates are highest for dolphin sets, followed by unassociated sets and, at a much lower level, floating-object sets. Sailfish, manta rays, and stingrays have higher bycatch rates in unassociated sets, followed by dolphin sets and then 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. Table 4 (page 24) shows the estimated numbers of sets during 1987-2002 by purse-seine vessels in the EPO.

2.5. Other groups

2.5.1. Marine mammals

Scientists of the U.S. National Marine Fisheries Service (NMFS) have made estimates of the abundances of several species of marine mammals based on large-scale line-transect surveys carried out from oceanographic research vessels between 1986 and 2000 in the EPO. Of the species not significantly impacted by the tuna fishery, short-finned pilot whales 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. Bryde's whales 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 showed no clear trend in estimated abundance over time, and the estimates of abundance of sperm whales tended to decrease in recent years.

2.5.2. Seabirds

Seabirds associate with subsurface predators such as fishes and cetaceans. Those predators drive prey to the surface where the prey become available to the birds. 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 the Tahiti petrel in the eastern tropical Pacific (ETP).

2.5.3. Forage

The forage taxa occupying the middle trophic levels in the EPO are obviously an important component of the ecosystem, providing a link between environmental variability and the upper-trophic-level predators. Very 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 lanternfishes, flyingfishes, and some squids, in the ETP during 1986-1990 and 1998-2000. Mean abundance estimates of all fish taxa, and to a lesser extent for squids, increased from 1986 through 1990. Estimates were low again in 1998 and 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.

Frigate and bullet tunas (*Auxis* spp.) are a common prey of many of the animals that occupy the upper trophic levels in the ETP. In the ETP ecosystem model (see Section 5), *Auxis* spp. comprise 10% or more of the diet of eight predator categories. Small quantities are captured and discarded at sea by purse-seine vessels, and by local artisanal fisheries in some coastal regions of Central and South America. The estimated annual discards of *Auxis* spp. in the EPO on fishing trips with observers onboard, in metric tons, during 1993 through 2002, were as follows:

	Set type		
	Floating object	**Unassociated**	**Dolphin**
1993	1,814	165	2
1994	322	198	2
1995	543	119	6
1996	781	239	33
1997	2,756	626	25
1998	1,033	1678	32
1999	2,594	473	29
2000	1,290	185	21
2001	724	41	0
2002	1,384	161	283

3. PHYSICAL ENVIRONMENT

Environmental conditions affect the target populations, all other components of the ecosystem, and the operations of the fishermen. Very few ocean areas of the world show changes as dramatic as those that take place in the EPO during El Niño events. In addition, many less dramatic events are constantly taking place. In broad terms, water temperature controls the horizontal and vertical distributions of the tunas and billfishes. The drift of floating objects, with their associated communities, depends on the currents. Currents also transport eggs and larvae, determining their location and their patchiness. Fronts change the productive conditions, and in some cases create areas of attraction for tunas and billfishes. Upwelling brings nutrients from the deeper layers to the surface, and in the EPO the Humboldt Current, off northern South America, is one of the most productive ocean areas of the world. Turbulence, at a very small scale, has a significant impact on the survival of fish larvae. Along the coastline, the contributions of organic matter, fresh water, nutrients, and debris that rivers bring to the ocean are quite significant, creating special conditions that in some cases result in high productivity and areas that are very favorable for the development of the early life stages of many species. Topographic features, such as islands and seamounts, change oceanographic conditions around them, and many constitute very rich habitats. Some species are permanent residents in these locations; others use them as stages in longer migrations.

El Niño events change not only water temperature, but also current speed and direction, upwelling intensity, precipitation patterns, and many other components of the environment. Longer-term inter-decadal changes were first described for the North Pacific a few years ago, but the most recent observations show that there are also changes with a periodicity of decades that affect the EPO ecosystem. One such shift may have happened in 1976-1978, and apparently 1998 may have been another pivotal year. The recruitment of yellowfin to the fishery was apparently considerably greater during 1985-1999 than during 1975-1984. Because the productivity in the system can change dramatically under different regimes, their effect on all components of the ecosystem is very important. These changes increase the uncertainty about the parameters used to model the target stocks (*i.e.* the carrying capacity is not the same; recruitment, growth and mortality may respond to the changes, *etc*.), the trends observed for all populations, and even the fishing operations (*e.g.* changes in current speeds, depth of the thermocline, *etc*.).

