IOTC-2005-SC-05

EXECUTIVE SUMMARY OF THE STATUS OF THE YELLOWFIN TUNA RESOURCE

(from IOTC-2005-WPTT-R [EN])

BIOLOGY

Yellowfin tuna is a cosmopolitan species distributed mainly in the tropical and subtropical oceanic waters of the three major oceans, where it forms large schools. The sizes exploited in the Indian Ocean range from 30 cm to 180 cm fork length. Smaller fish (juveniles) form mixed schools with skipjack and juvenile bigeye tuna and are mainly limited to surface tropical waters, while larger fish are found in surface and sub-surface waters. Intermediate age yellowfin are seldom taken in the industrial fisheries, but are abundant in some artisanal fisheries, mainly in the Arabian Sea.

Stock structure is unclear, and a single stock with complete mixing is usually assumed for stock assessment purposes. Longline catch data indicates that yellowfin are distributed continuously throughout the entire tropical Indian Ocean, but some more detailed analysis of fisheries data suggests that the stock structure may be more complex and that mixing may be incomplete. A study of stock structure using DNA was unable to detect whether there were subpopulations of yellowfin tuna in the Indian Ocean.

Spawning seems to occur mainly from December to March in the equatorial area (0-10°S), with the main spawning grounds between 50° and 70°E. However, secondary spawning grounds are known to exist, for instance off Sri Lanka and the Mozambique Channel and in the eastern Indian Ocean off Australia. Yellowfin size at first maturity has been estimated at around 100 cm, and recruitment occurs predominantly in July. Newly recruited fish are primarily caught by the purse seine fishery on floating objects. Males are predominant in the catches of larger fish at sizes than 150 cm (this is also the case in other oceans).

A new growth study fitting a two-stanza growth curve to length frequency data was presented to the WPTT. In addition, the Working Party refitted a two-stanza growth curve to the Stequert otolith data. Both growth curves suggested similar growth rates for fish over 70 cm, but growth rates differed substantially for smaller fish. The two growth curves are illustrated in Figure 7.

There are no direct estimates of natural mortality (M) for yellowfin in the Indian Ocean. In stock assessments, new estimates of M at length based on those from other oceans have been used. These were then converted to estimates of M at age using the two growth curves. This indicated a higher M on juvenile fish than for older fish.

There is little information on yellowfin movement patterns in the Indian Ocean, and what information there is comes from analysis of fishery data, which can produce biased results because of their uneven coverage. However, there is good evidence that medium sized yellowfin concentrate for feeding in the Arabian Sea. Feeding behaviour is largely opportunistic, with a variety of prey species being consumed, including large concentrations of crustacea that have occurred recently in the tropical areas and small mesopelagic fishes which are abundant in the Arabian Sea.

FISHERY

Catches by area, gear, country and year from 1950 to 2003 are shown in Table 1 and illustrated in Figure 1. Contrary to the situation in other oceans, the artisanal fishery component in the Indian Ocean is substantial, taking approximately 20-25% of the total catch.

The geographical distribution of yellowfin tuna catches in the Indian Ocean in recent years by the main gear types (purse-seine, longline and artisanal) is shown in Figure 2. Most yellowfin tuna are caught in Indian Ocean north of 12°S and in the Mozambique Channel (north of 25°S).

Although some Japanese purse seiners have fished in the Indian Ocean since 1977, the purse seine fishery developed rapidly with the arrival of European vessels between 1982 and 1984. Since then, there has been an increasing number of yellowfin tuna caught although a larger proportion of the catches is made of adult fish, when compared to the case of the bigeye tuna purse-seine catch. Purse seine catches of yellowfin with fork lengths between 30 and 180 cm increased rapidly to around 131,000 t in 1993. Subsequently, they have fluctuated around that level, until 2003 when they increased substantially to 227,000 t.

The purse seine fishery is characterized by the use of two different fishing modes: the fishery on floating objects (FADs), which catches large numbers of small yellowfin in association with skipjack and juvenile bigeye, and a fishery on free swimming schools, which catches larger yellowfin on mixed or pure sets. Between 1995 and 2003, the FAD component of the purse seine fishery represented 48-66% of the sets undertaken (60-80% of the positive sets) and took 36-63% of the yellowfin catch by weight (59-76% of the total catch). Since 1997, the proportion of log sets has steadily decreased from 66% to 48%.

The longline fishery started in the beginning of the 1950’s and expanded rapidly over the whole Indian Ocean. It catches mainly large fish, from 80 to 160 cm fork length, although smaller fish in the size range 60 cm – 100 cm have been taken by longliners from Taiwan, China since 1989 in the Arabian Sea. The longline fishery targets several tuna species in different parts of the Indian Ocean, with yellowfin and bigeye being the main target species in tropical waters. The longline fishery can be subdivided into an industrial component (deep-freezing longliners operating on the high seas from Japan, Korea and Taiwan, China) and an artisanal component (fresh tuna longliners). The total longline catch of yellowfin reached a maximum in 1993 (196,000 t). Since then, it has declined, and in 2003 was 83,500 t.

Artisanal catches, taken by bait boat, gillnet, troll, hand line and other gears have increased steadily since the 1980s. In 2003, the total artisanal yellowfin catch was 51,000 t, while the catch by gillnets (the dominant artisanal gear) was 79,000 t.

Yellowfin catches in the Indian Ocean were much higher than previous levels during 2003 and 2004, while skipjack and bigeye catches remained at their average levels. Purse seiners currently take the bulk of the yellowfin catch — mostly from the western Indian Ocean. In 2003, their total catch was 227,000 t — over 48% more than the previous largest purse seine catch, which was recorded in 1995. Artisanal yellowfin catches were also near their highest level in 2003. Japanese longliners also recorded higher than normal catches in the tropical western Indian Ocean in 2003. Preliminary data suggest that purse seine and longline catches during 2004 are even higher than 2003.

Yellowfin catches in number by gear (purse seine, longline and bait boat) are reported in Figure 3. Current estimates of annual mean weights of yellowfin caught by different gears and by the whole fishery are shown in Figure 4. After an initial decline, mean weights in the whole fishery remained quite stable from the 1970s to the early 1990s. Since 1993, mean weights in the catches in the industrial fisheries have declined. Prior to 2003, although total catch in biomass has been stable for several years, catches in numbers have continued to increase, as there has been more fishing effort directed towards smaller fish. As described above, this situation changed during 2003 and 2004; where most of the very large catches were obtained from fish of larger sizes.

AVAILABILITY OF INFORMATION FOR ASSESSMENT PURPOSES

The reliability of the estimates of the total catch has continued to improve over the past few years, and the Secretariat conducted several reviews of the nominal catch databases during 2004. This has led to marked increases in estimated catches of yellowfin tuna since the early 1970s. A comparison of time series of estimates of total catches made by the Secretariat in 2004 and in 2005 is given in Figure 5. In particular, the estimated catches for the Yemen artisanal fishery have been revised upwards sharply, based on new information, but they still remain highly uncertain. In 2005, Taiwan, China provided size data for yellowfin tuna by IOTC area for 1980 – 2003, thereby substantially improving the information available to estimate catches by size.

