Executive Summary Of The Status Of The Bigeye Tuna Resource

(11 November 2005)

Draft changes reflecting the revised BET stock assessment by the Working Party on Tropical Tunas in 2006 and minor editing are shown for the consideration of the SC in Nov06

BIOLOGY

Bigeye tuna inhabit the tropical and subtropical waters of the Pacific, Atlantic and Indian Oceans. It ~~is a tropical tuna species~~ lives~~ing~~ in ~~surface~~ waters down to ~~about~~ around 300 m~~ depth or more~~. Juveniles ~~of this species~~ frequently school at the surface underneath floating objects in single-species groups or in aggregations with yellowfin and skipjack tunas. Association with floating objects appears less common as ~~they~~ bigeye grow older.

Currently a single bigeye stock is assumed for the Indian Ocean, based on circumstantial evidence. The range of the stock (as indicated by the distribution of catches) includes tropical areas, where reproductively active individuals are found, and temperate waters, usually considered to be feeding grounds.

Of the three tropical tuna species, bigeye tuna lives the longest (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 long and over 200 kg and ~~Bigeye tuna~~ start reproducing when they are approximately three years old, at a length of about 100 cm.

~~FISHERY~~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 ~~119,000~~123,000 t over the period 2001~~0~~ to 2005~~4~~. 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 ~~has~~ increased steadily ~~since~~ from the 1950's~~, with~~ to~~catches~~ reaching ~~around~~ 100,000 t ~~over~~ in 1993 and around 140,000–150,000 t for a short period from 1997-1999.~~the period 1996-2000~~ (Figure 1). ~~The recent drop in total catches directly reflects lower catches in the longline fishery. In 2003 and 2004, the longline catches were 87,500 t and 82,300 t, respectively. Japan, Indonesia and~~ Taiwan,China ~~are~~ is the major longline fleet~~s~~ 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 3). ~~More recently (s~~Since the early 1990s~~)~~ bigeye tunas have 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 ~~have~~ has averaged around 25,~~600~~ 000 t in recent years (2001~~0~~-2005) (Table 1). Forty to sixty boats have operated in this fishery since 1984. Most of the bigeye ~~catches~~ captured ~~reported under~~by purse seiners are juveniles (~~under~~ averaging around 5~~10~~ kg) (Figure 3) and while p~~, and this results in p~~urse seiners take much lower tonnages of bigeye compared to longliners (Figure 1), they tak~~ing a~~e larger numbers of individual fish ~~than longliners~~ (Figure 4). ~~Large bigeye tuna (above 30 kg) are primarily caught by longlines, and in particular deep longliners (Figure 3).~~

~~In~~ 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 1 and 2).~~ Catches of bigeye decreased in 2000 and 2001 relative to earlier years, in the eastern and western parts of the Indian Ocean, but increased in recent years in the western Indian Ocean~~. The relative increase in catches in the eastern Indian Ocean in the late 1990's was~~is~~ 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.

~~An important part of the longline catch is taken by longliners from non-reporting flags (see Table 1). The Commission has initiated sampling programmes in various ports in the Indian Ocean to better estimate catches from this component.~~

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.

Information on biological parameters is scarce and improvements are needed in particular concerning natural mortality. The large-scale tagging programme to be initiated soon is oriented towards improving knowledge of this and other biological characteristics. A new growth curve was presented in 2003 which was considered to be an important improvement over previously existing information.

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 5).

For the longline fishery, the Japanese longline CPUE (1960 to 2004) for 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. The CPUE index generally declined from 1960 until 2002 (except for markedly higher indices in 1977 and 1978). Indices in 2003 and 2004 were higher than the historical low in 2002 (Figure 5). In 2006 a new analysis of the Taiwanese longline CPUE data was also presented. The index from the Taiwanese fleet shows a variable but generally decreasing trend, similar to that of the Japanese fleet (Figure 5). The WPTT recalled that in previous years there were major differences in the regression models and the trends of the respective Japanese and Taiwanese CPUE indices but it was not still not clear why there was such agreement in the latest results. The WPTT concluded that the relationship between the CPUE indices from the Japanese and Taiwanese longline fisheries is poorly understood and that more work is needed to investigate this. For example, the changes in the trend for the last few years on the Taiwanese index appeared to be influenced to a great extent by the standardisation procedure. In the meantime, the WPTT decided that the Japanese LL index was to be used in the 2006 bigeye stock assessment.