This list, although by no means complete, shows the diversity and complexity of the ways in which the environment affects the target species and the rest of the ecosystem. It is, of course, not possible or necessary for the staff to address more than a small fraction of these. However, use is made of the results of work by national and international research groups that are investigating this area.

4. AGGREGATE INDICATORS

Food web diagrams are useful for representing the structure and flows of ecosystems. A simplified foodweb diagram, with approximate trophic levels (TLs), of the pelagic ETP is shown in Figure ECO1. Sharks (average TL 5.25) and billfishes (average TL 5.08) are top-level predators. Tunas and other pelagic fishes (*e.g.* dorado) occupy slightly lower TLs. Smaller pelagic fishes (*e.g. Auxis* spp.) and cephalopods 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 zooplankton (TL = 2) feed on the producers (TL = 1), phytoplankton and bacteria. In exploited pelagic ecosystems, the fisheries often act as apex predators.

Mean TL of fisheries catches and discards can be used as an index of sustainability in exploited marine ecosystems. TLs were estimated, based on the EPO ecosystem model (see Section 5), for a time series of total catches by year for three fishing modes of the purse-seine fishery from 1993 to 2001. The TLs of the summed catches of all surface fisheries were fairly constant from year to year (Figure ECO2: average for surface gear). The TL of the floating-object sets varied more than those of the other fisheries, due to the interannual variability in the sizes of the tunas caught and the species compositions of the bycatches in those sets.

Trophic levels were also estimated separately for the time series of retained and discarded catches by year for the surface fisheries from 1993 to 2001 (Figure ECO3). The TLs of the landings were quite stable from year to year, and the TLs of the discarded catches varied considerably. The largest variation occurred for sets on unassociated fish.

5. ECOSYSTEM MODELING

It is clear that the different components of an ecosystem interact. The best way to describe the relationships and explore their effects is through ecosystem modeling. Our understanding of this complex maze of connections 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 staff has developed a model of the pelagic ecosystem in the tropical EPO 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, dolphin sets by purse seiners, floating-object sets by purse seiners, and sets on unassociated schools by purse seiners. 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, so 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 a proxy 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 ratios more by the environment than by fishing.

6. OTHER ECOSYSTEM STUDIES IN PROGRESS

A new study, jointly funded by the Pelagic Fisheries Research Program of the University of Hawaii; the IATTC; the Centro Interdisciplinario de Ciencias Marinas (CICIMAR) of the Instituto Politénico Nacional, , La Paz, Mexico; and the Secretariat of the Pacific Community, Nouméa, New Caledonia has commenced in 2003. Scientists from these four agencies will compare the pelagic food web in the EPO with that of the more-oligotrophic western Pacific using two kinds of analyses. This study will provide important information on the trophic position of the forage fishes and cephalopods in the tropical EPO, which is not currently available. Results will be incorporated in ecosystem models to help define the ecosystem linkages leading to tuna production and the effect of climate variability on fisheries production.

7. ACTIONS BY THE IATTC AND AIDCP ADDRESSING ECOSYSTEM CONSIDERATIONS

Both the IATTC and 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:

7.1. 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. Studies to determine why tunas associate with dolphins have been carried out.

c. The incidental mortality of each stock of dolphins has been limited to levels that are insignificant compared to stock sizes.

7.2. Sea turtles

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

b. A resolution on releasing and handling of sea turtles captured in purse-seine nets has been adopted.

c. A resolution on webbing under FADs has been adopted.

7.3. Other species

A resolution on live release of sharks, rays, and other bycatch species has been adopted.

7.4. All species

a. Data on the bycatches by Class-6 purse-seine vessels have been collected, and plans have been made to expand the activity to smaller vessels and other gears.

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.

8. FUTURE DEVELOPMENTS FOR ECOSYSTEM ANALYSES

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 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 ("Longhurst regions") 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.

