EXECUTIVE SUMMARIES OF THE STATUS OF THE MAJOR INDIAN OCEAN TUNAS

SYNTHESE SUR L'ETAT DES RESSOURCES DES PRINCIPALES ESPECES DE THONS DANS L'OCEAN INDIEN

Executive summary of the status of the albacore tuna resource

(As adopted by the IOTC Scientific Committee on 9 November 2007)

Marked changes are factual changes related mainly to the inclusion of the latest fisheries statistics. A stock assessment was undertaken in 2008 and relevant sections have been updated using the text from the 2008 WPTe report and other related sources. All changes are suggestions only for the consideration of the SC in Dec08

BIOLOGY

Albacore (*Thunnus alalunga*) is a temperate tuna living mainly in the mid oceanic gyres of the Pacific, Indian and Atlantic oceans. Indian Ocean albacore is distributed from 5°N to 40°S. In the Pacific and Atlantic oceans there is a clear separation of southern and northern stocks associated with the oceanic gyres that are typical of these areas. In the Indian Ocean, there is probably only one southern stock because there is no northern gyre.

Albacore is a highly migratory species and individuals swim large distances during their lifetime. It can do this because it is capable of thermoregulation, has a high metabolic rate, and advanced cardiovascular and blood/gas exchange systems. Pre-adults (2-5 year old albacore) appear to be more migratory than adults. In the Pacific Ocean, the migration, distribution availability, and vulnerability of albacore are strongly influenced by oceanographic conditions, especially oceanic fronts. It has been observed on all albacore stocks that juveniles concentrate in cold temperate areas (for instance in a range of sea-surface temperatures between 15 and 18°C), and this has been confirmed in the Indian Ocean where albacore tuna are more abundant north of the subtropical convergence (an area where these juvenile were heavily fished by driftnet fisheries during the late 1980's). It appears that juvenile albacore show a continuous geographical distribution in the Atlantic and Indian oceans in the north edge of the subtropical convergence. Albacore may move across the jurisdictional boundary between ICCAT and IOTC.

The maximum age reported for Indian Ocean albacore is eight years. However, this may be an underestimate as albacore have been reported live to at least 10 years in the Pacific Ocean.

Little is known about the reproductive biology of albacore in the Indian Ocean but it appears, based on biological studies and on fishery data, that the main spawning grounds are located east of Madagascar between 15° and 25°S during the 4th and 1st quarters of each year (Figure 1). In the Pacific Ocean, albacore grow relatively slowly (compared to skipjack and yellowfin) and become sexually mature at about 5-6 years old. Like other tunas, adult albacore spawn in warm waters (SST>25°C). It is likely that the adult Indian Ocean albacore tunas do yearly circular counter-clockwise migrations following the surface currents of the south tropical gyre between their tropical spawning and southern feeding zones. In the Atlantic Ocean, large numbers of juvenile albacore are caught by the South African pole-and-line fishery (catching about 10.000 t yearly) and it has been hypothesized that these juveniles may be taken from a mixture of fish born in the Atlantic (north east of Brazil) and from the Indian Ocean.

Overall, the biology of albacore stock in the Indian Ocean is not well known and there is relatively little new information on albacore stocks.

FISHERIES

Albacore are caught almost exclusively under drifting longlines (98 %), and between 20° and 40°S (Table 1, Figure 1), with remaining catches recorded under purse seines and other gears (Table 1).

A fleet using drifting gillnets targeting juvenile albacore operated in the southern Indian Ocean (30° to 40° South) between 1985 and 1992 harvesting important amounts of this species. This fleet, from Taiwan,China, ceased fishing with this gear in 1992 due to a worldwide ban on the use of drifting gillnets. Albacore is currently both a target species and a bycatch of industrial longline fisheries and a bycatch of other fisheries.

The catches of albacore increased rapidly during the first years of the fishery, remaining relatively stable until the mid-1980s, except for some very high catches recorded in 1973, 1974 and 1982. The catches increased markedly during the 1990's due to the use of drifting gillnets, with total catches reaching around 30,000 t. Catches have steadily increased since 1993, after the drop recorded in 1992 and 1993 as a consequence of the end of the drifting gillnet fishery. Catches between 1998 and 2001 were relatively high (ranging from 37,700 t to 40,600 t). By contrast, the average annual catch for the period from 2003 to 2007 was 25,500 t.

Longliners from Japan and Taiwan,China have been operating in the Indian Ocean since the early 1950s and they have been the major fishers for albacore since then (Table 1). While the Japanese albacore catch ranged from 8,000 t to 18,000 t in the period 1959 to 1969, in 1972 catches rapidly decreased to around 1,000 t due to changing the target species mainly to southern bluefin and bigeye tuna, then ranged between 200 t to 2,500 t as albacore became a bycatch fishery. In recent years the Japanese albacore catch has been around 2,000 to 6,000 t. By contrast, catches by Taiwanese longliners increased steadily from the 1950's to average around 10,000 t by the mid-1970s. Between 1998 and 2002 catches ranged between 21,500 t to 26,900 t, equating to just over 60 % of the total Indian Ocean albacore catch. Since 2003 the albacore catches by Taiwanese longliners have been less that 16,900 t.

The catches of albacore by longliners from the Republic of Korea, recorded since 1965, have never been above 10,000 t. Important albacore catches of around 3,000 t to 5,000 t have been recorded in recent years for a fleet of fresh-tuna longliners operating in Indonesia (Figure 3).

Large sized albacore are also taken seasonally in certain areas (Figure 5), most often in free-swimming schools, by the purse seine fishery.

A feature of Indian Ocean albacore fisheries is that it is the only ocean where juvenile albacore are rarely targeted by fisheries. In the Atlantic and Pacific oceans surface fisheries often actively target small albacore to the extent that juveniles contribute to the majority of albacore catches. This, however, does not discount the possibility that the juvenile albacore from the Indian Ocean are not being subjected to significant levels of fishing pressure as the small fish targeted off the west coast of South Africa may have migrated to the Atlantic Ocean from the Indian Ocean (Figure 1).

AVAILABILITY OF INFORMATION FOR STOCK ASSESSMENT

Nominal Catch (NC) Data

The catches of albacore recorded in the IOTC databases are thought to be complete, at least until the mid-1980s. The fleets for which the majority of the catches of albacore are recorded have always reported good catch statistics to the IOTC. The catches of albacore recorded for Illegal and/or Unregulated and/or Unreported (IUU) fleets (recorded mostly as NEI- in the IOTC Database), which have been operating in the Indian Ocean since the early 1980s, have always been estimated by the Secretariat. In recent years the quantities of the NEI catches have decreased markedly.

Catch-and-Effort (CE) Data

Catch and effort data are fully or almost fully available up to the early 1990s but only partially available since then, due to the almost complete lack of catch and effort records from IUU and the Indonesian longline fleet.

The effort statistics are thought good quality for most of the fleets for which long catches series are available, with the exception of the Republic of Korea and Philippines. The use of data for these countries is, therefore, not recommended.

Size Frequency Data

The size frequency data for the Taiwanese longline fishery for the period 1980-2006 is now available. In general, the amount of catch for which size data for the species are available before 1980 is still very low. The data for the Japanese longline fleets is available; however, the number of specimens measured per stratum has been decreasing in recent years. Few data are available for the other fleets.

STOCK ASSESSMENT

In 2008, an age structured production model was used to examine the effect of the interaction between age at selection by the fishery and age-at-maturity and how this might affect stock status. The total catch biomass (1950-2007) and Taiwanese long-line CPUE data (1980-2006) was used to estimate the parameters of the model. Two scenarios were examined: Case 1 where selection begins one age-class before maturation i.e selectivity is at age 4 and maturity is at age 5; and Case 2 where selection follows the maturity ogive i.e. selectivity is at age 5 and maturity is at age 5, but spawning occurs before fishing.

For both scenarios there was no outstanding indications that the stock was over-fished (B2007/BMSY >1), or that overfishing is occurring (hcurrent < hMSY); however, there were considerable differences in the estimates of other stock parameters (the current levels of exploitation rate and current relative to MSY levels). It appears that the interaction of age-at-maturity and age-at-selection has a major influence on the results. In scenario 1 fish are available to the fishery a little earlier than they mature (it does not fully select immature fish but assumes the fishery begins to take fish before they can effectively spawn). For scenario 2 the ages at selection and maturation are the same and, given that the population model assumes that fishing occurs post-spawning, all fish are allowed to spawn at least once before they are exploited. This makes a large difference to the estimated MSY levels. For the values of steepness here (in fact even for lower values) if the fish are permitted to spawn at least once before being exploited then the model estimates that population can permanently sustain very high levels of exploitation.

For scenario 1, MSY was estimated to be 28,260 t (95% CI = 25,353t -31,333 t) and for scenario 2, MSY was estimated to be 34,415 t (28,414t -38,037 t). Both scenarios indicated that annual catches at the historically high level experienced over the period 1998 to 2001 (range 35,000 to 43,000 t, average 38,300 t) would likely exceed MSY levels.

There appears to be a well defined spatial nature to the dynamics of albacore, with relatively few juvenile and immature fish being available to the fishery compared to mature fish. With more information on the spawning condition of fish by location, growth and maturity, as well as improvements to the current indices of abundance and how to interpret the catch data, a well defined spatial assessment model for albacore may be possible in the future.

MANAGEMENT ADVICE

Current status

Based on the preliminary analyses undertaken in 2008 there are no indications that that the albacore stock is over-fished (B2007/Bmsy >1) and overfishing is currently likely not occurring for the scenarios envisaged. Point estimates of MSY ranged from 28,260 t to 34,415 t. ~~However~~This indicated, ~~there was an indication~~ that continuous annual catches at a level approaching 38,000 t (equivalent to the historically high level of catch experienced over the period 1998 to 2001) may not be sustainable in the long term.

Albacore catches have been around 26,000 t annually over the past five years (2003-2007) and this level is only slightly higher than the historical average annual catch taken for the past 50 years (23,000 t). Other fisheries-based indicators show considerable stability over long periods. The mean weight of albacore in the catches has remained relatively stable over a period of more than 50 years. Furthermore, the average weight of albacore in the Indian Ocean is higher than that reported in the other oceans and is likely to result in a higher yield per recruit. The catch rates of albacore have also been stable over the past 20 years.

Because of the low value (Figure comparison of tuna and swordfish prices) and, as a likely result, low profitability of the albacore longline fishery compared to the fisheries for other tuna species, there is likely to be very little incentive for an increase in fishing effort on this species in the immediate future.

On balance of the information available, albacore is considered to be not overfished and overfishing is not occurring.

Recommendation.

The WPTe acknowledges the preliminary nature of the albacore tuna assessment in 2008, but on balance of the available stock status information and stable considers that the status of the stock of albacore is not ~~going~~ likely to change markedly over the next 2-3 years and if the price of albacore remains low compared to other tuna species, ~~and~~ no immediate action ~~is~~ should be required on the part of the Commission. The WPTe recommend that a new albacore tuna assessment be presented to the Scientific Committee at the latest in 2010.

ALBACORE TUNA SUMMARY

Maximum Sustainable Yield:	point estimates ranged from 28,260 t to 34,415 tunknown
Preliminary catch in 2007 *(data as of October 2008)*	32,200 t
Mean catch over the last 5 years (2003-07)	25,500 t
Catch in 2006	24,700 t
Catch in 2003	25,300 t
Current Replacement Yield	-
Relative Biomass ($B_{current}/B_{MSY}$)	> 1
Relative Fishing Mortality ($F_{current}/F_{MSY}$)	hcurrent/hmsy point estimates ranged from 0.48 to 0.91 t

Note: This Executive Summary has been updated to take account of recent catch data. The management advice, and stock assessment results are based on data up to 2006.

Table 1. *Best scientific estimates of the catches of albacore tuna (as adopted by the IOTC Scientific Committee) by gear and main fleets for the period 1958-2007 (in thousands of tonnes).*
Data as of October 2008

Gear	Fleet	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84
Purse seine	France																											0.3
	Spain																											0.2
	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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	Total																							*0.0*	*0.0*	*0.0*	*0.0*	*0.6*
Longline	China																											
	Taiwan,China	1.0	1.2	1.1	1.4	1.3	1.6	1.5	1.1	1.7	1.6	7.6	7.7	7.2	7.0	7.0	12.0	17.4	6.4	9.7	9.8	12.8	15.0	11.0	12.3	21.9	17.0	13.9
	Japan	6.3	10.4	11.1	15.2	17.6	12.6	17.8	11.4	13.1	14.1	10.1	8.6	4.9	3.3	1.4	2.0	2.8	1.3	1.2	0.4	0.4	0.4	0.6	1.2	1.3	1.7	1.8
	Indonesia																	0.0	0.1	0.1	0.1	0.2	0.3	0.2	0.2	0.2	0.2	0.3
	Korea, Republic of								0.5	0.6	6.2	0.9	4.4	1.6	2.4	3.8	9.1	9.7	3.9	4.2	2.1	4.6	2.0	1.8	0.9	0.6	0.6	0.4
	Other Fleets	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.0	0.8	0.2	0.6	0.5	0.5	0.4	0.2	0.1	0.0	0.1	0.1	0.0	0.0	0.1	0.1	0.2	0.2
	Total	*7.3*	*11.6*	*12.1*	*16.6*	*19.0*	*14.1*	*19.4*	*13.2*	*15.6*	*22.0*	*19.3*	*20.8*	*14.4*	*13.3*	*12.7*	*23.4*	*30.2*	*11.6*	*15.3*	*12.5*	*18.1*	*17.7*	*13.7*	*14.7*	*24.2*	*19.6*	*16.7*
Gillnet	Taiwan,China																									0.1	0.1	
	Total																									*0.1*	*0.1*	
Other gears	*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*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.4*	*0.0*	*0.1*
All	*Total*	*7.3*	*11.6*	*12.1*	*16.6*	*19.0*	*14.2*	*19.4*	*13.2*	*15.6*	*22.0*	*19.3*	*20.9*	*14.4*	*13.3*	*12.8*	*23.5*	*30.3*	*11.7*	*15.3*	*12.5*	*18.1*	*17.7*	*13.7*	*14.7*	*24.7*	*19.8*	*17.3*

Gear	Fleet	Av03/07	Av58/07	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07
Purse seine	France	0.4	0.2	0.5	0.2	0.2	0.2	0.0	0.0	0.9	1.4	0.3	0.3	0.4	0.4	0.5	0.5	0.2	0.4	0.7	0.3	0.6	0.1	0.1	0.9	0.3
	Spain	0.3	0.2	0.1		0.0	0.1		0.1	1.1	1.5	0.9	1.8	0.6	0.8	1.0	0.3	0.2	0.4	0.3	0.2	0.5	0.1	0.0	0.4	0.2
	Other Fleets	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.2	0.3	0.4	0.1	0.5	0.4	0.4	0.5	0.8	0.2	0.4	0.3	0.3	0.4	0.1	0.0	0.3	0.2
	Total	*0.8*	*0.5*	*0.7*	*0.2*	*0.2*	*0.3*	*0.0*	*0.3*	*2.2*	*3.3*	*1.3*	*2.6*	*1.3*	*1.6*	*2.0*	*1.6*	*0.6*	*1.2*	*1.3*	*0.8*	*1.5*	*0.2*	*0.2*	*1.5*	*0.7*
Longline	China																									
	Taiwan,China	12.5	10.7	6.2	11.1	13.1	11.0	7.1	5.8	13.1	11.1	12.0	14.4	14.2	16.9	15.2	21.6	22.5	21.7	26.9	21.5	13.1	12.5	10.4	9.5	16.9
	Japan	4.6	4.7	2.3	2.5	2.3	1.3	0.9	1.0	1.0	1.8	1.3	1.8	2.0	2.4	3.2	3.2	2.3	2.6	3.0	3.2	2.3	3.6	4.1	6.4	6.4
	Indonesia	3.2	0.7	0.3	0.1	0.3	0.3	0.4	0.4	0.3	0.5	0.4	0.6	0.7	1.3	1.6	1.5	1.7	2.7	2.9	2.6	4.8	4.2	2.6	2.2	2.2
	NEI-Deep-freezing	1.0	1.5	0.0	0.7	0.7	1.7	1.0	1.2	2.5	1.8	3.2	4.2	4.2	7.3	4.8	9.0	9.5	8.2	5.8	3.8	1.4	0.7	1.8	0.7	0.5
	France-Reunion	0.5	0.1							0.0	0.0	0.1	0.1	0.1	0.3	0.2	0.3	0.3	0.5	0.6	0.3	0.3	0.4	0.7	0.5	0.8
	NEI-Fresh Tuna	0.5	0.1					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.2	1.1	1.1
	Belize	0.5	0.1																	1.4	0.6	0.2	0.1	0.7	0.7	0.7
	Spain	0.4	0.1													0.0	0.0	0.0	0.1	0.2	0.2	0.1	0.1	0.8	0.6	0.6
	Seychelles	0.4	0.1															0.0	0.4	0.8	1.1	1.2	0.1	0.1	0.1	0.4
	Korea, Republic of	0.2	1.3	0.5	0.4	0.4	0.4	0.3	0.2	0.3	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.1	0.4	0.2	0.3	0.3
	Other Fleets	0.8	0.3	0.0	0.1	0.1	0.2	0.5	0.5	0.6	0.7	0.6	0.8	0.4	0.2	0.2	0.7	0.5	0.2	0.3	0.2	0.3	0.4	0.6	1.0	1.7
	Total	*24.5*	*19.6*	*9.3*	*14.7*	*17.0*	*14.9*	*10.2*	*9.0*	*17.8*	*16.0*	*17.7*	*22.1*	*21.8*	*28.6*	*25.5*	*36.4*	*37.1*	*36.5*	*42.0*	*33.7*	*23.7*	*22.3*	*22.2*	*23.1*	*31.4*
Gillnet	Taiwan,China	0.0	1.9	0.7	18.2	14.0	14.4	10.6	25.7	9.0	2.6															
	Total	*0.0*	*1.9*	*0.7*	*18.2*	*14.0*	*14.4*	*10.6*	*25.7*	*9.0*	*2.6*															
Other gears	*Total*	*0.1*	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.1*	*0.0*	*0.0*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.2*	*0.1*	*0.1*	*0.1*	*0.2*	*0.1*	*0.1*
All	*Total*	*25.5*	*22.1*	*10.8*	*33.2*	*31.3*	*29.6*	*20.8*	*35.1*	*29.1*	*22.0*	*19.1*	*24.7*	*23.1*	*30.2*	*27.6*	*38.0*	*37.7*	*37.8*	*43.4*	*34.6*	*25.3*	*22.7*	*22.5*	*24.7*	*32.2*

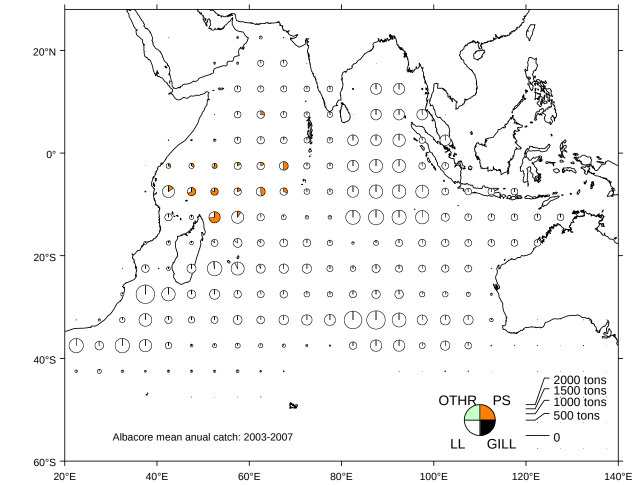


Figure 1. *Average albacore catches by gear during the period 2003-2007. Map shows the distribution of albacore extending from the Indian Ocean to the Atlantic Ocean. LL = longline, PS = purse seine, SU = pole and line. Data as of October 2008*

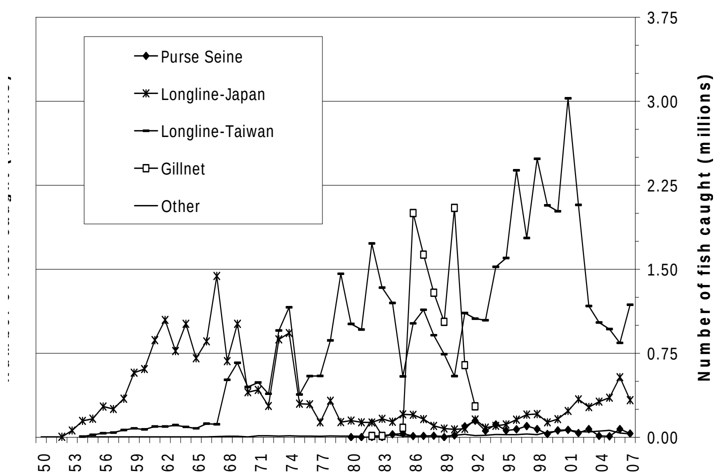


Figure 2. *Catches of albacore per fleet and year recorded in the IOTC Database (1958-2007). Data as of October 2008*

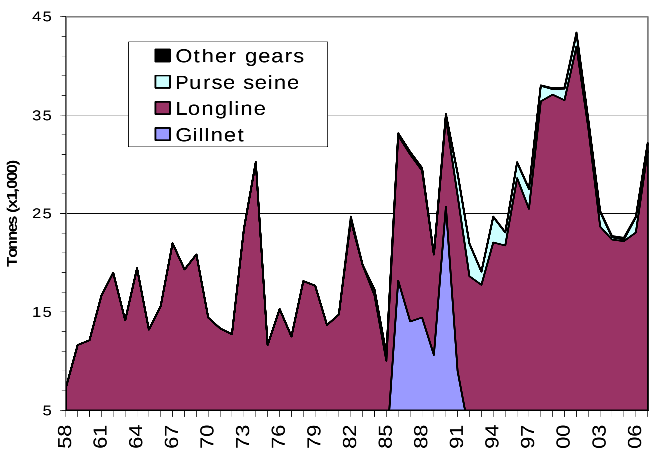


Figure 3. *Annual of catches albacore (thousand of metric tonnes) by gear from 1958 to 2007. Data as of October 2008*

