

EXECUTIVE SUMMARY: STATUS OF THE INDIAN OCEAN BIGEYE TUNA (*THUNNUS OBESUS*) RESOURCE

TABLE 1. Status of bigeye tuna (*Thunnus obesus*) in the Indian Ocean.

Area ¹	Indicators – 2011 assessment			2011 stock status determination
		SS3 ³	ASPM ⁴	2009 ²
Indian Ocean	Catch (1000 t):	102.0 t	71.5 t	
	Average catch last 5 years:	104.7 t	104.7 t	
	MSY (1000 t):	114 (95–183 t)	102.9 t (86.6–119.3 t)	
	F_{curr}/F_{MSY} :	0.79 (0.50–1.22)	0.67 (0.48–0.86)	
	SB_{curr}/SB_{MSY} :	1.20 (0.88–1.68)	1.00 (0.77–1.24)	
	SB_{curr}/SB_0 :	0.34 (0.26–0.40)	0.39	

¹Boundaries for the Indian Ocean stock assessment are defined as the IOTC area of competence.

²The stock status refers to the most recent years' data used for the assessment.

³Central point estimate is adopted from the 2010 SS3 model, percentiles are drawn from a cumulative frequency distribution of MPD values with models weighted as in Table 12 of 2010 WPTT report (IOTC-2010-WPTT12-R); the range represents the 5th and 95th percentiles.

⁴Median point estimate is adopted from the 2011 ASPM model using steepness value of 0.5 (values of 0.6, 0.7 and 0.8 are considered to be as plausible as these values but are not presented for simplification); the range represents the 90 percentile Confidence Interval.

Current period (_{curr}) = 2009 for SS3 and 2010 for ASPM.

Colour key	Stock overfished ($SB_{year}/SB_{MSY} < 1$)	Stock not overfished ($SB_{year}/SB_{MSY} \geq 1$)
Stock subject to overfishing ($F_{year}/F_{MSY} > 1$)		
Stock not subject to overfishing ($F_{year}/F_{MSY} \leq 1$)		

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

The WPTT **RECOMMENDED** the following management advice for bigeye tuna in the Indian Ocean, for the consideration of the Scientific Committee.

Stock status. Both assessments suggest that the stock is above a biomass level that would produce MSY in the long term and that current fishing mortality is below the MSY-based reference level (i.e. $SB_{current}/SB_{MSY} > 1$ and $F_{current}/F_{MSY} < 1$) (Table 1 and Fig. 1). Current spawning stock biomass was estimated to be 34–40 % (Table 1) of the unfished levels. The central tendencies of the stock status results from the WPTT 2011 when using different values of steepness were similar to the central tendencies presented in 2010.

Outlook. The recent declines in longline effort, particularly from the Japanese, Taiwan, China and Republic of Korea longline fleets, as well as purse seiner effort have lowered the pressure on the Indian Ocean bigeye tuna stock, indicating that current fishing mortality would not reduce the population to an overfished state.

Catches in 2010 (71,489 t) were lower than MSY values and catches in 2009 (102,664 t) were at the lower range of MSY estimates. The mean catch over the 2008–2010 period was 93,761 t which is lower than estimated MSY.

The Kobe strategy matrix (Combined SS3 and ASPM) illustrates the levels of risk associated with varying catch levels over time and could be used to inform management actions (Table 2). Based on the ASPM projections this year (2011) with steepness 0.5 value for illustration, there is relatively a low risk of exceeding MSY-based reference points by 2020 both when considering current catches of 71,489 t (maximum of 15% risk of $B < B_{MSY}$) or 2009 catches of 102,664 t (<40% risk that $B_{2020} < B_{MSY}$ and $F_{2020} > F_{MSY}$). Moreover, the SS3 projections from last year (2010) show that there is a low risk of exceeding MSY-based reference points by 2019 if catches are maintained at the lower range of MSY levels or at the catch level of 102,664 t from 2009 (< 30% risk that $B_{2019} < B_{MSY}$ and < 25% risk that $F_{2019} > F_{MSY}$) (Table 1).

The WPTT **RECOMMENDED** that the Scientific Committee consider the following:

- The Maximum Sustainable Yield estimate for the Indian Ocean ranges between 102,000 and 114,000 t (range expressed as the median value for 2010 SS3 and steepness value of 0.5 for 2011 ASPM for illustrative purposes (see Table 1 for further description)). Annual catches of bigeye tuna should not exceed the lower range of this estimated which corresponds to the 2009 catches and last year management advice.
- If the recent declines in effort continue, and catch remains substantially below the estimated MSY of 100,000–114,000 t, then immediate management measures are not required. However, continued monitoring and improvement in data collection, reporting and analysis is required to reduce the uncertainty in assessments.

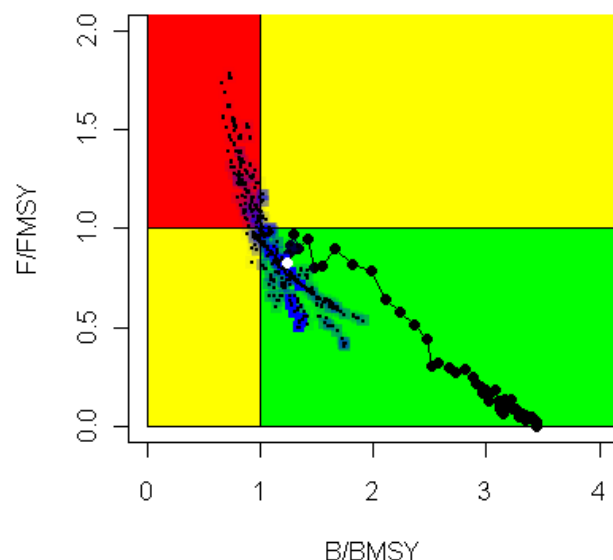


Fig. 1. SS3 Aggregated Indian Ocean assessment Kobe plot. Black circles represent the time series of annual median values from the weighted stock status grid (white circle is 2009). Blue squares indicate the MPD estimates for 2009 corresponding to each individual grid C model, with colour density proportional to the weighting (each model is also indicated by a small black point, as the squares from highly down weighted models are not otherwise visible).