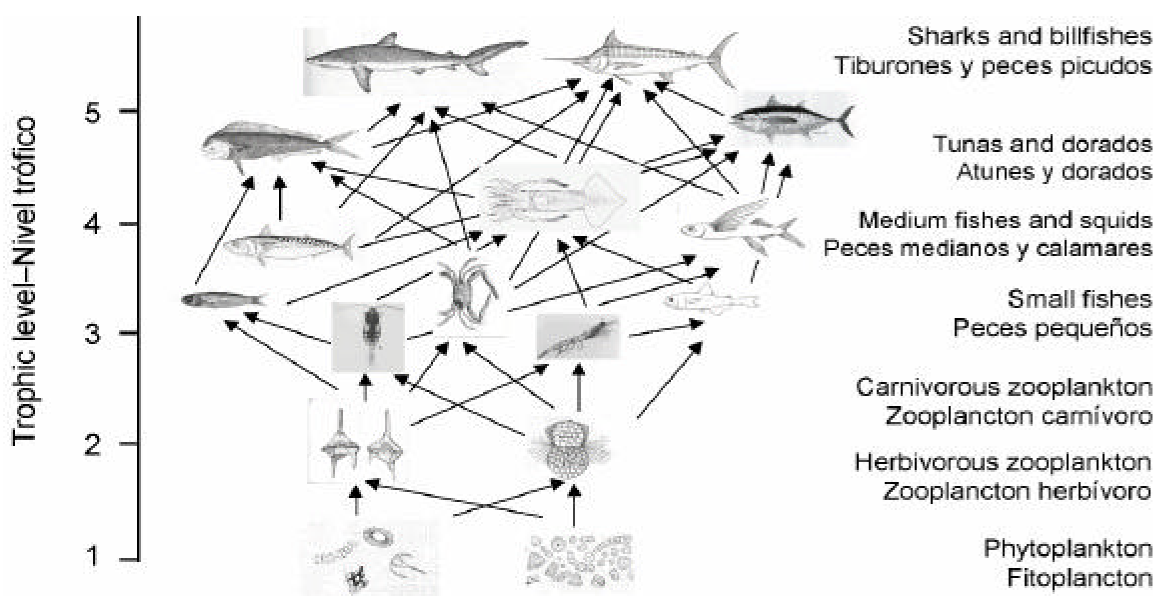


FIGURE ECO1. Simplified food-web diagram of the pelagic ecosystem in the eastern tropical Pacific Ocean.

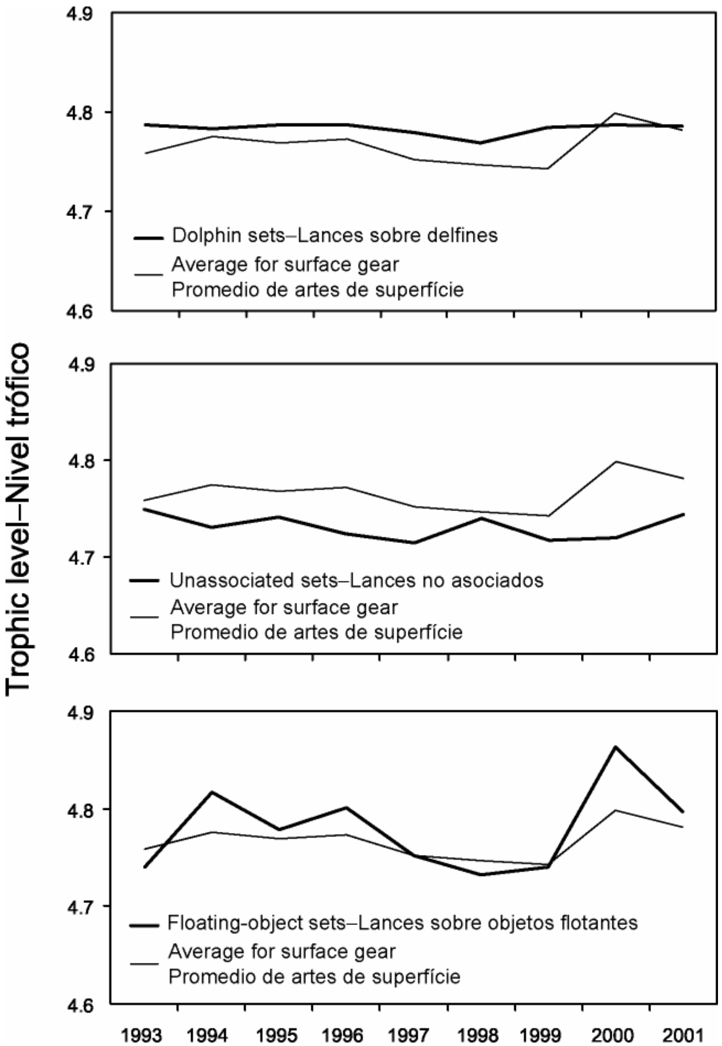


FIGURE ECO2. Yearly trophic level estimates of the catches (retained and discarded) by the purse-seine fishery in the eastern tropical Pacific Ocean.