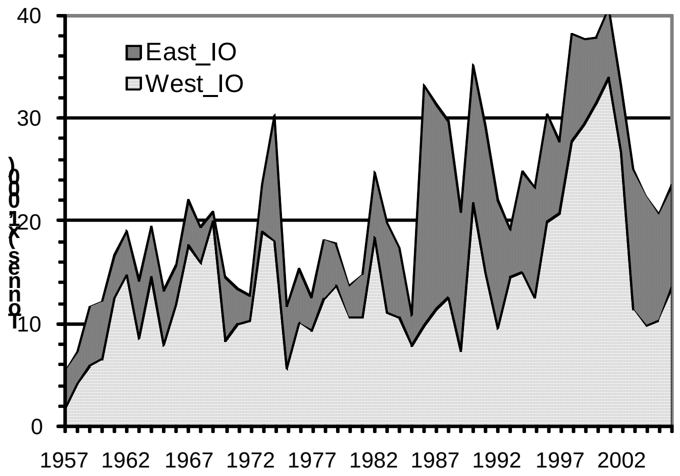


Figure 4. *Catches of albacore in relation to the eastern and western areas of the Indian Ocean (1957-2006). Data as of October 2007 (to be updated)*

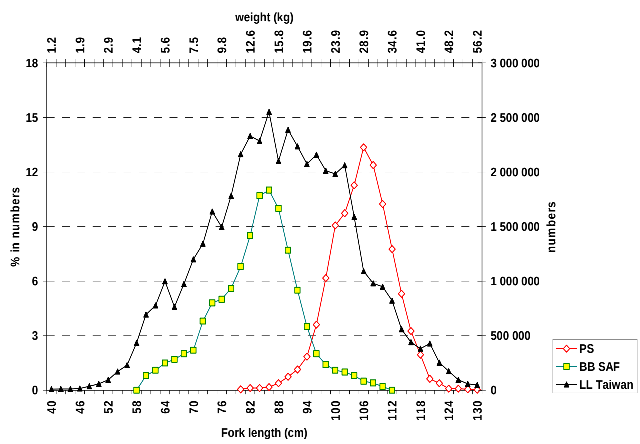


Figure 5. *Average sizes of albacore taken by various fisheries in the Indian Ocean, longliners and purse seiners, and by the pole-and-line fishery in the west coast of South Africa (Atlantic Ocean).'*

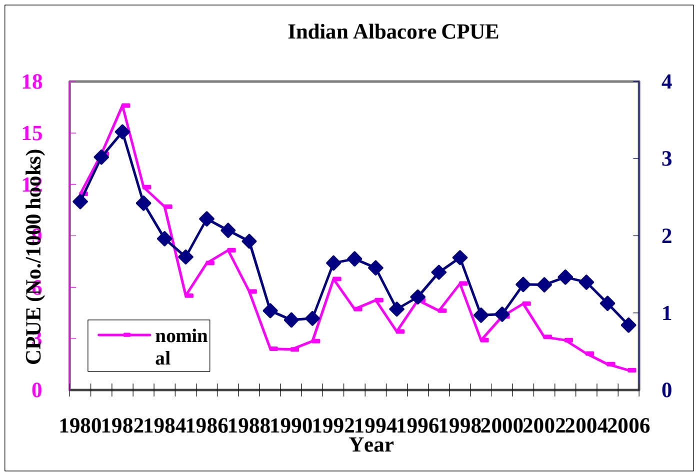
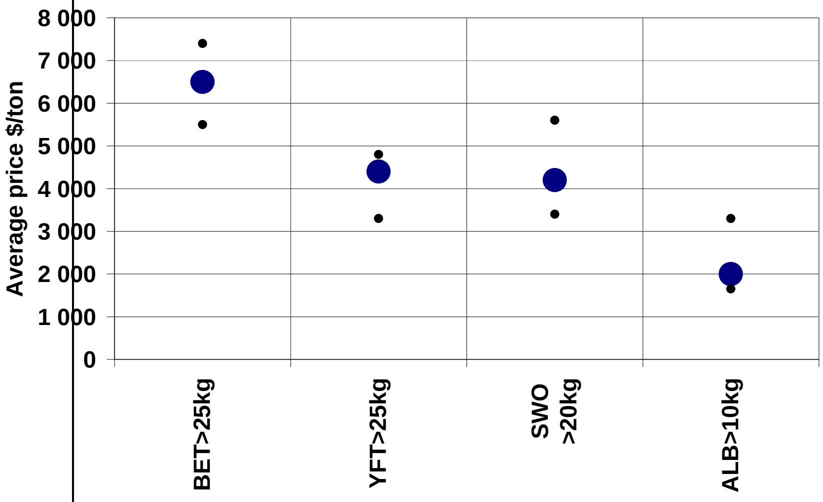


Figure 6. Nominal and standardised CPUE indices for the Taiwanese longline fishery for albacore in the Indian Ocean...

ADD price figure comparing albacore with other species



Executive summary of the status of the bigeye tuna resource

(As adopted by the IOTC Scientific Committee on 9 November 2007)

Marked changes are factual changes related mainly to the inclusion of the latest fisheries statistics. A preliminary stock assessment was undertaken in 2008 and relevant sections have been updated using the text from the 2008 WPTT report and other related sources. All changes are suggestions only for the consideration of the SC in Dec08

BIOLOGY

Bigeye tuna *(Thunnus obesus)* inhabit the tropical and subtropical waters of the Pacific, Atlantic and Indian Oceans in waters down to around 300 m. Juveniles frequently school at the surface underneath floating objects with yellowfin and skipjack tunas. Association with floating objects appears less common as bigeye grow older.

The tag recoveries from the RTTP-IO provide evidence of fast and large scale movements of juvenile bigeye in the Indian Ocean, thus supporting the current assumption of a single stock for the Indian Ocean. The new information on the apparent movements ~~spatial distribution~~ of tagged ~~fish~~ bigeye (September 2008) ~~compared with the spatial extent of the purse seine fishery~~ is presented in Figure 1. The average distance between bigeye tagging and recovery positions is presently estimated at 525 naut. miles, an information dealing only for the juvenile bigeye presently recovered. The range of the stock (as indicated by the distribution of catches) includes tropical areas, where reproduction occurs, and temperate waters which are believed to be feeding grounds. Of the three tropical tuna species, bigeye tuna lives the longest (probably more than 15 years) and that makes it the species most vulnerable, in relative terms, to over-exploitation. Bigeye have been reported to grow to 200 cm (fork length) long and over 200 kg and start reproducing when they are approximately three years old, at a length of about 100 cm.

The ~~Preliminary~~ analyses ~~using the~~of tagging/recovery data of the RTTP-IO widely support the hypothesis of a ~~two~~multi-stanza growth pattern for bigeye tuna, with slow growing juveniles~~, an assumption that has not been considered so far in stock assessments~~. This pattern is similar to the multistanza growth pattern now estimated for yellowfin. This growth curve will need to be modelled in order to be introduced in future stock assessment models.

THE FISHERIES

Bigeye tuna is mainly caught by industrial fisheries and appears only occasionally in the catches of artisanal fisheries. Total annual catches have increased steadily since the start of the fishery, reaching the 100,000 t level in 1993 and peaking at 150,000 t in 1999. Total annual catches averaged 121,700 t over the period 2003 to 2007. Bigeye tunas have been caught by industrial longline fleets since the early 1950's, but before 1970 they only represented an incidental catch. After 1970, the introduction of fishing practices that improved the access to the bigeye resource and the emergence of a sashimi market made bigeye tuna a target species for the main industrial longline fleets. Total catch of bigeye by longliners in the Indian Ocean increased steadily from the 1950's to reaching 100,000 t in 1993 and around 140,000–150,000 t for a short period from 1997-1999. (Figure 2). The average annual catch by longliners for the period from 2003 to 2007 was 96,200t. Taiwan,China is the major longline fleet fishing for bigeye and it currently takes just under 50% of the total catch (Table 1). Large bigeye tuna (averaging just above 40 kg) are primarily caught by longlines, and in particular deep longliners (Figure 4). Since the early 1990’s, bigeye tuna has been caught by purse seine vessels fishing on tunas aggregated on floating objects. Total catch of bigeye by purse seiners in the Indian Ocean reached 40,700 t in 1999, but the average annual catch for the period from 2003 to 2007 was 23,900 t (Table 1). Forty to sixty boats have operated in this fishery since 1984. Purse seiners mainly take small juvenile bigeye (averaging around 5 kg) whereas longliners much larger and heavier fish (Figures 4, 5 and 6~~); ~~), and while purse seiners take much lower tonnages of bigeye compared to longliners (Figure 2), they take larger numbers of individual fish (Figure 7).

By contrast with yellowfin and skipjack tunas, for which the major catches take place in the western Indian Ocean, bigeye tuna is also exploited in the eastern Indian Ocean (Figures 2 and 3). The relative increase in catches in the eastern Indian Ocean in the late 1990’s was mostly due to increased activity of small longliners fishing for fresh tuna. This fleet started operating around 1985. In the western Indian Ocean, the catches of bigeye are mostly the result of the activity of large longliners and purse seiners.

Availability of information for assessment purposes

The reliability of the total catches has continued to improve over the past years, although still up to 25% of the catch has to be estimated. The fact that most of the catch of bigeye tuna comes from industrial fisheries has facilitated the estimation of total catches. Catch and effort data, potentially useful to construct indices of abundance, is also considered to be of good overall quality. Size-frequency information is considered to be relatively good for most of the purse-seine fisheries, but insufficient for the longline fisheries. This is due primarily to a lack of reporting from the Korean fleets in the 1970's, lack of reporting from Taiwanese fleets since 1989 and insufficient sample sizes in recent years in the Japanese fishery.

Various ~~Information~~ information on biological parameters have been recently obtained from the tagging programme and they have already widely ~~is scarce and~~ improve~~ments~~d our knowledge concerning the bigeye growth and movement patterns. The recovery data that are already available will also soon allow to directly estimate the natural mortality of juvenile bigeye~~ are needed in particular concerning natural mortality. The ongoing large-scale tagging programme is expected to improve knowledge on a range of biological characteristics. A new growth curve was presented in 2003 which was considered to be an important improvement over previously existing information~~. These improved data will be of major importance to improve the use of analytical models that are using indirectly or directly these information (such as ASPM or MF-CL).

In the case of the purse-seine fishery, it was not possible to derive indices of abundance from catch-and-effort information, because the interpretation of nominal fishing effort was complicated by the use of FADs and increases in fishing efficiency that were difficult to quantify. In the case of the longline fisheries, indices of abundance were derived, although there still remain uncertainties whether they fully take into account targeting practices on different species (Figure 8).

The Japanese longline standardised CPUE (1960 to 2004) for the Indian Ocean tropical waters is currently used to derive the index of bigeye abundance. In 2006, sea surface temperature and gear characteristics were included in the GLM standardisation procedure. This index generally declined from 1960 until 2002, with the exception of higher values in 1977 and 1978. Abundance values in 2003 and 2004 were higher than the lowest historical value in 2002 (Figure 8). A similar analysis of the Taiwanese CPUE series was also presented in 2006. After standardisation, this index shows a variable but generally decreasing trend, similar to that of the Japanese fleet (Figure 8). This is in contrast with previous years, when significant differences could be observed between both indices; and appears to be the result of an increase in the information input into the analysis by Taiwanese researchers. Given that the standardisation procedure of the Taiwanese index is still work in progress, the WPTT decided to apply the Japanese index in the recent stock assessment runs, while recognizing and encouraging the significant improvements achieved in the generation of an index of abundance for the Taiwanese fleet.

Catch at size and catch at age data were updated in 2006. Given that a catch-at-size matrix is an integral part of both length and age based assessment methods, the WPTT expressed their ongoing concerns about the low levels of size sampling being collected in the Indian Ocean. Notwithstanding these concerns the WPTT was encouraged by the potential of the information being obtained from the RTTP-IO in the belief that this programme is going to be important alternative source of size data in the very near future.

Stock assessment

In 2006, five stock assessment models were applied to the Indian Ocean bigeye tuna stock using an agreed list of input parameters. Ten year projections were also carried out for a range of scenarios.

Results

From the range of MSY estimates, the SC chose the value of 111,200 t. This was the MSY estimated by the ASPM and it was reported ahead of the estimates from the other methods because ASPM results have been reported in previous executive summaries; and the WPTT noted that several of the other assessment approaches used in 2006 needed further exploration and development. Given that the mean annual catch for the period 2003-2007 was 121,700 t and the preliminary catch estimate for 2007 is 117,900 t, it appears that the stock is being exploited at around its maximum level. Results from the ASPIC analysis plotting the annual catches as a function of fishing mortality illustrate the MSY and its uncertainty (Figure 9).

Despite the broad agreement of the models in estimating MSY, they produced quite different estimates of absolute levels of virgin and current biomass, and thus in the ratios of current levels of F and SSB to MSY. This was probably due to how the variations in CPUE were interpreted by each model. While acknowledging the value of assessing the status of bigeye from a wide range of modelling perspectives, the WPTT recommended that the results of the ASPM (Table 2) would be used in the Bigeye Executive Summary in 2006.

The ASPM results indicate that the 2005 catch is close to the MSY. Furthermore, spawning stock biomass appears to be above the level that would produce MSY, and the fishing mortality in 2004 appears to below the MSY level.

Biomass trajectories indicate that the spawning stock biomass is currently just above the MSY level, but it has been declining since the late 1970's (Figure 10). Similarly, the current fishing mortality is estimated be to just above the MSY level, but fishing mortality has been increasing steadily since the 1980's (Figure 11).

Ten year projections were carried out using the following scenarios:

- constant catch at 2004 levels
- with a 10% reduction in 2004 catch levels
- constant F at 2004 levels, at 2000-02 levels and at 1998-01 levels

If 2004 catch levels were to continue, SSB is predicted to decline gradually over the next 10 years (Figure 12). At a constant catch equivalent to 10 % below the 2004 catch level, the rate of decline in SSB is less severe.

Three different fishing mortality at age scenarios were selected as they reflected different patterns of exploitation for juvenile and adult bigeye. In the period 1998-2000, the fishing pressure on juveniles was higher than it was during the period 2000-2002. The 2004 scenario reflects a fishery in which there was relatively lower pressure on juveniles compared to the other time periods. Scenarios based on F levels were presented, and the results indicate that the three levels considered (2004, 2000-02 and 1998-2001) would not have a strong effect in the trajectories of future SSB, as the differences are relatively minor given the current level of uncertainty (Figure 13).

The effects of the three scenarios of fishing mortality were also considered in terms of yield per recruit. A multi-fleet YPR analysis indicated that an exploitation pattern such as the one observed in 2004 would have a positive impact on the yield per recruit obtained, when compared to the 2000-02 and 1998-01 fishing mortalities by fleet. A slightly higher yield per recruit resulted from a pattern of exploitation in which there was lower pressure on juveniles. Yield per recruit increased from 1.98 kg for the 1998-2001 pattern of exploitation, to 2.06 kg for the 2000-02 pattern, up to 2.22 kg if the 2004 pattern of exploitation were to be retained.

Despite the progress made in the 2006 assessments, uncertainties in the results and projections still exist. These uncertainties relate to:

- Uncertainties concerning the available indices of abundance.
- How well the model structures used in the assessments approximate the true dynamics of the population, and about the quality of the estimation of some of the model key parameters.
- Insufficient size information for the catches of longline fisheries, especially in recent years.
- Uncertainties associated with estimating catch-at-size and catch-at-age.
- Uncertainty about the natural mortality at various life stages, including uncertainty about the functional form of its dependency with age.
- Uncertainty about the changes in catchability of the different fisheries involved, especially in the purse-seine fishery. Future consideration of an increase in efficiency could result in a more pessimistic appraisal of the stock status. For example, it is possible that the fishing mortality that would result in the MSY has already been exceeded.

Notes about exploitation patterns

The exploitation patterns observed in 2003 and 2004 could be considered anomalous, and heavily influenced by the high abundances of yellowfin tuna, which concentrated the activity of the surface fleets. The decrease in the fishing pressure on bigeye currently observed is likely to be temporal, as the fleets appear to have come back in the second half of 2005 to their previous pattern of activity.

Two other factors could also influence the short term evolution of the fishery. Rising fuel costs appear to be having an effect on the operating procedures of the surface fleets. Distances travelled at night, and consequently the number of FADs visited, are being reduced to save on fuel costs. The effect of this change could be however reduced by the increasing use of supply vessels, tasked with visiting FADs and informing purse seiners of the abundance of fish around them. The second factor is the limitation on the activity of all fishing fleets on the coast and EEZ of Somalia, due to the increase in the activity of pirates in the area. Some purse seine fleets have receive indications from their governments not to venture into those waters. An important fishery on FADs has traditionally taken place in this area on the last quarter of the year, with significant catches of juvenile bigeye. Because of piracy acts off Somalia, the fishery has shifted into the South of the Arabian Sea where much lesser proportion of bigeye is taken on FADs.

Another factor to consider when analysing the possible futures trends in SSB is the increasing trend in effective fishing power observed in the fleets involved in this purse seine fishery on FADs.

In 2008 a simple surplus production model was applied to Japanese longline CPUE and total catch biomass data. Parametric boot-strap approaches were used to explore the uncertainty in the key parameters. Monte Carlo distributions for key parameters (M, age at maturity and steepness) were defined then used to estimate r the intrinsic rate of increase parameter for the surplus production model.

This was considered to be a preliminary analysis; however, the results indicated that the probability of B2007 being greater than B_{MSY} was 0.863 and exploitation rates for ages 0-2 years appear to be below MSY levels. Notwithstanding these results, given the limited nature of the work carried out on bigeye in 2008, no new advice was provided for the stock.

MANAGEMENT ADVICE

The results of the stock assessments conducted in 2006 were broadly similar and, in general, were more optimistic than previous ones. The ASPM results indicate that the 2005 catch is close to the MSY. Furthermore, spawning stock biomass seems to be above the level that would produce MSY, and the fishing mortality in 2004 seems to below the MSY level. Current (2004) catches of juveniles bigeye by the surface fleets are also less detrimental in terms of yield-per-recruit that previous patterns.

However, the current outlook could revert to a more pessimistic one, if the exploitation pattern is to return to the pre-2003 levels, as expected. Changes in the fishery occurred in 2003 and 2004, but these were due to the exceptional catches of yellowfin, which seem to be the result of anomalous conditions. In 2005, the fishery is already showing a return to the previous pattern of exploitation, which is likely to increase the catches of bigeye tuna associated with floating objects.

If the level in catch in numbers of juvenile bigeye tuna by purse seiners fishing on floating objects returns to pre-2003 levels, this is likely to be detrimental to the stock, as fish of these sizes are below the optimum size for maximum yield-per-recruit.

The Scientific Committee also noted that juvenile bigeye tuna are caught in the FAD purse-seine fishery that targets primarily skipjack tuna. Some measures to reduce the catches of bigeye tuna in this fishery could be expected to result in a decrease in the catches of skipjack tuna.

In view of the most current assessment, the SC recommended that catches should not exceed the MSY and fishing effort should not increase further from the 2004 levels.

BIGEYE TUNA SUMMARY

Maximum Sustainable Yield:	111,200 t (95,000 – 128,000)
Preliminary catch in 2007	117,900 t

(data as of October 2008)	
Catch in 2006	112,100 t
Mean catch over the last 5 years (2003-2007)	121,700 t
Current Replacement Yield	-
Relative Biomass (SSB_{2004}/SSB_{MSY})	1.34 (1.04 – 1.64)
Relative Fishing Mortality (F_{2004}/F_{MSY})	0.81 (0.54 – 1.08)
90% Confidence intervals provided in brackets	

Note: This Executive Summary has been updated to take account of recent catch data. The management advice, and stock assessment results are based on data up to 2004.