~~One of the major difficulties faced in the bigeye tuna stock assessment was related to the divergent trends observed since the early nineties between Japanese and Taiwanese CPUEs. While the Japanese CPUE has shown a steady decline in the past ten years, the Taiwanese CPUE has been relatively stable but shows a substantial increase in the last two years.~~

~~These diverging trends have occurred at the same time as changes in the species composition in the catch of the two fleets. In their main equatorial fishing grounds where bigeye is fished, the two fleets have obtained similar species composition of their catches until the early nineties. However, it can be noted that since 1993, the Japanese longliners have been showing catches dominated by yellowfin (60% during recent years in the area), while catches by Taiwanese longliners in this area are now widely dominated by bigeye (about 70% of their catch in the area). This divergence between CPUEs and species composition of catches taken simultaneously in the same areas by the two fleets could be due, either to statistical problems, or to changes in the targeting by one of the two fleets (or by both fleets) that are currently not accounted for in the CPUE standardization. The trend of the Japanese CPUE was assumed to be a better representation of the true biomass trends, but this assumption remains questionable, as the divergence between the CPUEs of the two fleets is not yet fully understood.~~

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 2004, the WPTT conducted a stock assessment on the basis of the best available information using age-structured production models (ASPM). Maximum sustainable yield (MSY) was estimated to be about 96,000 t (95% CI's: 59,000 - 121,000 t), from the results considered to be the most reliable. The assessment suggests that the population is currently above the MSY level but has been declining since the late 1980s (Figure 6). The overall fishing mortality is estimated to be currently that expected at the MSY level, but recent catches, although declining in two of the past three years, have continued to exceed the estimated MSY and therefore they do not appear sustainable. This apparent paradox can be explained by noting that, according to the results of the assessment, the current biomass is above the biomass at MSY. In this case, even a fishing mortality rate less than that at MSY can produce a catch which is greater than MSY, at least temporarily. However, it should also be noted that considerable uncertainty remains around the estimates of current fishing mortality and the estimated fishing mortality at MSY (Figure 11).

The present situation is linked to the rapid increase in both fishing mortality and catches over the last ten years. If current catches are maintained, the population will fall soon to levels below those of MSY.

The recruitment parameters estimated by the model suggest a very weak dependency of the recruitments on the spawning biomass level. However, those parameters are considered to be poorly estimated. In 2004, the WPTT conducted forward projections for the period 2003-2013 on the basis of the results of the ASPM assessment (using Japanese(1960-2002) CPUE in the whole Indian Ocean), assuming three different scenarios:

- A constant catch scenario, where the catches are maintained at 2002 levels throughout the projected period.
- A constant fishing mortality (F) scenario, in which the fishing mortality is assumed to remain constant at the levels estimated for 1999.
- An increasing fishing mortality scenario, in which fishing mortality is assumed to continue to increase at a rate of 6 % per year during the projected period.

These projections are presented in Figures 7, 8 and 9.

The constant catch scenario predicts the continued steady decline of both the spawning stock and the total biomass, indicating that the current catches are not sustainable (Figure 7).

Projections under the constant F scenario indicate that the spawning stock and the total biomasses would reach an equilibrium at the MSY level by around 2008 (Figure 8). This is a direct consequence of the assumed fishing mortality for the projected period that has been estimated to be exactly the fishing mortality level that would produce MSY.

Projections assuming an increasing F at an annual rate of 6 % are similar to those achieved under the constant catch scenario, i.e., a continued steady decline of both the spawning stock biomass and the total biomass (Figure 9). Of particular concern is the predicted reduction by the year 2013 of the spawning stock biomass to below 20 % of its virgin level, a value that is often considered as a limit reference point.

Given that the current assessment suggests that recruitment is almost independent of spawning stock biomass, the results of the projections reflect mostly yield-per-recruit effects, which could also be evaluated using a multi-gear yield-per-recruit analysis such as the one depicted in Figure 10. This figure illustrates the changes in long-term yield-per-recruit that arise from changes in the fishing mortalities (relative to the current fishing mortality) of the two major fishing gears that exploit bigeye tuna. This calculation was done on the basis of the results and assumptions on input values from the 2003 assessment.

A number of uncertainties in the assessments and the projections conducted have been identified. These uncertainties include:

- Uncertainty about how well the model structure used in the assessment approximates 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.
- Uncertainty about the procedure utilized in converting the catch-at-size to 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.
- There are uncertainties concerning the available indices of abundance as they provide contradictory information about recent trends in the population.

Although there is scope for improvement in the current assessment, it is unlikely that these uncertainties will be substantially reduced for the next assessment cycle.