TABLE 2. Bigeye tuna: Combined 2010 SS3 and 2011 ASPM Aggregated Indian Ocean assessment Kobe II Strategy Matrix. Probability (percentage) of violating the MSY-based reference points for five constant catch projections (2009 and 2010 catch levels, $\pm 20\%$ and $\pm 40\%$) projected for 3 and 10 years. K2SM adopted from the 2011 ASPM model using steepness value of 0.5 (values of 0.6, 0.7 and 0.8 are considered to be as plausible as these values but are not presented for simplification).

Reference point and projection timeframe	Alternative catch projections (relative to 2009) and probability (%) of violating reference point				
	2010 SS3				
	60% (61,200 t)	80% (81,600 t)	100% (102,000 t)	120% (122,400 t)	140% (142,800 t)
SB ₂₀₁₂ < SB _{MSY}	19	24	28	40	50
F ₂₀₁₂ > F _{MSY}	<1	<6	22	50	68
SB ₂₀₁₉ < SB _{MSY}	19	24	30	55	73
F ₂₀₁₉ > F _{MSY}	<1	<6	24	58	73
Reference point and projection timeframe	Alternative catch projections (relative to 2010) and probability (%) of violating reference point				
	2011 ASPM				
	60% (42,900t)	80% (57,200t)	100% (71,500t)	120% (85,800t)	140% (100,100t)
SB ₂₀₁₃ < SB _{MSY}	4	8	15	24	35
F ₂₀₁₃ > F _{MSY}	<1	<1	1	8	33
SB ₂₀₂₀ < SB _{MSY}	<1	<1	1	11	41
F ₂₀₂₀ > F _{MSY}	<1	<1	<1	5	38

SUPPORTING INFORMATION

(Information collated from reports of the Working Party on Tropical Tunas and other sources as cited)

CONSERVATION AND MANAGEMENT MEASURES

Bigeye tuna (*Thunnus obesus*) in the Indian Ocean is currently subject to a number of conservation and management measures adopted by the Commission:

- Resolution 08/04 concerning the recording of catch by longline fishing vessels in the IOTC area.
- Resolution 09/02 On the implementation of a limitation of fishing capacity of contracting parties and cooperating non-contracting parties.
- Resolution 10/02 mandatory statistical requirements for IOTC Members and Cooperating non-Contracting Parties (CPC's).
- Resolution 10/03 concerning the recording of catch by fishing vessels in the IOTC area.
- Resolution 10/07 concerning a record of licensed foreign vessels fishing for tunas and swordfish in the IOTC area.
- Resolution 10/08 concerning a record of active vessels fishing for tunas and swordfish in the IOTC area.
- Recommendation 10/13 On the implementation of a ban on discards of skipjack tuna, yellowfin tuna, bigeye tuna, and non targeted species caught by purse seiners.
- Recommendation 11/06 Concerning the Recording of Catch by Fishing Vessels in the IOTC Area of Competence.

FISHERIES INDICATORS

General

Bigeye tuna (*Thunnus obesus*) inhabit the tropical and subtropical waters of the Pacific, Atlantic and Indian Oceans in waters down to around 300 m. Table 3 outlines some of the key life history traits of bigeye tuna relevant for management.

TABLE 3. Biology of Indian Ocean bigeye tuna (*Thunnus obesus*)

Parameter	Description
Range and stock structure	Inhabits 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 rapid and large scale movements of juvenile bigeye tuna in the Indian Ocean, thus supporting the current assumption of a single stock for the Indian Ocean. The average minimum distance between juvenile tag-release-recapture positions is estimated at 657 nautical miles. 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.
Longevity	15 years
Maturity (50%)	Age: females and males 3 years. Size: females and males 100 cm.
Spawning season	Spawning season from December to January and also in June in the eastern Indian Ocean.
Size (length and weight)	Maximum length: 200 cm FL; Maximum weight: 210 kg. Newly recruited fish are primarily caught by the purse seine fishery on floating objects. The sizes exploited in the Indian Ocean range from 30 cm to 180 cm fork length. Smaller fish (juveniles) form mixed schools with skipjack tuna and juvenile yellowfin tuna and are mainly limited to surface tropical waters, while larger fish are found in sub-surface waters.

SOURCES: Nortmorn (2004); Froese & Pauly (2009)

Catch trends

Bigeye tuna are mainly caught by industrial purse seine and longline fisheries and appears only occasionally in the catches of other fisheries (Fig. 2). However, in recent years the amounts of bigeye tuna caught by gillnet fisheries are likely to be considerably higher than what is reported, due to the major changes experienced in some of these fleets, notably changes in boat size, fishing techniques and fishing grounds.

Total annual bigeye tuna 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 (Fig. 2). Total annual catches averaged 130,849 t over the period 2001–2005 and 104,635 t over the period 2006–2010 (Table 4). In 2010, preliminary catches of bigeye tuna have been estimated to be at around 71,489 t, representing a large decrease in catches with respect to those estimated for 2009 and previous years (Figs. 2, 3).

The recent drop in catches of bigeye tuna could be related to the expansion of piracy in the western tropical Indian Ocean, which has led to a marked drop in the levels of longline effort in the core fishing area of the species (Figs. 4a, b).

Bigeye tuna has been caught by industrial longline fleets since the early 1950's, but before the mid-1970's they only represented an incidental component of the total catch. With the introduction of fishing practices that improved the access to the bigeye tuna resource and the emergence of a sashimi market in the mid-1970's, bigeye tuna became an important target species for the main industrial longline fleets (Figs. 2, 3). The catches estimated for 2010 are at around 46,000 t, representing less than half the longline catches of bigeye tuna recorded before the onset of piracy in the Indian Ocean.

The total catch of bigeye tuna by purse seiners in the Indian Ocean reached 40,700 t in 1999, but the average annual catch for the period 2006–2010 was 26,000 t (25,000 t for 2001–2005) (Fig. 2). Purse seiners mainly take small juvenile bigeye tuna (averaging around 5–6 kg) whereas longliners catch much larger and heavier fish; and therefore while purse seiners take much lower tonnages of bigeye tuna compared to longliners, they take larger numbers of individual fish.

