EXECUTIVE SUMMARY: BIGEYE TUNA

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

Status of the Indian Ocean bigeye tuna (BET: *Thunnus obesus*) resource

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

Area[1]	Indicators		2015 stock status[2] determination
Indian Ocean	Catch in 2014: Average catch 2010–2014:	100,231 t 102,214 t	
	MSY (1,000 t) (plausible range): F_{MSY} (plausible range): SB_{MSY} (1,000 t) (plausible range): F_{2012}/F_{MSY} (plausible range): SB_{2012}/SB_{MSY} (plausible range): SB_{2012}/SB_0 (plausible range):	132 (98–207)[3] n.a. (n.a.–n.a.)[3] 474 (295–677)[3] 0.42 (0.21–0.80)[3] 1.44 (0.87–2.22)[3] 0.40 (0.27–0.54)[3]	

[1]Boundaries for the Indian Ocean stock assessment are defined as the IOTC area of competence.
[2]The stock status refers to the most recent years' data used in the assessment.
[3]The point estimate is the median of the plausible models investigated in the 2013 SS3 assessment.

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 ($F_{year}/F_{MSY} \leq 1$)		
Not assessed/Uncertain		

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. No new stock assessment was carried out for bigeye tuna in 2014 or 2015, thus, stock status is determined on the basis of the 2013 assessment and other indicators presented in 2015. The 2013 stock assessment model results did not differ substantively from the previous (2010 and 2011) assessments; however, the final overall estimates of stock status differ somewhat due to the revision of the catch history and updated standardised CPUE indices. All the runs (except 2 extremes) carried out in 2013 indicate the stock is above a biomass level that would produce MSY in the long term (i.e. $SB_{2012}/SB_{MSY} > 1$) and in all runs that current fishing mortality is below the MSY-based reference level (i.e. $F_{2012}/F_{MSY} < 1$) (Table 1 and Fig. 1). The median value of MSY from the model runs investigated was 132,000 t with a range between 98,000 and 207,000 t. Current spawning stock biomass was estimated to be 40% (Table 1) of the unfished levels. Catches in 2013 (≈109,000 t) remain lower than the estimated MSY values from the 2013 stock assessments (Table 1). The average catch over the previous five years (2010–14; ≈102,000 t) also remains below the estimated MSY. In 2012 catch levels (≈120,000 t) of bigeye tuna increased markedly (≈29% over values in 2011: ≈92,000 t), but have declined to ≈102,000 t in 2014. Thus, on the weight-of-evidence available in 2015, the bigeye tuna stock is determined to be **not overfished** and is **not subject to overfishing** (Table 1).

Outlook. Declines in longline effort since 2007, particularly from the Japanese, Taiwan,China and Rep. of Korea longline fleets, as well as purse seine 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 in the near future. The Kobe strategy matrix based on all plausible model runs from SS3 in 2013 illustrates the levels of risk associated with varying catch levels over time and could be used to inform future management actions (Table 2). The SS3 projections from the 2013 assessment show that there is a low risk of exceeding MSY-based reference points by 2015 and 2022 if catches are maintained at catch levels of 115,800 t at the time of the last assessment (0% risk that $B_{2022} < B_{MSY}$ and 0% risk that $F_{2022} > F_{MSY}$) (Table 2).

Management advice. If catch remains below the estimated MSY levels, 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.

The following key points should also be noted:

- **Maximum Sustainable Yield (MSY)**: The median value of MSY from the model runs investigated was 132,000 t with a range between 98,000 and 207,000 t (range expressed as the different runs of SS3 done in 2013 using steepness values of 0.7, 0.8 and 0.9; different natural mortality values; and catchability increase for longline CPUE) (see Table 1 for further description). Current stock size is above SB_{MSY} and predicted to increase on the short term. Catches at the level of 132,000 t have a low probability of reducing the stock below SB_{MSY} in the short term (3–5 years) and medium term (10 years). Therefore, the annual catches of bigeye tuna should not exceed the median value of MSY. However, for lower productivity model options, catches at the median MSY level will reduce stock biomass over the long-term (10–15 years).
- **Interim reference points**: Noting that the Commission has agreed to Resolution 15/10 *on target and limit reference points and a decision framework*, the following should be noted:
    - **Fishing mortality**: Current fishing mortality is considered to be below the interim target reference point of F_{MSY}, and therefore below the interim limit reference point of $1.4*F_{MSY}$ (Fig. 1).
    - **Biomass**: Current spawning biomass is considered to be above the interim target reference point of SB_{MSY}, and therefore above the interim limit reference point of $0.4*SB_{MSY}$ (Fig. 1).
- **Main fishing gear** (Average catch 2011–14): Longline ≈56.0% (frozen ≈43.5%, fresh ≈12.5%); Purse seine ≈21.2% (FAD associated school ≈16.1%; free swimming school ≈5.1%); Line other ≈9.6%; Other ≈6.8%.
- **Main fleets** (Average catch 2011–14): Indonesia ≈27%; Taiwan,China ≈22%; European Union ≈16% (EU,Spain: ≈10%; EU,France: ≈6%); Seychelles ≈11; Japan ≈5%; All other fleets ≈19%.

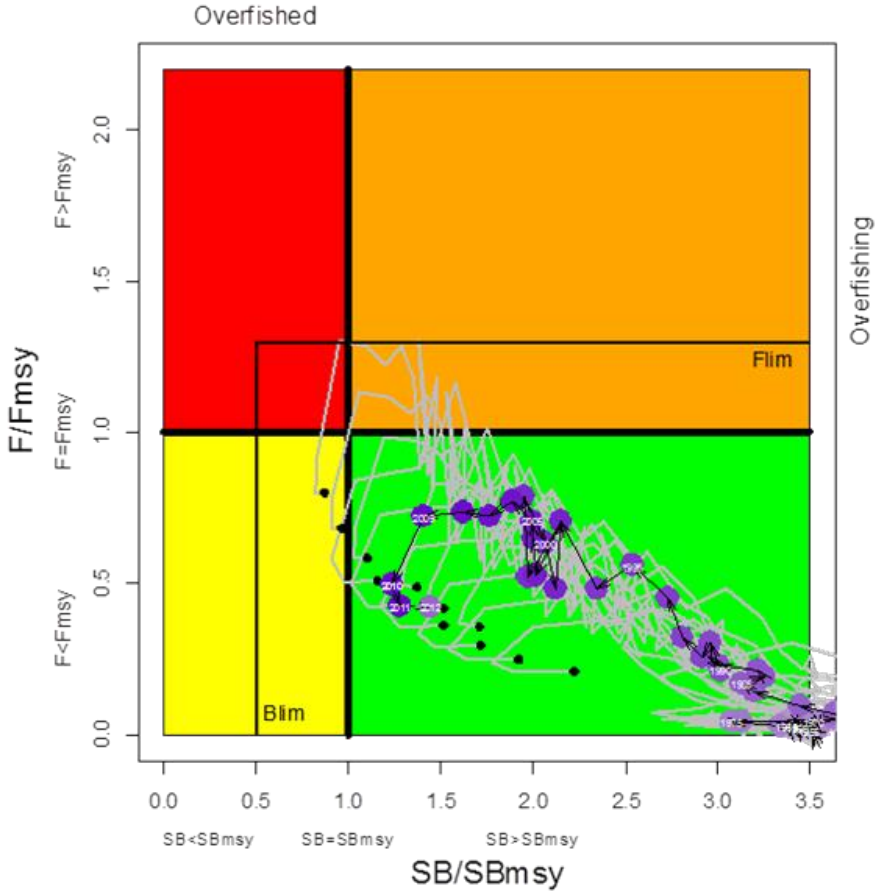


Fig. 1. Bigeye tuna: SS3 Aggregated Indian Ocean assessment Kobe plot. The Kobe plot presents the trajectories for the range of 12 plausible model options included in the formulation of the final management advice (grey lines with the black point representing the terminal year of 2012). The trajectory of the median of the 12 plausible model options (purple points) is also presented. The biomass (B_{lim}) and fishing mortality limit (F_{lim}) reference points are also presented.

Table 2. Bigeye tuna: 2013 SS3 aggregated Indian Ocean assessment Kobe II Strategy Matrix. Probability (percentage) of weighted distribution of models violating the MSY-based reference points for five constant catch projections (2012 catch level, ± 10%, ± 20%, ± 30% and ± 40%) projected for 3 and 10 years. Note: from the 2013 stock assessment using catch estimates at that time.