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

Given the range of the estimates of MSY from the five models (111,195 to 137,427 t) and that the mean annual catch for the period 2001-2005 was 130,000 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 6).

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 7). 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 8).

Projections

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 9). 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 10).

Yield per recruit analysis

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 2000-02 pattern, up to 2.22 kg if the 2004 pattern of exploitation were to be retained.

Uncertainty in the 2006 assessment

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.

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 fishery..

MANAGEMENT ADVICE

The results of the stock assessments conducted in 2006 were broadly similar and, in general, were more optimistic than previous ones. These 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 results of further assessments of the bigeye tuna stock using age-structured production models presented in 2004 to the WPTT are more pessimistic than previous assessments.~~

~~The Scientific Committee had already noted with concern the rapid increase of catches of bigeye tuna at its meeting in 1999. Since then, catches have decreased for two of the past three years. Nevertheless, taking into account the results of the current assessment, which represents the best effort to date to analyse the available data in a formal context, it is likely that current catches are still above MSY and it is possible that fishing effort has exceeded the effort that would produce MSY.~~

~~The current level in catch in numbers of juvenile bigeye tuna by purse seiners fishing on floating objects is likely to be detrimental to the stock if it continues, as fish of these sizes are well below the optimum size for maximum yield per recruit.~~

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.

~~The Committee recommends that a reduction in catches of bigeye tuna from all gears, eventually to the level of MSY, be started as soon as possible and that fishing effort should be reduced or, at least, it should not increase further.~~In view of the most current assessment, the SC recommended that catches and fishing effort should not increase further.

BIGEYE TUNA SUMMARY

Maximum Sustainable Yield :	~~96,000~~111,200 t (95,000 – 128,000)
Current (~~2004~~2005) Catch:	~~106,000~~112,400 t
Mean catch over the last 5 years (200~~0~~1-200~~4~~5)	~~118,800~~122,800 t
Current Replacement Yield	-
Relative Biomass (SSB200~~0~~4/SSBMSY)	~~1.31~~1.34 (1.04 – 1.64)
Relative Fishing Mortality (F200~~0~~4/FMSY)	~~1.00~~0.81 (0.54 – 1.08)
90% CI in brackets~~Management Measures in Effect~~	~~none~~

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 2003.

***Table 1**. Catches of bigeye tuna by gear and main fleets for the period ~~1955~~1956-~~2004~~ 2005 (in thousands of tonnes). Data as of 9 October 2006.*

Gear	Fleet	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82
Purse seine	France																										0.0	0.0
	Other Fleets																							0.0	0.0	0.0	0.0	0.1
	Total																							0.0	0.0	0.0	0.0	0.1
Longline	Taiwan,China	0.6	0.9	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
	Indonesia																		0.0	0.2	0.4	0.3	0.3	0.4	0.4	0.5	0.5	0.8
	Japan	12.2	11.1	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
	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
	Other Fleets									0.2	0.4	0.4	0.1	1.9	0.5	1.6	1.3	1.2	0.9	0.5	0.2	0.1	0.2	0.2	0.0	0.2	0.3	0.3
	Total	12.8	12.0	11.7	9.9	16.1	15.0	18.5	13.3	18.0	19.5	24.1	24.8	39.5	30.4	27.7	23.0	20.0	17.4	28.3	37.7	28.5	35.9	50.5	33.5	34.9	34.8	43.4
All	Total	12.8	12.0	11.7	9.9	16.1	15.0	18.5	13.3	18.0	19.5	24.1	24.8	39.5	30.4	27.8	23.0	20.1	17.5	28.5	37.8	28.7	36.1	50.7	33.6	35.0	35.1	43.6