Although the activities of purse seiners have been affected by piracy in the Indian Ocean, the effects have not been as marked as with longliners. The main reason for this is the presence of security personnel onboard purse seine vessels since the mid-2009, which has made it possible for purse seiners to operate in the northwest Indian Ocean without a reduction in fishing effort (Fig. 4). However, in the IOTC area an approximate 30% reduction of the number of purse seiner has been observed since 2006.

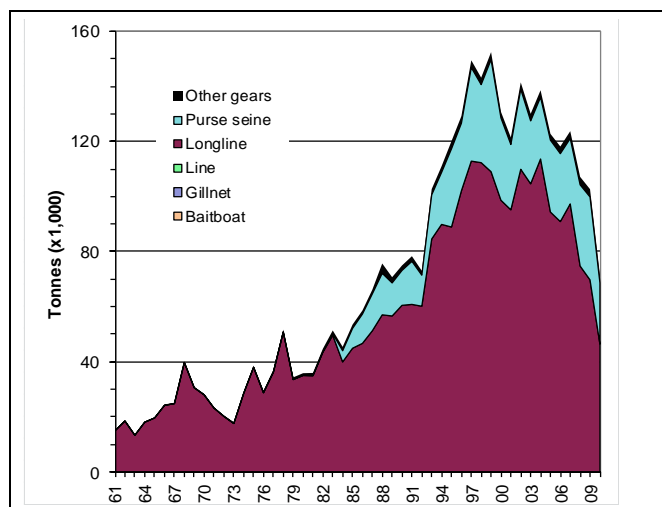


Fig. 2. Annual catches of bigeye tuna by gear recorded in the IOTC Database (1961–2010) (Data as of September 2011).

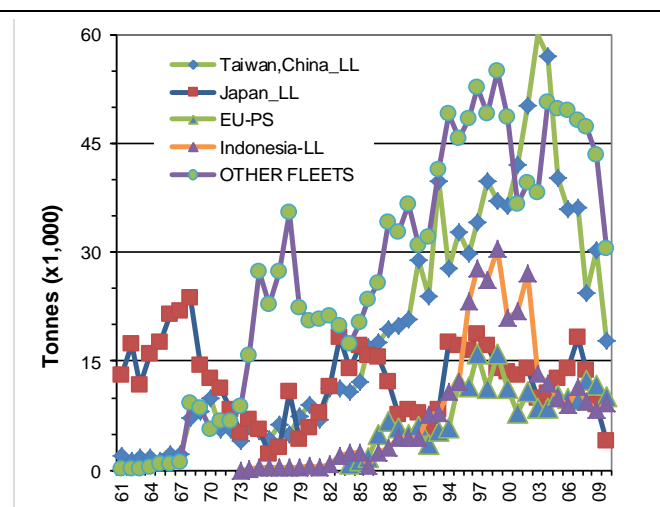


Fig. 3. Annual catches of bigeye tuna by fleet recorded in the IOTC Database (1961–2010) (Data as of September 2011).

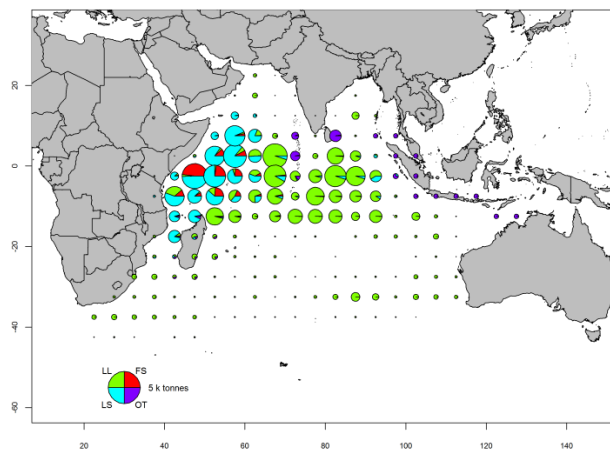
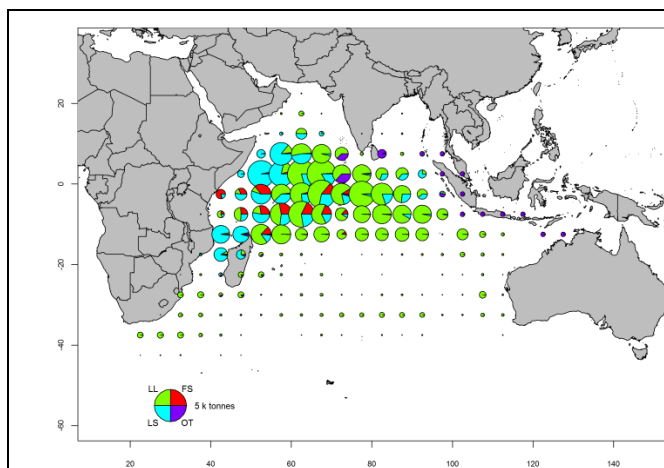


Fig. 4a–b. Time-area catches (total combined in tonnes) of bigeye tuna estimated for 2009 and 2010 by type of gear: Longline (LL), Purse seine free-schools (FS), Purse seine associated-schools (LS), and other fleets (OT), including pole-and-line, drifting gillnets, and various coastal fisheries (Data as of September 2011).

TABLE 4. Best scientific estimates of the catches of bigeye tuna (*Thunnus obesus*) by gear and main fleets [or type of fishery] by decade (1950–2000) and year (2001–2010), in tonnes. Data as of October 2011. Catches by decade represent the average annual catch, noting that some gears were not used for all years (refer to Fig. 2).