Reference point and projection timeframe	**Alternative catch projections (relative to the average catch level for 2012) and probability (%) of violating MSY-based target reference points ($SB_{targ} = SB_{MSY}$; $F_{targ} = F_{MSY}$)**								
	60% (69,480 t)	**70%** (81,060 t)	**80%** (92,640 t)	**90%** (104,220 t)	**100%** (115,800 t)	**110%** (127,400 t)	**120%** (139,000 t)	**130%** (150,500 t)	**140%** (162,100 t)
$SB_{2015} < SB_{MSY}$	n.a.	n.a.	n.a.	n.a.	0	0	0	0	0
$F_{2015} > F_{MSY}$	n.a.	n.a.	n.a.	n.a.	0	0	0	8	17
$SB_{2022} < SB_{MSY}$	n.a.	n.a.	n.a.	n.a.	0	0	8	17	25
$F_{2022} > F_{MSY}$	n.a.	n.a.	n.a.	n.a.	0	0	8	17	25
Reference point and projection timeframe	**Alternative catch projections (relative to the average catch level for 2012) and probability (%) of violating MSY-based limit reference points ($SB_{lim} = 0.5\ SB_{MSY}$; $F_{Lim} = 1.3\ F_{MSY}$)**								
	60% (69,480 t)	**70%** (81,060 t)	**80%** (92,640 t)	**90%** (104,220 t)	**100%** (115,800 t)	**110%** (127,400 t)	**120%** (139,000 t)	**130%** (150,500 t)	**140%** (162,100 t)
$SB_{2016} < SB_{Lim}$	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
$F_{2016} > F_{Lim}$	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
$SB_{2023} < SB_{Lim}$	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
$F_{2023} > F_{Lim}$	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

APPENDIX I

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 15/01 *on the recording of catch and effort by fishing vessels in the IOTC area of competence*
- Resolution 15/02 *mandatory statistical reporting requirements for IOTC Contracting Parties and Cooperating Non-Contracting Parties (CPC's)*
- Resolution 15/06 *On a ban on discards of bigeye tuna, skipjack tuna, yellowfin tuna and a recommendation for non-targeted species caught by purse seine vessels in the IOTC area of competence*
- Resolution 15/10 *On target and limit reference points and a decision framework*
- Resolution 15/11 *on the implementation of a limitation of fishing capacity of Contracting Parties and Cooperating Non-Contracting Parties*
- Resolution 14/02 *for the conservation and management of tropical tunas stocks in the IOTC area of competence*.
- Resolution 14/05 *concerning a record of licensed foreign vessels fishing for IOTC species in the IOTC area of competence and access agreement information*
- Resolution 10/08 *concerning a record of active vessels fishing for tunas and swordfish in the IOTC area*

FISHERIES INDICATORS

Bigeye tuna – 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. Bigeye tuna: 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: Nootmorn 2004, Froese & Pauly 2009

Bigeye tuna – Fisheries and main catch trends

- Main fishing gear (2011–14): industrial fisheries account for the majority of catches of bigeye tuna, i.e. deep-freezing and fresh longline (≈50%) and purse seine (≈30%) (**Table 4; Fig. 2**).

  In recent years catches by gillnet fisheries have also been increasing, due to major changes experienced in some of these fleets (e.g., Sri Lanka and I.R. Iran); notably changes in boat size, fishing techniques and fishing grounds, with vessels using deeper gillnets on the high seas in areas important for bigeye tuna targeted by other fisheries.

- Main fleets (and primary gear associated with catches): percentage of total catches (2011–14):

Indonesia (fresh longline, coastal longline, coastal purse seine): 27%; Taiwan,China (longline): 22%; Seychelles (longline and purse seine): 10%; EU-Spain (purse seine): 10% (**Fig. 4**).

- Main fishing areas: Primary: Western Indian Ocean, in waters off Somalia (West A1), although in recent years fishing effort has moved eastwards due to piracy. Secondary: Eastern Indian Ocean (East A2) (**Table 5; Fig.3**).

  In contrast to yellowfin tuna and skipjack tuna – where the majority catches are taken in the western Indian Ocean – bigeye tuna is also exploited in the eastern Indian Ocean, particularly since the late 1990's due to increased activity of small longliners fishing tuna to be marketed fresh (e.g., Indonesia). However, in recent years catches of bigeye tuna in the eastern Indian Ocean have shown a decreasing trend, as some vessels have moved south to target albacore.

- Retained catch trends:

  Total catches of bigeye tuna in the Indian Ocean increased steadily from the 1970's, from around 20,000 t in the 1970s, to over 150,000 t by the late 1990s with the development of the industrial longline fisheries and arrival of European purse seiners during the 1980s. Since 2007 catches of bigeye tuna by longliners have been relatively low - less than half the catch levels recorded - before the onset of piracy in the Indian Ocean (e.g., ≈50,000 t).

  Longline fisheries:

  Bigeye tuna have been caught by industrial longline fleets since the early 1950's, but before 1970 only represented incidental catches. After 1970, the introduction of fishing practices that improved catch rates of bigeye tuna, and emergence of a sashimi market, resulted in bigeye tuna becoming a primary target species for the industrial longline fleets. Large bigeye tuna (averaging just above 40 kg) are primarily caught by longliners, in particular deep-freezing longliners.

  Since the late 1980's Taiwan,China has been the major longline fleet targeting bigeye tuna in the Indian Ocean, accounting for as much as 40-50% of the total longline catch in the Indian Ocean (**Fig. 3**).

  Between 2007 and 2011 catches have fallen sharply, largely due to the decline in the number of Taiwanese longline vessels active in the north-west Indian Ocean in response to the threat of piracy. Since 2012 catches appear to show some signs of recovery as a consequence of improvements in security in the area off Somalia and return of fleets (mostly Taiwan,China longline vessels) resuming activities in their main fishing grounds (West (A1)). However current catches still remain far below levels recorded in 2003 and 2004.

  Purse seine fisheries:

  Since the late 1970's, bigeye tuna has been caught by purse seine vessels fishing on tunas aggregated on floating objects and, to a lesser extent, associated to free swimming schools (**Fig. 2**) of yellowfin tuna or skipjack tuna. Purse seiners under flags of EU countries and Seychelles account for the majority of purse seine catches of bigeye tuna in the Indian Ocean (**Fig. 4**) – mainly small juvenile bigeye (averaging around 5 kg) compared to longliners which catch much larger and heavier fish. While purse seiners take lower tonnages of bigeye tuna compared to longliners, they take larger numbers of individual fish.

  While the activities of purse seiners have also been affected by piracy in the Indian Ocean, the decline in catches of tropical tunas have not been as marked as for longline fleets. The main reason is the presence of security personnel onboard purse seine vessels of the EU and Seychelles, which has made it possible for vessels under these flags to continue operating in the northwest Indian Ocean (**Fig. 5**).

- Discard levels: Low, although estimates of discards are unknown for most industrial fisheries, excluding industrial purse seiners flagged in EU countries for the period 2003–07.

***Changes to the catch series*:** no major changes to the catch series since the WPTT meeting in 2014.

Table 4. Bigeye tuna: Best scientific estimates of the catches of bigeye tuna (*Thunnus obesus*) by gear and main fleets [or type of fishery] by decade (1950–2009) and year (2005–2014), in tonnes. Catches by decade represent the average annual catch, noting that some gears were not in operation since the beginning of the fishery (data as of November 2015).

Fishery	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
BB	21	50	264	1,517	2,932	5,010	5,499	5,117	5,972	6,035	6,788	6,701	6,788	6,787	7,164	6,458
FS	-	-	0	2,339	4,823	6,197	8,484	6,407	5,672	9,646	5,302	3,792	6,223	7,180	4,654	3,841
LS	-	-	1	4,853	18,317	20,273	17,557	18,526	18,105	19,875	24,708	18,486	16,386	10,434	22,814	18,828
LL	6,488	21,861	30,413	43,077	62,230	71,158	75,813	72,752	73,867	51,376	51,390	31,784	34,944	65,404	46,562	38,270
FL	-	-	218	3,066	26,282	23,490	19,637	18,788	22,450	23,323	15,810	9,782	12,031	12,495	14,616	14,104
LI	43	295	658	2,386	4,443	6,103	6,385	6,177	7,211	7,166	8,318	8,997	9,333	9,310	10,473	11,707
OT	38	63	166	878	1,393	3,774	4,063	4,637	4,574	4,769	6,041	5,569	6,693	7,943	7,493	7,022
Total	**6,589**	**22,269**	**31,720**	**58,118**	**120,419**	**136,003**	**137,438**	**132,403**	**137,851**	**122,189**	**118,356**	**85,111**	**92,397**	**119,554**	**113,777**	**100,231**

Gears: Pole-and-Line (**BB**); Purse seine free-school (**FS**); Purse seine associated school (**LS**); Deep-freezing longline (**LL**); Fresh-tuna longline (**FL**); Line (handline, small longlines, gillnet & longline combine) (**LI**); Other gears nei (gillnet, trolling & other minor artisanal gears)(**OT**).

Table 5. Bigeye tuna: Best scientific estimates of the catches of bigeye tuna (*Thunnus obesus*) by area [as used for the assessment] by decade (1950–2009) and year (2005–2014), in tonnes. Catches by decade represent the average annual catch (data as of November 2015).

Fishery	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
A1	2,484	12,015	17,591	34,756	58,601	76,974	84,897	81,685	80,167	67,277	57,817	37,427	38,157	71,865	66,807	58,854
A2	3,900	7,240	10,301	18,834	46,962	48,818	43,119	44,829	53,667	50,269	57,002	42,710	48,644	41,253	39,254	34,580
A3	205	3,014	3,828	4,527	14,856	10,211	9,424	5,888	4,017	4,645	3,537	4,973	5,596	6,438	7,715	6,796
Total	**6,589**	**22,268**	**31,720**	**58,118**	**120,419**	**136,003**	**137,440**	**132,403**	**137,851**	**122,190**	**118,356**	**85,110**	**92,397**	**119,555**	**113,776**	**100,230**

Areas: West Indian Ocean, including Arabian sea (A1); East Indian Ocean, including Bay of Bengal (A2); Southwest and Southeast Indian Ocean, including southern (A3). Catches in Areas (**0**) were assigned to the closest neighbouring area for the assessment.