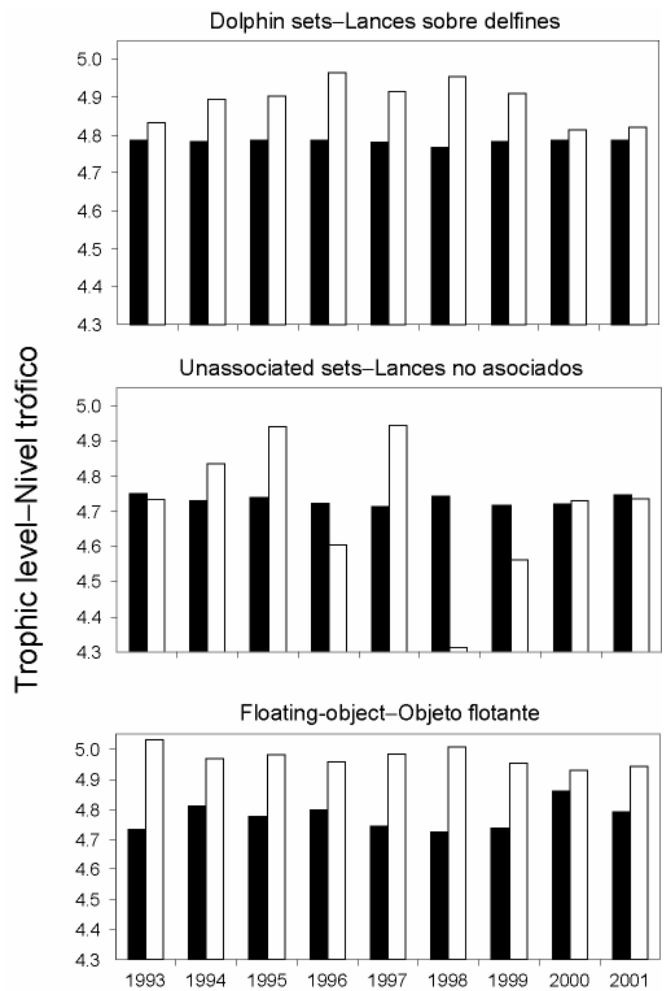


FIGURE ECO3. Trophic level estimates of the retained catches (solid bars) and discarded catches (open bars) by purse-seine fishing mode in the eastern tropical Pacific Ocean.

TABLE ECO1. Preliminary estimates of mortalities of dolphins in 2002, estimates of population abundance pooled for 1986-1990 (from Report of the International Whaling Commission, 43: 477-493), and estimates of relative mortality (with approximate 95-percent confidence intervals), by stock. All the data for 2002 are preliminary.

Species and stock	Incidental mortality	Population abundance	Relative mortality (%)
Offshore spotted dolphin—Delfín manchado de altamar			
Northeastern—Nororiental	442	730,900	0.06 (0.046,0.076)
Western/southern—Occidental y sureño	203	1,298,400	0.02 (0.012,0.022)
Spinner dolphin—Delfín tornillo			
Eastern—Oriental	405	631,800	0.06 (0.040,0.097)
Whitebelly—Panza blanca	186	1,019,300	0.02 (0.011,0.024)
Common dolphin—Delfín común			
Northern—Norteño	69	476,300	0.01 (0.008,0.031)
Central	155	406,100	0.04 (0.020,0.075)
Southern—Sureño	4	2,210,900	<0.01 (0.0001,0.0003)
Other dolphins—Otros delfines[1]	50	2,802,300	<0.01 (0.001,0.002)
Total	**1,514**	**9,576,000**	**0.02 (0.014,0.018)**

[1] "Other dolphins" includes the following species and stocks, whose observed mortalities were as follows: striped dolphins (*Stenella coeruleoalba*), 2; bottlenose dolphins (*Tursiops truncatus*), 10; Central American spinner dolphins (*Stenella longirostris centroamericana*), 3; rough-toothed dolphin (*Steno bredanensis*), 5; short-finned pilot whale (*Globicephala macrorhynchus*), 1; and unidentified dolphins, 29.