Fishery	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
LL-TW	6,008	18,684	23,647	28,226	19,759	14,699	14,693	14,091	11,217	13,288	15,299	17,261	19,630	14,336	9,812	4,490
LL-JP	481	3,288	6,820	17,716	68,347	80,201	80,472	95,807	93,398	100,341	79,064	73,632	77,695	60,417	59,917	41,875
FS	0	0	0	2,067	4,808	6,042	4,260	4,099	7,172	3,658	8,501	6,406	5,670	9,648	5,317	3,827
LS	0	0	0	4,234	18,224	20,147	19,457	24,944	15,662	18,749	17,568	18,249	18,066	19,831	24,773	18,438
OT	154	279	575	1,544	2,298	2,577	2,564	2,504	2,573	2,549	2,315	2,616	2,667	2,897	2,846	2,859
Total	6,642	22,252	31,043	53,787	113,437	123,666	121,447	141,445	130,023	138,584	122,748	118,164	123,728	107,129	102,664	71,489

Fisheries: Longline Taiwan,China and assimilated fleets (LL-TW); Longline Japan and assimilated fleets (LL-JP); Purse seine free-school (FS); Purse seine associated school (LS); Other gears nei (OT).

Uncertainty of catches

Retained catches are thought to be well known for the major fleets (Fig. 5); but are uncertain for the fleets listed below, noting that catches for these fleets are considered to represent a small proportion of total catches:

- Non-reporting industrial purse seiners and longliners (NEI) and for other industrial fisheries (longliners of India and Philippines).
- Some artisanal fisheries including the pole-and-line fishery in the Maldives.
- The gillnet fisheries of Iran and Pakistan.
- The gillnet/longline fishery in Sri Lanka.
- The artisanal fisheries in Indonesia, Comoros and Madagascar.

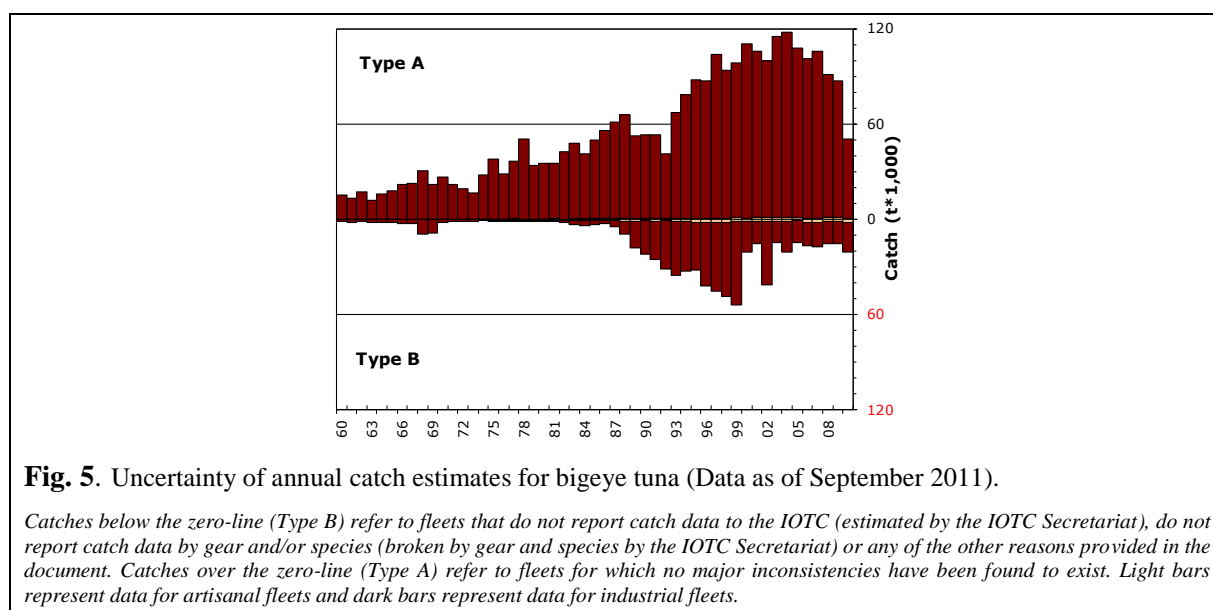


Fig. 5. Uncertainty of annual catch estimates for bigeye tuna (Data as of September 2011).

Catches below the zero-line (Type B) refer to fleets that do not report catch data to the IOTC (estimated by the IOTC Secretariat), do not report catch data by gear and/or species (broken by gear and species by the IOTC Secretariat) or any of the other reasons provided in the document. Catches over the zero-line (Type A) refer to fleets for which no major inconsistencies have been found to exist. Light bars represent data for artisanal fleets and dark bars represent data for industrial fleets.

- The catch series for bigeye tuna has not been significantly revised since the WPTT12 in 2010.
- Levels of discards are believed to be low although they are unknown for most industrial fisheries, excluding industrial purse seiners flagged in EU countries for the period 2003–2007.
- Catch-and-effort series are generally available from the major industrial fisheries. However, these data are not available from some fisheries or they are considered to be of poor quality, especially throughout the 1990s and in recent years, for the following reasons:
 - non-reporting by industrial purse seiners and longliners (NEI).
 - no data are available for the fresh-tuna longline fishery of Indonesia, over the entire time series, and very little data available for the fresh-tuna longline fishery of Taiwan,China.
 - uncertain data from significant fleets of industrial purse seiners from Iran and longliners from India, Indonesia, Malaysia, Oman, Philippines, and Taiwan,China (fresh tuna up to 2006).
 - no data available for the highseas gillnet fisheries of Iran and Pakistan and the gillnet/longline fishery of Sri Lanka, especially in recent years.

Effort trends

Total effort from longline vessels flagged to Japan, Taiwan,China and EU,Spain by five degree square grid from 2007 to 2010 are provided in Fig. 6, and total effort from purse seine vessels flagged to the EU and Seychelles (operating under flags of EU countries, Seychelles and other flags), and others, by five degree square grid and main fleets, for the years 2007 to 2010 are

provided in Fig. 7. The total number of fishing trips by vessels flagged to the Maldives by 5 degree square grid, type of boat and gear, for the years 2009 and 2010 are provided in Fig. 8.