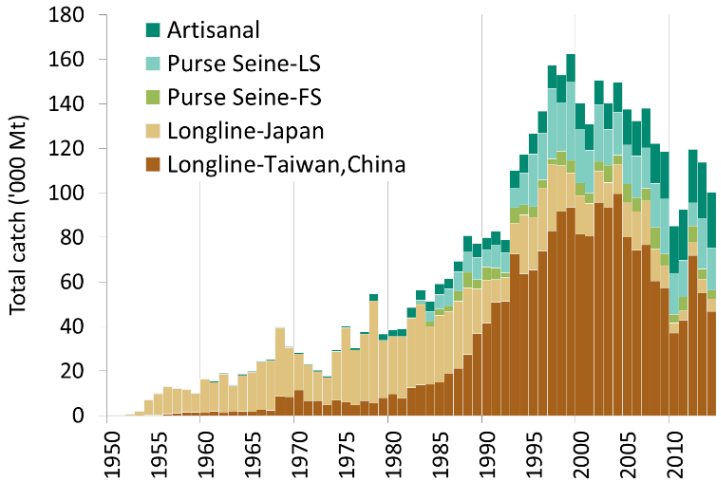


Fig. 2. Annual catches of bigeye tuna by gear (1950–2014) (data as of November 2015).

Gears (as agreed by WPTT): Longline Taiwan,China and associated fleets **(Longline-Taiwan);** Longline Japan and associated fleets **(Longline-Japan)**; Purse seine free-school (**FS**); Purse seine associated school (**LS**); Other gears nei (pole-and-Line, handline, small longlines, gillnet, trolling & other minor artisanal gears) (**Artisanal**).

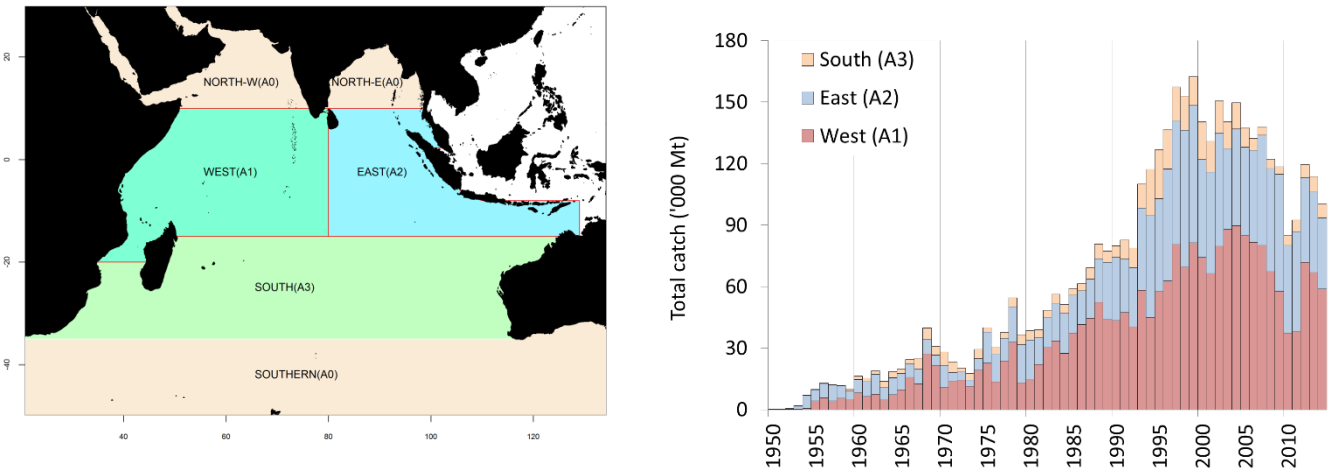


Fig. 3(a-b). Bigeye tuna: Catches of bigeye tuna by area by year estimated for the WPTT (1950–2014). Catches outside the areas presented in the map were assigned to the closest neighbouring area for the assessment (data as of November 2015).

Areas: West Indian Ocean (**A1**); East Indian Ocean (**A2**); Southwest and Southeast Indian Ocean (**A3**). Catches in Areas (**0**) were assigned to the closest neighbouring area for the assessment.

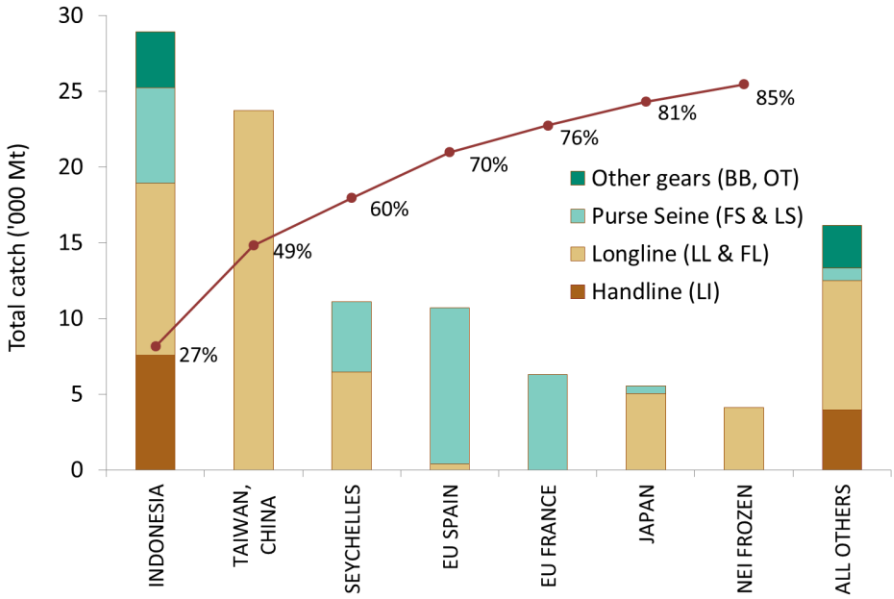


Fig. 4. Bigeye tuna: average catches in the Indian Ocean over the period 2011–14, by country. Countries are ordered from left to right, according to the importance of catches of bigeye reported. The red line indicates the (cumulative) proportion of catches of bigeye for the countries concerned, over the total combined catches of this species reported from all countries and fisheries (data as of November 2015).