***Table 1**. Best scientific estimates of the catches of bigeye tuna (as adopted by the IOTC Scientific Committee) by gear and main fleets for the period 1958-2007 (in thousands of tonnes).*

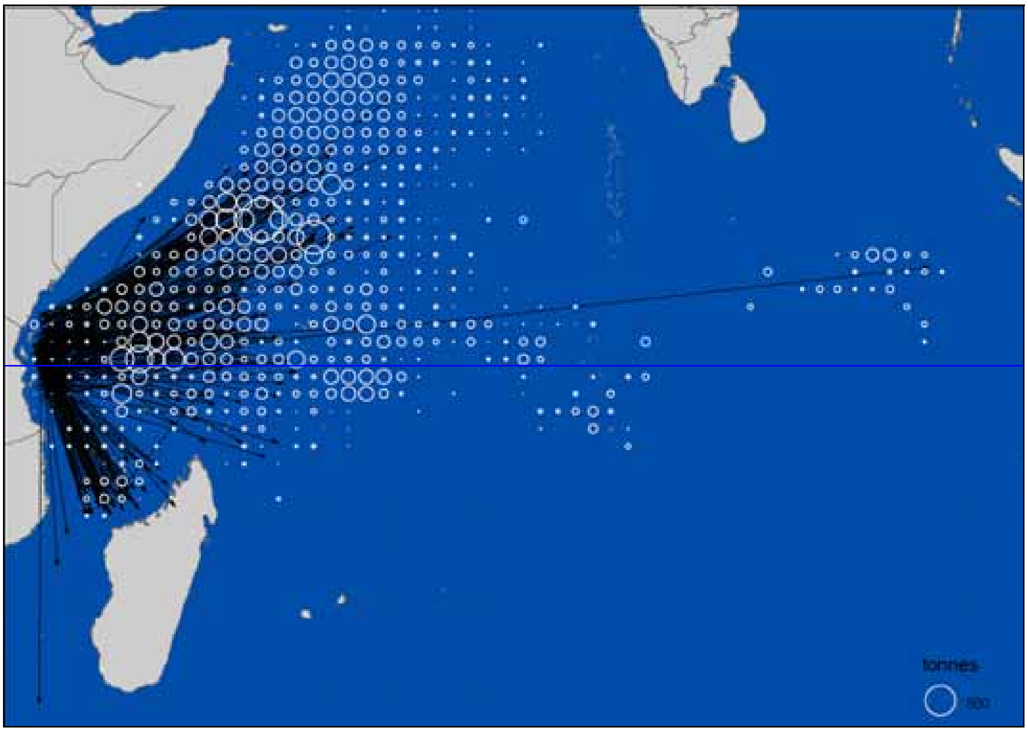
Data as of October 2008

Gear	Fleet	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84
Purse seine	Spain																											0.8
	France																								0.0	0.0	0.2	2.3
	NEI-Other																										0.0	0.5
	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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.5
	Total																					*0.0*	*0.0*	*0.0*	*0.0*	*0.1*	*0.6*	*4.0*
Longline	China																											
	Taiwan,China	1.5	1.5	1.3	1.9	1.2	1.7	1.8	1.4	2.2	2.3	7.2	8.0	10.0	5.6	5.5	4.0	6.0	5.3	4.2	6.2	4.9	7.4	8.9	6.8	11.3	11.3	10.9
	Japan	10.2	8.4	14.8	13.0	17.3	11.6	16.0	17.6	21.4	21.8	23.6	14.4	12.7	11.2	8.3	5.2	6.9	5.5	2.1	3.1	10.9	4.2	5.9	7.8	11.4	18.3	14.0
	Indonesia																0.0	0.2	0.4	0.3	0.3	0.4	0.4	0.5	0.5	0.8	1.9	2.4
	Seychelles																										0.0	0.1
	Korea, Republic of								0.2	0.2	0.6	6.8	7.6	3.5	4.9	4.9	7.3	14.7	26.2	21.8	26.1	34.1	21.5	19.3	19.4	19.5	17.4	11.8
	Other Fleets	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.4	0.1	1.9	0.5	1.6	1.3	1.2	1.0	0.6	0.2	0.1	0.2	0.2	0.0	0.2	0.3	0.3	0.5	0.6
	Total	*11.7*	*9.9*	*16.1*	*15.0*	*18.5*	*13.3*	*18.0*	*19.5*	*24.1*	*24.8*	*39.5*	*30.5*	*27.8*	*23.0*	*20.0*	*17.4*	*28.4*	*37.7*	*28.6*	*35.9*	*50.6*	*33.5*	*34.9*	*34.8*	*43.4*	*49.5*	*39.7*
Other gears	*Total*	*0.1*	*0.1*	*0.0*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.0*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.2*	*0.1*	*0.1*	*0.1*	*0.2*	*0.1*	*0.2*	*0.4*
All	*Total*	*11.7*	*9.9*	*16.1*	*15.0*	*18.5*	*13.4*	*18.1*	*19.6*	*24.2*	*24.8*	*39.6*	*30.5*	*27.9*	*23.0*	*20.1*	*17.6*	*28.5*	*37.8*	*28.7*	*36.1*	*50.7*	*33.6*	*35.0*	*35.1*	*43.6*	*50.3*	*44.1*

Gear	Fleet	Av03/07	Av58/07	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07
Purse seine	Spain	9.4	3.8	1.3	1.8	5.0	6.8	5.9	4.9	6.0	3.6	5.4	5.9	12.2	11.4	15.9	11.2	16.0	11.3	7.8	10.9	8.5	8.6	10.3	10.0	9.8
	France	5.8	2.8	4.3	7.1	7.0	6.2	3.6	4.6	5.4	3.8	5.0	5.4	7.3	6.9	7.8	6.4	8.5	6.7	5.5	7.3	5.3	5.8	6.5	5.3	6.1
	Seychelles	4.0	0.7							0.0	0.0					0.9	2.0	3.0	1.8	2.8	3.7	3.4	4.4	4.8	3.5	3.9
	Thailand	1.5	0.2																0.2	0.1				1.6	4.0	1.7
	NEI-Ex-Soviet Union	1.3	0.5						0.0		0.4	1.0	0.3	1.3	1.1	1.2	1.9	3.9	2.9	2.6	0.7	2.4	2.2	1.4	0.7	
	NEI-Other	1.0	1.1	0.6	1.0	0.8	0.8	0.5	1.0	1.5	0.9	1.9	2.5	3.4	3.4	6.2	5.2	7.5	6.0	3.1	4.1	2.4	0.9	0.6	0.6	0.5
	Other Fleets	0.9	0.8	0.9	0.7	0.7	1.3	2.0	2.2	2.6	2.5	2.6	4.8	4.2	1.7	2.0	1.6	1.7	1.1	1.8	2.4	0.8	0.5	0.8	0.7	1.8
	Total	*23.9*	*9.9*	*7.2*	*10.6*	*13.4*	*15.1*	*12.0*	*12.7*	*15.6*	*11.3*	*16.0*	*18.9*	*28.4*	*24.5*	*34.0*	*28.3*	*40.7*	*29.9*	*23.7*	*29.0*	*22.8*	*22.4*	*26.1*	*24.7*	*23.7*
Longline	China	7.5	1.1											0.2	0.6	1.7	2.3	2.4	2.8	3.1	2.8	4.6	8.3	8.9	8.7	7.2
	Taiwan,China	45.8	18.0	12.2	16.8	17.6	19.4	19.9	20.8	29.0	24.0	39.7	27.8	32.7	29.8	34.1	39.7	37.1	36.4	42.1	50.2	60.0	56.9	40.2	35.8	36.1
	Japan	13.3	12.5	17.2	15.8	15.5	12.3	7.7	8.2	7.8	5.6	8.3	17.5	17.2	16.5	18.8	17.1	14.0	13.6	13.0	13.9	10.0	10.6	12.5	14.0	19.2
	Indonesia	9.1	5.8	2.4	0.7	2.4	3.2	4.5	4.5	4.5	7.6	7.9	10.8	12.2	23.2	27.9	26.1	30.5	20.9	21.1	26.3	11.8	10.3	8.8	7.2	7.2
	Seychelles	5.3	0.6	0.1									0.0	0.0	0.1	0.0	0.1	0.1	0.5	1.0	2.2	3.7	7.0	6.1	4.1	5.6
	NEI-Deep-freezing	4.4	3.2	0.1	1.1	0.9	2.9	2.8	4.4	5.5	3.8	10.7	8.1	9.7	13.0	10.8	16.7	16.7	14.0	8.3	8.3	5.6	6.5	4.5	2.5	2.9
	NEI-Fresh Tuna	3.7	1.3					1.9	2.6	2.3	2.6	2.9	4.6	3.8	4.3	5.3	4.7	4.8	4.6	0.6	2.0	2.6	3.4	3.6	4.5	4.5
	Korea, Republic of	2.5	8.4	12.8	11.9	14.4	17.1	12.2	10.7	2.3	4.8	5.3	8.8	6.6	11.7	11.1	3.6	1.5	3.6	1.6	0.2	1.2	2.5	2.7	3.1	3.1
	Philippines	1.5	0.3														1.4	1.0	1.3	0.9	0.8	1.4	0.9	1.5	1.8	2.1
	NEI-Indonesia Fresh	0.0	1.5		0.1		2.0	7.5	9.2	9.4	11.4	9.2	11.9	6.5	2.7	2.9	0.2	0.0								
	Other Fleets	3.0	0.7	0.0	0.3	0.3	0.2	0.0	0.0	0.0	0.3	0.5	0.2	0.1	0.2	0.2	0.4	0.9	0.9	2.7	2.5	2.2	2.5	2.9	3.2	3.9
	Total	*96.2*	*53.3*	*44.9*	*46.6*	*51.2*	*57.0*	*56.6*	*60.4*	*60.8*	*60.1*	*84.5*	*89.7*	*88.9*	*101.9*	*112.9*	*112.3*	*109.0*	*98.6*	*94.3*	*109.2*	*103.1*	*109.0*	*91.7*	*85.0*	*91.9*
Other gears	*Total*	*1.7*	*0.5*	*0.3*	*0.2*	*0.4*	*2.2*	*0.7*	*0.7*	*0.7*	*0.5*	*0.6*	*0.7*	*1.2*	*0.9*	*0.9*	*0.9*	*1.2*	*0.6*	*1.1*	*1.2*	*1.3*	*1.2*	*1.2*	*2.4*	*2.2*
All	*Total*	*121.7*	*63.7*	*52.4*	*57.5*	*65.0*	*74.3*	*69.3*	*73.8*	*77.1*	*71.9*	*101.1*	*109.3*	*118.5*	*127.4*	*147.7*	*141.6*	*150.8*	*129.1*	*119.1*	*139.4*	*127.2*	*132.6*	*118.9*	*112.1*	*117.9*

Table 2. *2006 bigeye tuna stock assessment. Summary of results obtained by the ASPM stock assessment methods. B = Total biomass, SSB = spawning stock biomass. Brackets contain 90 % CI's.*

	ASPM Results
B_0	1,380,000 t
B_{2004}	720,000 t
B_{MSY}	
Ratio B_{2004} / B_0	0.52 (0.43-0.61)
Ratio B_{2004} / B_{MSY}	
SSB_0	1,150,000 t
SSB_{2004}	430,000 t
SSB_{MSY}	350,000 t
Ratio SSB_{2004} / SSB_{MSY}	1.34 (1.04-1.64)
Ratio SSB_{2004} / SSB_0	0.39 (0.31-0.47)
MSY	111,195 t (94,738-127,652)
C_{2004}	126,518 t
F_{2004}	0.29
F_{MSY}	0.30
Ratio F_{2004} / F_{MSY}	0.81 (0.54-1.08)



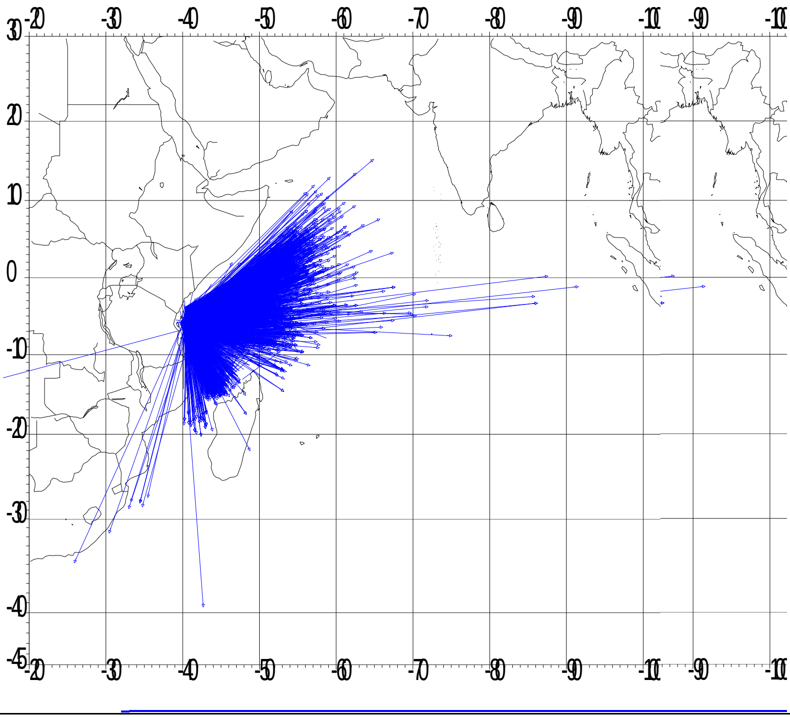


Figure 1. *Tag recapture trajectories for bigeye tuna tagged in the south west Indian Ocean by the RTTP-IO ~~and location of purse seine fishing in 2006. The reference circle represents 500 t~~.*

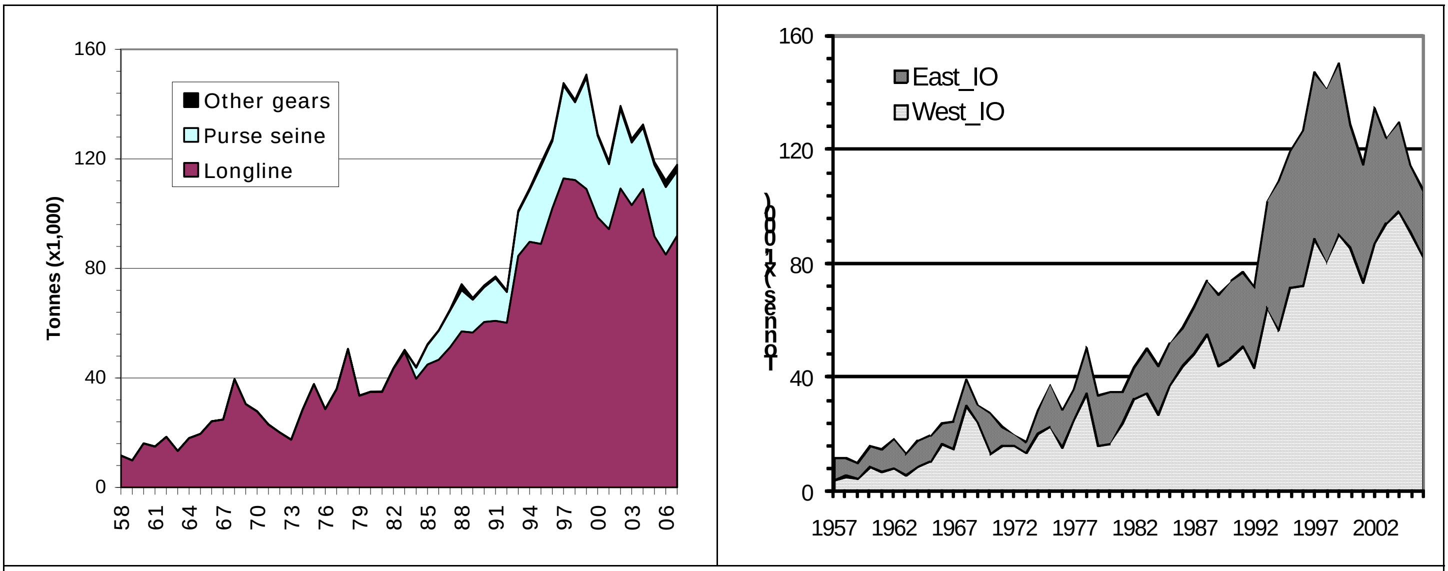


Figure 2. *Yearly catches (thousand of metric tonnes) of bigeye tuna by gear from 1958 to 2007 (left) and by area (Eastern and Western Indian Ocean, right (not updated)).* *Data as of October 2008*

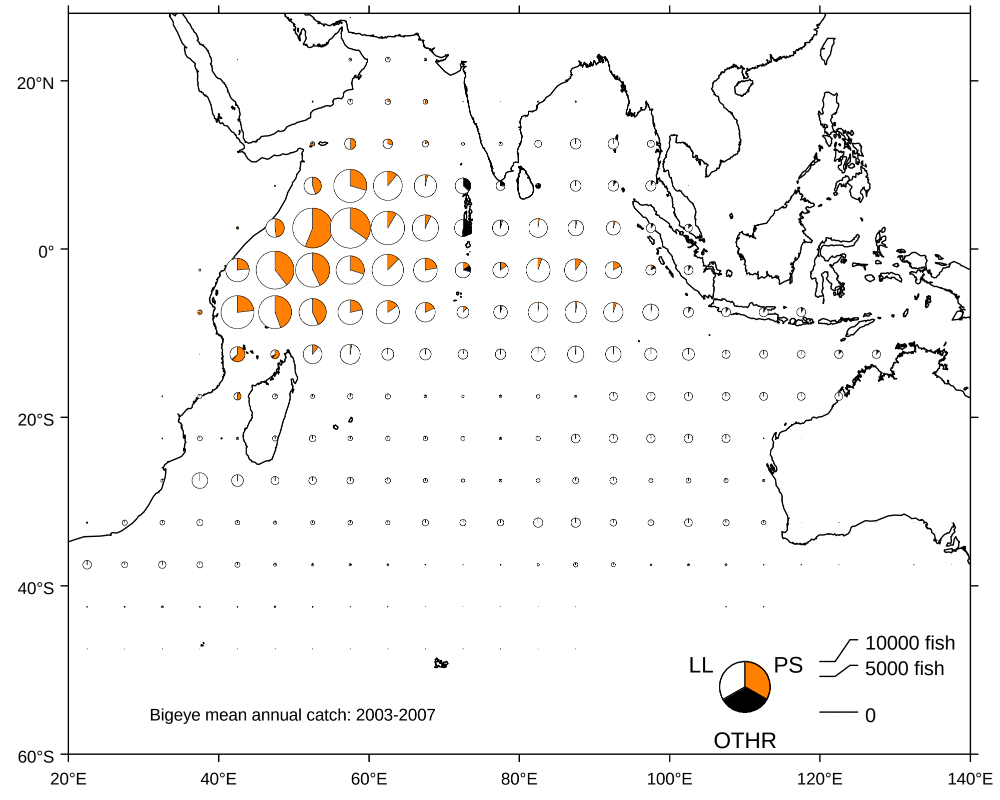


Figure 3. *Mean of annual total catches of bigeye tuna (t) by longline and purse seine vessels operating in the Indian Ocean over the period 2003 to 2007.* *Data as of October 2008*

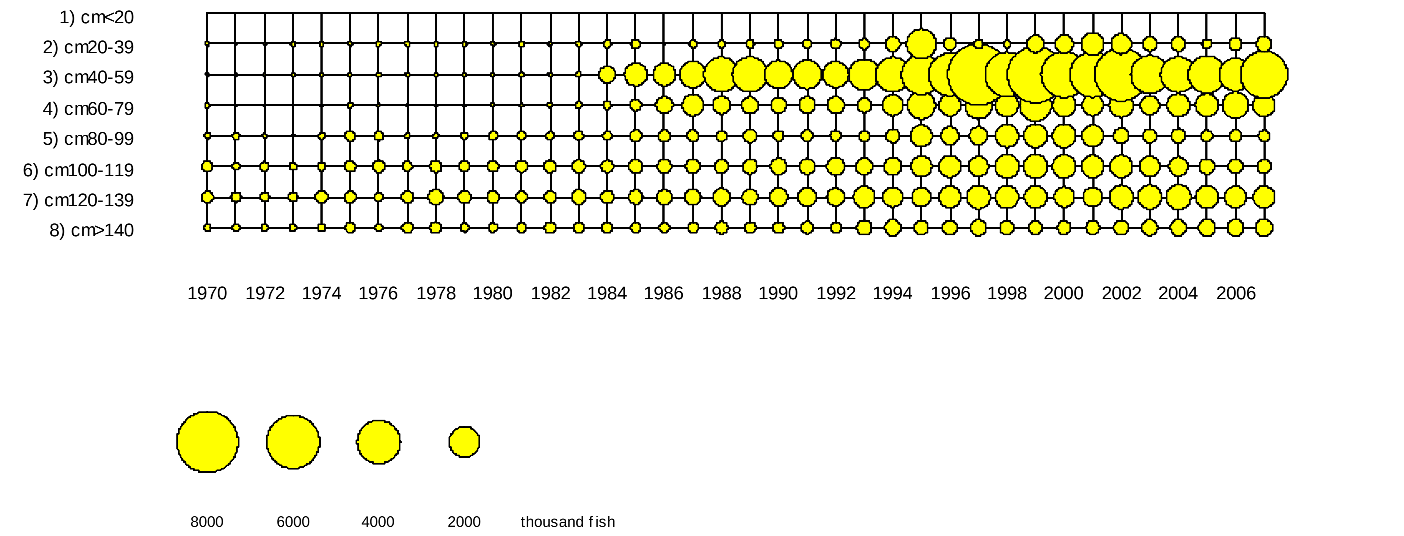


Figure 4. *Mean catch at size of bigeye in purse seine, longline and other gear catches over the period 1970-2007*

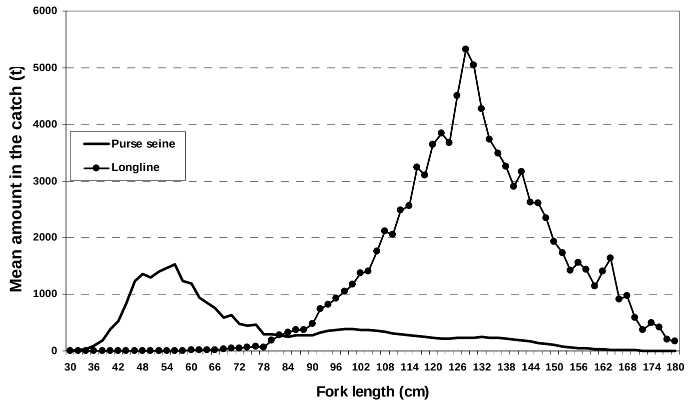


Figure 5. *Mean catch at size (weight) of bigeye measured from purse seine and longline catches from 1996-2005(to be updated).*

