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Indian Ocean Tuna Commission
Commission des Thons de l'Océan Indien

SEVENTH SESSION OF THE SCIENTIFIC COMMITTEE

MAHÉ, SEYCHELLES, 8-12 NOVEMBER 2004

EXECUTIVE SUMMARY OF THE STATUS OF THE BIGEYE TUNA RESOURCE

BIOLOGY

Bigeye tuna is a tropical tuna species living in surface waters down to about 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 grow older.

Currently a single 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 tuna start reproducing when they are approximately three years old, at a length of about 100cm.

FISHERY

Bigeye tuna is predominantly caught by industrial fisheries and appears only occasionally in the catches of artisanal fisheries. 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 the 1950's, with catches exceeding 100,000 in the period 1996-2000 (Figure 1). In 2003 the longline catch was 115,000 t. Japan, Indonesia and Taiwan,China are the major longline fleets fishing for bigeye (Table 1). More recently (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 in 2003 was 23,000 t, down from 29,000 t in 2002 (Table 1). Forty to sixty boats have operated in this fishery since 1984. Most of the bigeye catches reported under purse seiners are juveniles (under 10 kg) (Figure 3), and this results in purse seiners taking a 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 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 increase in catches in the eastern Indian Ocean 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). 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.

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.

MANAGEMENT ADVICE

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.

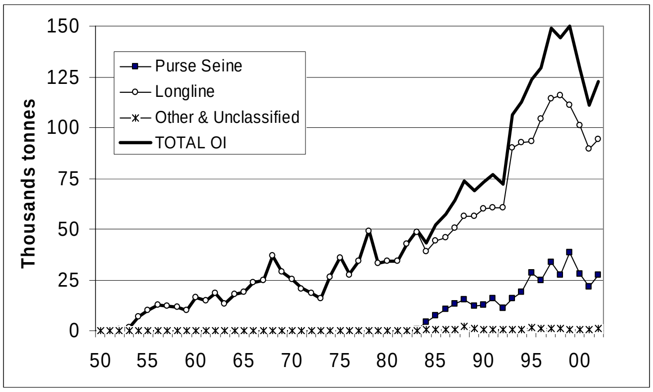
BIGEYE TUNA SUMMARY

Maximum Sustainable Yield :	96,000 t (59,000 - 121,000 t)
Current (2003) Catch:	139,300 t
Mean catch over the last 5 years	133,000 t
Current Replacement Yield	-
Relative Biomass (B_{2000}/B_{msy})	1.31
Relative Fishing Mortality (F_{2000}/F_{MSY})	1.00
Management Measures in Effect	none

Table 1. Catches of bigeye tuna by gear and main fleets for the period 1954-2003 (in thousands of tonnes). Data as of 20 November 2004.

Gear	Fleet	Av99/03	Av54/03	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78
Purse seine	Other Fleets	1.2	0.7																									0.0
	Total	29.3	8.0																									0.0
Baitboat	Total	1.0	0.3																	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1
Longline	China																											
	Taiwan,China	42.3	14.3	0.1	0.2	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
	Indonesia	25.0	5.4																				0.0	0.2	0.4	0.3	0.3	0.4
	Japan	13.0	12.2	6.8	9.5	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
	Republic of Korea,	1.5	8.1										0.2	0.2	0.5	6.8	7.6	3.5	4.8	4.9	7.3	14.6	26.1	21.8	26.1	34.1
	Other Fleets	2.4	0.6									0.2	0.4	0.4	0.1	1.9	0.5	1.5	1.3	1.2	0.9	0.5	0.2	0.1	0.2	0.2
	Total	102.7	46.6	6.9	9.7	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	22.9	20.0	17.4	28.3	37.6	28.5	35.9	50.5
Gillnet	Total	0.1	0.1	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
Line	Total	0.1	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
All	Total	133.1	54.9	6.9	9.7	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	20.0	17.5	28.4	37.7	28.7	36.0	50.6