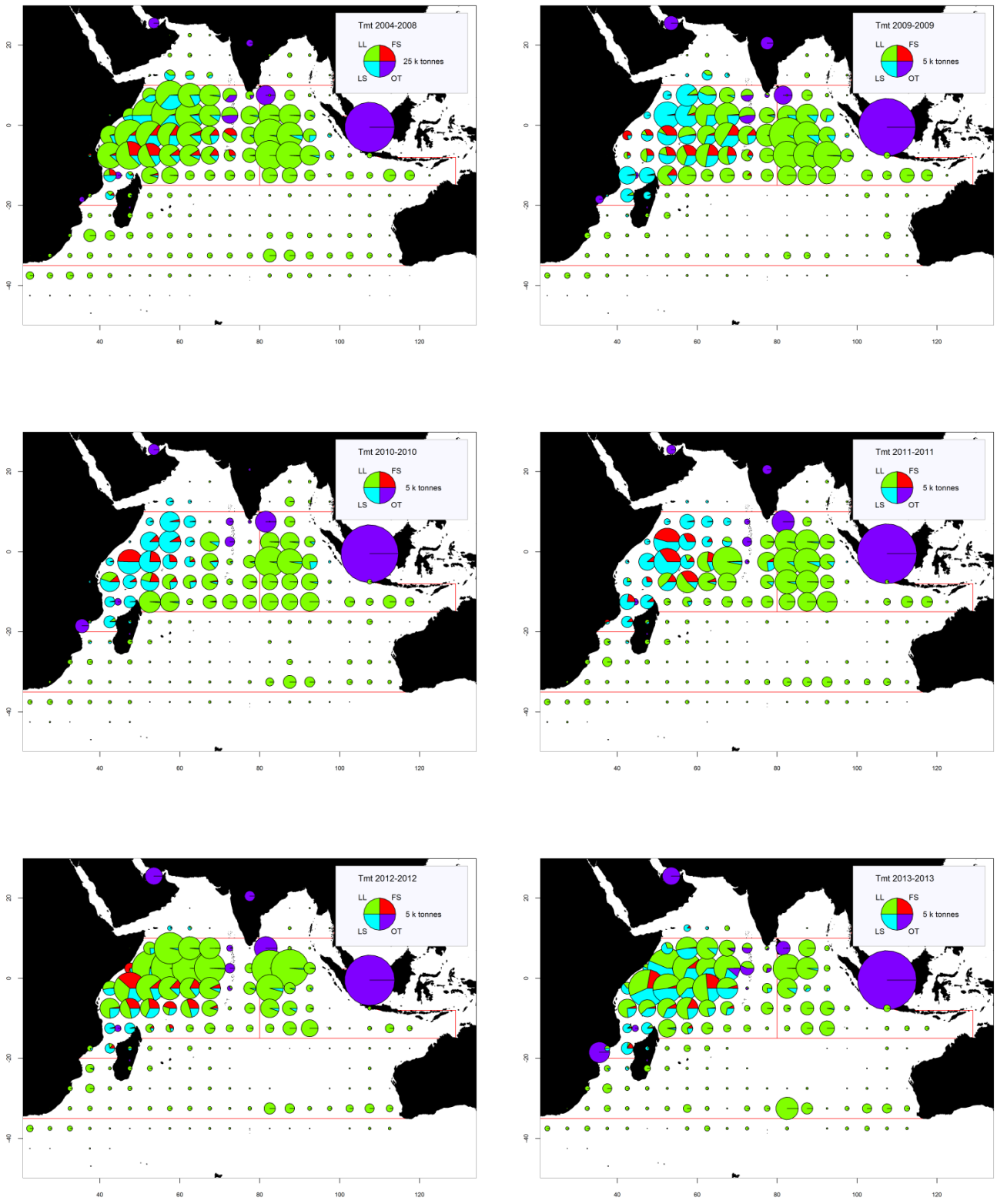


Fig. 5(a-f). Time-area catches (total combined in tonnes) of bigeye tuna estimated for the period 2004–2008 by type of gear and for 2009–13, by year and type of gear. Longline (**LL**), Purse seine free-schools (**FS**), Purse seine associated-schools (**LS**), and other fleets (**OT**), including pole-and-line, drifting gillnets, and various coastal fisheries. The catches of fleets for which the flag countries do not report detailed time and area data to the IOTC are recorded within the area of the countries concerned, in particular driftnets from I.R. Iran, gillnet and longline fishery of Sri Lanka, and coastal fisheries of Indonesia.

Bigeye tuna: data availability and related data quality issues

Retained catches

- Data are considered to be well known for the major industrial fleets, with the proportion of catches estimated, or adjusted, by the IOTC Secretariat relatively low (**Fig. 6a**). Catches are less certain for the following fisheries/fleets:
  - Non-reporting industrial purse seiners and longliners (NEI) and other industrial fisheries (e.g. longliners of India).
  - Some artisanal fisheries, including: pole-and-line fishery in Maldives, drifting gillnet fisheries of I.R. Iran (before 2012) and Pakistan (drifting gillnets), Sri Lanka (gillnet-longline fishery) and the artisanal fisheries in Indonesia, Comoros (before 2011) and Madagascar.

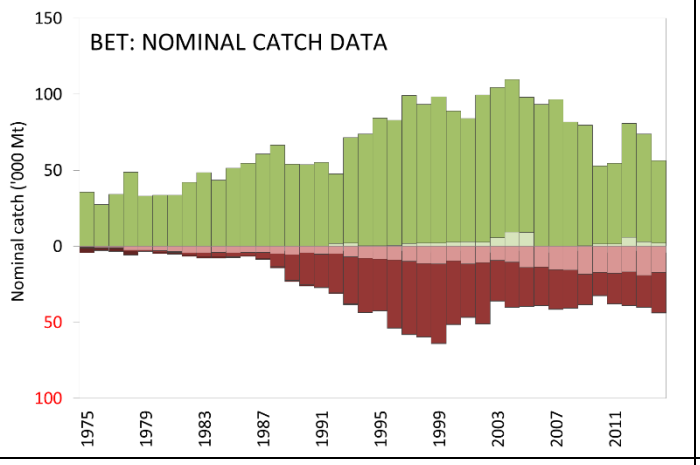
Nominal Catch-per-unit-effort (CPUE) trends

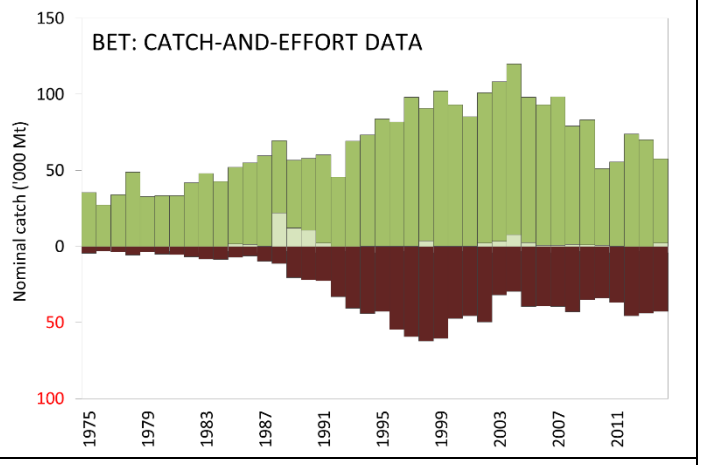
- Availability: Catch-and-effort series are available for the major industrial fisheries (e.g. Japan, Rep. of Korea, Taiwan,China).

  For most other fisheries, catch-and-effort are either not available (**Fig. 6b**), or are considered to be of poor quality – especially since the early-1990s and for the following fisheries/fleets:
  - 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, while data for the fresh-tuna longline fishery of Taiwan,China are only available since 2006;
  - uncertain data from significant fleets of industrial purse seiners from I.R. Iran and longliners from India, Indonesia, Malaysia, Oman, and Philippines;
  - incomplete or missing data for the driftnet fisheries of I.R. Iran and Pakistan and the gillnet/longline fishery of Sri Lanka, especially in recent years.

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

- Average fish weight: can be assessed for several industrial fisheries although they are incomplete (**Fig. 6c**) or of poor quality for most fisheries before the mid-1980s and for some fleets in recent years (e.g. Japan and Taiwan,China longline) (**Fig. 7**).
- Catch-at-Size (Age) table: data are available, but the estimates are more uncertain for some years and some fisheries due to:
  i. 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 and Taiwan,China)
  ii. the paucity of catch by area data available for some industrial fleets (NEI, India, Indonesia, I.R. Iran, Sri Lanka).
- Catch at length trends: Purse seine free swimming school (**Fig 9a**) and purse seine FAD associated school (**Fig 9b**) length frequency distributions and total number of specimens sampled for lengths (raised to total catch). **Fig. 10** provides the length frequency distributions (total amount of fish measured by 2 cm length class)





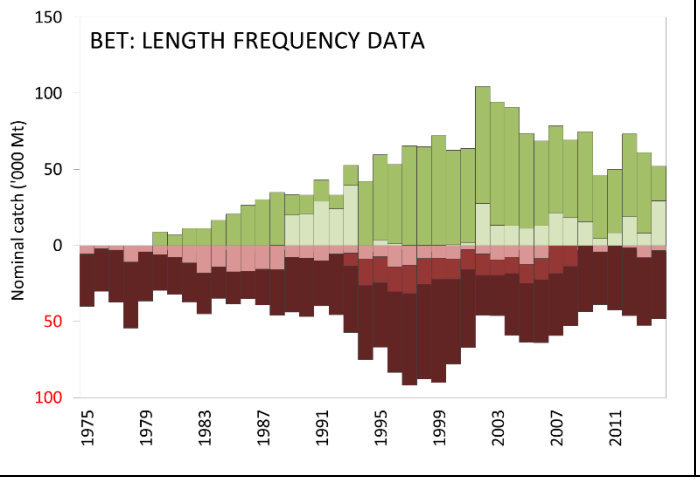
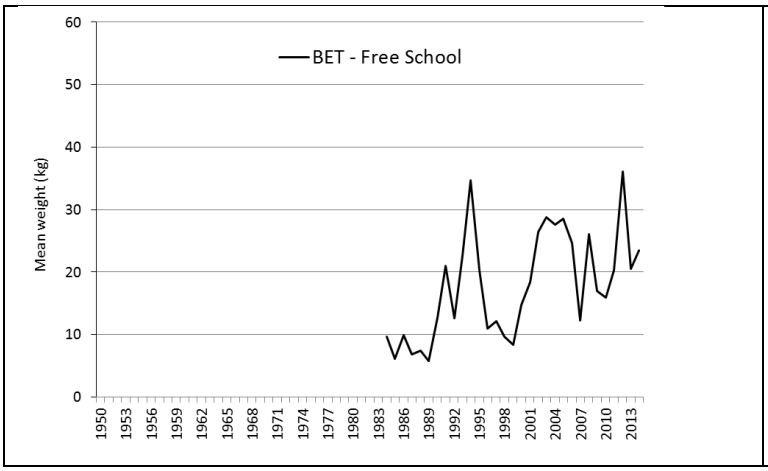
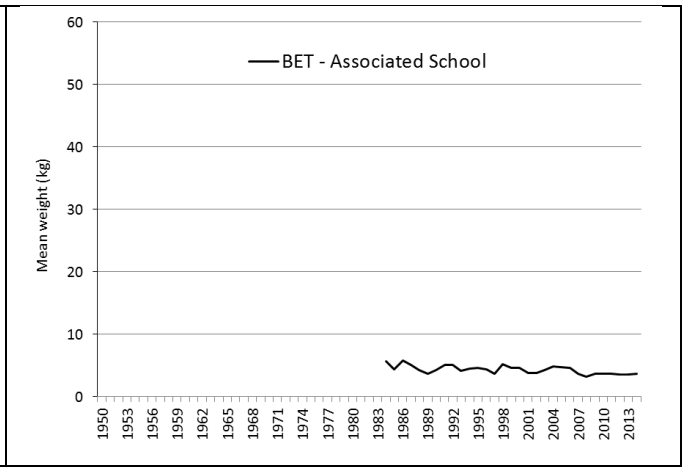


Fig. 6a-c. Bigeye tuna: data reporting coverage (1975–2014).