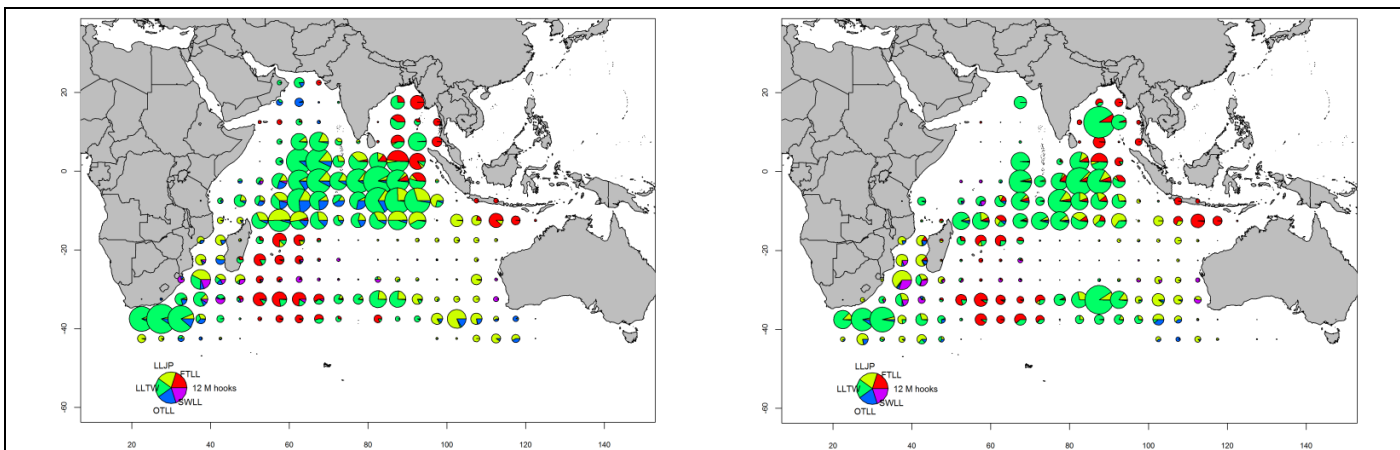


Fig. 6. Number of hooks set (millions) from longline vessels by five degree square grid and main fleets, for the years 2009 (left) and 2010 (right) (Data as of August 2011).

LLJP (light green): deep-freezing longliners from Japan
 LLTV (dark green): deep-freezing longliners from Taiwan,China
 SWLL (turquoise): swordfish longliners (Australia, EU, Mauritius, Seychelles and other fleets)
 FTLL (red) : fresh-tuna longliners (China, Taiwan,China and other fleets)
 OTLL (blue): Longliners from other fleets (includes Belize, China, Philippines, Seychelles, South Africa, Rep. of Korea and various other fleets)

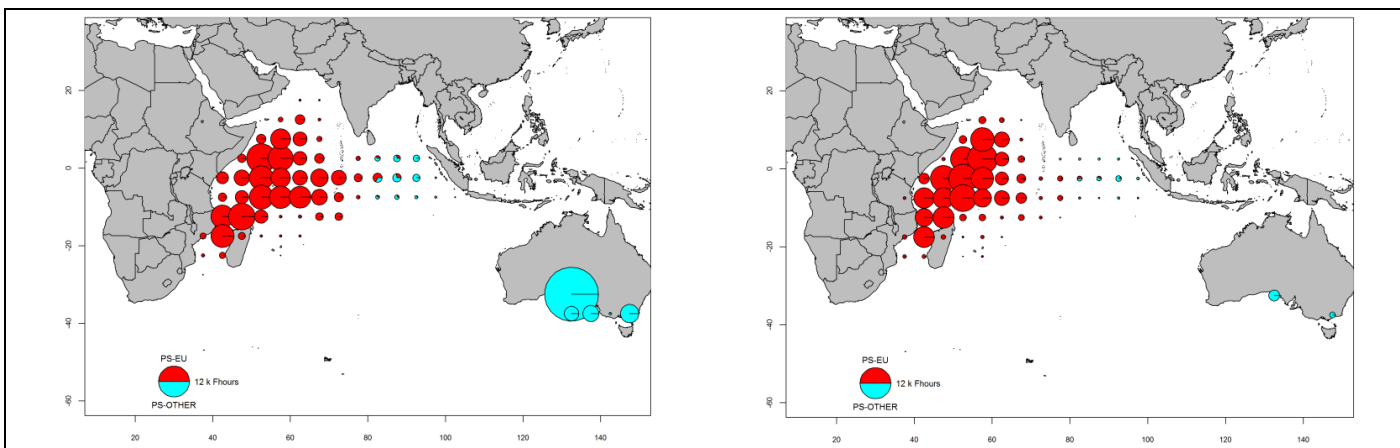


Fig. 7. Number of hours of fishing (Fhours) from purse seine vessels by five degree square grid and main fleets, for the years 2009 (left) and 2010 (right) (Data as of August 2011).

PS-EU (red): Industrial purse seiners monitored by the EU and Seychelles (operating under flags of EU countries, Seychelles and other flags)
 PS-OTHER (green): Industrial purse seiners from other fleets (includes Japan, Mauritius and purse seiners of Soviet origin) (excludes effort data for purse seiners of Iran and Thailand)