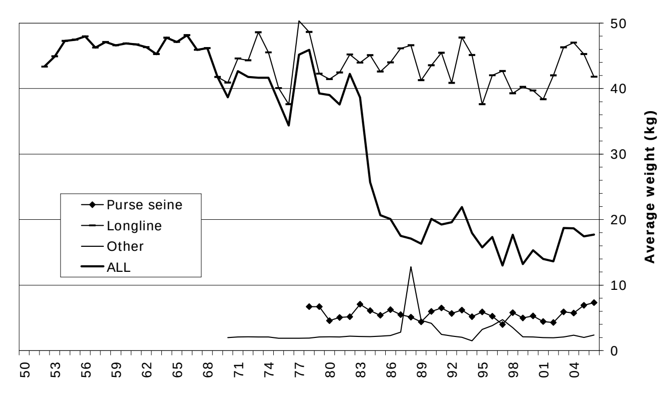


Figure 6. *Mean weight of bigeye measured from purse seine (PS) and longline (LL) catches over time. Data as of July 2007(to be updated)*

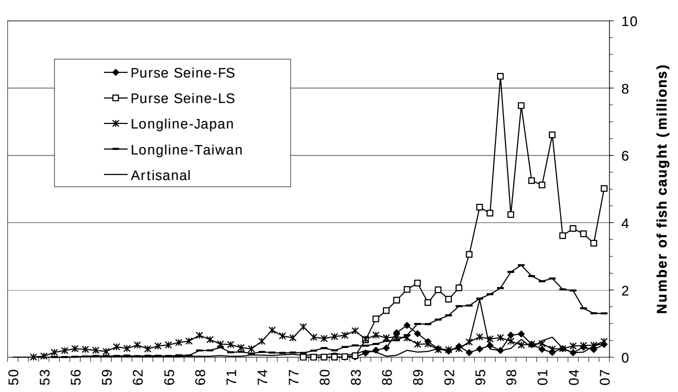


Figure 7. *Catch in numbers of bigeye tuna by gear (PS: purse seine; LL: longline and other gears). Data as of October 2008*

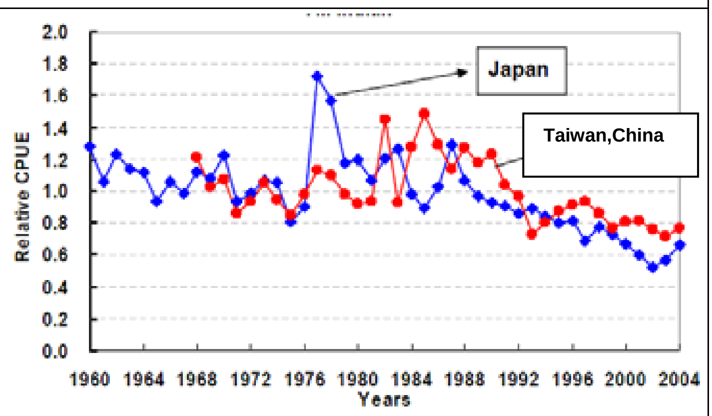


Figure 8. *Standardised CPUE indices for the Japanese and Taiwanese longline fleets in the Indian Ocean tropical waters*

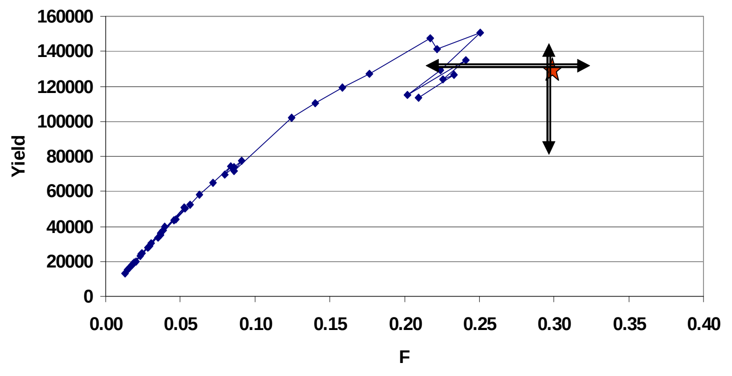


Figure 9. *2006 bigeye tuna stock assessment: Plot of annual bigeye tuna catches as a function of mean fishing mortality derived from the ASPIC model. The star represents MSY and the arrowed lines represent the associated uncertainty (source A. Fonteneau).*

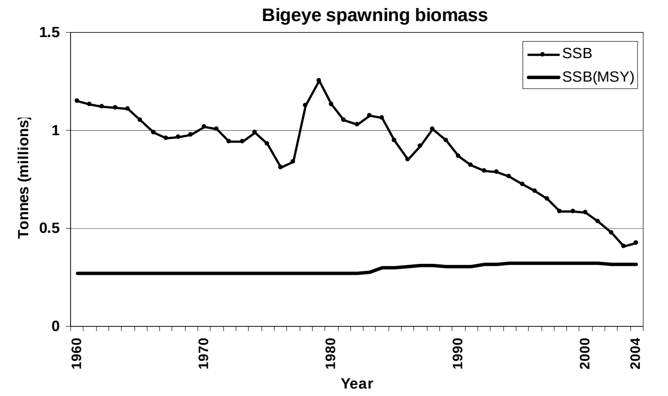


Figure 10. *2006 bigeye tuna stock assessment (ASPM): Spawning stock trajectories relating estimates of annual spawning stock size and the estimated maximum sustainable yield of the spawning stock biomass.*

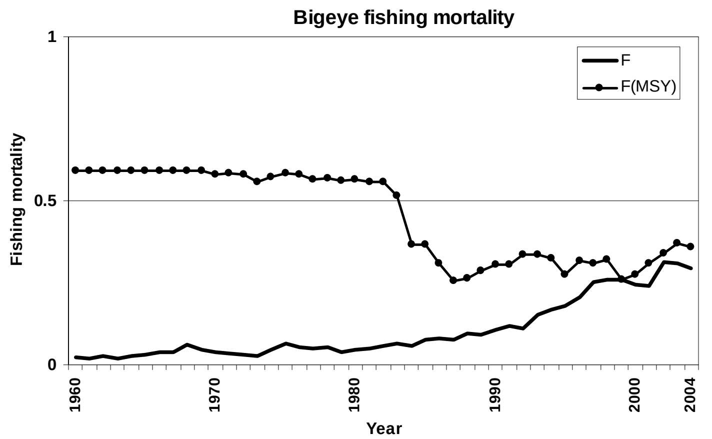


Figure 11. *2006 bigeye tuna stock assessment (ASPM): Fishing mortality trajectories relating estimates of annual fishing mortality and the estimated maximum sustainable level of fishing mortality.*

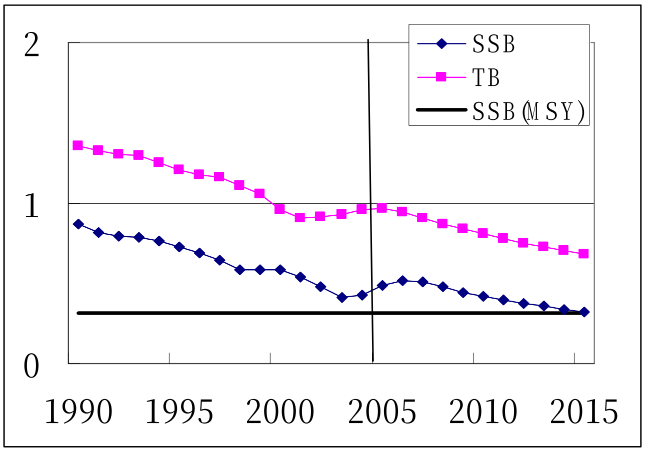
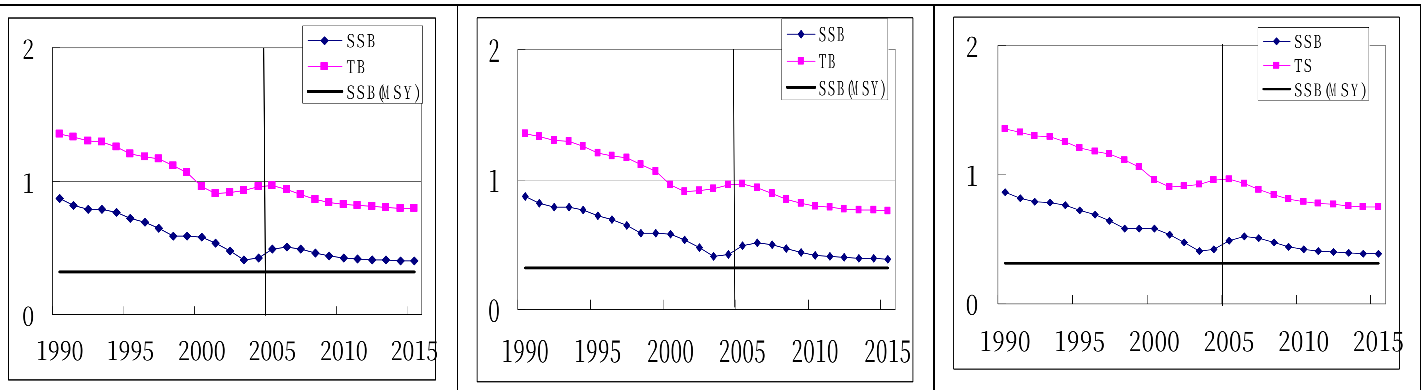


Figure 12. *2006 bigeye tuna stock assessment: Forward projections from the ASPM model illustrating trends in total biomass and spawning biomass for bigeye tuna in the Indian Ocean if catches were maintained at the 2004 level.*



(a) F (2004) = 0.293	(b) F (2000-2002) = 0.265	(c) F (1998-2001) = 0.251

Figure 13. *2006 bigeye tuna stock assessment: Forward projections from the ASPM model illustrating trends in total biomass and spawning biomass for bigeye tuna in the Indian Ocean at various levels of fishing mortality (a) F in 2004 (b) F between 2000-02 (c) F between 1998 and 2001.*

Executive summary of the status of the skipjack tuna resource

(As adopted by the IOTC Scientific Committee on 9 November 2007)

BIOLOGY

Skipjack tuna (*Katsuwonus pelamis*) is a cosmopolitan species found in the tropical and subtropical waters of the three oceans. It generally forms large schools, often in association with other tunas of similar size such as juveniles of yellowfin and bigeye.

Skipjack exhibits characteristics that result in a higher productivity when compared to other tuna species. ~~Preliminary t~~Tagging recoveries of the RTTP-IO show that skipjack is exploited for at least 4 to 5 years in the Indian ocean. This species has a high fecundity, and spawns opportunistically throughout the year in the whole inter-equatorial Indian Ocean (north of 20°S, with surface temperature greater than 24°C) when conditions are favourable. The size at first maturity is about 41-43 cm for both males and females (and as such most of the skipjack taken by the fisheries are fish that have already reproduced).

~~Little is known about t~~The growth of skipjack has now been fully estimated, based on the recently available recovery data, and the meeting of the WP on tagging data analysis. These results are consistent with the results obtained in the mid nineties by the IPTP tagging programme in Maldives.~~,~~ Skipjack recoveries are also already showing that the species is h~~y~~ighly mobile, and covering great distances at sustained speed. The average distance between skipjack tagging and recovery positions is presently estimated at 640 naut. miles~~and no new information or document on biology were presented at the working party. It is still a priority to gain more knowledge on the skipjack time-and-space variability in growth patterns~~.

The tag recoveries from the RTTP-IO provide evidence of rapid, large scale movements of skipjack tuna in the Indian Ocean, thus supporting the current assumption of a single stock for the Indian Ocean. The new information on the spatial distribution of tagged fish compared with the spatial extent of the purse seine fishery is presented in Figures 1 and 2.

Because of the above characteristics, skipjack tuna stocks are considered to be resilient and not prone to overfishing.

FISHERIES

Catches of skipjack increased slowly from the 1950s, reaching around 50,000 t at the end of the 1970s, mainly due to the activities of baitboats (or pole and line) and gillnets. The catches increased rapidly with the arrival of the purse seiners in the early 1980s, and skipjack became one of the most important tuna species in the Indian Ocean. Annual total catches exceeded 400,000 t in the late 1990's and the average annual catch for the period from 2003 to 2007 was 509,000 t (Figure 3 and Table 1). Preliminary data indicate that catches in 2007 may have been the lowest reported since 2002 447,100 t).

It should be noted that an important amount of the skipjack catch (an average of 75,000 t since 2000) is estimated from data (mainly from some artisanal fisheries) which do not identify the species in the catch. Figure 4 illustrates the evolution of the importance of the catch which has to be disaggregated.

In recent years, the proportions of the catch taken by the industrial purse seine fishery and the various artisanal fisheries (baitboat, gillnets and others) have been fairly consistent, the majority of the catch originating from the western Indian Ocean (Figure 3). In general, there is low inter-annual variability in the catches taken in the Indian Ocean compared to those taken in other oceans.

The increase of skipjack catches by purse seiners is due to the development of a fishery in association with Fish Aggregating Devices (FADs). Currently, 80 % of the skipjack tuna caught by purse-seine is taken under FADs. Catch rates by purse seiners show an increasing trend in two of the three main fishing areas (Figure 5) possibly due to an increase in fishing power and to an increase in the number of FADs (and the technology associated with them) in the fishery.

The Maldivian fishery has effectively increased its fishing effort with the mechanisation of its pole and line fishery since 1974, and the use of anchored FADs since 1981. Skipjack represents some 75 % of its total catch, and catch rates have regularly increased since the beginning of the 1980s (Figure 6).

Little information is available on the gillnet fisheries (mainly from Sri Lanka, Iran, Pakistan, India and Indonesia). However, it is estimated that the gillnet fisheries take around 30 to 40 % of the total catch of skipjack.

The average weight of skipjack caught in the Indian Ocean is 2.8 kg for purse-seine (2000-2005 average), 3.0 kg for the Maldivian baitboats and 4-5 kg for the gillnet (Figure 7). For all fisheries combined, it fluctuates between 3.0-3.5 kg; this is larger than in the Atlantic, but smaller than in the Pacific.

Declines of catch rates in 2007 have appeared in both the industrial purse seine fishery and Maldives artisanal fishery. While the activities of pirates from Somalia have meant that vessels have been avoiding traditional skipjack fishing grounds where catch rates were high, it appears that the decline of catches in the Maldives fishery could be due to environmental causes such as anomalously high sea surface temperatures. The marked increase of the fuel price has also substantially reduced the fishing operations in the Maldivian fishery.

AVAILABILITY OF INFORMATION FOR STOCK ASSESSMENT

In 2008, a review of skipjack was undertaken including a range of stock status indicators and an examination of exploitation rates from external analyses of the tagging data. ~~During its last assessment in 2003, the WPTT analyzed the information available and considered that the uncertainties in the information were too large to conduct a complete assessment of the Indian Ocean skipjack tuna.~~

Fishery indicators

As an alternative, the WPTT decided to analyse various fishery indicators to gain a general understanding of the state of the stock. Several of these indicators were updated in 2008~~6~~.

1. **Trends in catches**: The trend in catches indicate a large and continuous increase in the catches of skipjack tuna since the mid-1980's (Figure 3). This is mainly due to the expansion of the FAD-associated fishery in the western Indian Ocean. There is no sign that the rate of increase in the catches of skipjack is diminishing.
2. **Nominal CPUE Trends:** Figure 5 shows the catch and nominal CPUE trends of the purse seine fishery for three major skipjack fishing areas: East-Somalia, North-West Seychelles and Mozambique Channel. In the Somalia and North-West Seychelles areas, catches have been variable but generally increasing. In each of these areas, despite some inter annual variation, the current nominal CPUE's are around the same as those of the early 1990's. Since this is a period during which it is believed that effective purse-seine effort has increased substantially (increase of efficiency), it is likely that the true abundance in these areas has decreased. In itself, this is not unexpected given the large increase in catches over that period. However, as these areas may be source of skipjack recruitment to the Maldives artisanal fishery, there is a potential for interactions to occur between these fisheries.
3. **Average weight in the catch by fisheries:** The Working Party noted that the average weights of the skipjack taken from various areas and gears have remained relatively stable since 1991 (Figure 8). Figure 7 shows catches at size expressed as average weight from the major gears, purse seine, baitboat and gillnet and others, as well as the mean weight for the total catch. The purse seine and the baitboat fisheries take the greatest catch around 40-65 cm while catches taken from gillnet fisheries ranges from 70-80 cm.
4. **Number of 1 CWP squares visited or fished:** This indicator (Figure 9) reflects the spatial extension of a fishery. Trends observed in the number of CWP with effort or catch since 1991 suggest that the area

exploited by the purse-seine fishery has changed little since 1991, apart in 1998 when a particularly strong El Niño episode resulted in a much wider spatial distribution of the fishery.

Length-based analyses

The WPTT did not develop a formal stock assessment for skipjack tuna. However, a length-based cohort analysis was carried during ~~the~~ a previous meeting to analyze skipjack catches and length frequencies (Figure 10). In the 1980's, there was a marked increase of catches of smaller size fish (40-60 cm) due to the development of the purse seine fishery. The largest mode (60 cm+) reflects the artisanal fisheries (mainly the Maldives's pole-and-line one). The marked increase in the catch of large skipjack (60-70 cm) since 2000 is reflected for most gears by marked increase of the mean weight of their catches (Figure 7).

The patterns of mean fishing mortality by fish for four 5 years periods (Figure 11) illustrate the evolution of the fishery and highlight the increased mortality due to the purse seine and the artisanal fisheries in the recent period.

In 2008, attempts to calculate standardized CPUEs from the purse seine fishery were carried out with incorporation of environmental covariates. CPUE was found correlated with 20° isotherm and chlorophyll content in the north equatorial area but the standardization undertaken on spatially-aggregated data does not modify the nominal CPUE. The CPUE series shows a declining trend from 1984 to 1998, then an increase till 2003 and a marked decrease from 2006 to 2007. The similarity between the nominal and the standardized index is because detailed information that reflect changes in the fishing power and efficiency of purse seiners (for instance the use of supply vessels, or technological improvements in sonar, bird radar etc) over time were not available. New developments to refine the PS-based standardization procedures are planned for 2009.

External analyses on tagging data were also conducted in 2008. For both 2006 and 2007 estimated abundances of skipjack were large than estimates of recruits of both bigeye and yellowfin even though they cover older ages, suggesting substantially larger numbers of skipjack than both yellowfin and bigeye tuna in the Indian Ocean. Exploitation rates are generally fairly low - never exceeding 20% even over the most selected age-range of the stock. Abundances in 2006 are predicted to be higher than those in 2007 and it is worth noting the stable age-structure apparent in both years - there is a very similar decrease in relative abundance from ages 2 to 5. This hints at a reasonably stable year-class regime at least for the cohorts that encompass these data (2000-2005).

Interaction between skipjack fisheries and other species

Purse seiners catch 40-60 cm skipjack whereas artisanal fisheries catch 60-70 cm fish, thus the fishing pressure applied by purse seiners on smaller size skipjack is likely to affect the catches of larger sized skipjack by the artisanal fisheries. Furthermore, large numbers of juvenile bigeye and yellowfin tuna are caught in the course of purse-seine sets on FADs that target skipjack tuna.

Managers need to be aware that such interactions between fleets, gears and species have the potential to cause competition and conflict and may affect the efficacy of management measures aimed at particular fleets or gears in isolation. For example, the western Indian Ocean purse-seine fishery for small skipjack versus the Maldivian baitboat fishery for larger skipjack; and the purse seine fishery for skipjack which catches juvenile bigeye versus the bigeye longline fishery; the purse seine catch of juvenile yellowfin on FADs versus their catch of large free school yellowfin). Such interactions have to be taken in account when management decisions are considered.

STOCK ASSESSMENT

No quantitative stock assessment is currently available for skipjack tuna in the Indian Ocean. The range of stock indicators available to the Scientific Committee does not signal that there are any problems in the fishery currently.

The Scientific Committee also notes that in most fisheries, declining catches combined with increasing effort are usually indicators that a stock is being exploited close or above its MSY. In the case of skipjack tuna, catches have continued to increase as effort increased. This is illustrated in the trend of yearly skipjack catches of the Indian Ocean using Relative Rate of Catch Increase (RRCI), a modified version of the Grainger and Garcia index (Figure 12). Furthermore, the majority of the catch comes from fish that are sexually mature (greater than 40 cm) and therefore likely to have already reproduced.

The SC noted that, although there might be no reason for immediate concern, it is clear that the catches cannot be increased at the current rate indefinitely. Therefore, it recommends that skipjack be monitored regularly.

MANAGEMENT ADVICE

The high productivity life history characteristics of skipjack tuna suggest this species is resilient and not prone to overfishing, and the stock status indicators indicate that there is no need for immediate concern about the status of skipjack tuna.