Gear	Fleet	Av01/05	Av56/05	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05
Purse seine	Spain	9.2	3.4		0.8	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
	France	6.1	2.6	0.2	2.3	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
	Seychelles	3.8	0.5									0.0	0.0					0.9	2.0	3.0	1.8	2.8	3.7	3.4	4.4	4.8
	NEI-Other	2.2	1.1	0.0	0.5	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
	NEI-Ex-Soviet Union	2.1	0.5								0.0		0.4	1.0	0.3	1.3	1.1	1.2	1.9	3.9	2.9	2.9	2.2	2.4	2.2	1.0
	Other Fleets	1.3	0.8	0.3	0.5	0.9	0.7	0.7	1.2	2.0	2.2	2.6	2.5	2.6	4.8	4.2	1.7	2.0	1.6	1.7	1.3	1.6	0.9	0.9	0.7	2.6
	Total	24.8	8.9	0.6	4.0	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	22.9	22.6	25.7
Longline	Taiwan,China	49.9	16.6	11.3	10.9	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
	Indonesia	15.9	5.5	1.9	2.4	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	10.9	9.3
	Japan	11.8	12.3	18.3	14.0	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	14.0	9.9	10.9	10.9
	China	5.5	0.8													0.2	0.5	1.7	2.3	2.4	2.8	3.1	2.8	4.6	8.3	8.9
	NEI-Deep-freezing	4.6	2.9			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	16.5	15.5	13.8	6.4	6.4	5.0	2.7	2.7
	Seychelles	3.9	0.4	0.0	0.1	0.1									0.0	0.0	0.1	0.0	0.1	0.1	0.5	1.0	2.2	3.7	7.0	5.5
	Korea, Republic of	1.6	8.2	17.4	11.7	12.8	11.9	14.4	17.1	12.2	10.7	2.3	4.8	5.3	8.5	6.4	11.3	10.6	3.4	1.4	3.4	1.5	0.2	1.2	2.5	2.6
	NEI-Fresh Tuna	0.8	1.0							1.9	2.6	2.3	2.6	2.9	4.6	3.8	4.3	5.3	4.7	4.8	4.6	0.2	0.4	0.5	1.2	1.7
	NEI-Indonesia Fresh Tuna		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	2.5	0.7	0.5	0.6	0.0	0.4	0.3	0.3	0.1	0.0	0.1	0.3	1.5	1.4	1.2	0.2	0.2	1.9	2.8	2.4	1.9	2.1	3.0	2.1	3.6
	Total	96.5	49.8	49.5	39.7	44.9	46.7	51.2	57.1	56.7	60.5	60.8	60.2	85.4	90.6	89.8	101.5	112.4	112.1	108.6	98.4	90.3	104.6	99.8	102.5	85.4
All	Total	122.5	59.1	50.3	44.1	52.4	57.8	65.0	72.4	69.0	73.5	77.0	71.9	102.0	110.2	119.4	126.9	147.3	141.4	150.5	128.9	115.0	134.9	124.0	126.4	112.4