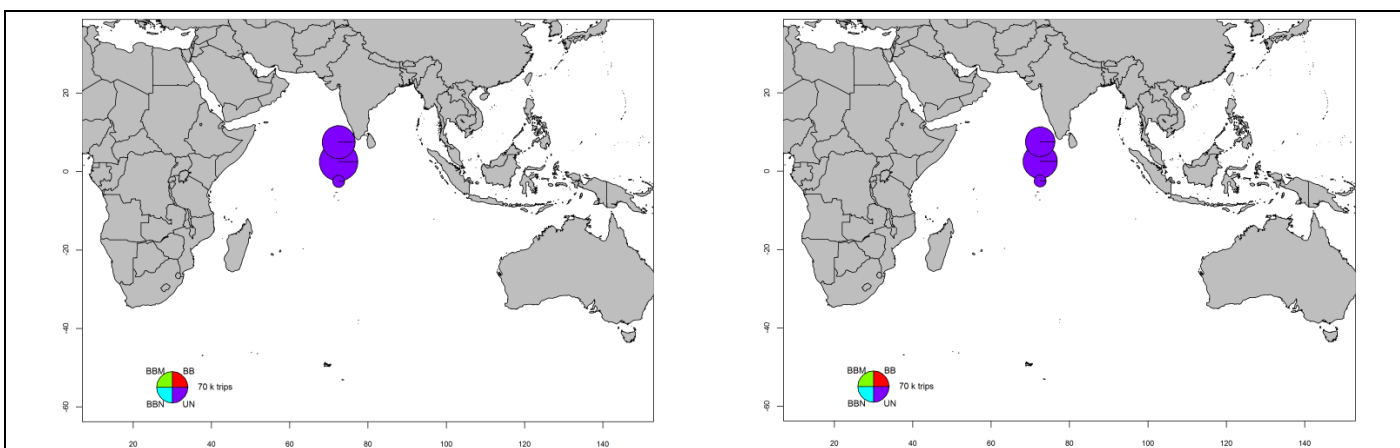


Fig. 8. Number of fishing trips by vessels flagged to the Maldives by five degree square grid, type of boat and gear, for the years 2009 (left) and 2010 (right) (Data as of August 2011).

BBN (blue): Baitboat non-mechanized; BBM (Green): Baitboat mechanized; BB (Red): Baitboat unspecified; UN (Purple): Unclassified gears
 Note that the above maps were derived using the available catch-and-effort data in the IOTC database, which is limited to the number of baitboat calls (trips) by atoll by month for Maldivian baitboats for the period concerned. Note that some trips may be fully devoted to handlining, trolling, or other activities (data by gear type are not available since 2002). No data are available for the pole-and-line fisheries of India (Lakshadweep) and Indonesia.

Standardised catch-per-unit-effort (CPUE) trends

Of the CPUE series available for assessment purposes, listed below, only the Japanese series from the tropical areas of the Indian Ocean was used in the stock assessment model for 2011 (shown in Fig. 10).

- Taiwan,China data (1980–2010): Series from document IOTC–2011–WPTT13–39 (Fig. 9).
- Japan data (1960–2010): Series 2 from document IOTC–2011–WPTT13–52. Whole Indian Ocean (Figs. 9 and 10).
- Rep. of Korean data (1977–2009): Series from document IOTC–2011–WPTT13–38 (Fig. 9).
- Japan data (1960–2010): Series1 from document IOTC–2011–WPTT13–52. Tropical area of Indian Ocean (Fig. 10).

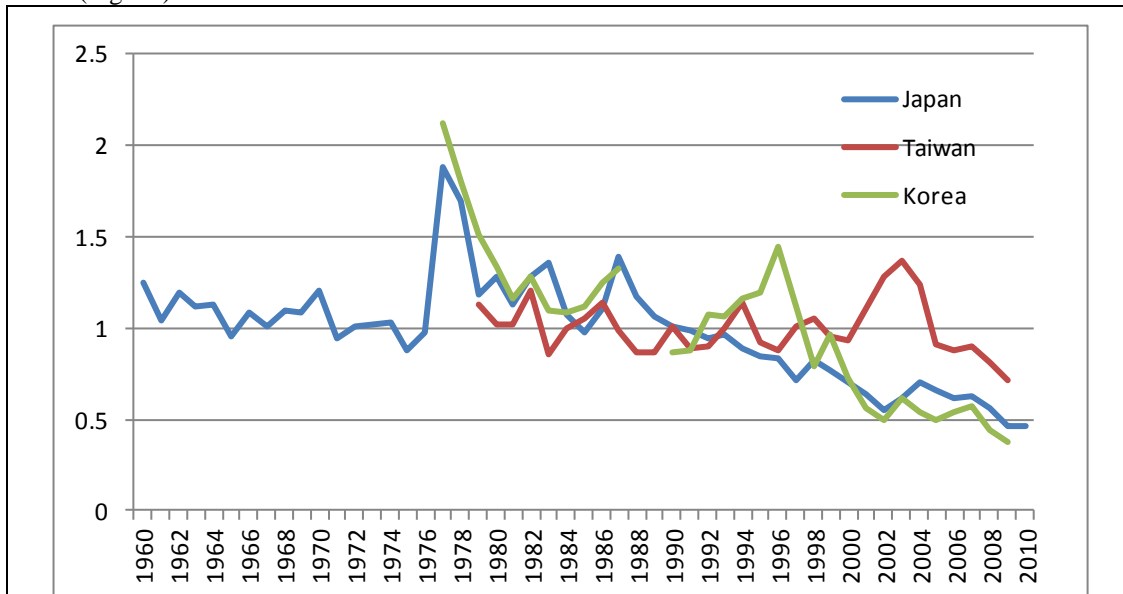


Fig. 9. Comparison of the three standardised CPUE series for Indian Ocean bigeye tuna. Series have been rescaled relative to their respective means from 1960–2010.