SKIPJACK TUNA SUMMARY

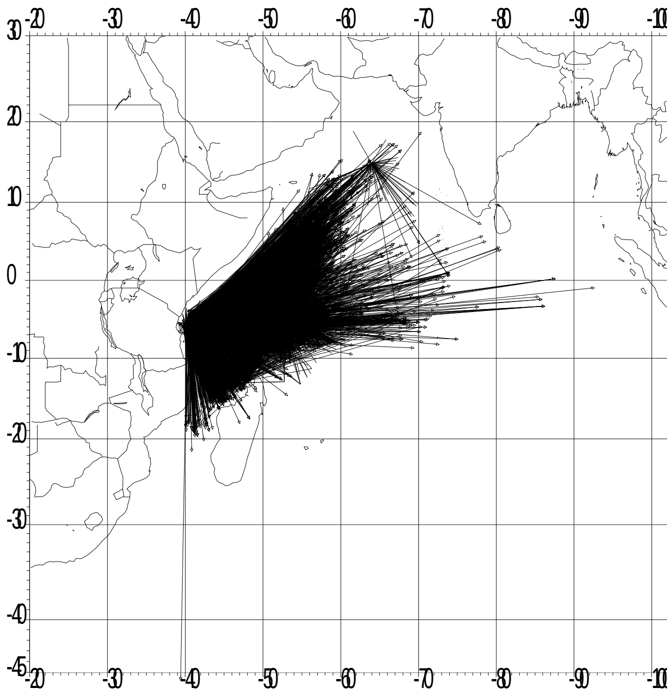
Maximum Sustainable Yield:	unknown
Preliminary catch in 2007 *(data as of October 2008)*	447,100 t
Catch in 2006	612,900 t
Mean catch over the last 5 years (2003-07)	509,000 t
Current Replacement Yield:	-
Relative Biomass (B_{cur}/B_{MSY}):	unknown
Relative Fishing Mortality (F_{cur}/F_{MSY}):	unknown

Note: This Executive Summary has been updated to take account of recent catch data. ~~The management advice, and stock assessment results are based on data up to 2002.~~

Table 1. *Best scientific estimates of the catches of skipjack tuna (as adopted by the IOTC Scientific Committee) by gear and main fleets for the period 1958-2007 (in thousands of tonnes).* *Data as of October 2008*

Gear	Fleet	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84
Purse seine	Spain																											6.4
	France																								0.2	1.0	9.4	27.3
	NEI-Other																										0.4	8.2
	Indonesia	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.3	0.3	0.4	0.6	0.4	0.4	0.6	0.7	0.7	1.0	1.2	1.0
	Japan																				0.1	0.9	0.6	0.4	0.1	0.5	0.6	0.7
	Other Fleets	0.0	0.0	0.0	0.0	0.0	0.0	0.2	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	1.8	2.7	1.5	3.1
	Total	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.2*	*0.4*	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	*0.1*	*0.2*	*0.2*	*0.3*	*0.3*	*0.4*	*0.6*	*0.6*	*1.3*	*1.2*	*2.1*	*2.7*	*5.2*	*13.1*	*46.8*
Baitboat	Maldives	10.0	10.0	9.0	8.0	8.0	8.0	8.0	14.1	16.9	18.9	17.5	19.6	27.6	28.0	17.5	19.5	22.5	14.9	18.6	13.7	13.2	17.3	22.2	19.6	15.3	19.3	32.3
	Indonesia	0.8	0.8	0.8	1.0	1.0	1.0	1.1	1.2	1.3	1.3	1.4	1.5	1.1	1.1	1.7	1.9	2.1	3.2	4.3	3.2	3.1	4.7	5.2	5.3	7.7	9.1	7.8
	India	0.3	0.2	0.4	0.6	0.2	0.4	0.3	0.3	0.2	0.3	0.3	0.3	0.3	0.6	0.6	2.6	0.8	1.0	1.9	1.3	1.7	2.3	2.7	1.7	2.2	2.5	3.2
	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	0.2	0.0	0.3	5.0	10.8	2.1	0.1	0.6	0.8	0.4	0.0	0.2	0.7	0.6	0.4
	Total	*11.1*	*11.0*	*10.2*	*9.6*	*9.2*	*9.4*	*9.3*	*15.6*	*18.4*	*20.5*	*19.2*	*21.3*	*29.2*	*29.8*	*20.1*	*29.1*	*36.2*	*21.3*	*24.9*	*18.8*	*18.8*	*24.6*	*30.1*	*26.8*	*25.9*	*31.4*	*43.7*
Gillnet	Sri Lanka	1.8	1.9	2.4	3.0	4.5	6.1	5.8	5.6	6.4	7.1	8.0	8.9	6.9	5.0	8.9	10.5	9.3	7.2	12.7	12.6	14.8	12.4	16.3	18.4	18.0	16.3	13.3
	Indonesia	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.3	0.3	0.5	0.5	0.5	0.8	1.1	0.8	0.8	1.2	1.3	1.4	2.0	2.4	2.0
	Pakistan	0.9	0.9	1.2	1.0	1.6	2.4	3.4	3.6	4.9	4.7	4.7	4.3	3.9	3.2	3.8	3.0	4.1	4.5	4.2	3.8	2.2	3.8	1.8	2.7	3.4	1.1	1.2
	Other Fleets	0.3	0.3	0.5	0.8	0.2	0.4	0.4	0.3	0.3	0.4	0.4	0.3	0.4	0.7	0.8	3.2	1.0	1.3	2.6	1.5	2.0	2.8	0.2	0.3	0.6	0.3	0.4
	Total	*3.2*	*3.3*	*4.3*	*5.0*	*6.6*	*9.2*	*9.8*	*9.9*	*11.8*	*12.6*	*13.5*	*13.9*	*11.5*	*9.2*	*13.9*	*17.2*	*15.0*	*13.9*	*20.7*	*18.8*	*19.9*	*20.2*	*19.7*	*22.8*	*24.0*	*20.2*	*17.0*
Line	Indonesia	0.4	0.3	0.3	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.5	0.5	0.8	0.9	1.0	1.5	2.0	1.5	1.4	2.2	2.4	2.4	3.6	4.2	3.6
	Other Fleets	0.5	0.5	0.6	0.7	1.0	1.4	1.3	1.2	1.4	1.6	1.8	2.0	3.1	2.8	3.1	3.7	3.5	3.5	4.7	4.2	4.2	3.8	4.7	5.1	3.3	3.4	3.4
	Total	*0.8*	*0.8*	*1.0*	*1.2*	*1.4*	*1.8*	*1.8*	*1.8*	*2.0*	*2.2*	*2.4*	*2.7*	*3.6*	*3.3*	*3.9*	*4.6*	*4.4*	*5.0*	*6.7*	*5.7*	*5.6*	*6.0*	*7.1*	*7.5*	*6.8*	*7.6*	*7.0*
Other gears	Indonesia	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.4	0.3	0.4	0.4	0.3	0.3	0.5	0.5	0.6	0.9	1.2	0.9	0.8	1.2	1.4	1.4	2.1	2.4	2.1
	Other Fleets	0.2	0.2	0.4	0.4	0.4	0.3	0.3	0.3	0.5	0.4	0.6	0.3	0.2	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	*0.4*	*0.4*	*0.6*	*0.6*	*0.7*	*0.5*	*0.6*	*0.7*	*0.9*	*0.7*	*1.0*	*0.7*	*0.5*	*0.4*	*0.7*	*0.5*	*0.6*	*0.9*	*1.2*	*0.9*	*0.9*	*1.3*	*1.4*	*1.4*	*2.1*	*2.4*	*2.1*
All	*Total*	*15.7*	*15.7*	*16.2*	*16.6*	*18.1*	*21.1*	*22.0*	*28.1*	*33.4*	*36.2*	*36.3*	*38.8*	*45.0*	*42.9*	*38.8*	*51.8*	*56.5*	*41.5*	*54.1*	*44.7*	*46.5*	*53.4*	*60.4*	*61.2*	*64.0*	*74.6*	*116.5*

Gear	Fleet	Av03/07	Av58/07	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07
Purse seine	Spain	86.1	28.5	18.6	19.1	27.9	39.7	63.9	47.9	41.8	46.7	51.3	61.6	69.6	66.3	62.9	58.6	74.3	79.4	68.5	91.3	88.0	64.4	94.3	118.9	65.0
	France	39.7	19.2	29.8	36.1	35.6	36.1	43.1	29.0	39.4	45.0	48.2	58.4	48.7	40.1	31.3	30.3	42.7	39.9	36.3	54.4	38.9	38.0	43.2	48.1	30.4
	Seychelles	38.0	5.8							1.8	0.6					4.9	10.7	15.8	11.6	26.2	29.9	36.8	30.0	46.0	47.5	29.7
	NEI-Ex-Soviet Union	11.3	4.0						0.7		10.1	8.7	8.2	18.4	14.7	11.2	10.2	17.3	19.8	19.2	6.8	24.7	17.8	11.3	2.8	
	NEI-Other	7.2	7.6	8.4	6.4	4.8	7.0	7.9	11.0	10.8	10.8	17.4	24.5	22.3	18.4	24.3	31.2	33.4	40.8	26.4	31.9	20.6	4.7	4.0	4.5	2.2
	Thailand	6.7	0.7																1.1	0.5				8.0	16.9	8.4
	Indonesia	6.4	1.6	1.1	1.1	1.3	1.4	1.6	1.4	1.5	1.6	1.9	2.0	1.9	2.7	3.1	2.9	3.0	3.0	3.6	2.3	2.4	3.3	3.0	11.7	11.7
	Japan	2.6	3.6	0.3	0.6	0.9	2.3	3.4	10.9	15.9	31.6	31.3	20.1	16.1	7.0	6.7	5.7	4.6	2.3	1.8	1.9	2.4	1.5	3.1	2.0	4.0
	Other Fleets	2.5	3.2	3.2	4.5	10.1	7.9	8.4	8.8	13.1	6.4	7.1	6.3	3.9	2.7	4.9	3.2	9.4	4.9	9.7	22.4	0.0	0.1	1.2	6.3	5.0
	Total	*200.6*	*74.4*	*61.5*	*67.7*	*80.6*	*94.3*	*128.5*	*109.7*	*124.3*	*153.0*	*165.9*	*181.2*	*180.9*	*151.8*	*149.4*	*152.9*	*200.6*	*202.8*	*192.1*	*240.9*	*214.0*	*159.8*	*214.1*	*258.6*	*156.5*
Baitboat	Maldives	115.0	44.6	42.2	45.1	42.6	58.2	57.8	60.7	58.3	57.6	58.0	69.0	69.9	66.2	68.1	77.8	92.3	78.8	86.8	113.9	107.5	104.5	130.4	136.7	95.8
	Indonesia	14.5	8.6	8.5	8.1	10.0	10.5	12.3	10.7	11.5	12.1	14.4	15.1	14.5	19.8	23.4	21.6	22.2	22.1	26.5	17.3	18.0	24.7	22.1	3.8	3.8
	India	4.4	2.9	3.1	4.0	5.4	4.7	5.9	5.4	5.6	5.9	12.7	6.8	6.9	7.2	7.8	2.0	2.3	4.6	2.7	3.2	3.1	4.0	0.4	7.2	7.2
	Other Fleets	0.0	0.6	0.4	0.5	0.6	0.5	0.5	0.6	0.6	0.7	0.7	0.1	0.5	0.2	0.0	1.9	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	*133.9*	*56.7*	*54.2*	*57.7*	*58.7*	*73.9*	*76.5*	*77.5*	*76.0*	*76.3*	*85.8*	*90.8*	*91.8*	*93.4*	*99.3*	*103.3*	*117.4*	*105.5*	*116.1*	*134.3*	*128.6*	*133.2*	*152.9*	*147.8*	*106.8*
Gillnet	Sri Lanka	68.7	26.1	14.9	14.6	15.3	15.9	17.4	20.5	23.1	27.0	31.5	38.8	40.6	47.3	56.1	56.9	72.6	79.4	74.7	72.9	83.0	83.2	48.0	60.2	69.3
	Iran, Islamic Republic	67.1	9.0					0.3	0.8	1.1	4.3	4.4	7.4	1.1	2.5	8.3	4.7	13.9	18.5	23.2	23.1	36.0	53.6	79.4	98.8	67.6
	Indonesia	10.7	2.9	2.2	2.1	2.6	2.7	3.2	2.8	3.0	3.2	3.8	3.9	3.8	5.2	6.1	5.6	5.8	5.8	6.9	4.5	4.7	6.4	5.8	18.3	18.3
	Pakistan	4.3	3.9	2.0	1.5	3.7	5.6	7.5	7.7	7.5	6.1	6.9	8.1	7.1	4.4	4.6	4.5	4.9	4.7	3.7	3.5	3.4	3.7	4.1	5.2	5.2
	Other Fleets	1.0	0.9	0.5	0.5	0.5	0.6	0.9	0.9	0.6	0.7	1.1	1.2	1.4	1.2	1.8	0.6	0.7	0.8	1.1	0.4	0.5	0.7	1.0	1.3	1.3
	Total	*151.8*	*42.8*	*19.6*	*18.8*	*22.2*	*24.8*	*29.3*	*32.6*	*35.4*	*41.3*	*47.7*	*59.5*	*54.1*	*60.5*	*76.9*	*72.4*	*97.8*	*109.1*	*109.6*	*104.4*	*127.6*	*147.6*	*138.3*	*183.7*	*161.7*
Line	Indonesia	11.1	4.4	3.9	3.7	4.6	4.8	5.7	4.9	5.3	5.6	6.6	6.9	6.7	9.1	10.8	9.9	10.2	10.2	12.2	8.0	8.3	11.4	10.2	12.8	12.8
	Other Fleets	7.1	3.9	3.2	3.3	3.3	3.4	6.2	6.3	6.3	10.7	7.7	4.5	4.7	4.5	4.8	4.5	3.5	3.9	4.0	4.8	4.0	9.5	6.2	8.2	7.7
	Total	*18.2*	*8.3*	*7.1*	*7.0*	*7.9*	*8.3*	*11.8*	*11.3*	*11.6*	*16.2*	*14.4*	*11.5*	*11.4*	*13.6*	*15.6*	*14.4*	*13.8*	*14.1*	*16.2*	*12.8*	*12.2*	*20.9*	*16.3*	*21.0*	*20.5*
Other gears	Indonesia	4.3	2.3	2.3	2.2	2.7	2.8	3.3	2.9	3.0	3.2	3.8	4.0	3.8	5.3	6.2	5.7	5.9	5.9	7.1	4.6	5.3	7.0	6.2	1.4	1.4
	Other Fleets	0.3	0.2	0.1	0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.2	0.6	0.1	0.3	0.3	0.2
	Total	*4.6*	*2.5*	*2.3*	*2.2*	*2.7*	*2.9*	*3.4*	*3.0*	*3.1*	*3.3*	*4.1*	*4.1*	*4.0*	*5.4*	*6.3*	*5.8*	*6.0*	*5.9*	*7.1*	*4.8*	*6.0*	*7.1*	*6.5*	*1.8*	*1.7*
All	*Total*	*509.0*	*184.7*	*144.7*	*153.4*	*172.2*	*204.1*	*249.5*	*234.0*	*250.4*	*290.1*	*317.8*	*347.1*	*342.2*	*324.6*	*347.5*	*348.9*	*435.6*	*437.5*	*441.0*	*497.2*	*488.4*	*468.5*	*528.1*	*612.9*	*447.1*



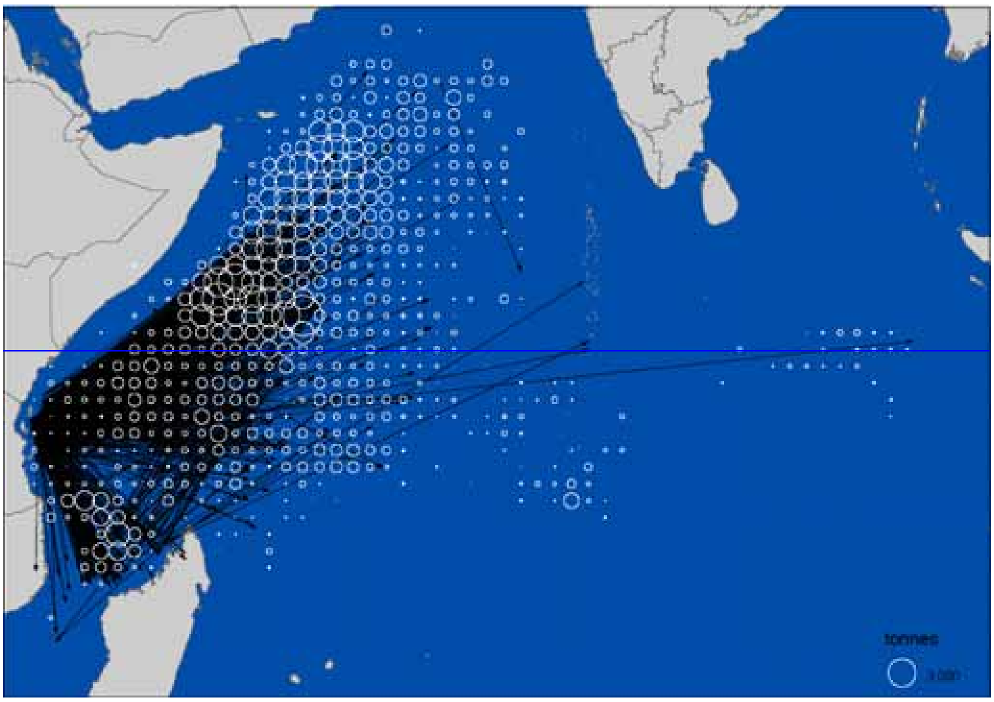


Figure 1. *Tag recapture trajectories for skipjack tuna tagged in the south west Indian Ocean by the RTTP-IO ~~and location of purse seine fishing in 2006. The reference circle represents 3000 t~~(September 2008).*

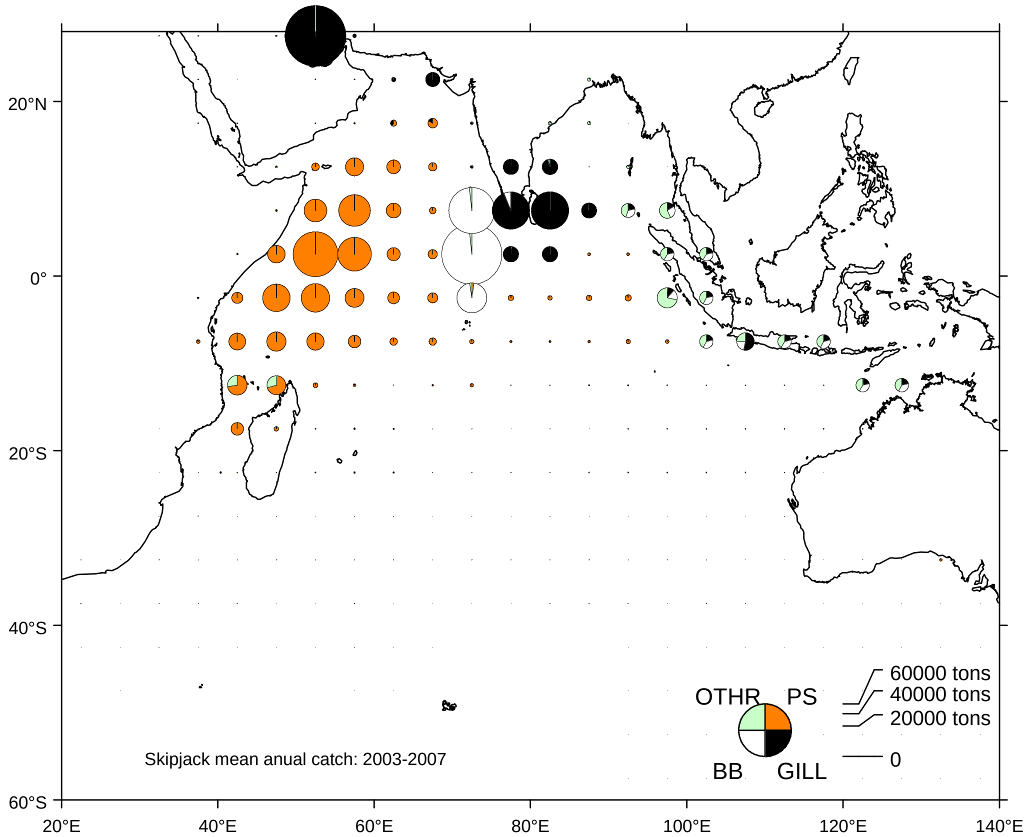


Figure 2. *Mean spatial distribution of skipjack tuna catches in the Indian Ocean by gear type, 2003-2007. BB = bait boat (pole and line); GILL = gillnet; LL = longline; PS = purse seine.* *Data as of October 2008*

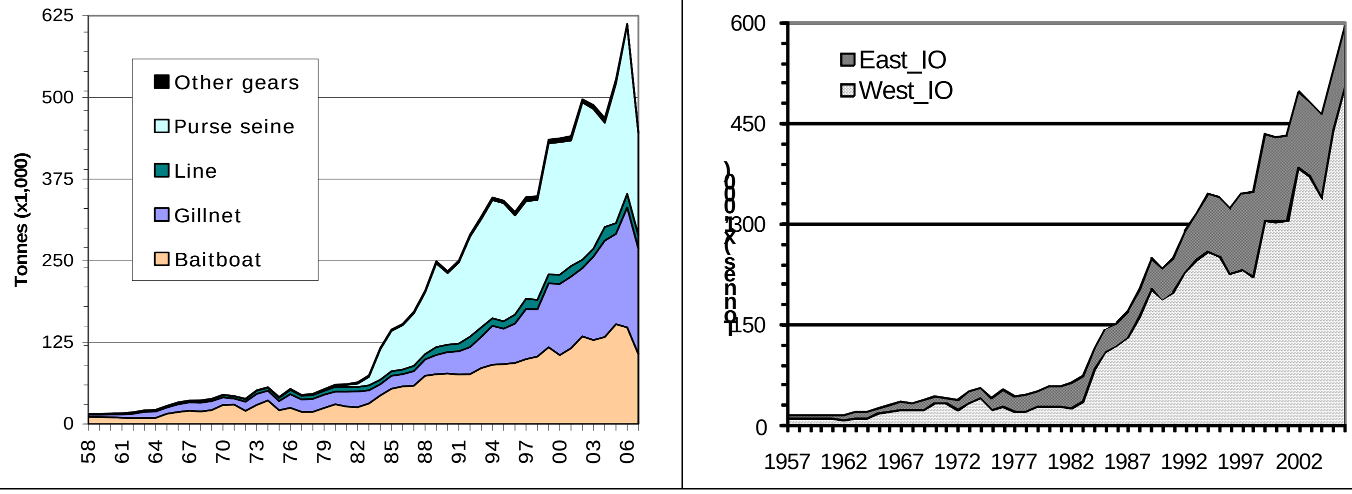


Figure 3. *Yearly catches (thousand of metric tonnes) of skipjack tuna by gear (left) and by area (Eastern and Western Indian Ocean, top right (to be updated)) from 1958 to 2007.* *Data as of October 2008*