Gear	Fleet	Av99/03	Av54/03	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03
Purse seine	Spain	10.9	3.1						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
	France	6.7	2.3			0.0	0.0	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
	NEI-Other	4.8	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	3.3
	Seychelles	2.9	0.4													0.0	0.0					0.9	2.0	3.0	1.8	2.8	3.7	3.4
	NEI-Ex-Soviet Union	2.8	0.4												0.0		0.4	1.0	0.3	1.4	1.1	1.2	1.9	3.9	2.9	2.9	2.2	2.2
	Other Fleets	1.2	0.7	0.0	0.0	0.0	0.1	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	0.5
	Total	29.3	8.0	0.0	0.0	0.0	0.1	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	24.6	33.9	28.3	40.7	29.9	23.7	29.0	23.3
Baitboat	Total	1.0	0.3	0.1	0.1	0.2	0.1	0.2	0.4	0.3	0.2	0.3	0.3	0.3	0.3	0.5	0.4	0.5	0.5	0.5	0.6	0.5	0.6	1.0	0.6	0.9	1.1	1.1
Longline	China	3.1	0.4																	0.2	0.5	1.7	2.3	2.4	2.8	3.1	2.8	4.6
	Taiwan,China	42.3	14.3	7.4	8.9	6.8	11.3	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	37.0	44.3	56.8
	Indonesia	25.0	5.4	0.4	0.5	0.5	0.8	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	26.3
	Japan	13.0	12.2	4.2	5.9	7.8	11.4	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	13.6	11.1
	NEI-Deep-freezing	10.6	2.9							0.1	1.1	0.9	2.9	2.8	4.4	5.5	3.9	10.5	7.9	9.5	12.4	10.2	18.4	18.0	14.8	8.6	5.7	5.7
	NEI-Fresh Tuna	3.2	1.0											1.9	2.6	2.3	2.6	2.9	4.6	3.6	3.9	5.5	4.4	4.2	4.2	2.3	2.6	2.6
	Republic of Korea	1.5	8.1	21.5	19.3	19.4	19.5	17.4	11.7	12.8	11.8	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
	Seychelles	1.5	0.2					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
	NEI-Indonesia Fresh Tuna	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	2.4	0.6	0.0	0.2	0.3	0.3	0.5	0.6	0.0	0.4	0.3	0.3	0.1	0.0	0.1	0.3	1.4	1.4	1.2	0.2	0.2	1.9	2.8	2.3	1.9	2.1	2.8
	Total	102.7	46.6	33.5	34.8	34.8	43.4	49.5	39.7	44.9	46.7	51.2	57.0	56.6	60.5	60.8	60.3	85.2	90.3	89.4	100.6	112.1	113.7	110.5	98.9	89.6	99.7	114.7
Gillnet	Total	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1	1.9	0.5	0.2	0.1	0.0	0.0	0.1	0.7	0.2	0.3	0.3	0.1	0.0	0.1	0.1	0.1
Line	Total	0.1	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	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.0
All	Total	133.1	54.9	33.6	35.0	35.1	43.6	50.3	44.1	52.4	57.8	65.1	74.3	69.5	73.7	77.1	72.0	101.8	109.9	119.1	126.1	146.9	143.0	152.3	129.4	114.3	130.0	139.3



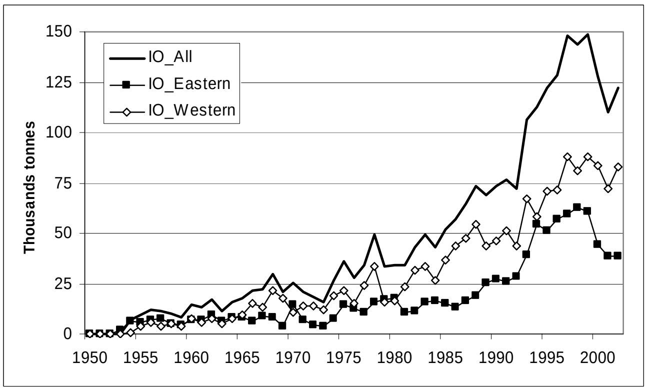


Figure 1. Yearly catches (thousand of metric tonnes) of bigeye tuna by gear from 1950 to 2002 (left) and by area (Eastern and Western Indian Ocean, right)