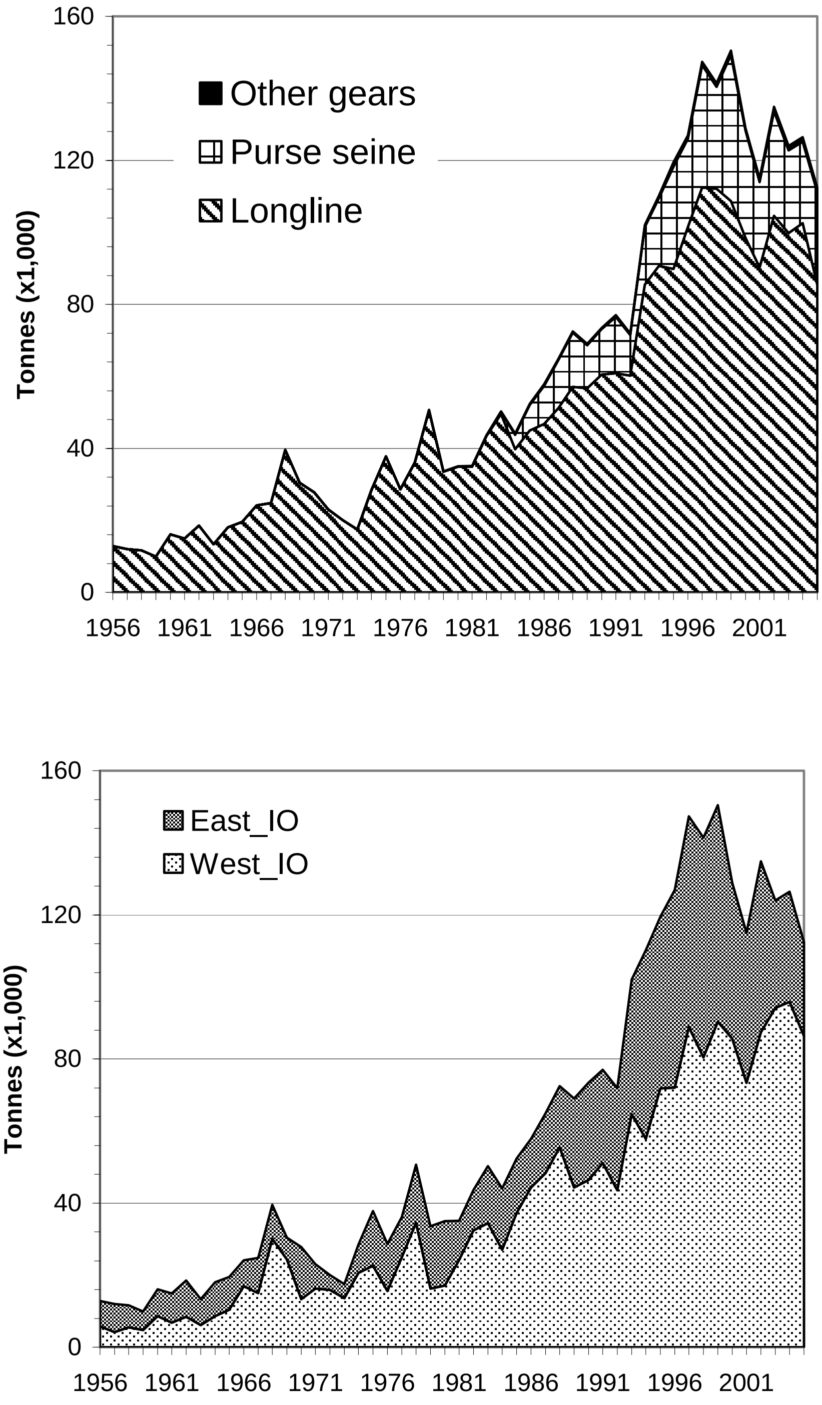


Figure 1. *Yearly catches (thousand of metric tonnes) of bigeye tuna by gear from 1956~~5~~ to 2005~~4~~ (left) and by area (Eastern and Western Indian Ocean, right). Data as of October 2006*

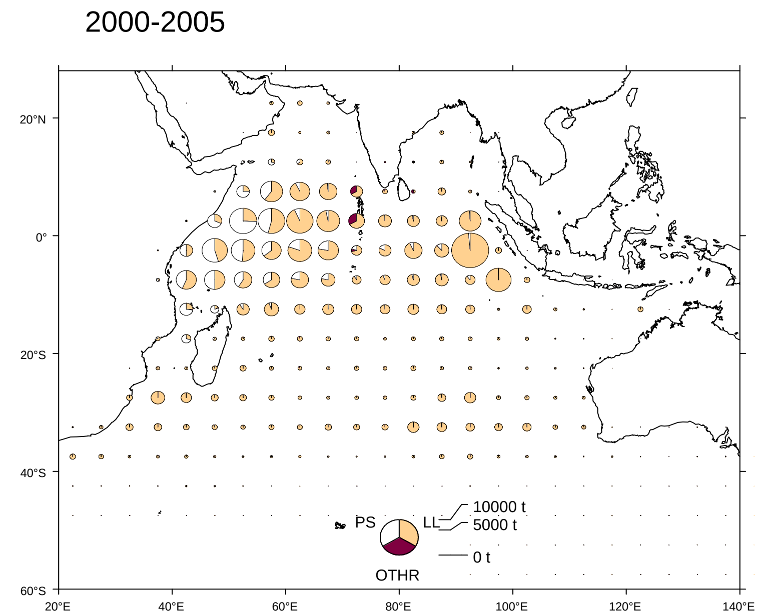


Figure 2. *Mean of annual total catches of bigeye tuna (t) by longline and purse seine vessels operating in the Indian Ocean over the period 2000 to ~~2003~~2005.* *Data as of October 2006*