Estimates of annual catches at size for yellowfin were calculated using the best available information prior to the 2005 WPTT meeting. A number of papers dealing with fisheries data, biology, CPUE trends and assessments were discussed by the WPTT in 2005, and additional data analyses were performed during that meeting. Estimated catches at age were calculated (Figure 6) using the catch-at-size data and two alternative growth curves (a refitted

Stequert growth curve and a new two-stanza growth model) are shown in Figure 7. The two growth curves were used to develop two sets of natural mortality at age, maturity at age and average weight at age schedules. M was assumed to be higher on juvenile than adult fish.

Standardized CPUE series for both Japanese and Taiwanese longline data were presented and used during the assessments. Standardised purse seine CPUE analyses were also presented and discussed, but these were not used during the assessments because it was believed that they still did not fully account for the increases in purse seine catching efficiency over time.

The two standardized longline CPUE series showed similar trends, with an initial steep decline, over a period when catches were relatively low and stable, followed by stable standardized CPUEs since the late 1970s, a period during which catches have increased strongly following the development of the purse seine fishery (Figure 8). The observed pattern of standardised longline CPUEs does not correspond well with the expected response of CPUE to changes in catch and biomass, if standardized CPUE is directly proportional to the abundance of the part of the stock exploited by the gear concerned. There are several possible explanations for this, such as changes in catchability or behaviour, or the population existing in two fractions with differential availability to purse seine and longline gears, or a substantial decrease in the accumulated biomass in the oldest age groups in the early years. However, current analyses are unable to distinguish which, if any, of these explanations is correct.

STOCK ASSESSMENT

A full assessment was attempted for yellowfin tuna in 2005 by the WPTT. Two papers presenting assessment results were presented, one using the age structured production model (ASPM) method and one using a new Bayesian two-age-class production model. Additional assessments were carried out during the WPTT meeting using agreed data sets and the following methods: the PROCEAN method, the CATAGE trend (statistical catch at age analysis) method, ASPM, and the Bayesian two-age-class production model.

Although there were differences in the details of results from the different assessments, the overall picture they presented was consistent, particularly in terms of estimated trends in stock biomass and fishing mortality rates. Estimated trends in the fishing mortality rates are shown in Figure 9. Estimates of catchability using the PROCEAN and CATAGE methods show a strong increasing trend since the mid-1980s for both the longline fleets and the purse-seine fleets (Figure 10). The assessment runs considered at this meeting consistently indicated that fishing mortality rates between 1992 and 2002 have been close to or at levels of F corresponding to the Fmsy estimated by the most plausible ASPM assessment. Catches during this period were in the vicinity of, or possibly above, the MSY levels estimated by PROCEAN and the most plausible ASPM assessment. Estimated catches in 2003 and 2004 were well above those MSY levels, and projections carried out indicate that these are not sustainable unless supported by very high recruitments.

The Scientific Committee emphasized, however, that there remain strong uncertainties in each of the assessments conducted. In particular, none are yet able to consistently explain the trends in standardized CPUEs in the early years of the fishery without using trends in catchabilities or recruitment for which there is no evidence. Consequently, the implications drawn from them regarding current stock status are also uncertain.

Since the early-1980s there has also been an increase in both purse seine fishing on floating objects and artisanal fisheries which has led to a rapid increase in the catch of juvenile yellowfin. The rapid expansion, particularly on juvenile fish, is cause for concern, since it displays all the symptoms of a potentially risky situation. The increases in catches in general has not been as a result of geographic expansion to previously unfished areas, but rather as a result of increased fishing pressure on existing fishing grounds.

EXCEPTIONAL CATCHES DURING 2003 AND 2004

Yellowfin catches in the Indian Ocean were very high during 2003 and 2004. The total catch in 2003 was substantially higher than the previous highest catch (in 1993) and 33% higher than the average catch in the previous 5 years. Preliminary indications are that the 2004 catch will be substantially higher still. These anomalous catches occurred all over the western Indian Ocean, in particular in a small area off eastern Africa, although the anomaly extended over a much wider area, from the Arabian Sea to South Africa, in both industrial (purse seine on free-swimming schools and longline) and artisanal fisheries. The fish caught were of large sizes (100-150 cm FL).The Scientific Committee discussed two possible hypotheses explaining the observed high catches, noting that it is possible that a combination of factors was responsible for this event. There are two main categories of factors:

Increase in the biomass of the population:

According to this hypothesis, several large recruitments to the population in the late 1990's or early 2000's could be responsible for the large increase in yellowfin catches. In these years, environmental conditions favourable to good recruitment may have occurred in the Indian Ocean. But recruitment is not the only process by which the biomass could increase. Additional explanations could be reduced natural mortality during some critical life stage and/or increased growth rates related to favourable environmental conditions.

The Scientific Committee noted there is no evidence from existing data of unusually large numbers of small fish being caught in the surface fisheries in the early 2000's. This could indicate that either the juveniles from these large cohorts were present, but outside the normal purse seine fishing grounds (e.g. in the eastern Indian Ocean), or that the recent cohorts were only at average levels.

An increase in catchability due to a concentration of the resource and/or an increase in the fishing efficiency:

It is also possible that during 2003 and 2004, the catchability of large yellowfin tuna had increased. Possible factors that could have caused this include aggregation of large yellowfin tuna over a relatively small area and/or depths that made it easier for purse seiners and longliners to catch them in large quantities and technological improvements on purse-seiners that could have the schools more vulnerable to fishing. No technological improvements have been reported for industrial longliners during this period.

While these factors might explain the high catches of industrial fisheries in a small area off eastern Africa, there are also reports of exceptionally high catches by the commercial and artisanal fisheries from Yemen, Oman, Iran, South Africa and Maldives.

Large concentrations of the shallow water crustacean *Natosquilla investigatoris* and swimming crab *Portunus trituberculatus*, were reported to have occurred in 2003 and 2004 in the western Indian Ocean, and yellowfin tuna were observed feeding voraciously on them. New information on anomalies in the thermocline depth and primary productivity in 2003 also supported the hypothesis that there may have been an increased catchability due in some part to environmental factors.

By the end of 2002, most purse seine vessels had new sonar equipment installed. These devices potentially enable skippers to locate schools at distances up to 5 km, both night and day. This could make schools more vulnerable to fishing, and catches could be expected to increase. However, there is no indication of similar increases in efficiency in the Atlantic Ocean, where vessels were also fitted with the same equipment. In addition, higher catches also occurred in artisanal and longline fisheries for which there is no indication of recent technological advances.

The Scientific Committee agreed that it was most likely that the increased catches were due to a combination of these two sets of factors, increased recruitment in the early 2000s and increased catchability of large yellowfin tuna during 2003 and 2004.

MANAGEMENT ADVICE

Considering all the stock indicators and assessments, as well as the recent trends in effort and total catches of yellowfin, the Scientific Committee considered that:

1) Fishing mortality rates between 1999 and 2002 were probably slightly below or around Fmsy, and total catches during that period, at an average level of 347,000 t, were probably close to, or possibly above MSY. Total catches in 2003 and 2004 were substantially above MSY; see below for interpretation of the possible reasons for and possible effects of these catches. In these circumstances, any further increase in both effective fishing effort and catch above average levels in 1999 - 2002 should be avoided.
2) The current fishing pressure on juvenile yellowfin by both purse seiners fishing on floating objects and artisanal fisheries is likely to be detrimental to the stock if it continues, as fish of these sizes are well below the optimum size for maximum yield per recruit estimated in 2002.
3) The Scientific Committee also noted that juvenile yellowfin tuna are caught in the purse-seine fishery that targets primarily skipjack tuna. Some measures to reduce the catches of juvenile yellowfin tuna in the FAD fishery will be accompanied by a decrease in the catches of skipjack tuna.