Each IOTC dataset (nominal catch, catch-and-effort, and length frequency) are assessed against IOTC reporting standards, where: a score of 0 indicates the amount of nominal catch associated with each dataset that is fully reported according to IOTC standards; a score of between 2 – 6 refers to the amount of nominal catch associated with each dataset that is partially reported by gear and/or species (i.e., adjusted by gear and species by the IOTC Secretariat) or any of the other reasons provided in the document; a score of 8 refers to the amount of nominal catch associated with catch-and-effort data that is not available. Data as of October 2015.





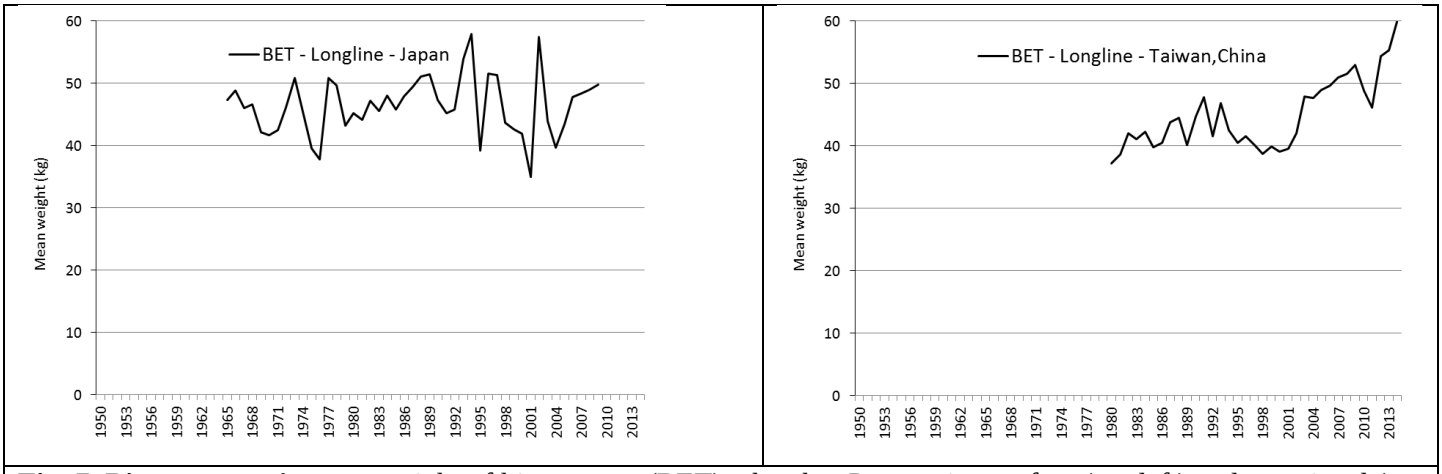


Fig. 7. Bigeye tuna: Average weight of bigeye tuna (BET) taken by: Purse seine on free (top left) and associated (top right) schools; and Longlines from Japan (botom left) and Taiwan,China (bottom right)

Bigeye tuna: Tagging data

- A total of 35,997 bigeye tuna (17.9%) were tagged during the Indian Ocean Tuna Tagging Programme (IOTTP). Most of them (96.0%) were tagged during the main Regional Tuna Tagging Project-Indian Ocean (RTTP-IO) and released off the coast of Tanzania in the western Indian Ocean, between May 2005 and September 2007 (**Fig. 8**). The remaining were tagged during small-scale projects, and by other institutions with the support of the IOTC Secretariat, in the Maldives, Indian, and in the south west and the eastern Indian Ocean.
- To date, 5,824 specimens (16.2% of releases for this species) have been recovered and reported to the IOTC Secretariat[1]. These tags were mainly reported from the purse seine fleets operating in the Indian Ocean (90.7%), while 5.4% were recovered from longline vessels.

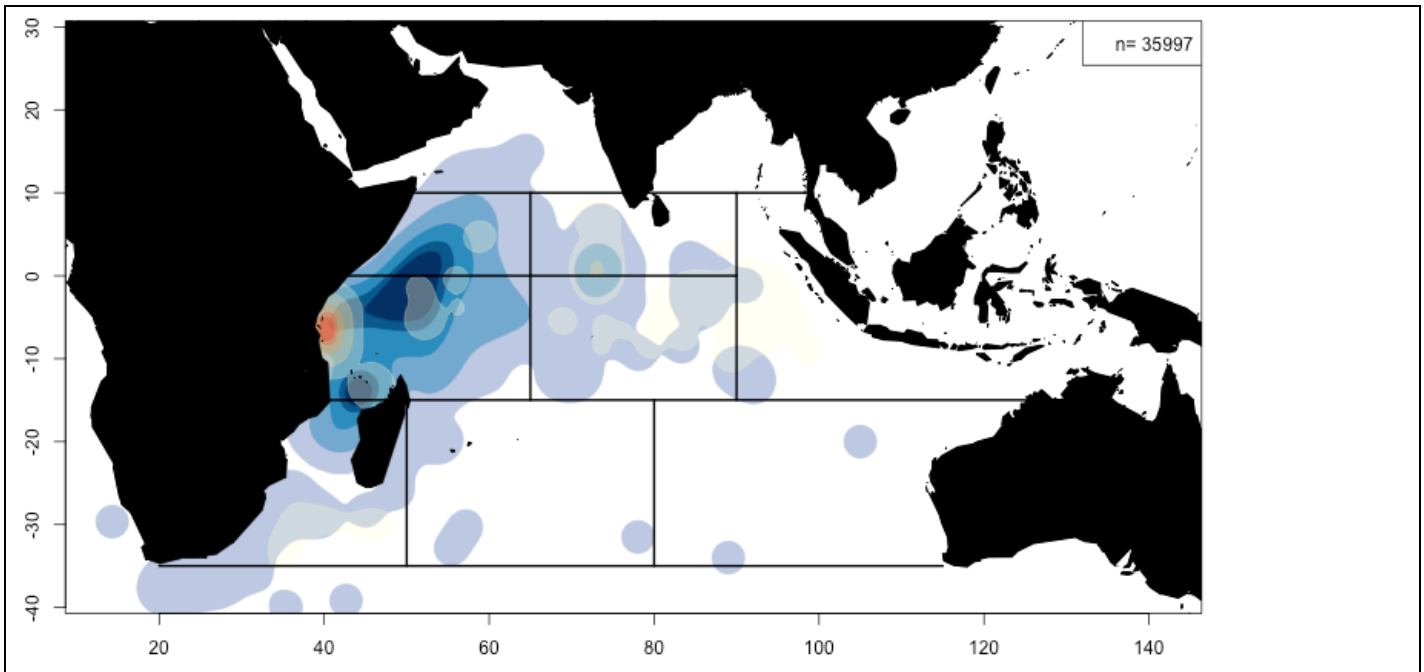


Fig. 8. Bigeye tuna: densities of releases (in red) and recoveries (in blue). The black line represents the stock assessment areas. Includes specimens tagged during the IOTTP and also Indian Ocean (Maldivian) tagging programmes during the 1990s. Data as of September 2012.

[1] Recoveries by species based on species ID recorded during tagging, prior to release.