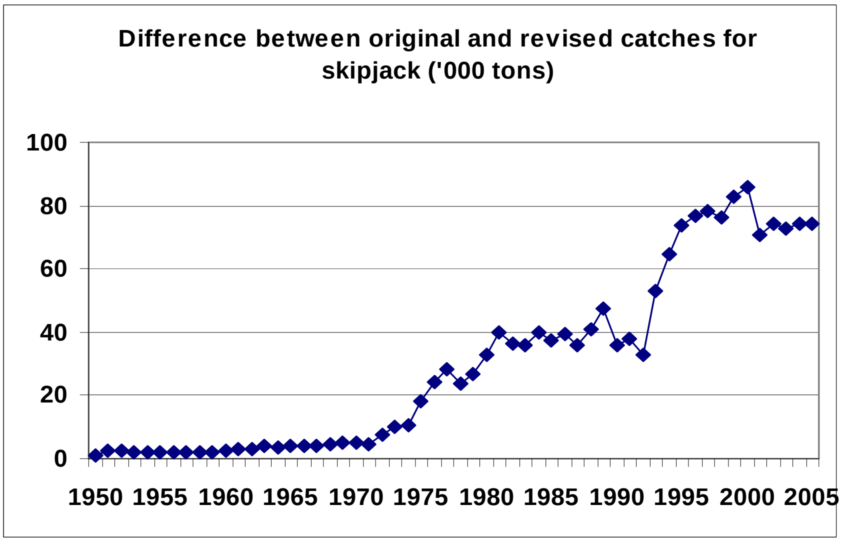


Figure 4. *Total amount of the skipjack catches estimated from aggregated data (to be updated)*

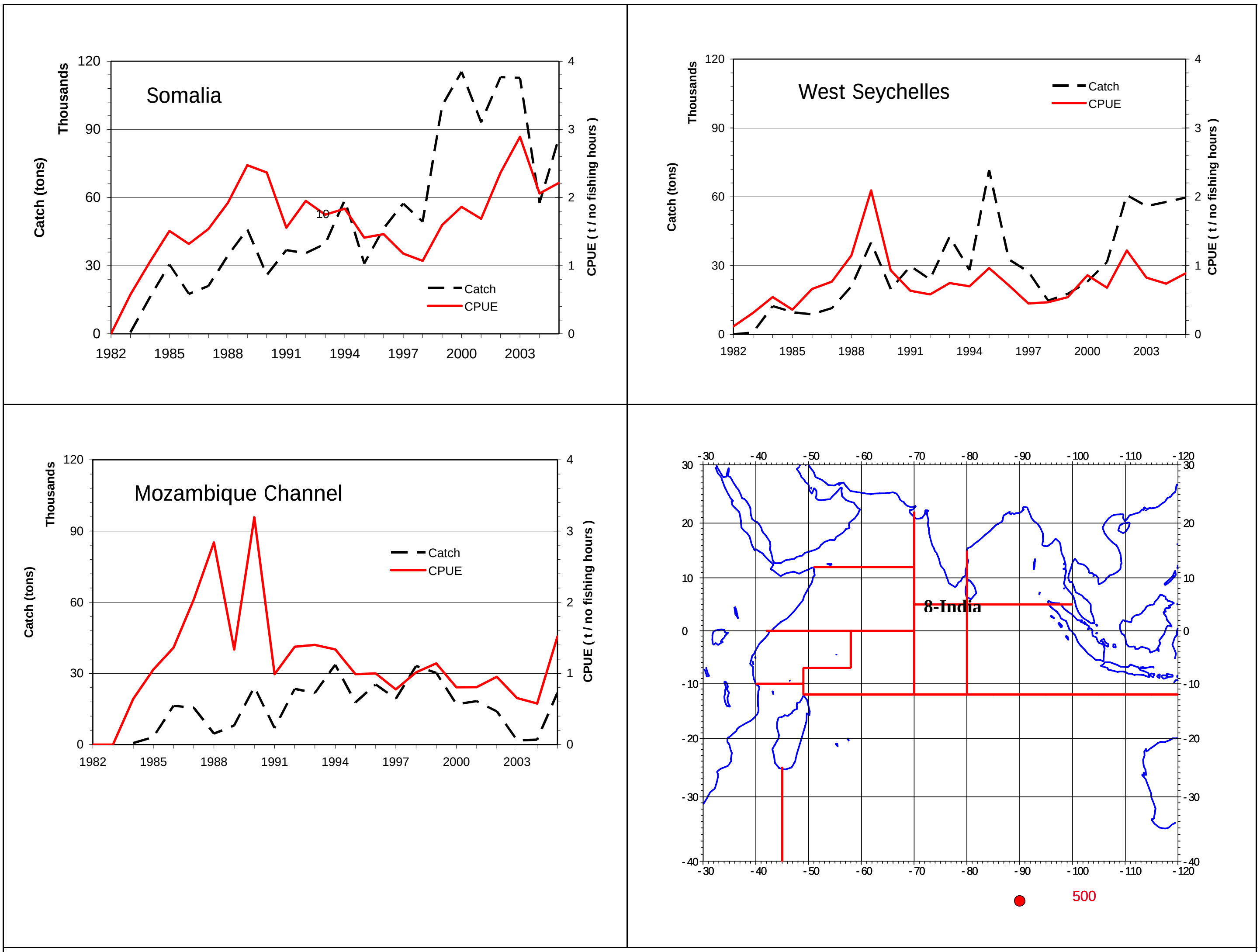


Figure 5. *Nominal CPUEs for three important purse seine fishing ground areas: East Somalia (top left); Mozambique Channel (top right) and North-West Seychelles (bottom left).*
Areas used for the calculation of the CPUE trends are represented (bottom right). Data as of July 2006

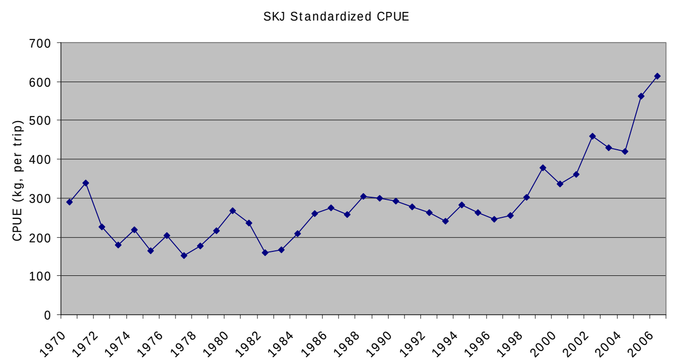


Figure 6. *Time series of CPUE, nominal and adjusted effort of the Maldivian baitboats fishery, 1970-2002 (from IOTC-2007-WPTT-R).*

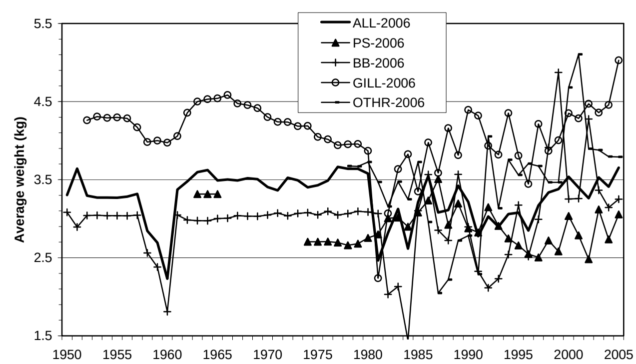
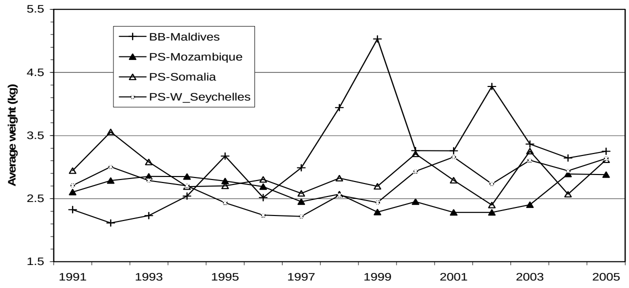


Figure 7. *Skipjack tuna average weight by main gear (from size-frequency data) and for the whole fishery (estimated from the total catch at size), 1950-2006. Data as of June 2007 (to be*

updated)



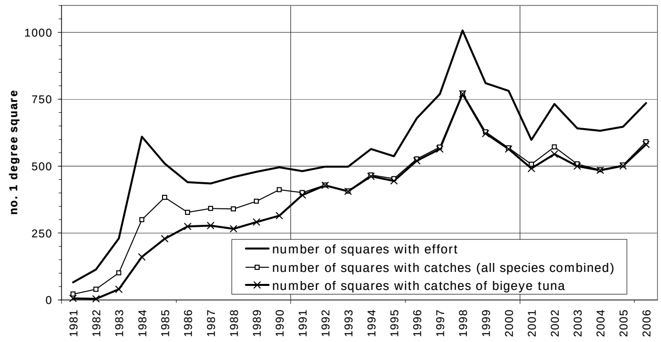


Figure 8. *Time series of average weight of skipjack caught by the purse seine and baitboat fisheries by major areas. (1991-2005).* *Data as of June 2006 (to be updated)*

Figure 9. *Number of one degree CWP squares explored by the purse seine fishery (IOTC-2007-WPTT-R) (to be updated)*

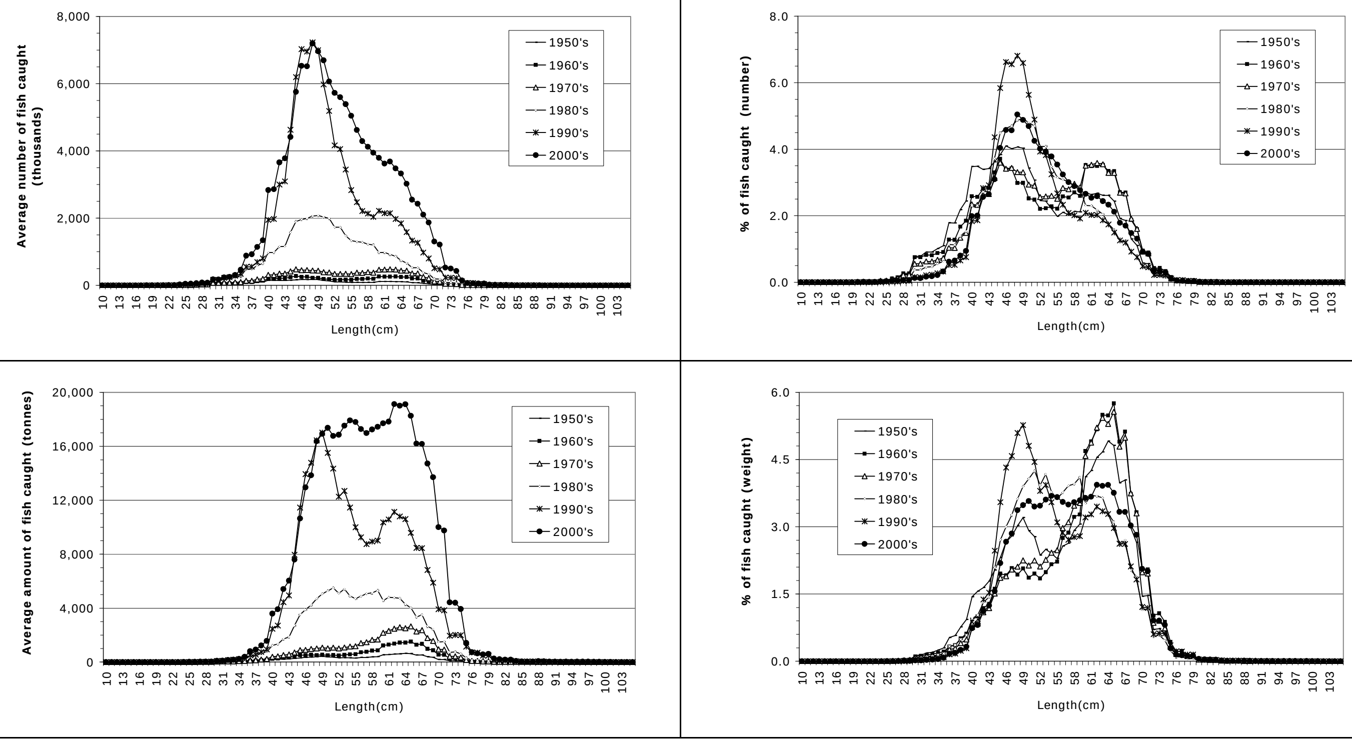
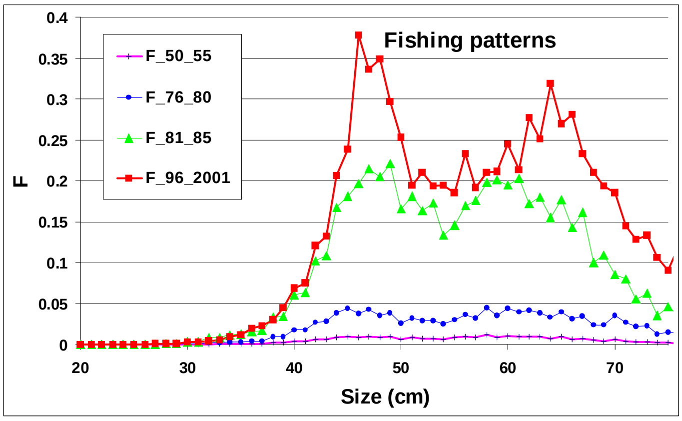


Figure 10. *Catch by size in numbers (top left) and weight (bottomleft) for the periods: 1950-59, 1960-69, 1970-79, 1980-89, 1990-99 and 2000-2005. Right panels are in proportions.* *Data as of June 2007 (to be updated)*



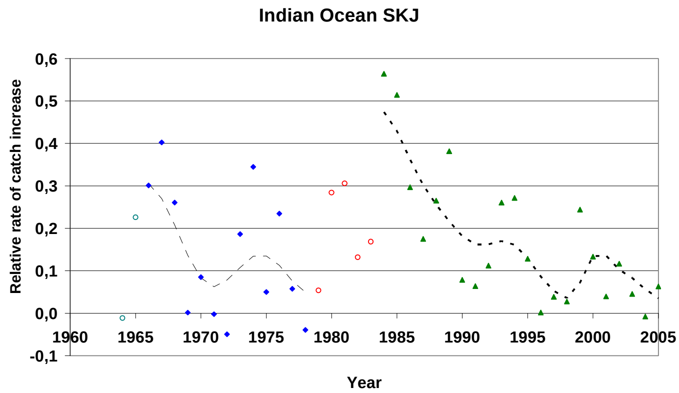


__Figure 11.__ Estimated mean fishing mortality by size for four periods: 1950-55, 1976-80, 1981-85, and 1996-2001 (to be updated).	*__Figure 12.__ Relative Rate of Catch Increase (RRCI) for skipjack, 1960-2005) (to be updated)*

Executive summary of the status of the yellowfin tuna resource

(As adopted by the IOTC Scientific Committee on 9 November 2007)

Marked changes are factual changes related mainly to the inclusion of the latest fisheries statistics. A stock assessment was undertaken in 2008 and relevant sections have been updated using the text from the 2008 WPTT report and other related sources. All changes are suggestions only for the consideration of the SC in Dec08

BIOLOGY

Yellowfin tuna *(Thunnus albacares)* 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.

The tag recoveries of the RTTP-IO provide evidence of large movements of yellowfin tuna, thus supporting the assumption of a single stock for the Indian Ocean. The average distance between skipjack tagging and recovery positions is presently estimated at 525 naut. Miles. Fisheries data indicate that medium sized yellowfin concentrate for feeding in the Arabian Sea, that a dispersion that has been already not being yetpartially reflected in the present set of tag recovery dataies. The new information on the spatial distribution of tagging and recovery positions ed fish compared with the spatial extent of the purse seine fishery is presented in Figure 1.

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. A study of stock structure using DNA was unable to detect whether there were subpopulations of yellowfin tuna in the Indian Ocean.

Spawning occurs mainly from December to March in the equatorial area (0-10°S), with the main spawning grounds west of 75°E. Secondary spawning grounds exist 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).

All the present analysis Preliminary tag data of the RTTP-IO recovery data now clearly support a twomulti-stanza growth pattern for yellowfin, a complex pattern that is also confirmed by the new age readings of otoliths and by modal progressions. but mMore work is needed to achieve an appropriate modelling of this complex growth pattern in order to be able to introduce integration of otoliths and tagging data and agree on athe modelled growth model to be used in the assessment of this stock.

There are no dDirect estimates of natural mortality (M) have been well estimated (M) for juvenile yellowfin (at sizes between 40 cm and 1 meter) in the Indian Ocean using the recovery data, and this result was a major result obtained from the tagging program. This natural mortality is much lower that its previously assumed levels, and this new M should be used in all analytical assessment models. 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 two growth curve models. This indicated a higher M on juvenile fish than for older fish.

There is little information on yYellowfin movement patterns are now quite well identified from the apparent trajectories of recoveries. These movements patterns should now be modelled incorporating the tagging and fishery data, and the reporting rates estimated for each gear.

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 of yellowfin has been extensively studied and it 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. Archival tagging of yellowfin has shown that yellowfin can dive very deep (over 1000m) probably to feed on meso pelagic preys. It has also been observed that the sizes of these preys are often independent of the yellowfin sizes, large fishes commonly feeding on very small preys, then widely increasing their potential target

FISHERY

Catches by area, gear, country and year from 1957 to ~~2006~~ 2007 are shown in Table 1 and illustrated in Figure 2. 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 is shown in Figure 3. 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 seiners typically take fish ranging from 40 to 140 cm fork length (Figure 4) and smaller fish are more common in the catches taken north of the equator (Figure 5). Catches of yellowfin increased rapidly to around 128,000 t in 1993. Subsequently, they fluctuated around that level, until 2003 and 2004 when they were substantially higher (224,200 t and 228,600 t, respectively). In recent years, catches appear to be higher in the first quarter of the year (Figure 6). The amount of effort exerted by the EU purse seine vessels (fishing for yellowfin and other tunas) varies seasonally and from year to year. Since 2000 between 800 and 1200 boat days per month were fished annually (Figure 7).

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 (Figure 4), 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, catches have typically fluctuated between 80,000 t and 123,000 t.

Artisanal catches, taken by bait boat, gillnet, troll, hand line and other gears have increased steadily since the 1980s. In recent years the total artisanal yellowfin catch has been around 130,000-140,000 t, with the catch by gillnets (the dominant artisanal gear) at around 80,000 t to 90,000 t.

Yellowfin catches in the Indian Ocean during 2003, 2004, 2005 and 2006 were much higher than in previous years but have returned to a lower level in 2007, while bigeye catches remained at their average levels. Purse seiners currently take the bulk of the yellowfin catch, mostly from the western Indian Oceana around Seychelles. In 2003, 2004, 2005 and 2006, purse seine total catches made in this area were 224,200 t, 228,600 t, 194,500 t, 159,800 t, respectively. Similarly, artisanal yellowfin catches have been near their highest levels and longliners have reported higher than normal catches in the tropical western Indian Ocean during this period. In 2007, purse seine catches decreased to their lowest levels since 1990 with a total catch of 97,600 t.

Yellowfin catches in number by gear (purse seine, longline and bait boat) are reported in Figure 8. Current estimates of annual mean weights of yellowfin caught by different gears and by the whole fishery are shown in Figure 9. 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 has conducted several reviews of the nominal catch databases in recent years. This has led to marked increases in estimated catches of yellowfin tuna since the early 1970s. 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.,

Estimates of annual catches at size for yellowfin were calculated using the best available information prior to the 2008 WPTT meeting. A number of papers dealing with fisheries data, biology, CPUE trends and assessments were discussed by the WPTT in 2008, and additional data analyses were performed during that meeting. Estimated catches at age were calculated using the catch-at-size data and two alternative growth curves. The growth curves were used to develop natural mortality at age, maturity at age and average weight at age schedules. M was assumed to be higher on juvenile than adult fish.

In 2008, new areas were defined and a new standardised Japanese longline CPUE for yellowfin tuna (1960 to 2007) was derived for each of the areas. The CPUE indices are variable from year to year but generally decline steeply from 1960 until the late 1970’s. From the late 1970’s to the early 1990’s the index is relatively stable. From the mid 1990’s to 2007 the index is at lower levels than previously, but again relatively stable (Figure 10). It has been noticed that these areas should be modified in the future analysis in order to be more consistent with environmental heterogeneity.

A new standardised CPUE for yellowfin tuna caught in the Taiwanese longline fishery (1979 to 2007) was also developed in 2008. Overall, the indices have been variable from year to year, but relatively stable. The catch rate has shown a slowly increasing trend since 1997 (Figure 11).

In 2008, attempts to calculate standardized CPUEs from the purse seine fishery were carried out with incorporation of environmental covariates. For small yellowfin (<10 kg), GLM results showed no clear trend in standardized CPUE through the whole period 1984-2007 with high interannual variations. No clear trend was also found on large yellowfin (> 30 Kg). Like skipjack, detailed information that reflect changes in the fishing power and efficiency of purse seiners (for instance the use of supply vessels, or technological improvements in sonar, bird radar etc) over time were not available. New developments to refine the PS-based standardization procedures are planned for 2009.