While there was greater consistency in the assessment results considered at this meeting than in 2002, the Scientific Committee emphasized that there remain considerable uncertainties in the assessments, as none as yet are able to fully explain the observed trends in standardized longline CPUEs over the duration of the fishery.

In interpreting the high catches of 2003 and 2004, the Scientific Committee noted that if the hypothesis of one or two high recruitments entering the adult stock is correct, the increased catches from these year classes are unlikely to be detrimental to the stock, but these catches would not be sustainable in the longer term unless supported by continued high recruitments.

On the other hand, there could be serious consequences if the hypothesis that there was an increased catchability during 2003 and 2004 is correct. In this case, the very large catches would represent a much higher fishing mortality and certainly would not be sustainable. Furthermore, they could lead to a sudden decline of the existing adult biomass of yellowfin tuna, potentially reducing the stock to below MSY levels. If such is the case, management action might be needed to reduce catches and fishing mortality to below the levels prevailing in 1999 – 2002 to allow the stock to recover.

If, as the Scientific Committee believes, the most likely cause of the exceptional catches is a combination of these factors, then some reduction of stock biomass is to be expected in the future. However, the extent of any such reduction will only become apparent in several years following detailed stock assessments.

YELLOWFIN TUNA SUMMARY

Maximum Sustainable Yield (MSY)	Approximately 300,000 - 350,000 t
Current (2003) Catch	458,000 t
Mean catch over previous five years (1998 – 2002)	343,000 t
Current Replacement Yield	
Relative Biomass B_{cur}/ Bmsy	
Relative Fishing Mortality F_{cur}/Fmsy	
Management Measures in Effect	None

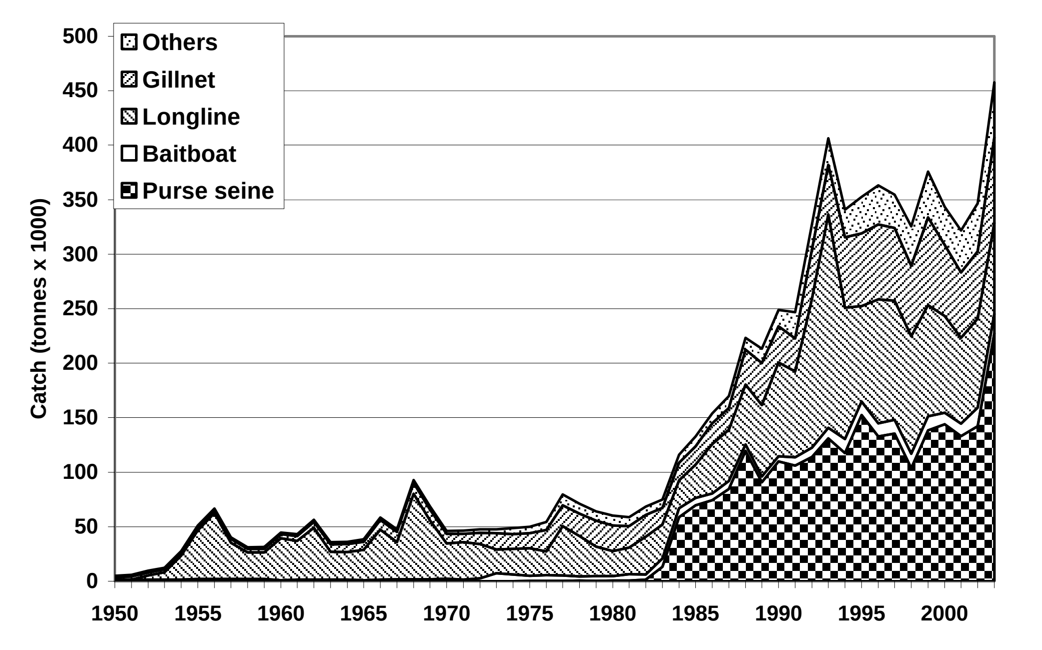
Table 1. Catches of yellowfin tuna by gear and main fleets for the period 1966 to 2003. 2004 is provisional data only.

YFT

Gear	Fleet	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Purse seine	Total									0.0	0.0	0.0									0.1	0.2	0.2	0.3	0.5	0.4	0.5
Baitboat	Maldives	2.0	2.0	2.0	2.0	2.0	1.0	1.5	1.5	1.5	1.5	1.0	1.5	1.7	1.7	1.8	2.3	1.4	2.5	6.9	5.0	4.6	5.2	4.9	3.8	4.4	4.4
	Other Fleets	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.6	1.2	0.2	0.0	0.0	0.0	0.0	0.0
	Total	2.0	2.0	2.0	2.0	2.0	1.0	1.5	1.5	1.5	1.5	1.0	1.5	1.7	1.7	1.8	2.3	1.4	2.6	7.4	6.2	4.8	5.2	4.9	3.8	4.4	4.4
Longline	China																										
	Taiwan,China	0.7	1.1	1.3	1.8	2.4	2.2	2.9	3.5	3.4	2.9	2.2	4.4	3.4	22.7	21.1	14.9	11.9	11.8	5.7	4.4	4.6	3.4	8.1	4.2	3.7	3.8
	Indonesia																			0.1	0.3	0.7	1.0	1.3	1.3	1.4	2.1
	Japan	44.2	59.5	31.9	22.6	22.2	36.1	32.7	44.2	22.0	22.2	24.9	40.8	30.2	48.3	23.1	10.3	13.4	7.9	3.9	4.9	6.4	2.8	2.1	4.6	3.3	3.2
	Korea, Republic of											0.1	0.1	0.4	5.3	9.1	5.2	7.4	10.3	10.8	13.1	13.3	13.7	33.1	26.5	18.0	13.2
	Other Fleets	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.5	0.5	0.1	2.3	0.6	1.9	1.6	1.5	1.1	0.7	0.2	1.1	0.9	0.2	0.4	0.5
	Total	44.9	60.6	33.1	24.5	24.6	38.3	35.6	47.7	25.4	25.3	27.7	45.7	34.0	78.6	53.9	32.3	34.3	31.5	21.7	23.5	25.3	21.9	45.4	37.0	26.9	22.8
Gillnet	Sri Lanka	0.7	0.8	1.0	1.1	1.2	1.5	1.8	2.7	3.5	3.4	3.2	3.6	4.1	4.5	5.0	3.9	2.8	4.4	5.3	4.7	3.8	6.9	6.3	6.7	7.4	8.2
	Oman	0.7	0.5	0.5	0.5	0.7	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.8	0.9	2.9	3.4	3.8	4.0	4.4	4.1	5.0
	Pakistan	0.6	0.5	1.4	0.7	0.7	0.9	0.8	1.2	1.8	2.5	2.7	3.6	3.5	3.5	3.2	2.9	2.4	2.8	2.2	3.0	3.3	3.1	2.8	1.6	2.8	1.3
	Indonesia	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.8	0.6	0.6	1.1	1.1	1.0	1.1	1.6	3.3	4.2	4.7	4.3
	Other Fleets	0.3	0.4	0.3	0.3	0.3	0.5	0.7	0.2	0.4	0.3	0.3	0.3	0.4	0.4	0.3	0.7	1.3	1.3	5.4	1.8	2.2	4.3	2.7	3.5	4.8	4.7
	Total	2.7	2.7	3.6	3.1	3.2	3.8	4.3	5.2	6.9	7.4	7.6	8.9	9.4	9.9	10.1	8.8	7.9	10.4	14.9	13.4	13.8	19.7	19.0	20.6	23.9	23.5
Line	Yemen	0.3	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.2	0.2	0.3	0.3	0.7	0.8	0.9	1.0	1.0	1.0	1.1
	Comoros																0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
	Indonesia	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.5	0.3	0.6	0.7	0.5
	Other Fleets	0.2	0.3	0.3	0.3	0.3	0.4	0.5	0.7	0.9	0.8	0.8	0.9	1.1	1.2	1.3	1.3	1.3	1.6	1.8	1.8	1.5	2.3	4.9	3.3	3.0	3.2
	Total	0.6	0.6	0.6	0.7	0.7	0.7	0.8	1.0	1.2	1.2	1.2	1.3	1.5	1.7	1.8	1.8	1.8	2.2	2.4	2.9	2.8	3.9	6.3	5.1	4.7	4.9
All	Total	50.1	65.9	39.4	30.2	30.5	43.8	42.3	55.5	35.1	35.4	37.5	57.4	46.7	91.9	67.7	45.2	45.4	46.6	46.4	46.0	46.9	50.9	75.9	66.9	60.3	56.0