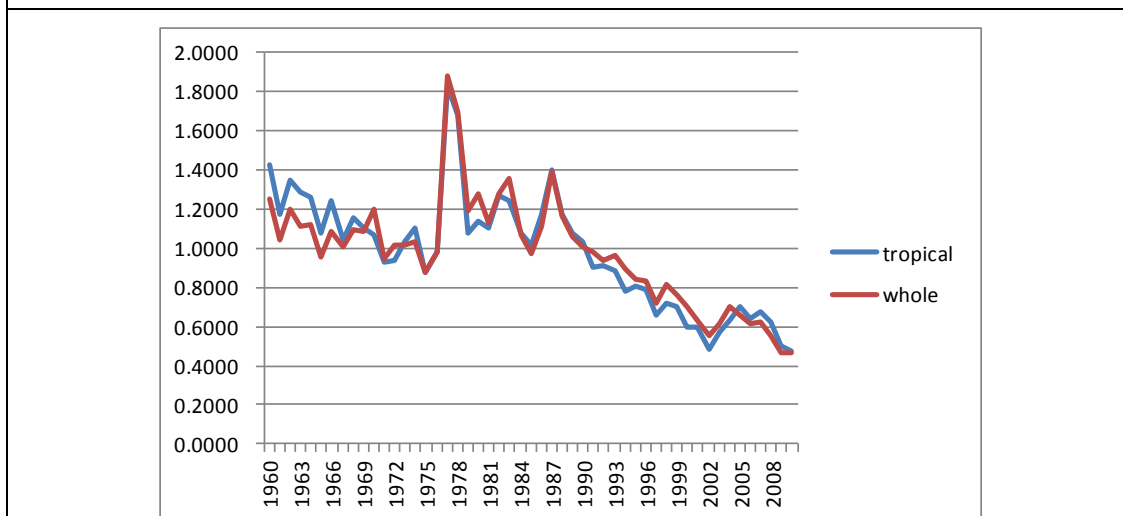


Fig. 10. Comparison of two Japanese standardised CPUE series for Indian Ocean bigeye tuna, one for the whole Indian Ocean and one for the tropical area only. Series have been rescaled relative to their respective means from 1960–2010.

The large increase in both the nominal and standardized bigeye tuna CPUEs for longline fleets in the Indian Ocean (as well as in the Atlantic) (Figs. 9 and 10). The increase in CPUEs may be due (1) to a large increase in the adult stock biomass, or (2) more probably to the introduction of deep longline in 1977. The fishery data does not allow to estimate a fully realistic trend of adult BET biomass during the seventies.

Fish size or age trends (e.g. by length, weight, sex and/or maturity)

Trends in average weight (Fig. 11) can be assessed for several industrial fisheries although they are incomplete or of poor quality for most fisheries before the mid-1980s and for some fleets in recent years (e.g. Japan longline) (see paper IOTC–2011–WPTT13–08).

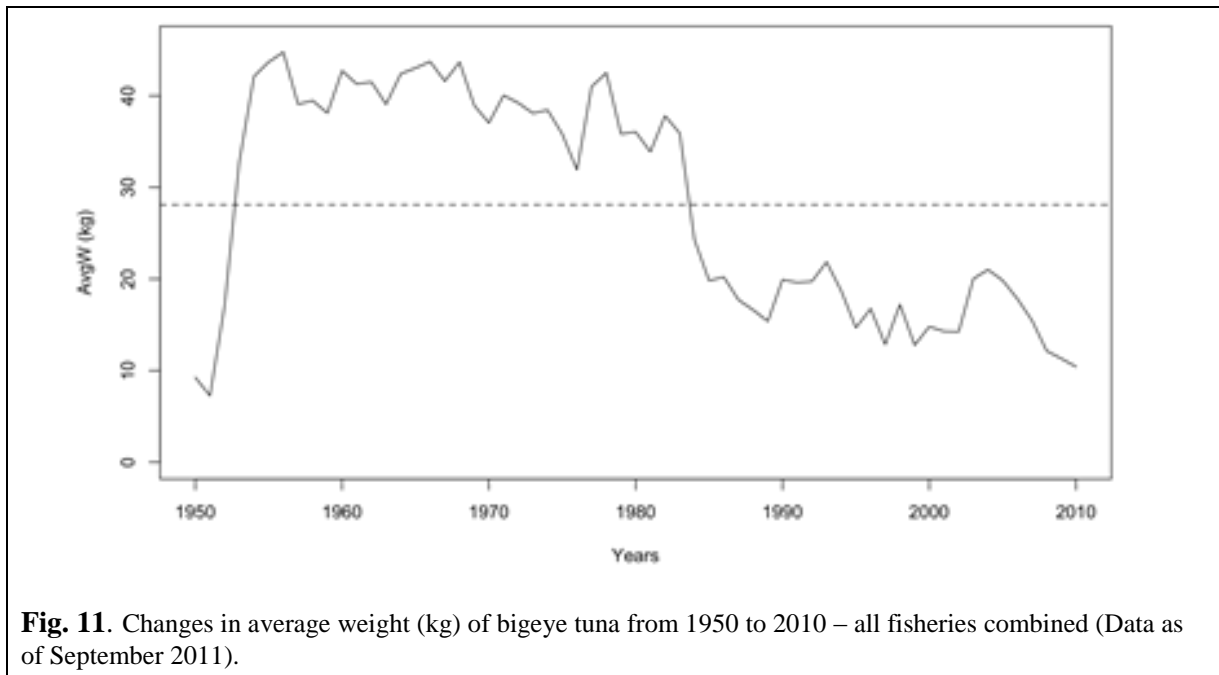


Fig. 11. Changes in average weight (kg) of bigeye tuna from 1950 to 2010 – all fisheries combined (Data as of September 2011).

- Catch-at-Size and Age tables are available but the estimates are highly uncertain for some periods and fisheries including:
 - the paucity of size data available from industrial longliners before the mid-60s, from the early-1970s up to the mid-1980s and in recent years (Japan).
 - the paucity of catch by area data available for some industrial fleets (NEI, India, Indonesia, Iran, Sri Lanka).

Tagging data

The WPTT **NOTED** that a total of 35,971 bigeye tuna were tagged during the Indian Ocean Tuna Tagging Programme (IOTTP) which represented a 17.8% of the total number of fish tagged. Most of the bigeye tuna tagged (96.1%) were tagged during the main EU-funded Regional Tuna Tagging Project-Indian Ocean (RTTP-IO) and were primarily released off the coast of Tanzania (Fig. 12) between May 2005 and September 2007. The remaining were tagged during small-scale projects around the Maldives, India and the southwest and eastern Indian Ocean by institutions with the support of IOTC. To date 5,563 (15.7%) of tagged fish have been recovered and reported to the IOTC Secretariat.