Since the early 1990’s the Taiwanese fleet has concentrated its operation in the Arabian Sea area whereas the Japanese fleet has operated more in the central and western Indian Ocean. It appears that the the Japanese and Taiwanese longline fisheries are now spatially distinct and both indices of abundance need to be viewed and modelled separately.

STOCK ASSESSMENT

The assessment of yellowfin tuna stock in the Indian Ocean represents a particular and difficult case because of the conflicting trends between total yearly catches and abundance index used based on the longline CPUE. Those trends are not consistent with production-model dynamics, or really with any known theory of fishing. For any fished stock, dramatic and continuous increase in yield that is not followed by subsequent decline in abundance, cannot be explained, unless there is some major unknown factors.

~~The yellowfin tuna stock assessment work in the Indian Ocean is an extremely difficult task because of the conflicting trends in the basic data, total yearly catches and abundance index used based on the longline CPUE: the observed trends in YFT catches and cpues are not consistent with production-model dynamics, or really with any known theory of fishing. For any fished stock, to give larger and larger yields with no significant decline in abundance, cannot be explained, unless there is some major unexplained factor~~

A range of assessments were presented in 2008, and the WPTT was able to consider in great detail their outputs as well as elaborate on further scenarios and assumptions to be explored. Most of the models appear to provide similar perspectives on the status of the stocks despite their different levels of complexity and the uncertainties.

An assessment model (Multifan-CL) was applied this year that was able to make use of the tagging data obtained through the RTTP-IO programme. The results from this model demonstrated the value of the tagging information for assessment purposes and improved the basis for the advice this group was able to provide compared with previous assessments of this stock. The value of this source of information is likely to increase over time as more tag are returned, over a wider area and for older fish, and as analyses on this dataset progress and improve.

All assessments are greatly dependent on the use of the longline CPUE series as indices of abundance of the stock. Although current standardization procedures applied various technological and environmental variables into the model it is uncertain if it could fully explain the change in fishing efficiency.

A simple surplus production model was used to explore the relative information content of the Japanese and Taiwanese longline CPUE. The two CPUE series were used separately and in combination. Both series produced very similar biomass trends over time and the early rapid declines in CPUE for low, stable catch levels seen in both series cannot be explained as reductions in abundance. Based on the production model results, the predicted stock status was very similar for all cases. Overall, the results indicated that the biomass is below the MSY-based level and that the catch and harvest rates are slightly above MSY levels.

A Stock Synthesis 2 (SS2) model using catch-at-length data, growth and a CPUE series to model the stock dynamics encountered difficulty in estimating some parameters and the MSY reference values. A model run using both the Japanese and Taiwanese longline CPUEs, and separating the PS fishery according to fishing mode, estimated values of MSY to be around the 300,000 t and would indicate that the stock was above the BMSY level.

An Age-structured Production Model (ASPM) used catch-at-age data and a CPUE series to estimate biomass trends and management-related parameters. 82 scenarios were examined; however, only three scenarios were able to produce converged estimates and provide biologically reasonable results. The results suggest that Indian Ocean yellowfin tuna is now entering into an overfished status after four years of high catches (2003-2006) and the stock will be likely recover to the SSBMSY level in a few years if the catch does not exceed the level of catch in 2007 (316,000 t).

Multifan-CL is a size-based, age- and spatially-structured population model that has the functionality to integrate the tagging data obtained from the Indian Ocean Tagging Programme. The model integrates information on the dynamics of the fish population, the fishery and tagged fish and creates observation models for the data and outputs estimates of a range of fisheries management parameters. Results obtained appear to indicate that recent levels of fishing mortality are at an historical high level and the stock has experienced a period of overfishing during 2003-2006 (i.e. Fcurrent > F_{MSY}) for all values of steepness. Current catches are likely to be higher than the estimated MSY, which ranges from 250,000 to 300,000 t, depending on the shape of the stock-recruitment relationship. Biomass based reference points also vary with the assumed level of steepness. For the lowest value of steepness (0.60), spawning biomass in 2007 is estimated to be below the MSY level ($SB/SB_{MSY} <1$); i.e. the stock is in an overfished state. For higher values of steepness, recent (2007) biomass is above the MSY level (SBcurrent > SB_{MSY}) and the stock is not in an overfished state. The model estimates that recent recruitment has been lower than average and on this basis total and spawning biomass could be expected to decline further over the next few years.

MANAGEMENT ADVICE

Current status

Estimates of current status of the stock in relation to biomass and fishing mortality reference points were sensitive to the value assumed for steepness of the stock-recruitment relationship so the following results are reported with respect to a range of plausible steepness values (0.6 to 0.8).

Estimates of total and adult biomass are above or just below their respective MSY-based reference points (B_{MSY} and SB_{MSY}), indicating that the stock is close to, or possibly has recently entered, an over-fished state (Figure 12).

Current (2007) fishing mortality estimates were above their respective MSY-based reference points for all but one of the assessments examined, i.e. $F_{CURRENT}/F_{MSY}$ ratios range from 0.9 to 1.60 indicating that overfishing is occurring (Figure 12). This current degree of overfishing is somewhat lower than that estimated occurred during the 2003-2006 period when the F/F_{MSY} ratio ranged from 1.22 to 1.75.

The stock assessments, including independent analyses of the tagging data, indicate that recruitment has declined in recent years.

The estimates of MSY ranged between 250,000 t and 300,000 t based on the integrated assessment that used the tagging data, although other model results expand this range to 360,000 t. The 2007 catch of 317,000 t may have been above the MSY while annual catches over the period 2003-2006 (averaging 464,000 t) were substantially higher than this range of MSY estimates.

Outlook

Catches in 2007 (317,000 t) were slightly lower than the average catch taken in period 1998-2002 (336,000 t) i.e. preceding the 2003 to 2006 period when extraordinarily high catches of yellowfin were taken. Purse seine catches in the first seven months of 2008 were slightly higher than those reported for the corresponding period in 2007 indicating that catch levels might be returning to pre-2003 levels. While there is a large amount of uncertainty about likely future catches, recent events in 2008 where some vessels have left the fishery, together with fleets avoiding the historically important fishing grounds in the waters adjacent to Somalia for security reasons, may reduce catches in the short-term to below the pre-2003 levels.

Two hypotheses have been put forward in the past to explain the very high catches in the 2003-2006 period: (i) an increase in catchability by surface fleets due to a high level of concentration across a reduced area and depth range, and (ii) increased recruitment over the 1999-2001 period. Recent analyses of environmental and oceanographic conditions appear to be consistent with the first hypothesis, which would mean that the catches likely resulted in a depletion of the stock. Conversely, MFCL accounts for the period of higher catches by estimating substantially higher than average levels of recruitment in 2001, 2002 and 2003. Environmental anomalies also appear to be a factor linked to the lower catches in 2007.

The range of model runs indicate that overfishing is currently occurring. Under equilibrium conditions, the recent (2003-2006) and current (2007) levels of fishing mortality will result in the stock becoming overfished ($B_{CURRENT} < B_{MSY}$ and $SB_{CURRENT} < SB_{MSY}$) in the medium term (3-5 years). Recent recruitments (in 2005, 2006 and possibly 2007) are estimated to be below the equilibrium (long-term average) level and if lower recruitment persists then the stock will decline below the MSY level more rapidly. Similarly, overfishing may continue to occur even if fishing pressure returns to pre-2003 catch levels, especially if recruitment continues to be low and the expected decrease in some age classes due to recent low recruitments eventuates.

Recommendation.

In spite of the the important progress in the quality and quantity of analyses conducted, there remain uncertainties in the application of the models that prevented the SC to determine the current status of yellowfin tuna in a precise way.

Nevertheless, most of the analyses conducted coincide in indicating that the stock is very close to an overfished state, or already overfished, and that the exploitation rate in recent years has exceeded the optimal level.

Therefore, the Scientific Committee recommends that the catch of yellowfin tuna does not exceed the average catch for the period 1998-2002 (i.e. 3~~??,~~30 000 t) when catches were stable, prior to the exceptional years of 2003-2006 when the stock might have been overexploited.

Similarly, the Scientific Committee recommends that the fishing effort does not exceed the level exerted in 2007 when the catch of yellowfin tuna returned to the pre-2003 levels.

While the WPTT acknowledges the preliminary nature of the yellowfin tuna assessment in 2008, all results indicate that fishing mortality should not return to the high levels observed in recent years (2003-2006).

Given the extraordinarily high catches in 2003-2006, it is likely that overfishing was occurring over that period; however, it is not clear if the stock is currently overfished or whether a return to a level of fishing pressure equivalent to that existing just prior to 2003 will lead to the stock being overfished.

The WPTT considers that the status of the stock of yellowfin is not going to change markedly over the next year and recommends that fishing pressure be closely monitored and assessments be undertaken annually for the next several years. However, the WPTT forewarns, that if the results of the 2008 assessment are confirmed in 2009, then changes to the current fishery in terms of catches and/or effort will likely be recommended

YELLOWFIN TUNA SUMMARY

Maximum Sustainable Yield (2007):	The results from 2008 assessment results ranged from (250,000 t – 360,000 t)
Preliminary catch in 2007 *(data as of October 2008)*	316,700 t
Catch in 2006	407,900 t
Mean catch over five years before 2003 (1998 – 2002)	336,500 t
Current Replacement Yield	-
Relative Biomass $B_{current}/ B_{MSY}$	< 1
Relative Fishing Mortality $F_{current}/_{FMSY}$	0.9 to 1.60

Note: This Executive Summary has been updated to take account of recent catch data. The management advice, and stock assessment results are based on data up to 2007.

Table 1. *Best scientific estimates of the catches of yellowfin tuna (as adopted by the IOTC Scientific Committee) by gear and main fleets for the period 1957 to 2007.* Data as of October 2008

Gear	Fleet	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84
Purse seine	Spain																											11.5
	France																								0.2	1.0	10.5	36.7
	NEI-Other																										0.7	8.4
	Other Fleets	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.2	0.5	0.4	0.3	0.1	0.3	1.6	1.8
	Total	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.1*	*0.1*	*0.0*	*0.0*	*0.0*	*0.1*	*0.0*	*0.0*	*0.1*	*0.1*	*0.1*	*0.0*	*0.0*	*0.2*	*0.5*	*0.4*	*0.3*	*0.3*	*1.3*	*12.7*	*58.3*
Baitboat	Maldives	1.9	1.9	1.0	1.4	1.4	1.4	1.4	1.0	1.4	1.6	1.6	1.7	2.3	1.4	2.5	6.9	5.0	4.6	5.2	4.9	3.8	4.4	4.4	5.6	4.5	7.7	8.2
	Other Fleets	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.8	1.3	0.3	0.2	0.2	0.4	0.5	0.5	0.6	0.5	0.2	0.3
	Total	*2.0*	*2.0*	*1.0*	*1.5*	*1.5*	*1.5*	*1.5*	*1.0*	*1.5*	*1.7*	*1.7*	*1.8*	*2.4*	*1.5*	*2.7*	*7.7*	*6.3*	*4.9*	*5.4*	*5.1*	*4.2*	*4.8*	*4.9*	*6.1*	*5.0*	*7.9*	*8.5*
Longline	China Taiwan,China	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	4.1	4.7	5.6	5.8
	Japan	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	4.9	7.3	7.8	7.9
	Indonesia																0.1	0.3	0.7	1.0	1.3	1.3	1.4	2.1	2.6	2.7	0.8	0.8
	Korea, Republic of								0.1	0.1	0.4	5.3	9.1	5.2	7.4	10.3	10.8	13.2	13.4	13.7	33.1	26.5	18.0	13.2	12.4	19.4	16.2	10.2
	Other Fleets	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.5	0.5	0.1	2.4	0.6	1.9	1.6	1.5	1.2	0.7	0.2	1.1	0.9	0.2	0.4	0.5	0.4	0.4	0.7	0.7
	Total	*24.5*	*24.6*	*38.3*	*35.6*	*47.7*	*25.4*	*25.3*	*27.7*	*45.7*	*34.0*	*78.6*	*53.9*	*32.4*	*34.4*	*31.5*	*21.7*	*23.5*	*25.3*	*21.9*	*45.4*	*37.0*	*26.9*	*22.8*	*24.4*	*34.5*	*31.2*	*25.5*
Gillnet	Sri Lanka	1.1	1.2	1.5	1.8	2.7	3.6	3.5	3.3	3.7	4.1	4.6	5.1	4.0	2.9	4.4	5.4	4.8	3.9	7.0	6.4	6.9	7.6	8.3	9.6	9.5	9.1	6.4
	Oman	0.3	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.5	1.5	1.8	2.0	2.2	2.4	2.2	2.7	2.5	1.9	0.8	2.5
	Pakistan	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	2.0	2.5	0.8	0.9
	Other Fleets	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.6	0.2	0.3	0.8	0.3	0.4	0.6	0.7	0.5	1.0	0.4	0.5
	Total	*2.2*	*2.3*	*2.8*	*3.1*	*4.3*	*5.8*	*6.4*	*6.4*	*7.7*	*8.1*	*8.6*	*8.8*	*7.3*	*5.7*	*7.9*	*8.7*	*9.6*	*9.3*	*12.9*	*11.6*	*11.3*	*13.1*	*13.0*	*14.7*	*14.8*	*11.2*	*10.3*
Line	Yemen	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.8	1.0	1.1	1.2	1.3	1.2	1.3	1.0	0.9	1.6	2.6
	Oman	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.8	1.0	1.1	1.2	1.3	1.2	1.5	1.4	1.0	0.5	1.3
	Comoros													0.1	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
	Maldives													0.3	0.2	0.2	0.3	0.3	0.3	0.5	0.4	0.5	0.7	0.7	0.7	0.3	0.3	0.3
	Other Fleets	0.8	0.8	1.0	1.2	1.2	1.5	1.7	1.5	1.6	1.7	1.9	2.0	1.5	1.6	2.2	3.1	2.2	1.8	2.7	6.1	5.8	5.7	5.2	3.9	5.0	3.9	3.3
	Total	*1.2*	*1.3*	*1.4*	*1.6*	*1.6*	*1.9*	*2.1*	*1.9*	*2.0*	*2.3*	*2.4*	*2.6*	*2.3*	*2.4*	*3.1*	*4.1*	*4.4*	*4.2*	*5.6*	*9.0*	*9.0*	*8.9*	*8.9*	*7.1*	*7.4*	*6.5*	*7.7*
Other gears	*Total*	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	*0.3*	*0.2*	*0.2*	*0.3*	*0.3*	*0.6*	*0.7*	*0.8*	*1.0*	*1.3*	*1.4*	*1.3*	*0.9*	*0.9*	*0.5*	*1.0*
All	*Total*	*30.0*	*30.4*	*43.7*	*42.0*	*55.3*	*34.9*	*35.6*	*37.4*	*57.3*	*46.4*	*91.6*	*67.4*	*44.7*	*44.2*	*45.6*	*42.6*	*44.4*	*44.4*	*46.6*	*72.4*	*63.3*	*55.5*	*51.2*	*53.5*	*63.9*	*69.9*	*111.2*

Gear	Fleet	Av03/07	Av58/07	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07
Purse seine	Spain	69.2	23.0	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	77.5	70.9	37.8
	France	52.2	20.2	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	57.2	44.3	32.7
	Seychelles	32.6	4.5							0.4	0.2					2.8	7.4	9.8	11.6	12.9	16.6	33.3	48.8	36.5	28.1	16.1
	NEI-Other	9.0	6.5	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	18.9	19.1	24.5	10.1	4.4	3.7	2.5
	Iran, Islamic Republic	7.4	1.3								1.5	2.4	1.9	3.0	1.6	1.9	3.3	2.5	2.2	2.2	5.0	8.3	11.0	7.3	8.4	2.3
	NEI-Ex-Soviet Union	7.4	2.7						0.8		5.2	8.7	5.8	14.6	11.7	9.8	5.3	11.8	10.9	8.9	2.2	15.1	13.8	7.8	0.4	
	Other Fleets	3.1	2.7	2.0	4.1	5.7	6.1	5.9	7.0	11.1	14.3	13.7	7.3	6.6	4.7	3.7	3.3	2.3	1.5	5.5	6.5	0.8	0.5	3.9	4.1	6.2
	Total	*181.0*	*60.8*	*69.0*	*73.8*	*84.0*	*118.8*	*89.8*	*108.7*	*105.5*	*112.4*	*127.5*	*113.7*	*148.3*	*129.8*	*132.3*	*100.5*	*134.9*	*140.4*	*130.1*	*139.1*	*224.2*	*228.6*	*194.5*	*159.8*	*97.6*
Baitboat	Maldives	14.9	6.7	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	16.1	14.4	14.9	15.8	13.2
	Other Fleets	1.4	0.5	0.6	0.5	0.5	0.3	0.3	0.4	0.5	0.6	0.6	0.6	0.6	0.6	0.7	0.6	0.7	0.8	0.7	0.7	0.8	0.6	2.7	1.5	1.5
	Total	*16.3*	*7.2*	*7.5*	*6.7*	*7.9*	*6.3*	*5.8*	*5.3*	*7.6*	*8.6*	*9.9*	*13.0*	*12.3*	*12.1*	*12.9*	*13.6*	*13.3*	*10.8*	*11.8*	*17.0*	*16.8*	*15.0*	*17.6*	*17.3*	*14.8*
Longline	China Taiwan,China	41.5	17.9	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	26.9	33.2	29.7	49.8	67.6	34.7	25.7
	Japan	19.6	14.9	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	13.9	17.2	16.0	21.5	23.1	20.3
	Indonesia	12.9	7.6	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	15.3	12.0	8.5	8.5
	NEI-Fresh Tuna	6.9	4.8					11.9	16.6	14.4	16.7	16.5	23.7	17.1	17.7	21.2	16.6	14.8	13.3	0.9	3.3	4.6	5.8	6.9	8.5	8.5
	NEI-Deep-freezing	4.1	2.9	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	7.7	6.6	4.2	5.3	3.3	6.8	6.8	2.0	1.5
	Korea, Republic of	3.3	7.2	12.5	15.5	13.2	14.1	8.7	7.5	3.2	4.4	4.3	3.9	2.6	3.8	4.0	2.6	1.0	2.0	1.6	0.3	2.2	4.2	3.5	3.4	3.4
	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	15.9	4.0	0.3	1.0	0.6	0.4	0.4	0.1	1.9	20.1	34.4	8.0	5.2	3.9	2.0	4.0	6.0	5.6	5.3	4.6	7.6	12.3	26.2	18.1	15.5
	Total	*104.2*	*61.2*	*30.5*	*45.2*	*46.9*	*54.9*	*65.2*	*86.0*	*78.8*	*136.7*	*196.4*	*120.4*	*88.6*	*113.6*	*109.1*	*109.3*	*103.7*	*89.9*	*81.2*	*84.8*	*84.7*	*110.2*	*144.6*	*98.2*	*83.5*
Gillnet	Iran, Islamic Republic	30.1	7.3					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	39.7	35.8	32.1	13.6
	Sri Lanka	37.5	13.3	6.9	7.1	7.4	7.7	8.3	9.6	11.6	13.9	16.6	21.5	18.9	23.7	29.5	29.2	37.0	33.8	30.7	32.4	38.5	39.3	26.5	38.9	44.1
	Oman	6.3	3.0	1.2	1.4	3.1	8.3	8.7	7.7	2.8	7.0	5.9	5.0	9.5	4.6	3.4	6.3	3.8	3.7	3.3	3.0	7.2	13.8	7.9	1.4	1.4
	Pakistan	3.2	2.9	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	9.3	5.3	3.9	3.4	3.6	3.4	2.2	1.7	5.1
	Other Fleets	1.9	0.7	1.1	0.6	0.8	0.5	0.7	1.0	0.8	0.9	0.9	0.9	0.8	0.9	1.0	0.8	0.9	1.0	0.9	0.9	1.0	0.8	2.2	2.8	2.8
	Total	*79.0*	*27.2*	*10.7*	*11.6*	*13.8*	*20.4*	*27.3*	*23.8*	*23.4*	*37.8*	*39.3*	*49.3*	*53.8*	*60.8*	*57.8*	*58.2*	*75.3*	*57.2*	*56.7*	*58.7*	*79.7*	*97.0*	*74.5*	*76.8*	*67.1*
Line	Yemen	24.0	7.3	3.3	4.1	4.8	5.5	6.3	7.1	7.9	8.7	7.8	8.5	13.4	15.2	17.3	19.3	21.4	23.4	25.5	27.5	25.7	31.7	26.8	19.6	16.3
	Oman	10.2	3.0	0.7	0.7	1.7	4.5	4.8	4.3	6.0	6.0	5.3	13.5	9.1	5.2	6.2	4.4	3.5	3.3	2.9	2.2	2.3	9.6	7.3	15.9	15.9
	Comoros	6.2	2.1	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	5.5	5.9	5.5	5.9	6.1	6.2	6.2	6.2	6.2
	Maldives	5.6	0.9	0.2	0.2	0.2	0.3	0.3	0.2	0.2	0.3	0.3	0.2	0.3	0.3	0.3	0.6	0.7	1.6	2.5	4.2	2.5	6.8	5.5	5.8	7.4
	Other Fleets	6.8	3.6	5.0	5.7	4.7	4.3	3.1	3.6	3.9	3.9	4.3	4.4	4.4	4.3	4.3	3.8	4.1	4.7	4.4	4.3	4.3	4.4	11.1	7.2	7.1
	Total	*52.8*	*17.0*	*9.4*	*10.9*	*11.7*	*14.9*	*18.1*	*18.9*	*21.7*	*23.8*	*22.7*	*32.5*	*33.0*	*30.8*	*33.7*	*33.6*	*35.0*	*38.9*	*40.8*	*44.1*	*40.8*	*58.6*	*56.8*	*54.8*	*52.9*
Other gears	*Total*	*1.5*	*0.9*	*0.9*	*1.2*	*1.5*	*3.2*	*3.0*	*2.7*	*0.4*	*0.7*	*0.6*	*1.2*	*3.3*	*2.2*	*0.6*	*1.0*	*0.6*	*0.6*	*0.5*	*0.5*	*1.4*	*1.9*	*2.3*	*0.9*	*0.8*
All	*Total*	*434.8*	*174.3*	*128.0*	*149.4*	*165.8*	*218.5*	*209.2*	*245.4*	*237.4*	*320.0*	*396.5*	*330.1*	*339.3*	*349.4*	*346.4*	*316.2*	*362.9*	*338.0*	*321.1*	*344.4*	*447.7*	*511.2*	*490.4*	*407.9*	*316.7*