Gear	Fleet	Av00/04	Av55/04	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04
Purse seine	Spain	62.1	19.3				11.5	18.4	20.0	26.3	44.9	41.1	43.7	44.0	37.8	47.8	43.1	65.1	59.4	61.0	38.6	51.9	49.4	47.7	53.4	79.0	80.8
	France	47.0	17.5	0.2	1.0	10.5	36.7	39.1	43.3	46.8	59.9	38.4	45.3	38.1	45.3	39.5	35.8	39.6	35.6	31.2	22.4	30.8	37.7	34.1	36.4	63.3	63.5
	Seychelles	24.6	2.9											0.4	0.2					2.8	7.4	9.8	11.6	12.9	16.6	33.3	48.8
	NEI-Other	20.0	6.3			0.7	8.4	9.4	6.3	5.2	7.9	4.5	11.9	11.9	8.1	15.5	19.7	19.3	16.7	21.9	20.3	25.8	27.1	19.4	19.1	24.5	10.1
	NEI-Ex-Soviet Union	8.5	2.3										0.8		5.2	8.7	5.8	14.6	11.7	9.8	5.3	11.8	10.9	9.8	6.8	15.1	
	Other Fleets	7.8	3.9	0.4	0.6	2.1	2.3	2.6	4.7	6.4	6.7	6.7	8.0	11.8	17.4	19.5	13.0	13.8	9.4	8.8	9.6	8.1	7.2	9.1	10.0	12.3	0.3
	Total	170.0	52.1	0.6	1.6	13.2	58.9	69.5	74.3	84.7	119.5	90.7	109.7	106.2	114.0	131.0	117.5	152.5	132.9	135.5	103.6	138.2	143.9	133.0	142.2	227.4	203.5
Baitboat	Maldives	10.9	5.7	5.6	4.5	7.7	8.2	6.9	6.2	7.4	5.9	5.5	4.9	7.0	8.0	9.3	12.4	11.8	11.5	12.2	13.0	12.6	10.0	11.1	16.3	17.2	
	Other Fleets	0.6	0.2	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.5	0.5	0.4	0.4	0.5	0.5	0.4	0.5	0.6	0.5	0.6	0.6	0.4
	Total	11.5	5.9	5.9	4.6	7.7	8.2	6.9	6.2	7.4	5.9	5.5	4.9	7.5	8.5	9.8	12.8	12.2	12.0	12.7	13.4	13.1	10.6	11.6	16.9	17.8	0.4
Longline	China																										
	Taiwan,China	26.2	14.9	4.1	4.7	5.6	5.8	7.3	16.2	22.3	22.7	22.4	31.6	30.7	56.0	88.2	34.1	23.1	27.9	18.4	23.4	17.7	17.4	18.9	27.7	24.8	42.3
	Indonesia	23.5	7.0	2.6	2.7	0.8	0.8	0.8	0.7	1.3	2.3	3.8	4.6	5.5	9.3	10.8	14.8	16.7	31.8	38.2	35.7	41.7	29.6	28.4	24.2	20.2	15.0
	Japan	16.4	16.4	4.9	7.3	7.8	7.9	9.5	10.7	8.3	9.3	4.6	6.3	4.4	5.7	5.7	9.7	8.0	12.8	15.6	16.8	14.7	15.5	13.9	14.0	17.3	21.3
	NEI-Fresh Tuna	8.4	4.6									11.9	16.6	14.4	16.7	16.5	23.7	17.1	17.7	21.2	16.6	14.8	13.0	7.9	7.4	8.3	5.4
	NEI-Deep-freezing	3.3	2.5					0.1	1.1	1.2	3.4	3.2	6.7	5.9	8.9	23.8	9.9	6.9	12.1	5.9	9.8	7.4	6.6	3.2	4.0	2.6	
	Korea, Republic of	2.0	7.0	12.4	19.3	16.2	10.2	12.5	15.4	13.2	14.1	8.7	7.5	3.2	4.4	4.3	4.0	2.7	4.0	4.2	2.6	1.0	2.0	1.5	0.3	2.1	4.1
	NEI-Indonesia Fresh Tuna	0.0	2.0						0.1		2.7	10.3	12.6	12.9	15.6	12.6	16.3	8.9	3.7	4.0	0.3	0.0					
	Other Fleets	4.7	2.5	0.4	0.4	0.7	0.7	0.3	1.1	0.7	0.5	0.5	0.1	1.9	20.1	33.7	8.2	4.2	3.8	1.9	2.6	4.6	4.6	4.7	4.2	8.1	2.1
	Total	84.6	56.8	24.4	34.5	31.1	25.5	30.4	45.3	47.0	55.0	65.3	86.1	78.8	136.7	195.7	120.7	87.6	113.8	109.2	107.8	101.9	88.7	78.6	81.9	83.5	90.1
Gillnet	Sri Lanka	24.9	10.1	9.4	9.2	8.9	6.3	6.8	7.0	7.3	7.6	8.2	9.4	11.5	13.7	16.4	21.3	18.6	23.4	29.2	28.9	36.7	33.3	27.8	29.9	33.5	
	Iran, Islamic Republic	16.0	4.9									1.0	2.3	3.2	12.1	13.3	19.5	22.5	28.5	20.0	18.0	24.3	13.5	18.0	19.0	29.5	
	Oman	5.5	5.1	4.8	3.5	1.6	4.6	2.3	2.5	5.9	15.6	16.2	14.4	9.0	13.5	11.5	19.2	21.4	11.6	9.9	11.3	7.4	7.1	6.3	5.3	8.8	
	Pakistan	3.8	2.8	2.0	2.5	0.8	0.9	1.5	2.6	2.4	3.8	8.6	3.3	4.9	3.9	2.6	2.4	2.1	3.2	3.9	3.9	9.4	5.3	4.0	3.3	3.5	3.2
	Indonesia	2.7	1.9	2.5	3.2	3.1	3.3	4.3	6.2	2.7	4.2	3.3	2.2	0.9	0.9	0.8	1.3	1.3	1.1	2.7	1.5	1.8	5.0	3.1	3.1	2.3	
	Other Fleets	1.0	1.3	0.9	1.5	0.7	1.0	1.9	0.9	1.4	0.8	1.2	1.7	0.9	1.0	0.9	0.9	0.8	0.9	1.0	0.9	1.0	1.0	1.0	1.0	1.1	0.8
	Total	53.9	25.9	19.5	20.0	15.1	16.0	16.7	19.1	19.8	32.0	38.5	33.2	30.4	45.2	45.6	64.6	66.7	68.7	66.7	64.5	80.5	65.3	60.0	61.5	78.5	4.1
Line	Yemen	27.2	6.0	0.8	0.8	1.5	2.3	3.1	3.9	4.6	5.4	6.2	6.9	7.7	8.5	7.6	8.3	13.2	15.0	17.0	19.1	21.1	23.1	25.2	27.2	29.2	31.3
	Comoros	4.6	1.6	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	3.7	3.7	3.7	5.0	5.0	5.9	5.9	5.8	5.6	5.6	5.4	5.9	5.4	5.8	6.1	
	Indonesia	3.3	2.3	0.1	0.5	0.4	0.3	1.7	1.1	2.3	1.5	0.2	0.9	9.1	6.5	8.3	7.9	11.2	11.9	4.9	8.9	12.3	1.5	2.3	4.3	8.3	
	Other Fleets	4.8	2.3	3.9	3.4	2.9	2.3	2.2	2.1	2.2	2.4	2.3	2.6	3.0	3.4	3.3	3.0	3.1	3.0	3.0	2.7	3.0	4.5	5.4	6.9	7.0	0.4
	Total	39.9	12.2	5.0	4.9	5.1	5.1	7.1	7.3	9.4	9.5	12.4	14.1	23.5	23.3	24.2	25.1	33.4	35.7	30.5	36.3	41.9	35.0	38.3	44.2	50.5	31.7
Other	Total	0.0	0.0								0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0	0.0	
All	Total	359.9	153.0	55.5	65.6	72.2	113.7	130.8	152.2	168.2	222.0	212.4	248.1	246.4	327.7	406.2	340.7	352.4	363.0	354.6	325.6	375.6	343.5	321.6	346.7	457.8	329.9