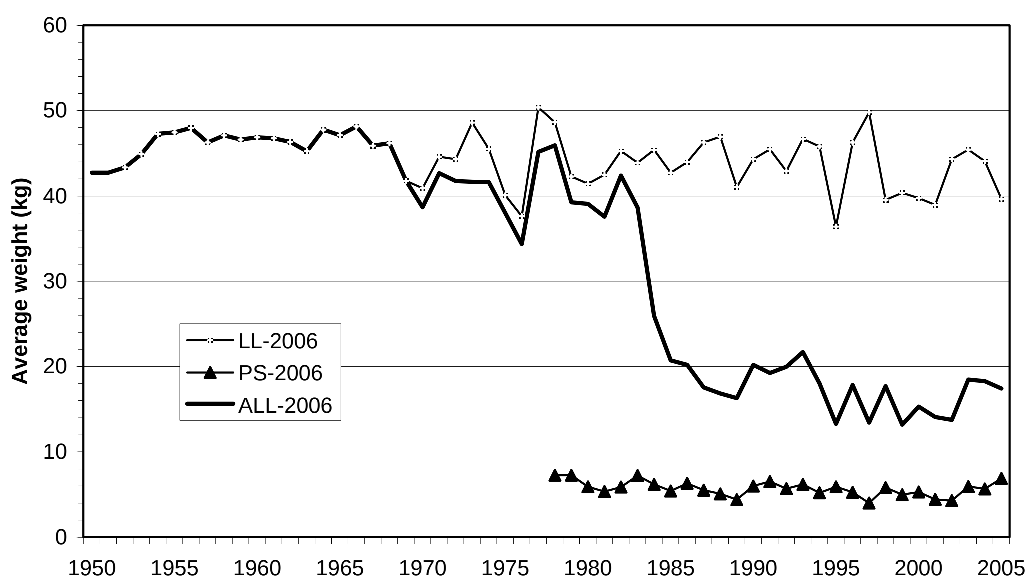


Figure 3. *Mean weight of bigeye measured from purse seine (PS) and longline (LL) catches over time.* *Data as of July 2006*

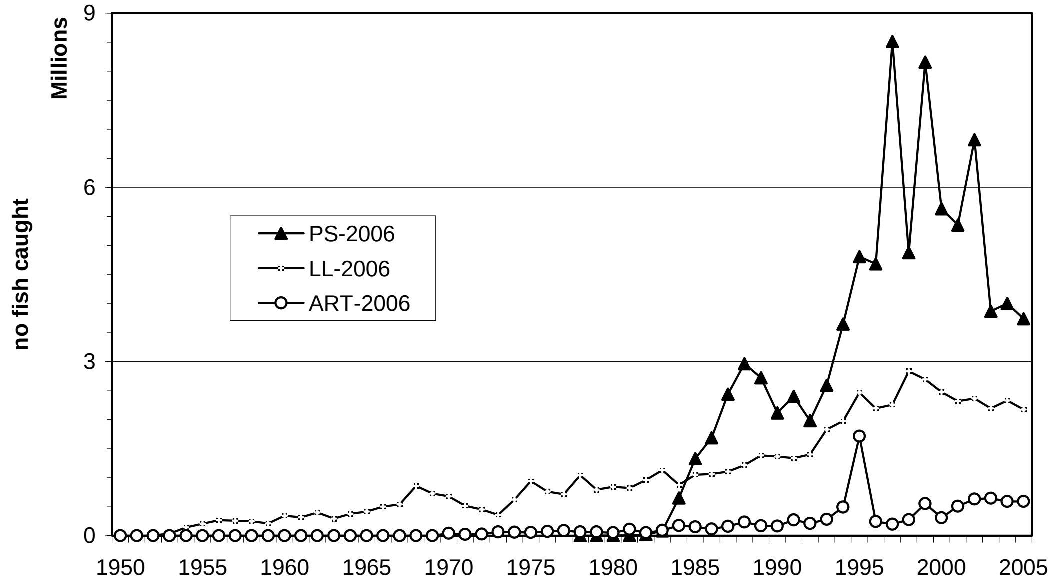


Figure 4. Catch in numbers of bigeye tuna by gear (PS: purse seine; LL: longline). *Data as of July 2006*

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)

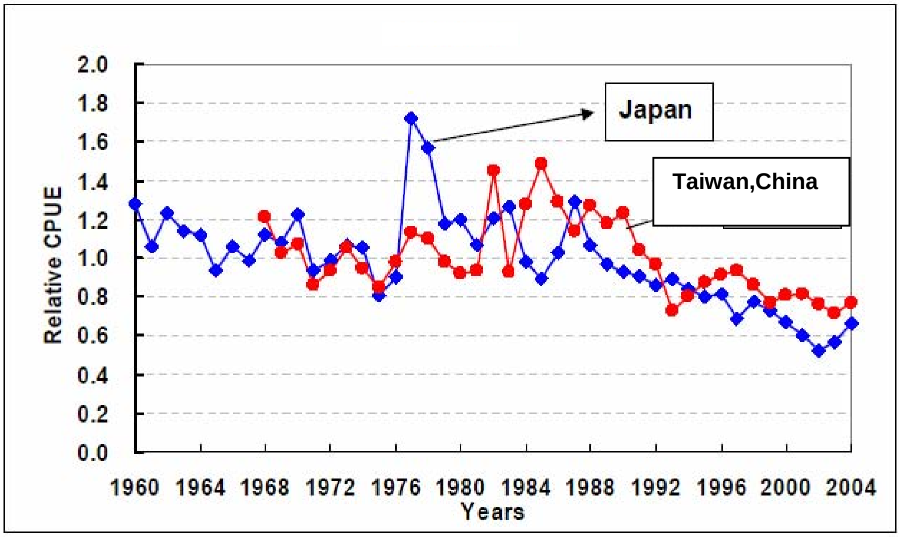


Figure 5. *~~-~~ Standardised CPUE indices for the Japanese and Taiwanese longline fleets in the Indian Ocean tropical waters~~Standardised bigeye tuna CPUE estimates by area.~~*