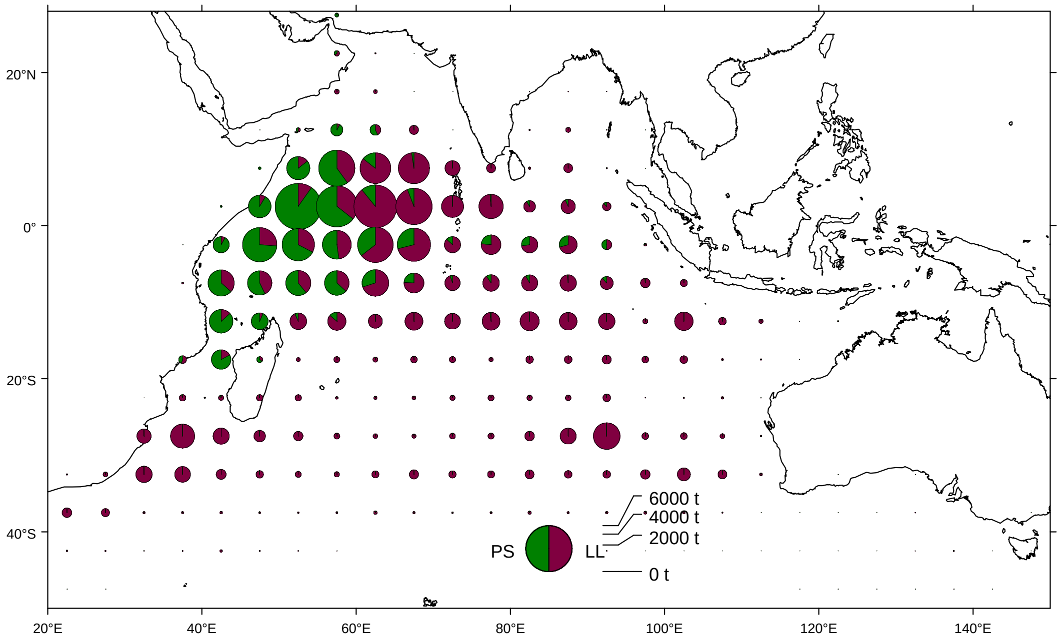


Figure 2. Mean of annual total catches of bigeye tuna (t) by longline (top) and purse seine (bottom) vessels operating in the Indian Ocean over the period 2000 to 2002.

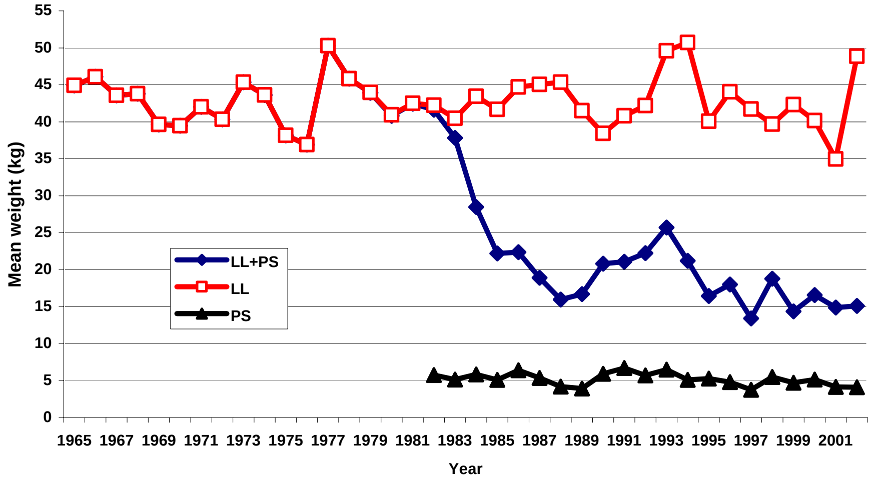


Figure 3. Mean weight of bigeye measured from purse seine (PS) and longline (LL) catches over time.

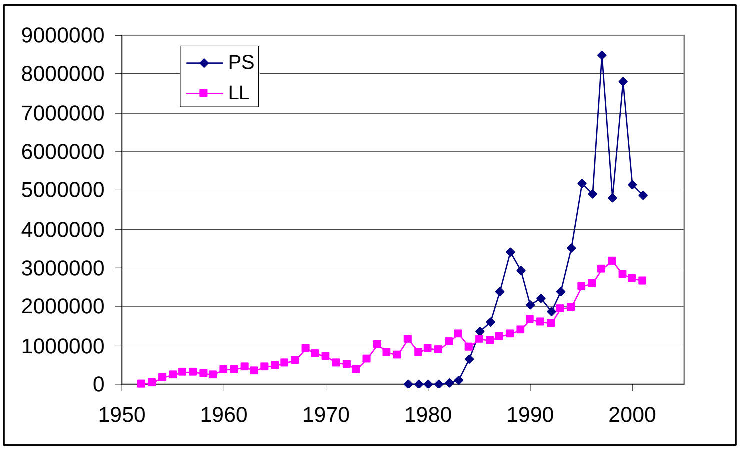


Figure 4. Catch in numbers of bigeye tuna by gear (PS: purse seine; LL: longline).