(a)



(b)

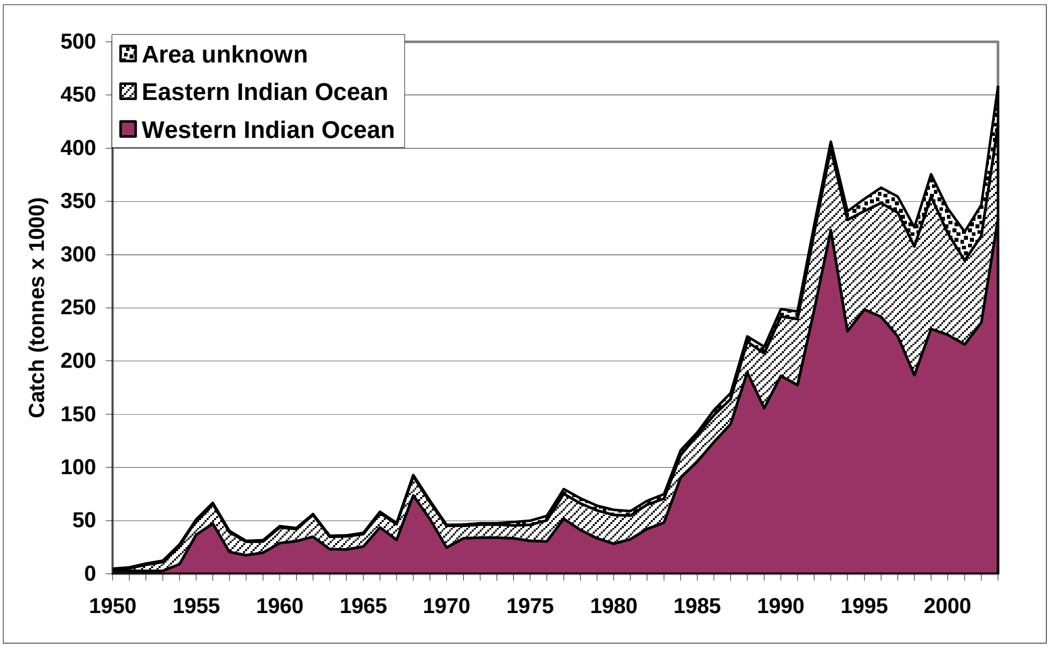


Figure 1. Yearly catches (tonnes x 1000) of yellowfin by (a) gear and (b) area from 1960 to 2003.