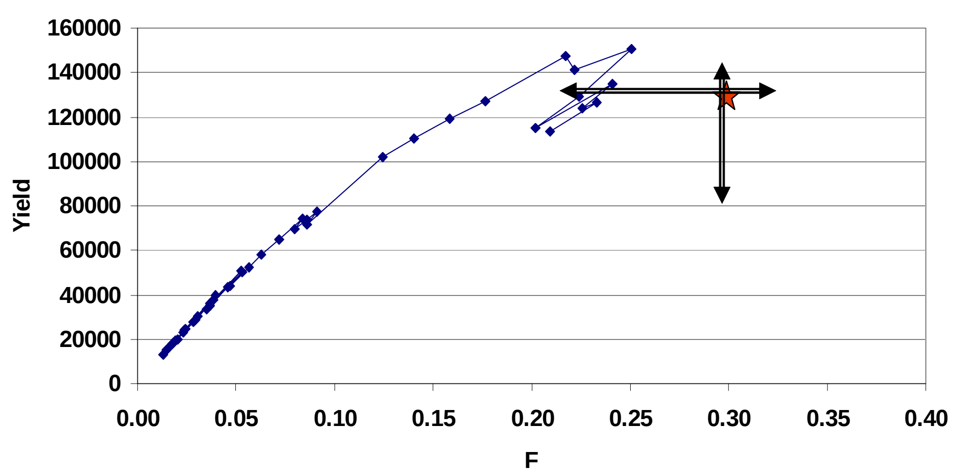


Figure 6. *2006 bigeye tuna stock assessment: Plot of annual bigeye tuna catches as a function of mean fishing mortality derived from the ASPIC model. The star represents MSY and the arrowed lines represent the associated uncertainty (source A. Fonteneau).*

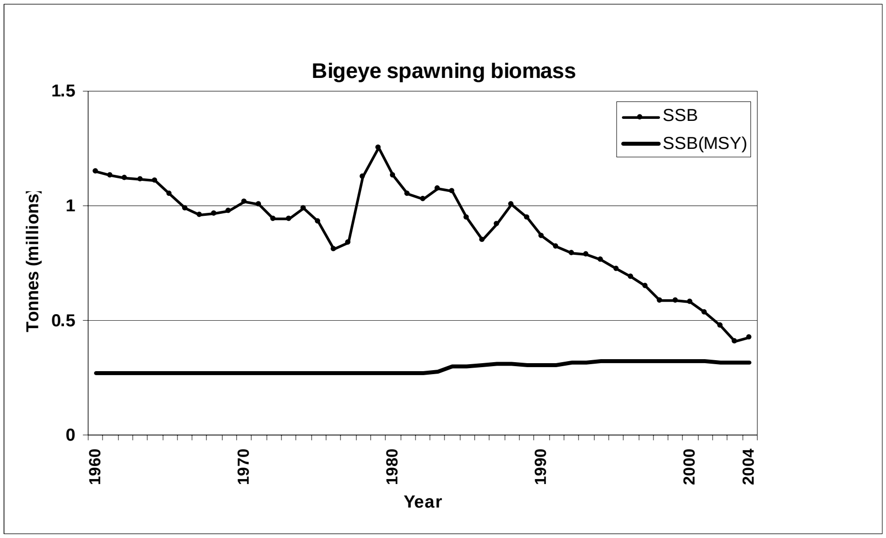


Figure 7. *2006 bigeye tuna stock assessment (ASPM): Spawning stock trajectories relating estimates of annual spawning stock size and the estimated maximum sustainable yield of the spawning stock biomass.*