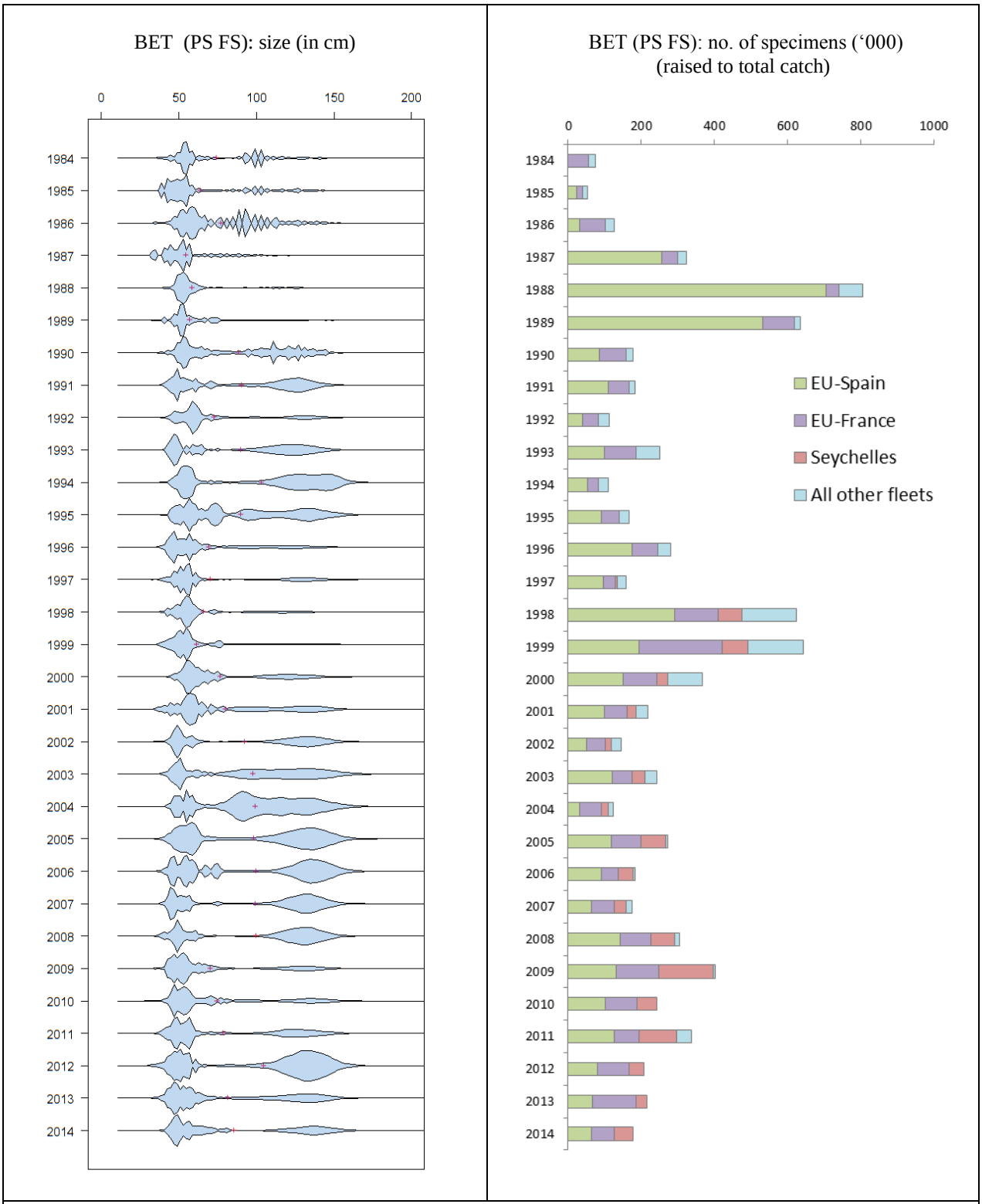


Fig. 9a. Bigeye tuna (PS Free school): **Left:** length frequency distributions for PS Free School fisheries (total amount of fish measured by 2 cm length class) derived from data available at the IOTC Secretariat. **Right**: Number of bigeye tuna specimens sampled for lengths (raised to total catch), by fleet (PS Free School only).

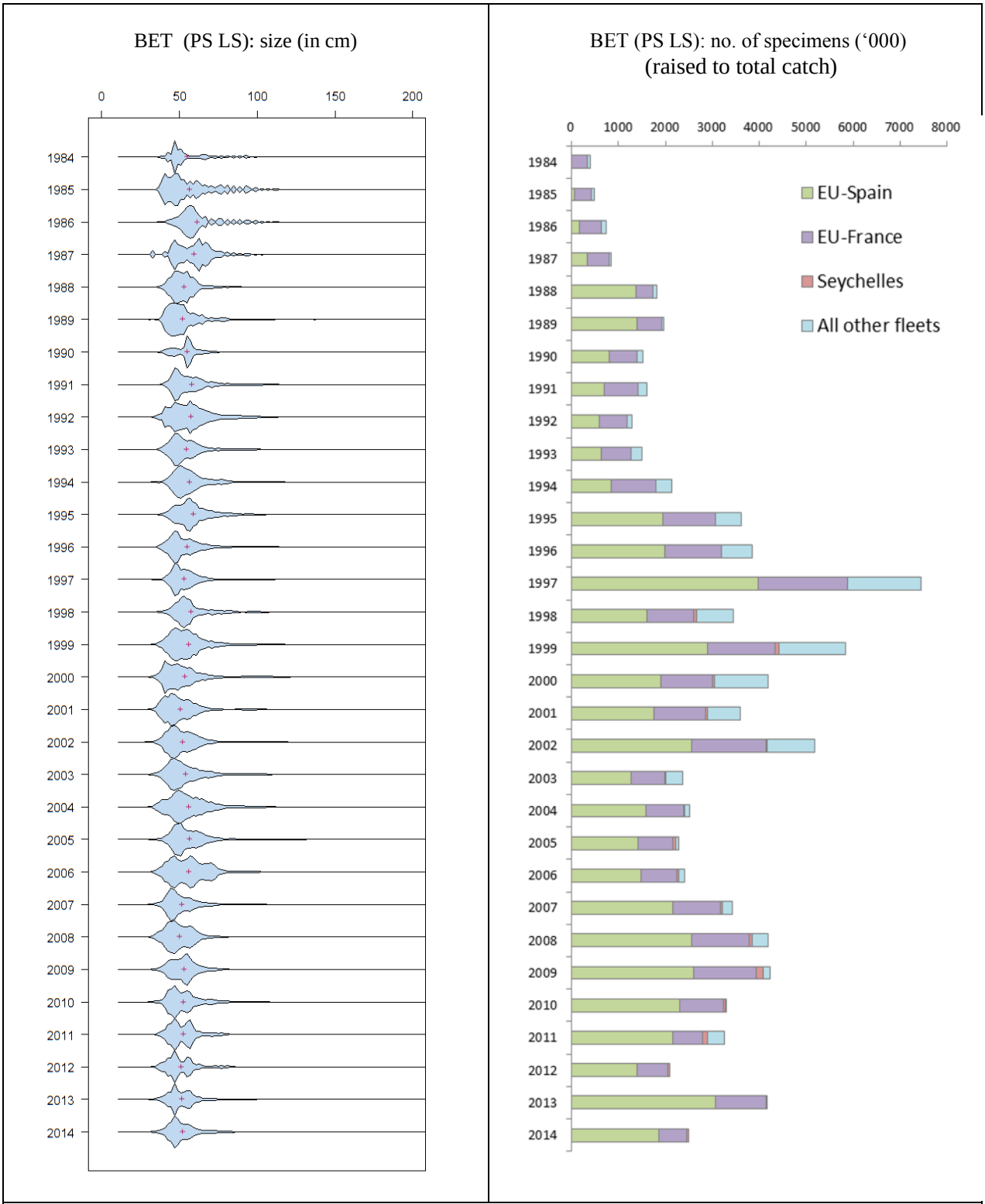


Fig. 9b. Bigeye tuna (PS Associated school): **Left:** length frequency distributions for PS Associated school fisheries (total amount of fish measured by 2 cm length class) derived from data available at the IOTC Secretariat. **Right**: Number of bigeye tuna specimens sampled for lengths (raised to total catch), by fleet (PS Associated school only).