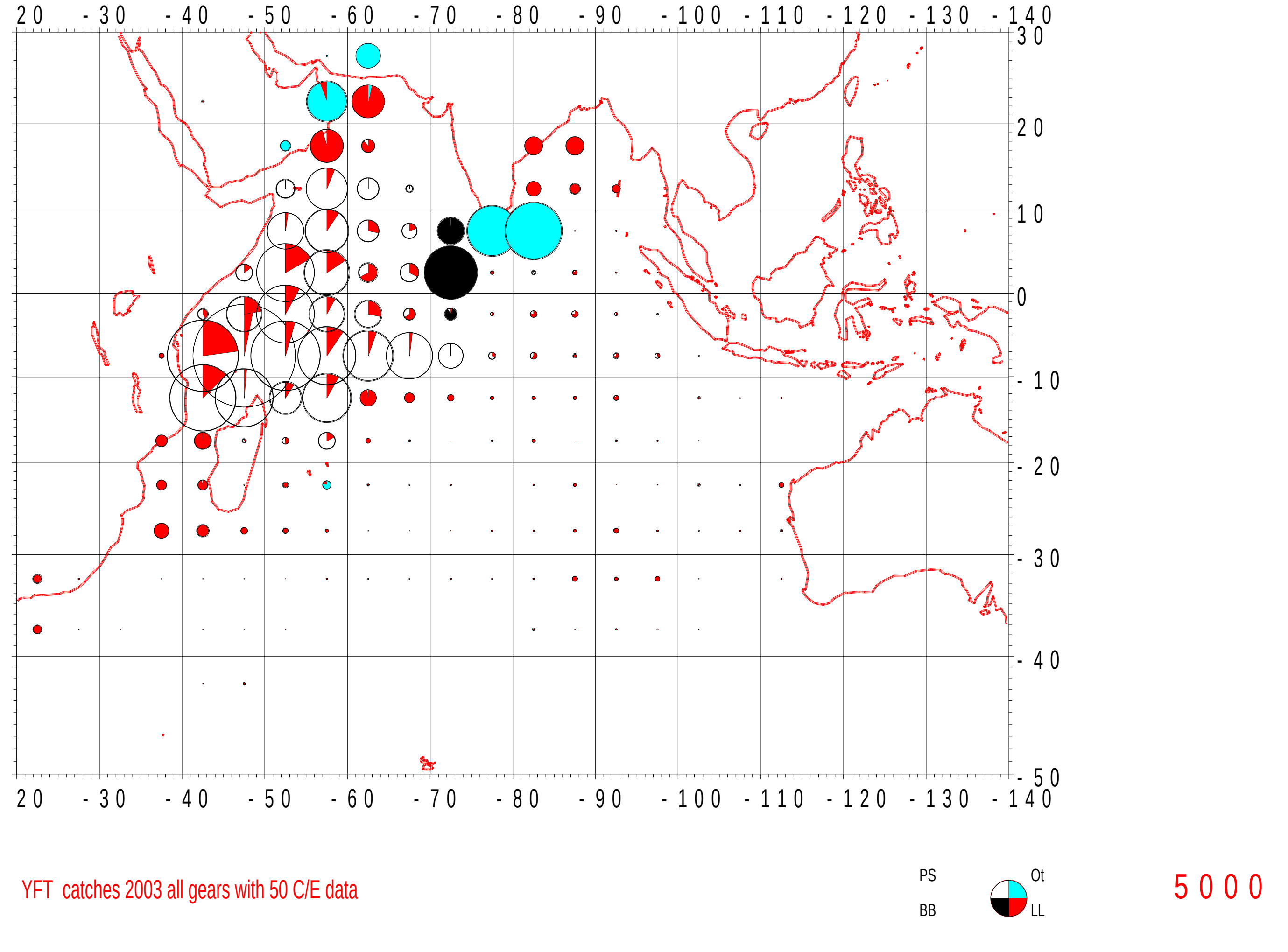


Figure 2. Location of yellowfin catches taken in the Indian Ocean in 2003. Legend circle equivalent to 5000 tonnes.

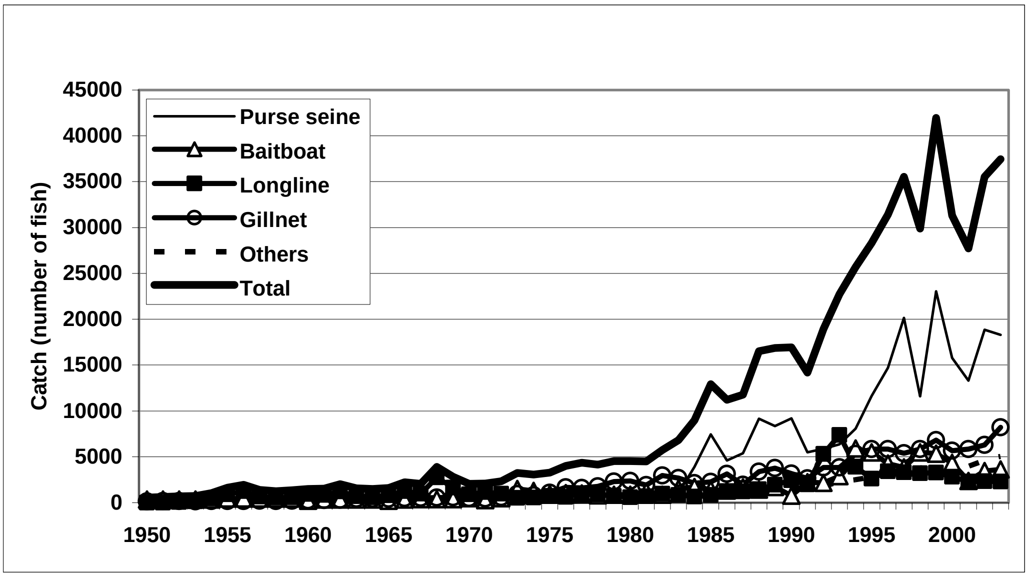


Figure 3. Numbers of yellowfin caught by gear-type.

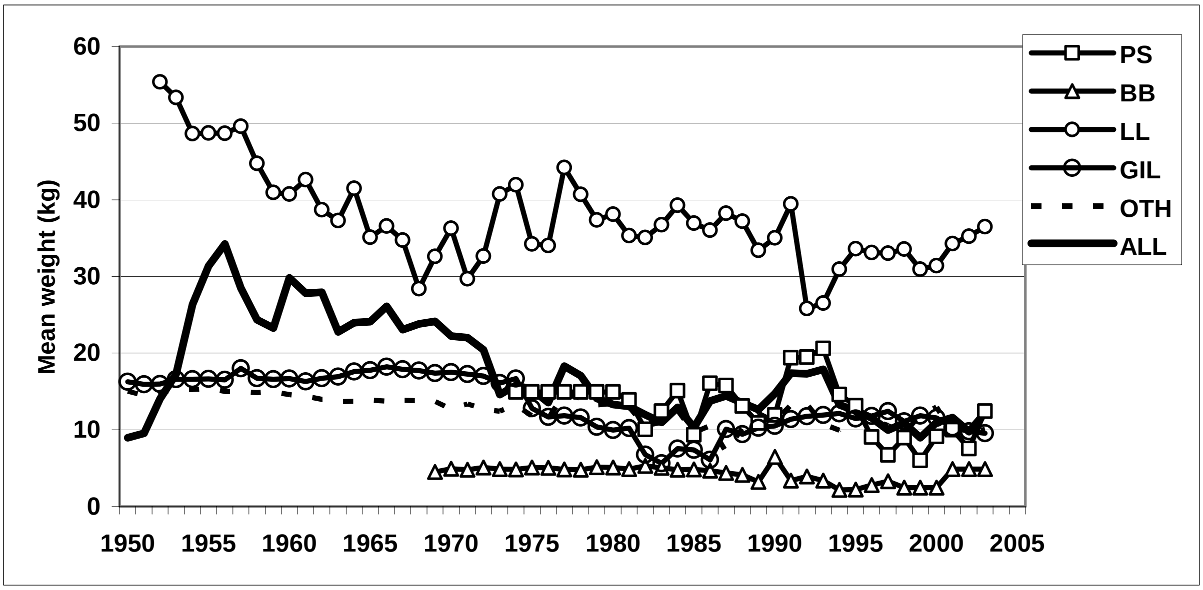


Figure 4. Mean weight (kg) of yellowfin individuals in the catch by gear and for all gear-types (estimated from the total catch at size). PS: purse seine, BB: bait boat, LL: longline, GIL: gillnet, OTH: other.