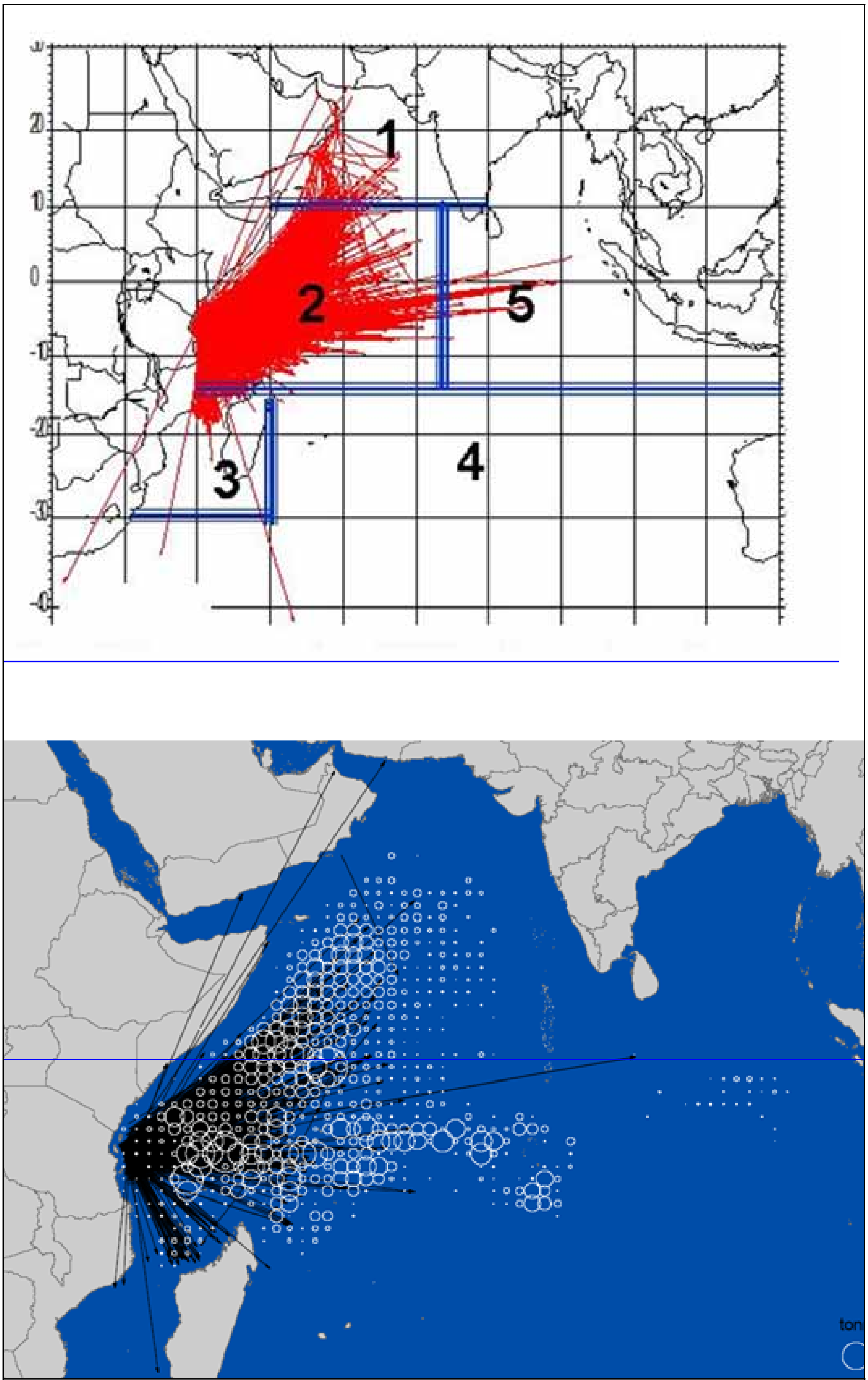


Figure 1. *Tag recapture trajectories for yellowfin tuna tagged in the south west Indian Ocean by the RTTP-IO and limits between areas presently used in the MF-CL model ~~and location of purse seine fishing in 2006. The reference circle represents 2000 t~~(September 2008).*

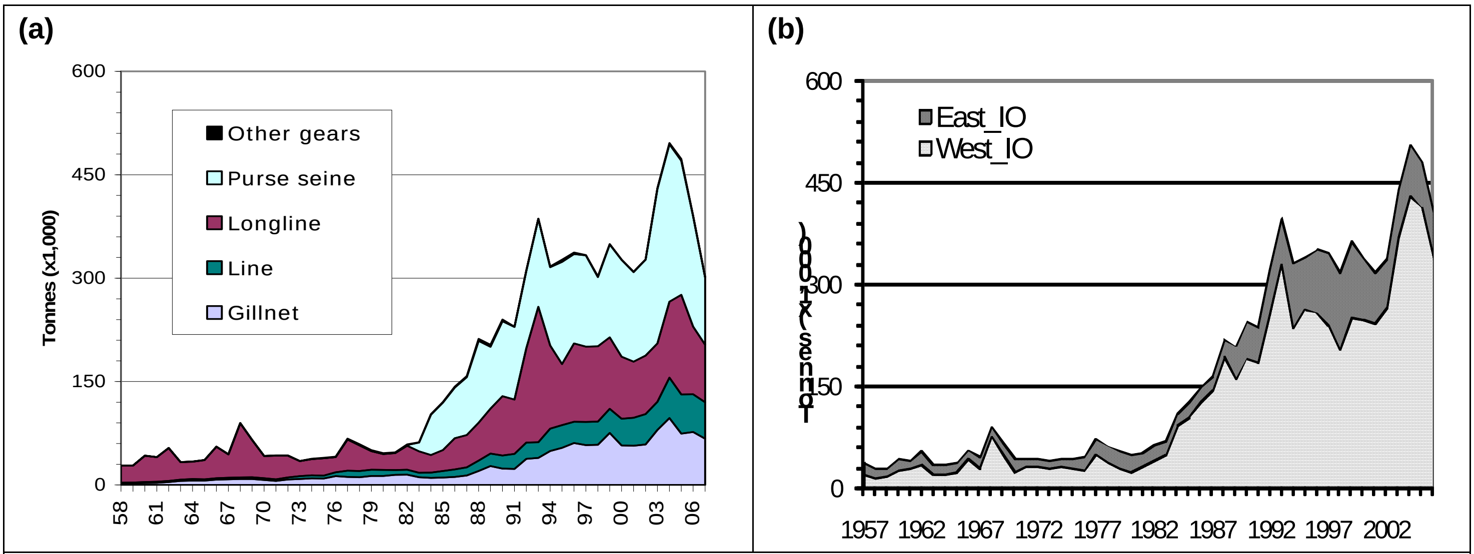
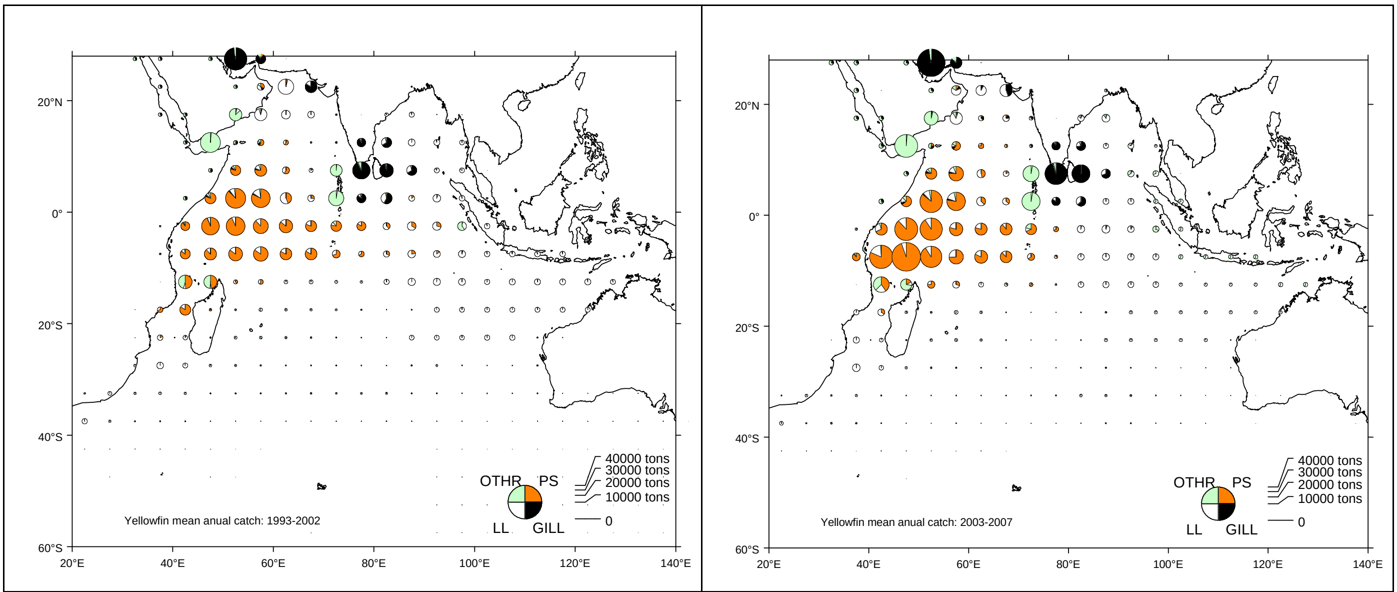


Figure 2. *Yearly catches (tonnes x 1000) of yellowfin by (a) gear and (b) area (to be updated) from 1958 to 2007.*

Data as of October 2007



1993-2002	2003-2007

Figure 3. *Location and size of yellowfin tuna catches in the Indian Ocean by gear type. GILL = gillnet, LL = longline, PS = purse seine. Data as of October 2008*

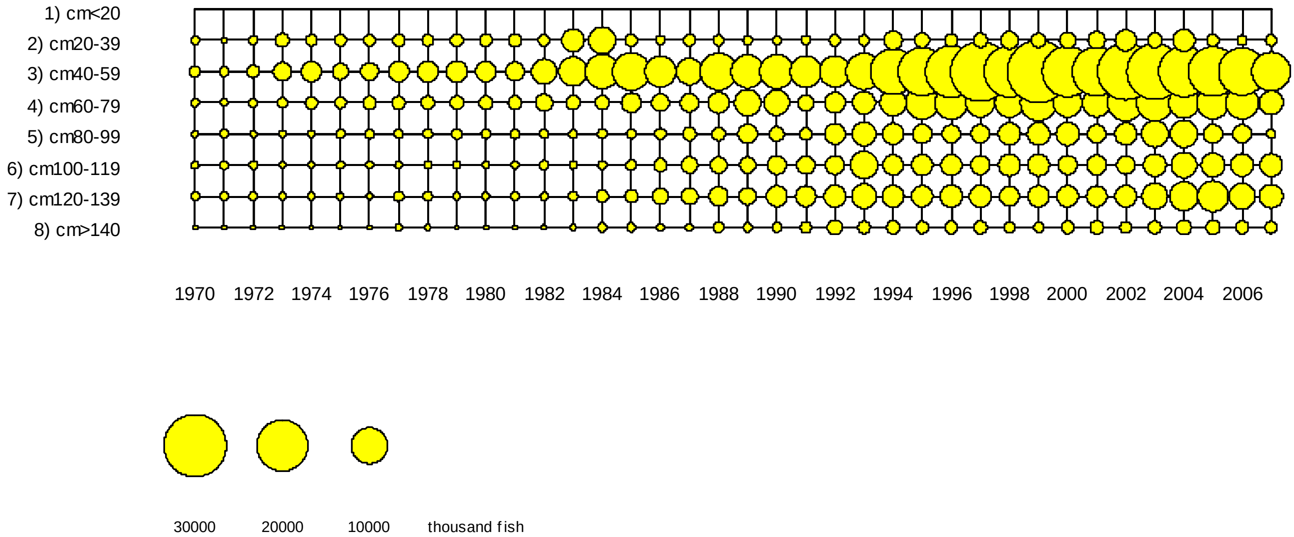


***Figure 4.** Yellowfin tuna: mean catches at size in the Indian Ocean from 1970 to 2007*

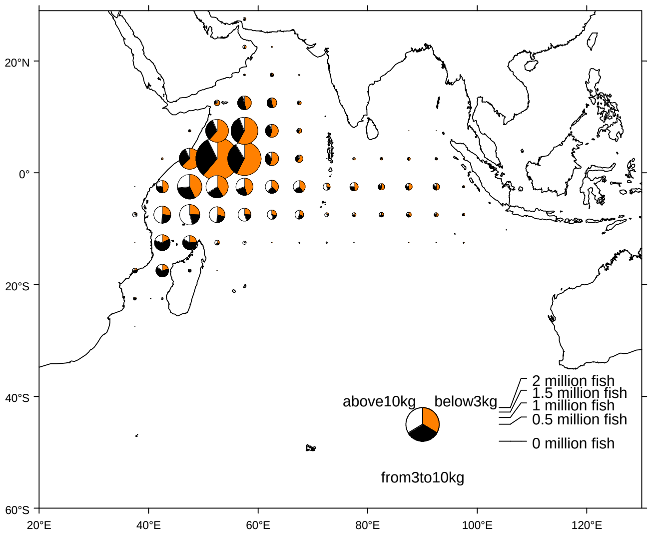


***Figure 5.** Yellowfin tuna: location of catches of small (<3 kg) medium (3-10 kg) and large (>10 kg) sized fish taken by purse seiners from 1997 to 2006.(to be updated)*

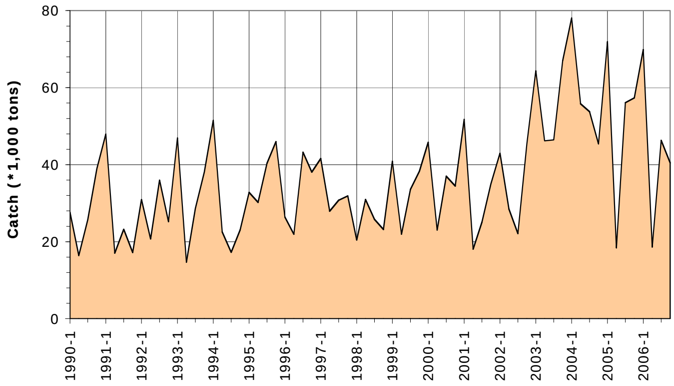


***Figure 6.** Yellowfin tuna: quarterly catches by purse seiners in the Indian Oceans over the period 1999 to 2005 (to be updated)*

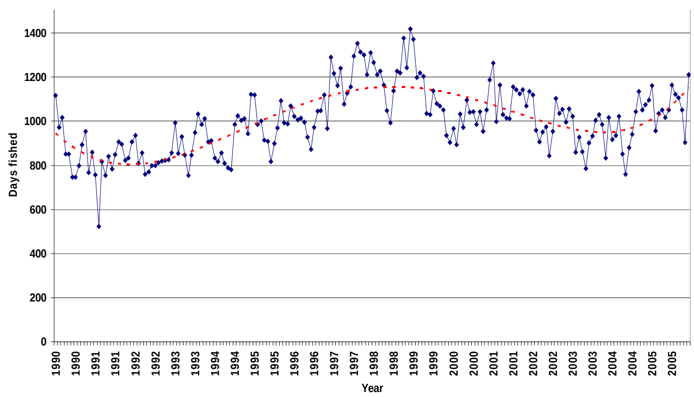


***Figure 7.** Amount of effort (boat days per month) exerted by the EU purse seine fleet in the Indian Ocean.(to be updated)*

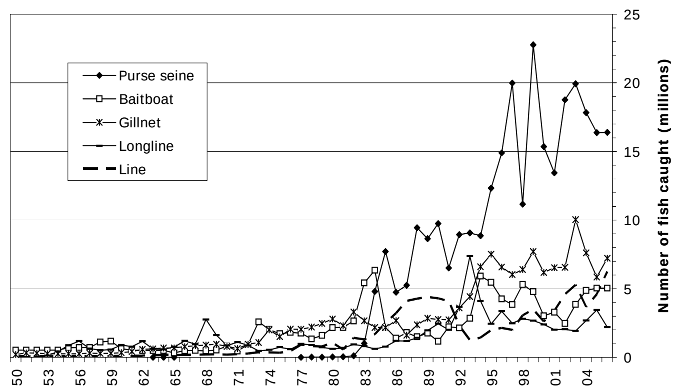


***Figure 8.** Numbers of yellowfin caught by gear-type.*
Data as of July 2007 (to be updated)

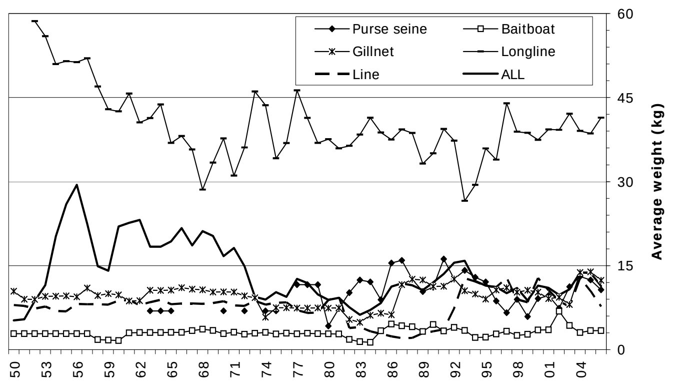


***Figure 9.** Mean weight (kg) of yellowfin individuals in the catch by gear and for all gear-types (estimated from the total catch at size). PS: purse seine, BB: bait boat, LL: longline, GIL: gillnet, OTH: other. Data as of July 2007 to be updated)*

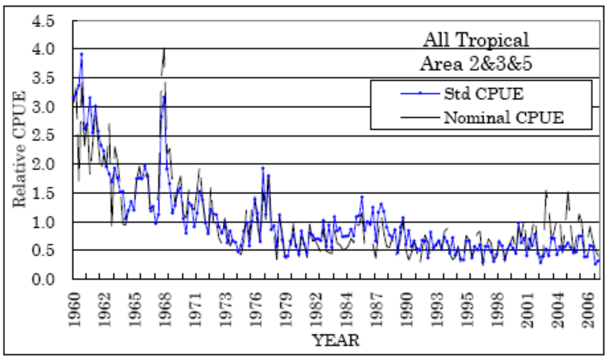


Figure 10. Nominal and Standardised CPUE for the Japanese longline fishery catching yellowfin tuna

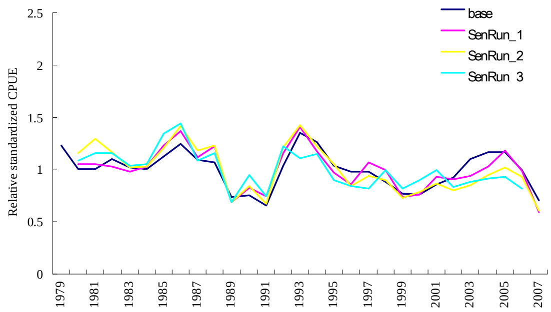


Figure 11. Standardised CPUE for the Taiwanese longline fishery catching yellowfin tuna

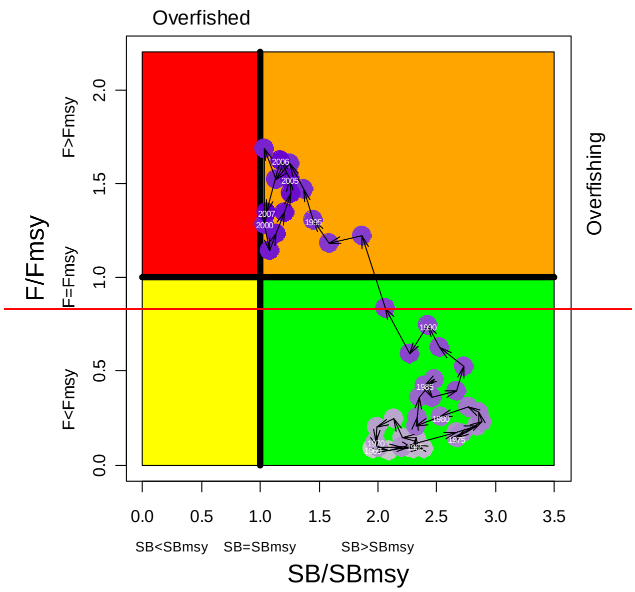


Figure 12. Temporal trend in annual stock status, relative to B_{MSY} (x axis) and F_{MSY} (y axis) reference points. The colour of the points is graduated from mauve (1960) to dark purple (2007) and the points are labelled at 5-year intervals.