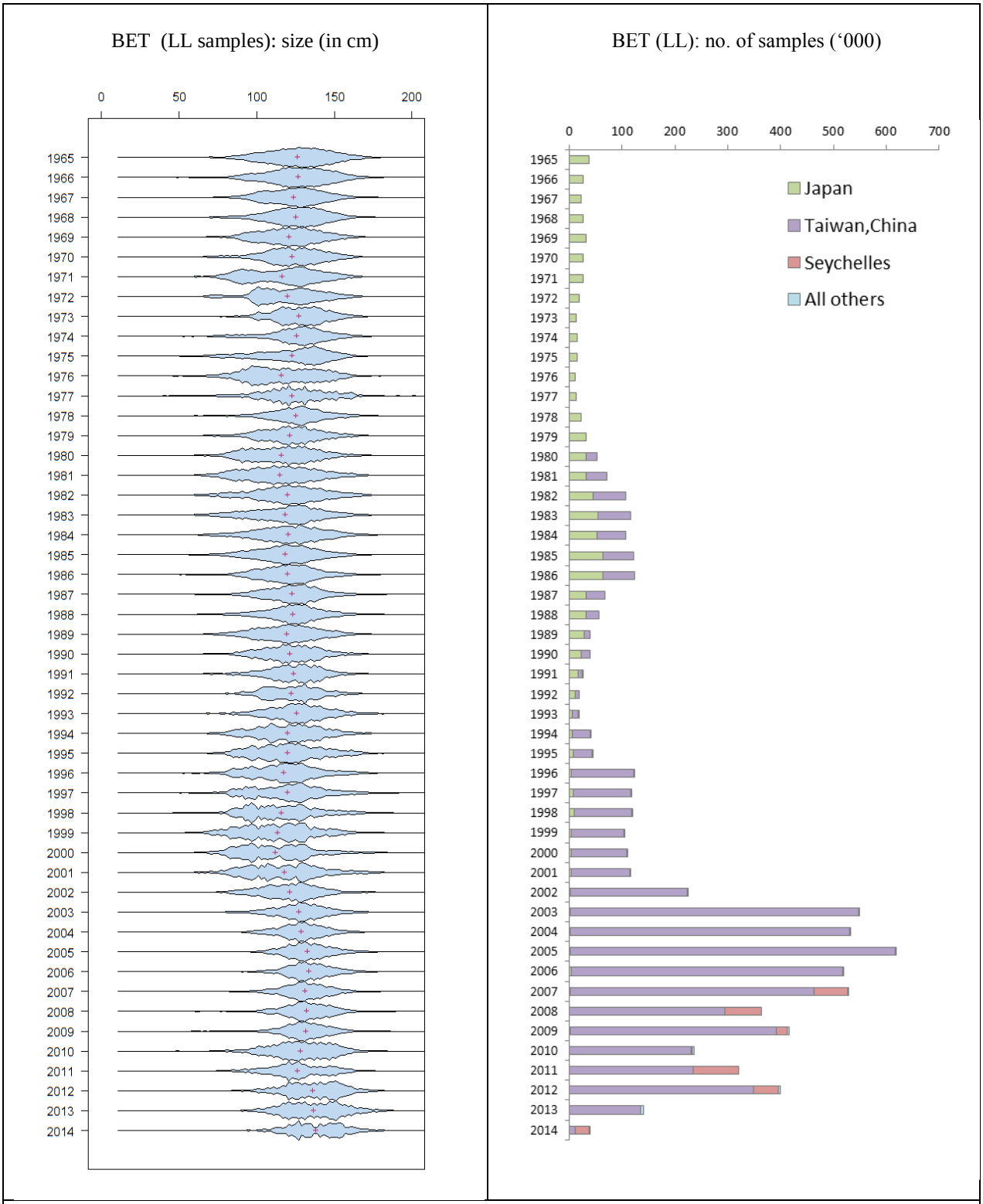


Fig. 10 Bigeye tuna (longline): **Left:** length frequency distributions for longline fisheries (total amount of fish measured by 2 cm length class) derived from data available at the IOTC Secretariat. **Right**: Number of bigeye tuna specimens sampled for lengths, by fleet (longline only).

Bigeye tuna – Effort trends

Total effort from longline vessels flagged to Japan, Taiwan,China and EU,Spain by five degree square grid in 2013 and 2014 are provided in Fig. 11, 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 2013 and 2014 are provided in Fig. 12. Total effort exerted by pole-and-line fleets in the Indian Ocean for the years 2013 and 2014 are provided in Fig. 13.

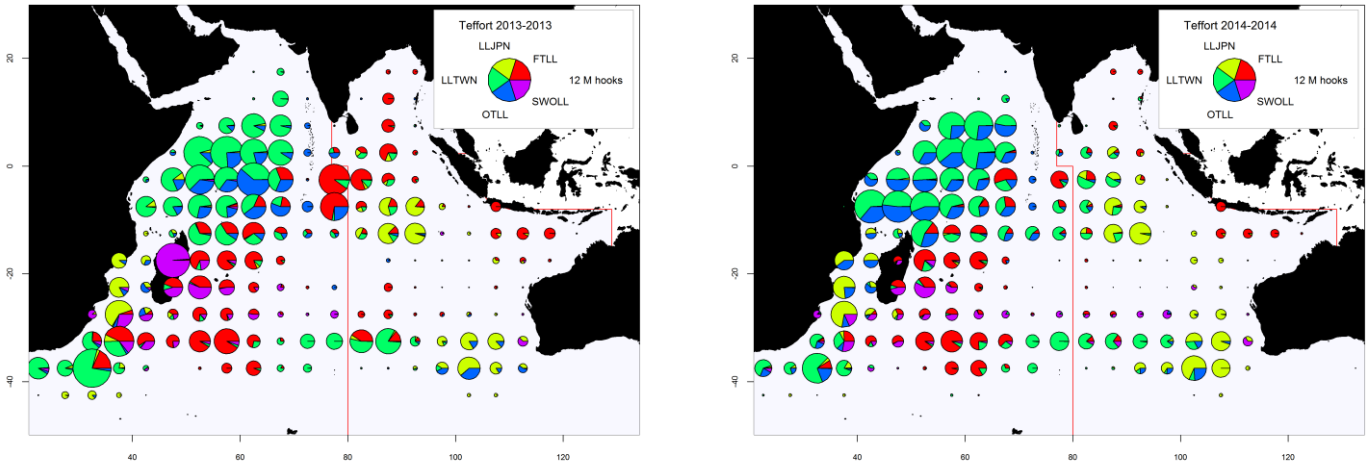


Fig. 11. Number of hooks set (millions) from longline vessels by five degree square grid and main fleets, for the years 2013 (left) and 2014 (right) (Data as of October 2015). **LLJP** (light green): deep-freezing longliners from Japan LLTW (dark green): deep-freezing longliners from Taiwan,China; **SWLL** (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).

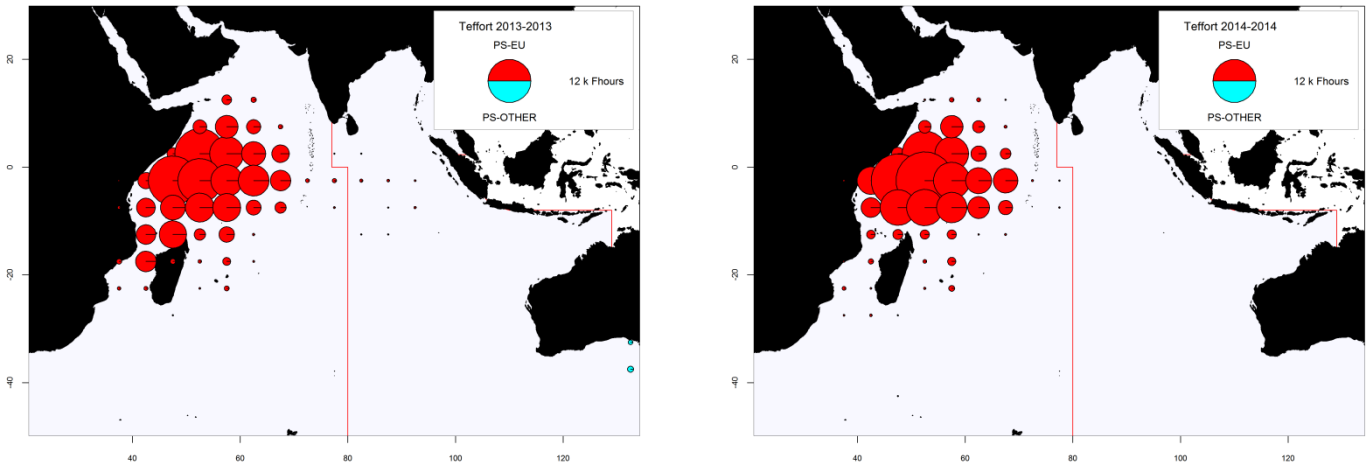


Fig. 12. Number of hours of fishing (Fhours) from purse seine vessels by 5 degree square grid and main fleets, for the years 2013 (left) and 2014 (right) (Data as of October 2015). **PS-EU** (red): Industrial purse seiners monitored by the EU and Seychelles (operating under flags of EU countries, Seychelles 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).

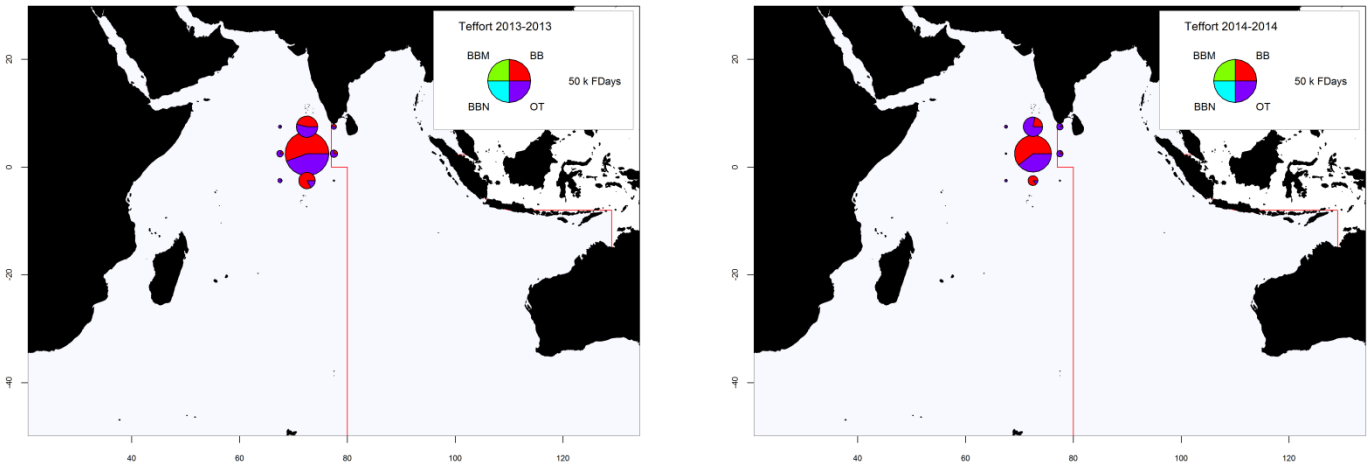


Fig. 13. Effort exerted by pole-and-line fleets in the Indian Ocean, in thousands (k) of trips (equivalent to fishing days), for the years 2013 (left) and 2014 (right) (data as of November 2015). **BBM** (green): Pole-and-line (mechanized baitboats); **BBN** (blue): Pole-and-line (non-mechanized baitboats); **BB** (red): Pole-and-line (all types of baitboat, especially mechanized); **OT** (purple): Pole-and-line and other gears unidentified (effort not available by gear).