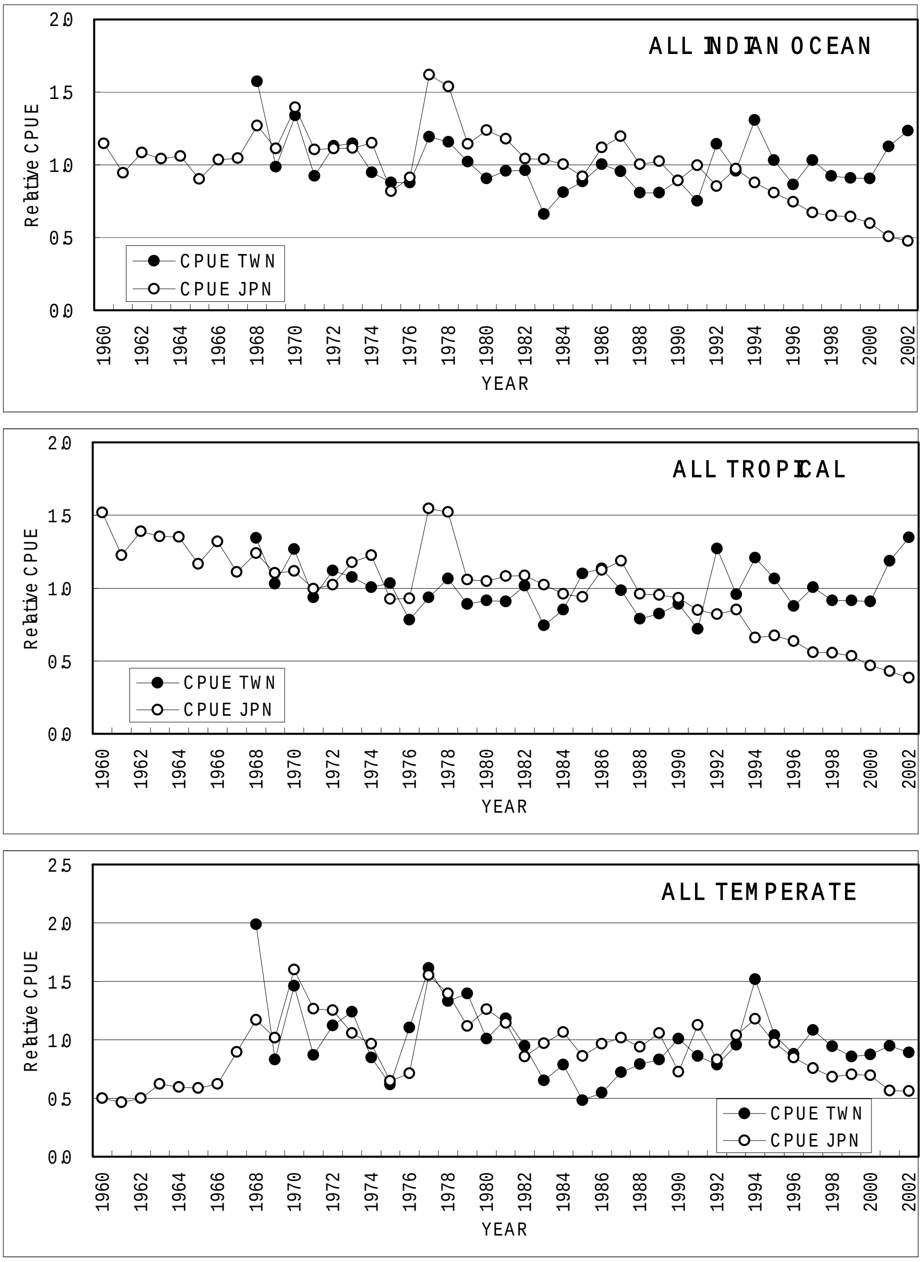


Figure 5. Standardised bigeye tuna CPUE estimates by area.