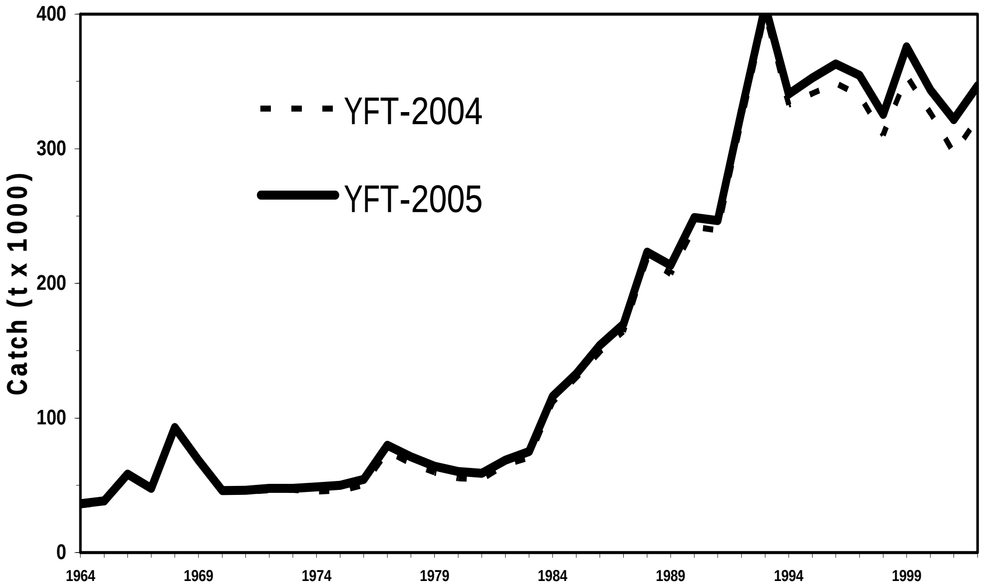


Figure 5: Yellowfin tuna catch estimates in 2005 following a review of the data by the IOTC Secretariat versus catch estimates in 2004 (1964-2002)

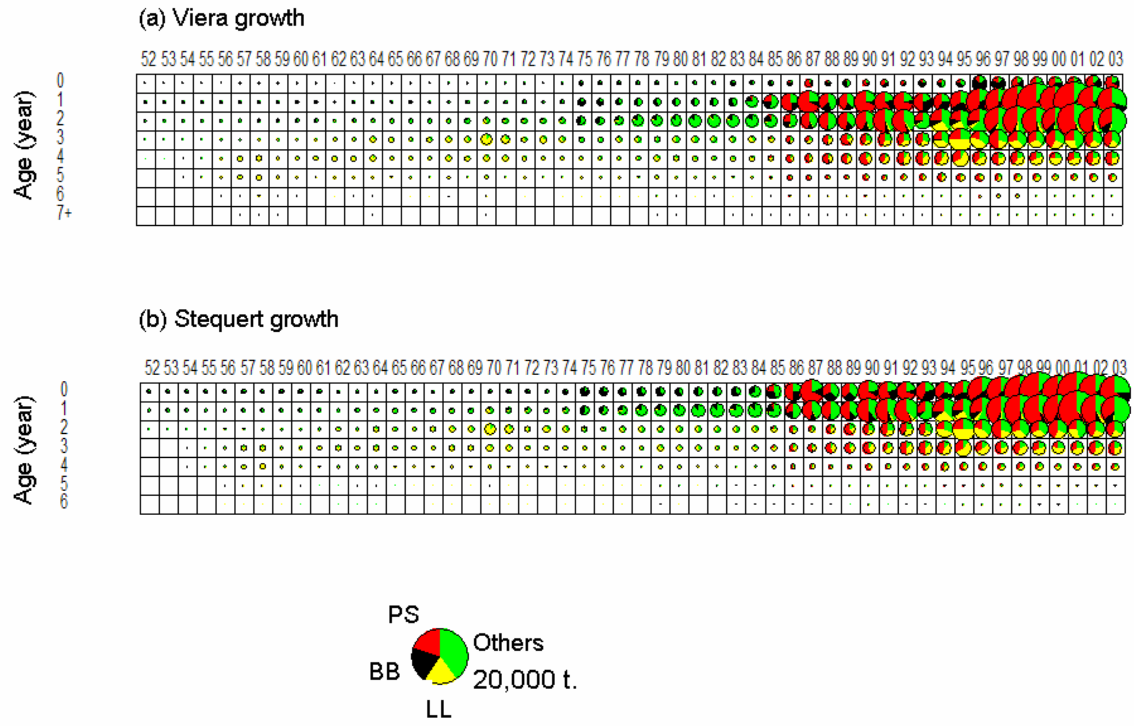


Figure 6. Catch at age (tonnes) for yellowfin tuna caught in the Indian Ocean (a) estimated using the revised Viera growth curve (b) estimated using the revised Stequert growth curve. PS: purse seine; BB: bait boat; LL: longline fishing.

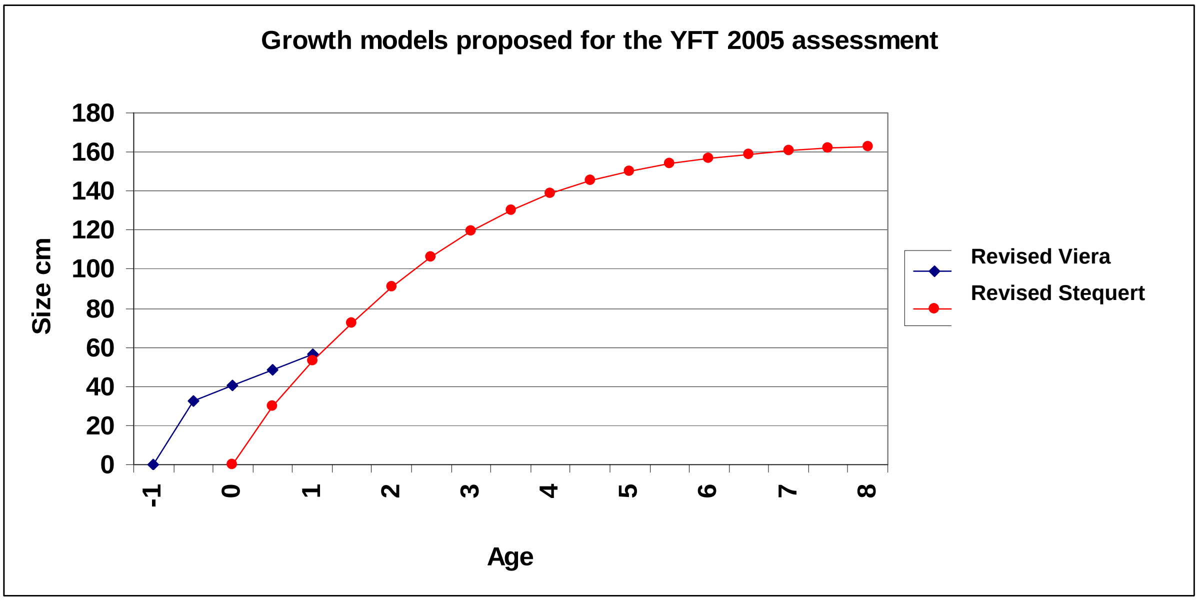


Figure 7. Yellowfin tuna growth curves used in the 2005 stock assessments.