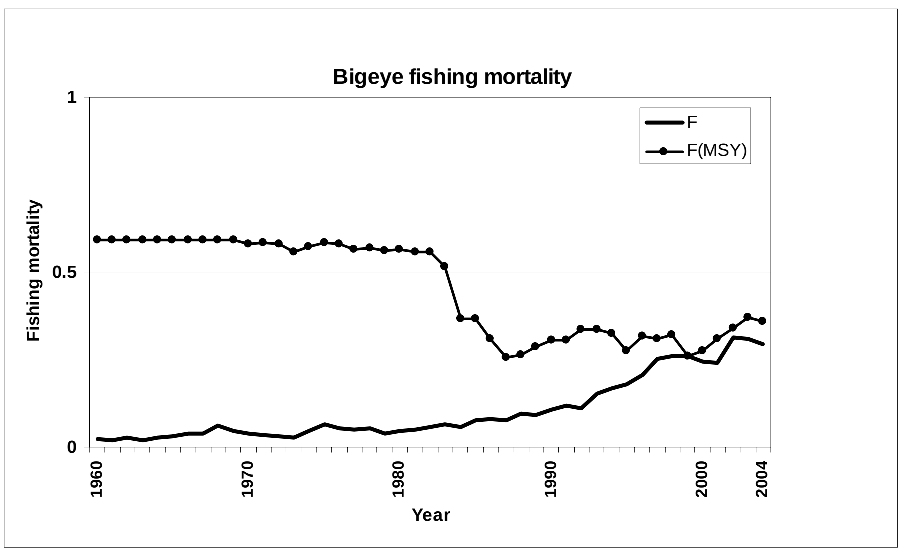


Figure 8. *2006 bigeye tuna stock assessment (ASPM): Fishing mortality trajectories relating estimates of annual fishing mortality and the estimated maximum sustainable level of fishing mortality.*

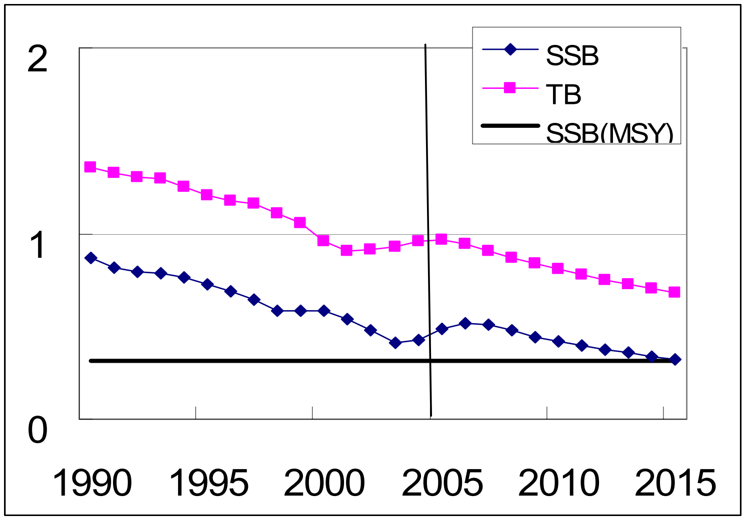
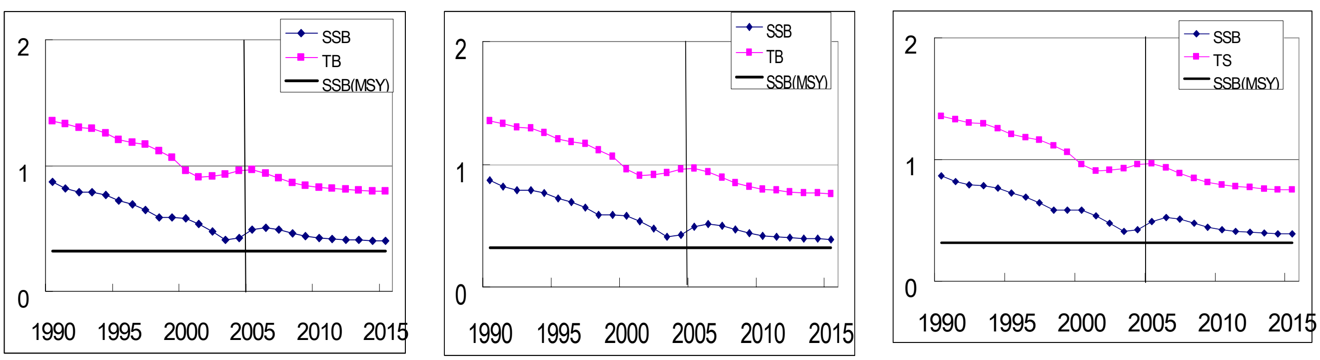


Figure 9. *2006 bigeye tuna stock assessment: Forward projections from the ASPM model illustrating trends in total biomass and spawning biomass for bigeye tuna in the Indian Ocean if catches were maintained at the 2004 level.*



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

Figure 10. *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.*