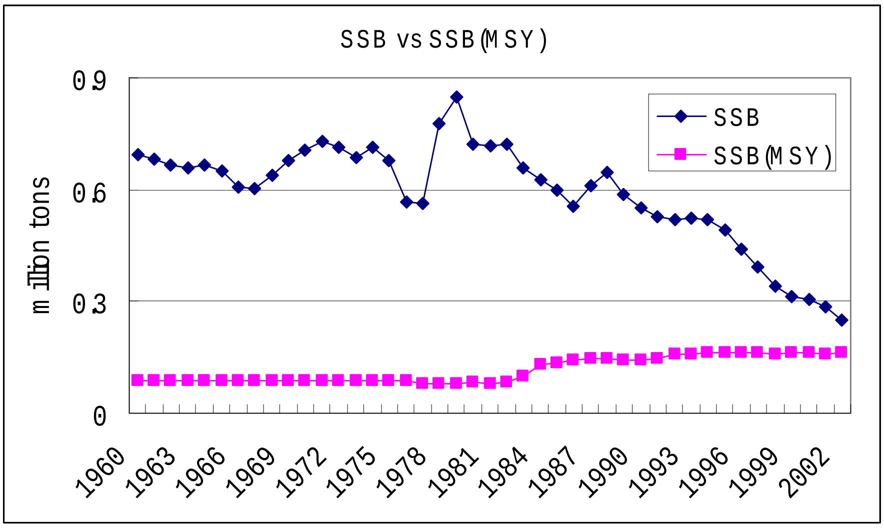


Figure 6. 2004 bigeye stock assessment: spawning biomass trajectories

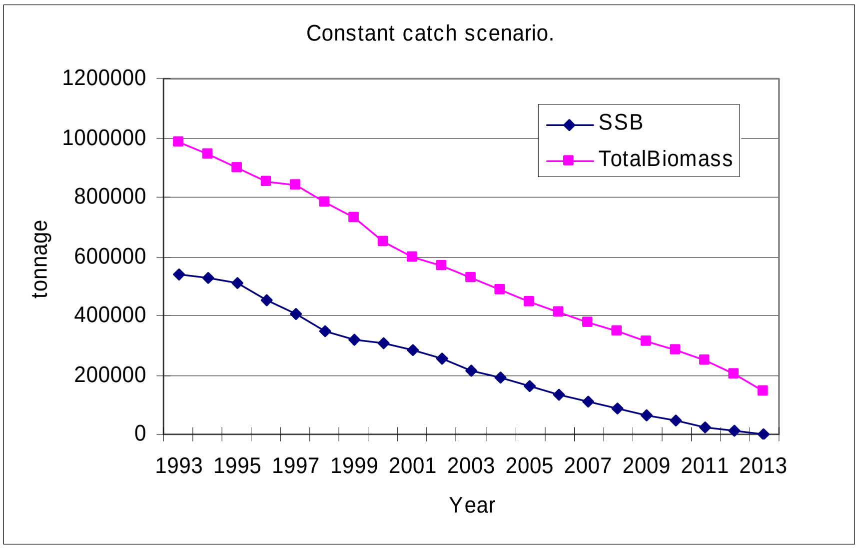


Figure 7. Forward projections. Trends of SSB and TB in current Catch (2002) level.

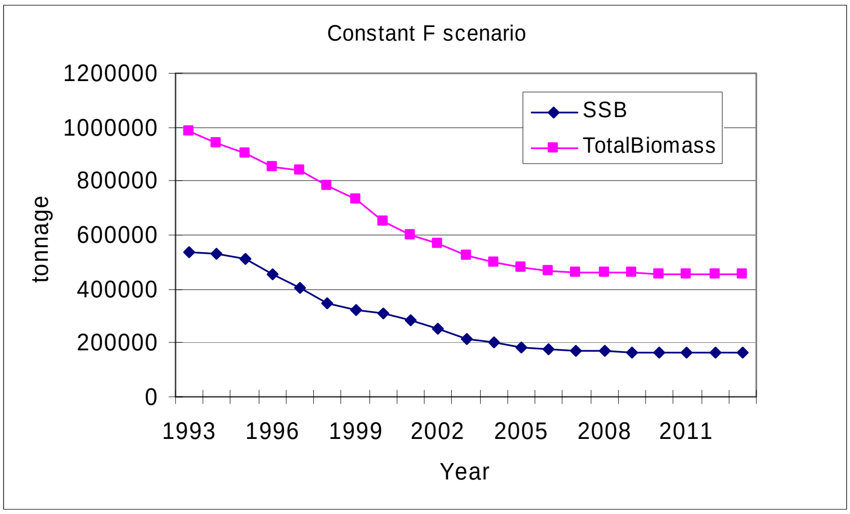


Figure 8. Forward projections. Trends of SSB and TB in current F (2002) level.