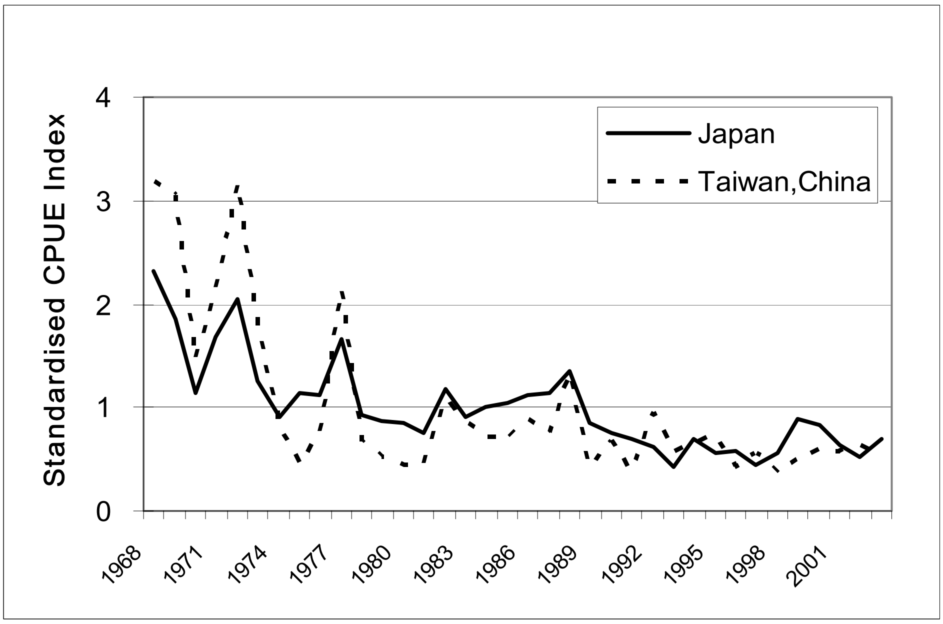


Figure 8. Yearly standardised CPUE indices for yellowfin tuna based on the Japanese and Taiwan,China longline catch rates in the Indian Ocean

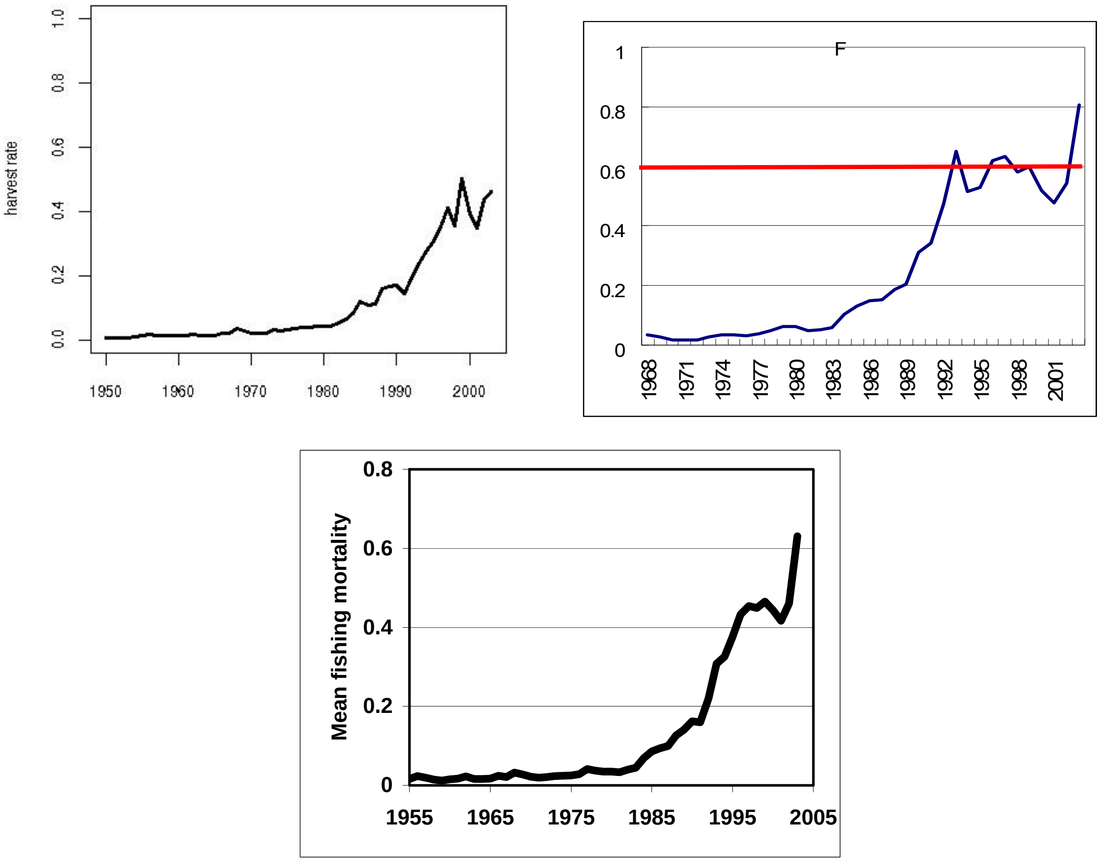


Figure 9. Yellowfin fishing mortality rate trends from each of the models in 2005. Bayesian (top left), ASPM (top right) and CATAGE (bottom).

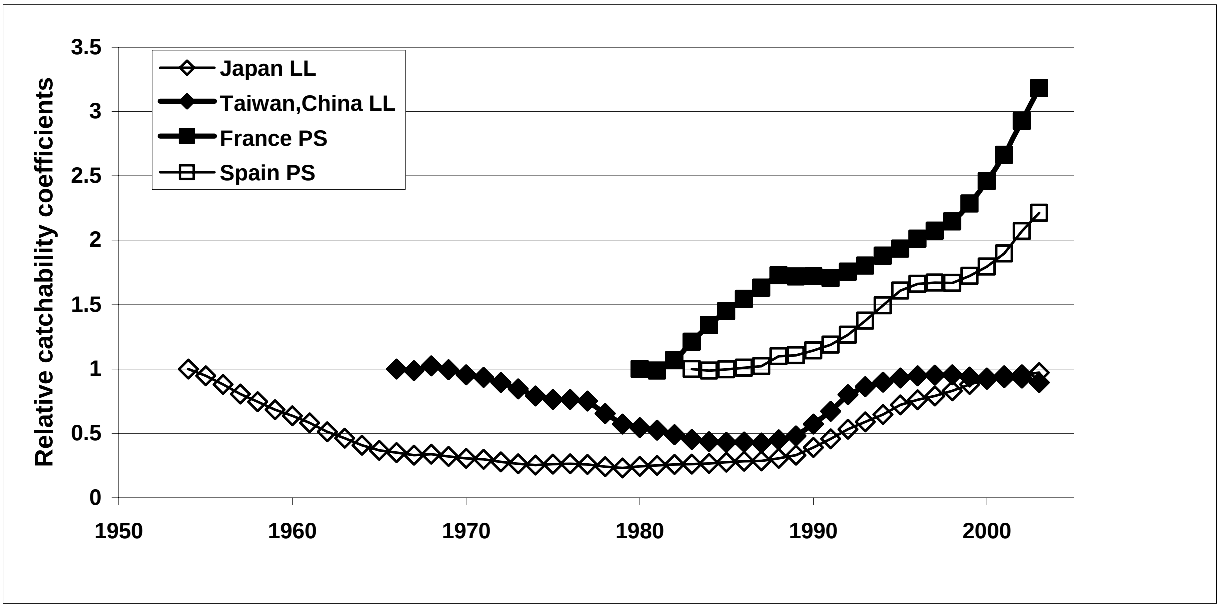


Figure 10. Mean yearly relative catchability coefficients estimated from CATAGE for Japanese longline (LL), Taiwan,China longline, French purse seine (PS) and Spanish purse seine.