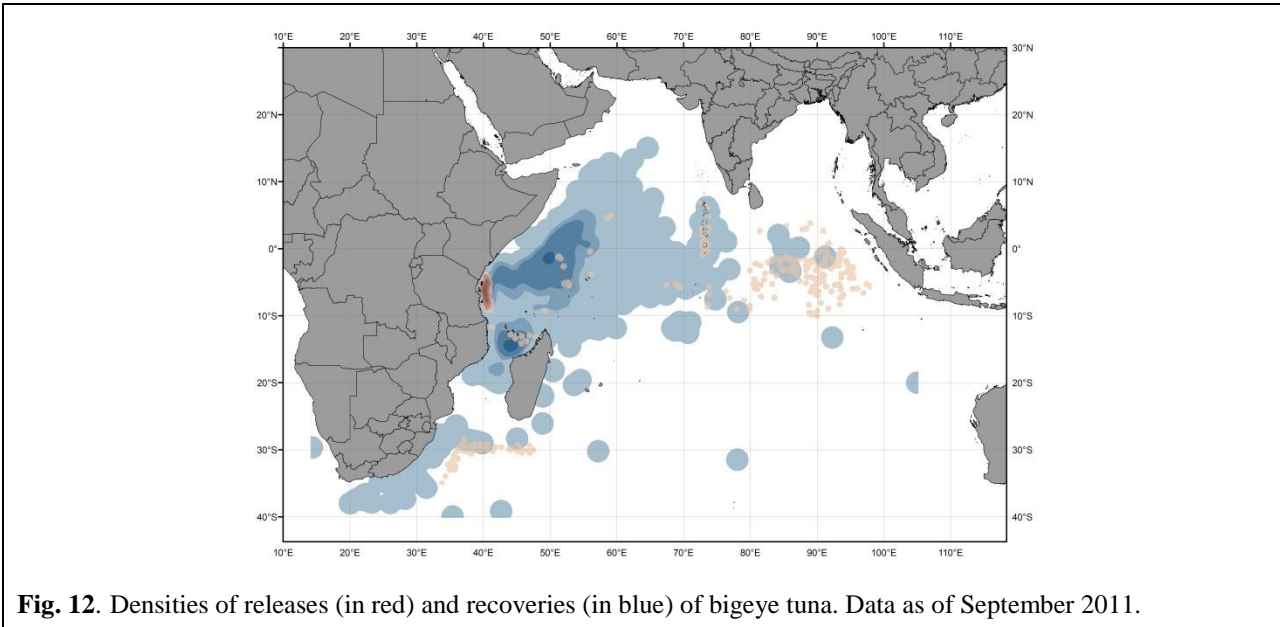


Fig. 12. Densities of releases (in red) and recoveries (in blue) of bigeye tuna. Data as of September 2011.

STOCK ASSESSMENT

A single quantitative modelling method (ASPM) was applied to the bigeye tuna assessment in 2011, using data from 1950–2010. The following is worth noting with respect to the modelling approach used:

- The steepness value ($h=0.5$) was selected on the basis of the likelihood and was near the lower boundary of what would be considered plausible for bigeye tuna. Selection of steepness on the basis of the likelihood was not considered reliable because i) steepness is difficult to estimate in general, and ii) substantial autocorrelation in the recruitment deviates was ignored in the likelihood term.

- Cohort-slicing to estimate ages from lengths introduces substantial errors, for long-living species such as bigeye tuna, except for the youngest ages.
- Uncertainty in natural mortality was not considered.

It is essential to include uncertainty in the steepness parameter as a minimum requirement for the provision of management advice. The general population trends and MSY parameters estimated by the ASPM model appeared to be plausibly consistent with the general perception of the fishery and the data. However, these results are considered to be uncertain because of i) uncertainty in the catch rate standardization, and ii) uncertainty in recent catches.

Management advice for bigeye tuna was based on the 2010 SS3 stock assessment and various steepness scenarios of the current 2011 ASPM stock assessment results (Tables 1, 5). For last year's SS3 assessment, the data did not seem to be sufficiently informative to justify the selection of any individual model and the results were combined on the basis of a model weighting scheme that was proposed to, and agreed by, the WPTT in 2010.

Key assessment results for the 2010 SS3 and 2011 ASPM stock assessments are shown in Tables 1, 2 and 5; Fig. 1.

Table 5. Key management quantities from the 2010 SS3 and 2011 ASPM assessments for bigeye tuna in the Indian Ocean.

Management Quantity	2010 SS3	2011 ASPM
2009 (SS3) and 2010 (ASPM) catch estimate (1000 t)	102	71.5
Mean catch from 2006–2010 (1000 t)	104.7	104.7
MSY (1000 t)	114 (95–183)	102.9 (86.6–119.3) ⁽²⁾
Data period used in assessment	1952–2009	1950–2010
F_{curr}/F_{MSY} ⁽³⁾	0.79 ⁽¹⁾ Range ⁽¹⁾ : 0.50 – 1.22	0.67 (0.48–0.86) ⁽²⁾
B_{curr}/B_{MSY} ⁽³⁾	–	–
SB_{curr}/SB_{MSY} ⁽³⁾	1.20 ⁽¹⁾ Range ⁽¹⁾ : 0.88 – 1.68	1.00 (0.77–1.24) ⁽²⁾
B_{curr}/B_0 ⁽³⁾	–	0.43 (n.a.)
SB_{curr}/SB_0 ⁽³⁾	0.34 ⁽¹⁾ Range ⁽¹⁾ : 0.26 – 0.40	0.39 ⁽²⁾
$B_{curr}/B_{0, F=0}$ ⁽³⁾	–	–
$SB_{curr}/SB_{0, F=0}$ ⁽³⁾	–	–

¹ Central point estimate is adopted from the 2010 SS3 model, percentiles are drawn from a cumulative frequency distribution of MPD values with models weighted as in Table 12 of 2010 WPTT report (IOTC–2010–WPTT12–R); the range represents the 5th and 95th percentiles.

² Median point estimate is adopted from the 2011 ASPM model using steepness value of 0.5 (values of 0.6, 0.7 and 0.8 are considered to be as plausible as these values but are not presented for simplification); the range represents the 90 percentile Confidence Interval.

³ Current period ($curr$) = 2009 for SS3 and 2010 for ASPM.

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