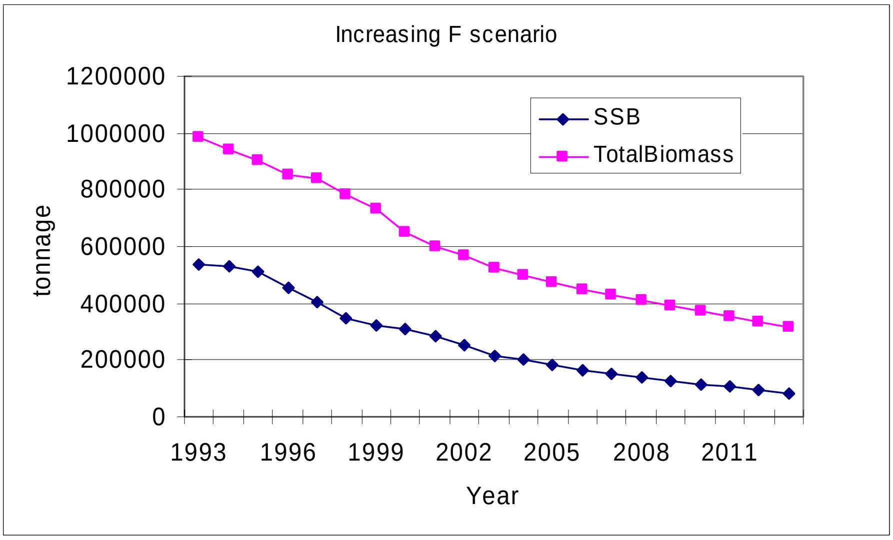


Figure 9. Forward projections. Trends of SSB and TB in increase F (6% per year).

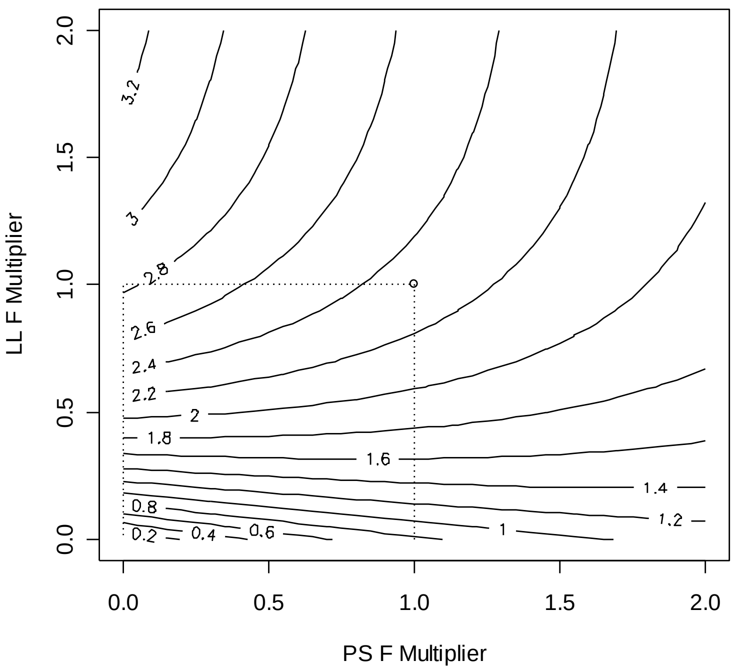


Figure 10. Multi-gear yield-per-recruit calculations, in kg/recruit, with the growth, natural mortality and fishing mortality assumptions from the base case in the ASPM assessment

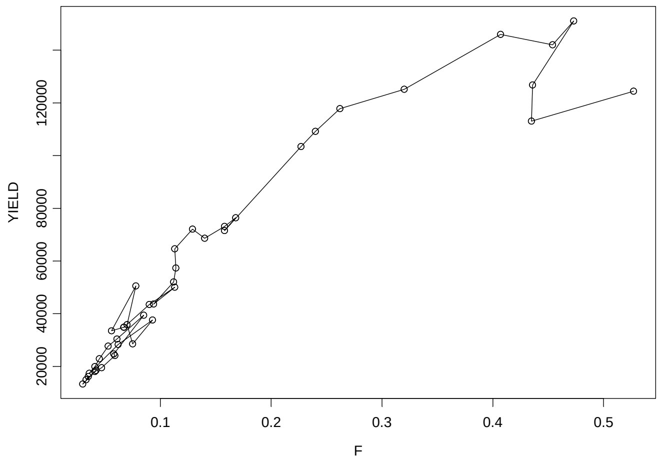


Figure 11. Annual yield (t) as a function of overall fishing mortality as estimated by the most recent assessment.