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.

Bigeye tuna: Standardised catch–per–unit–effort (CPUE) trends

The CPUE series presented at the WPTT16 meeting in 2014 are listed below. However, only the Japanese longline CPUE index (quarterly) for the whole Indian Ocean (1960–2013) (**Fig. 14**) was utilised for the final stock assessment model runs and in the development of management advice, noting that the Japanese series from the tropical areas and the Indian Ocean as a whole, showed very similar trends.

- Taiwan,China data (1979–2012): Series (core, core east, core west, south) from document IOTC–2014–WPTT16–55.
- Japan data (1960–2013): Series (whole Indian Ocean, tropical area, temperate area) from document IOTC–2014–WPTT16–29 Rev_1.
- Rep. of Korea data (1977–2013): Series (whole Indian Ocean, tropical area, southern area) from document IOTC–2014–WPTT16–30.

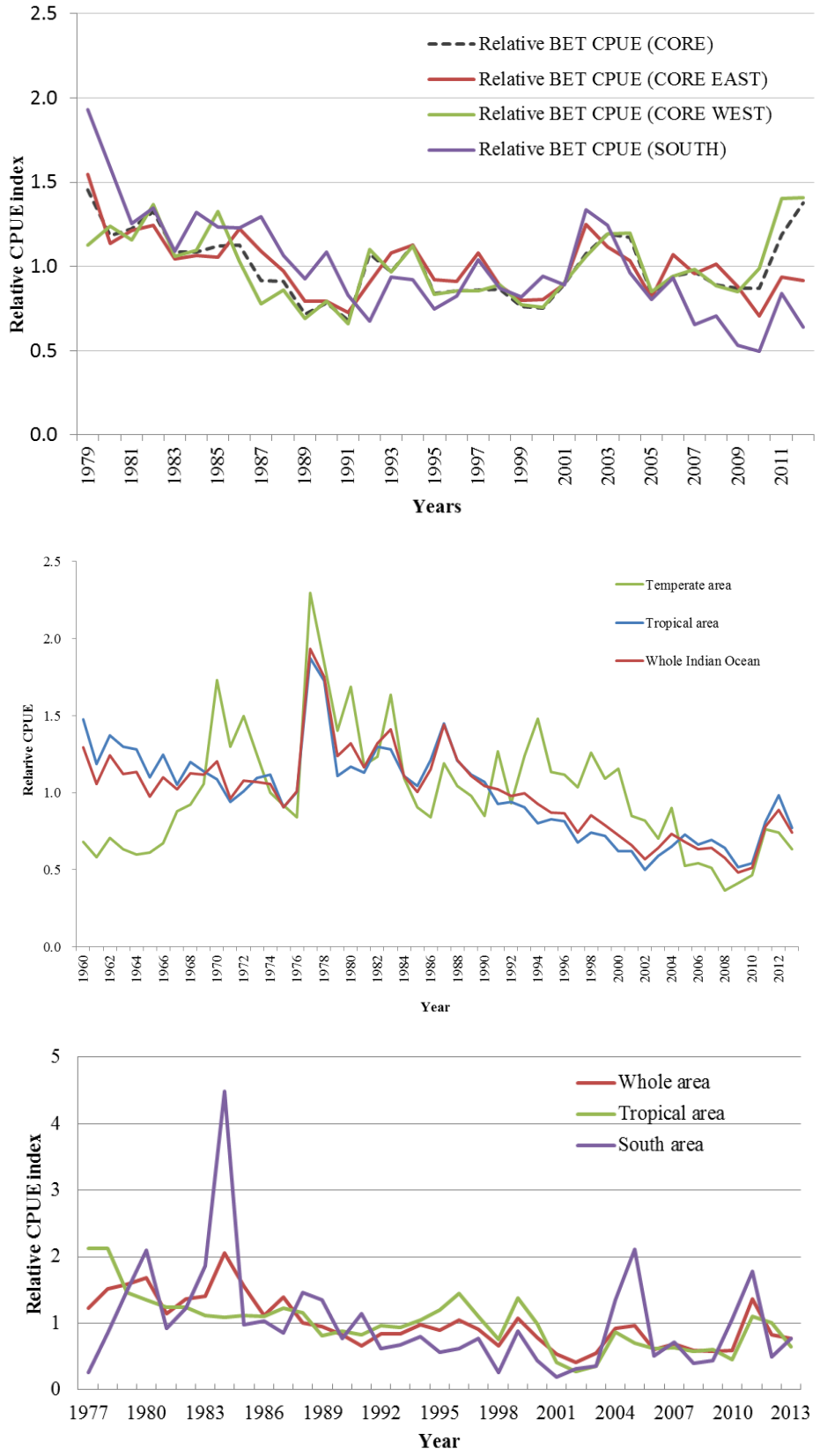


Fig. 14. Bigeye tuna: Standardised CPUE series for: top) Comparison of the standardised longline CPUE series (by area) for Taiwan,China. Series have been rescaled relative to their respective means from 1979–2012; middle) Comparison of the standardised longline CPUE series for Japan. Series have been rescaled relative to their respective means from 1960–2013; bottom) Comparison of the standardised longline CPUE series for the Rep. of Korea. Series have been rescaled relative to their respective means from 1977–2013.

STOCK ASSESSMENT

No new assessments were carried out on bigeye tuna in 2014. A range of quantitative modelling methods (ASAP, ASPM and SS3) were applied to bigeye tuna in 2013. Management advice for bigeye tuna is based on the range of results from the SS3 models. The SS3 results were preferred to the other assessment platforms (ASPM and ASAP) because a more comprehensive range of model options were investigated and a range of diagnostics indicated that the models represented a reasonable fit to the main datasets. The range of plausible SS3 model options was considered to adequately represent the range of uncertainty in the assessment. Integrating across all outcomes, the 2013 stock assessment model results did not differ substantively from the previous (2010 and 2011) assessments or amongst the models applied, although, the final overall estimates of stock status differ somewhat due to the revision of the catch history, new information, and updated standardised CPUE indices.

All the runs (except 2 extremes) carried out in 2013 indicate that the stock is above a biomass level that would produce MSY in the long term (i.e. $SB_{2012}/SB_{MSY} > 1$) and in all runs that current fishing mortality is below the MSY-based reference level (i.e. $F_{2012}/F_{MSY} < 1$). This is illustrated in **Fig. 15**, which shows the time trajectories in F/F_{MSY} and B/B_{MSY} across the range of model results applied to characterise uncertainty in stock status.

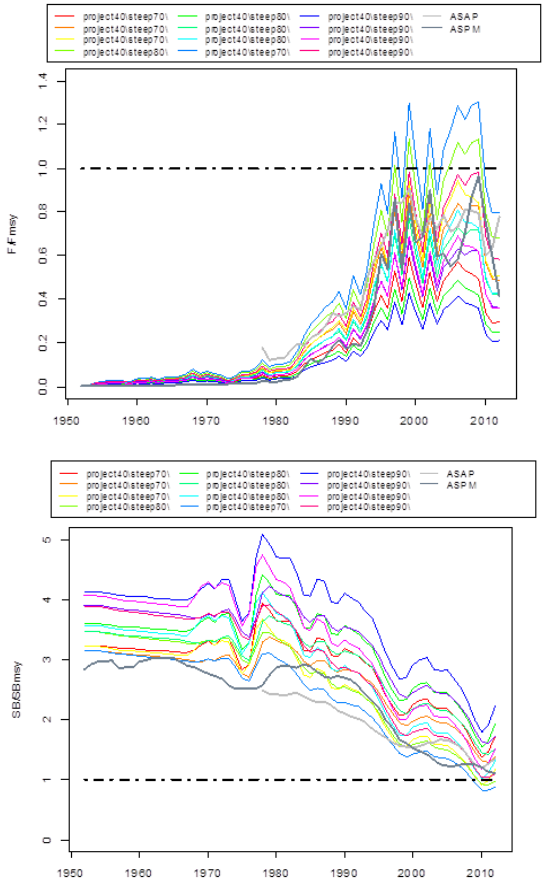


Fig. 15. Bigeye tuna: Ranges of F/F_{MSY} (top) and B/B_{MSY} (bottom) over time, indicating the range of uncertainty in stock assessment outcomes from the stock assessment models used in 2013 (SS3). ASAP and ASPM base cases are presented for comparative purposes.

Key assessment results for the 2013 SS3 stock assessment are shown in **Table 6**; **Fig. 1**.

Table 6. Bigeye tuna: Key management quantities from the SS3 assessment, for the aggregate Indian Ocean.

Management Quantity	**Aggregate Indian Ocean**
2013 catch estimate	109,343 t
Mean catch from 2009–2013	105,924 t
MSY [plausible range] (1,000 t)	132 [98–207]
Data period used in assessment	1952–2012
F_{MSY} [plausible range]	n.a. (n.a.–n.a.)3
SB_{MSY} (1,000 t) [plausible range]	474 (295–677)3
F_{2012}/F_{MSY} [plausible range]	0.42 [0.21–0.80]
B_{2012}/B_{MSY}	n.a.
SB_{2012}/SB_{MSY} [plausible range]	1.44 [0.87–2.22]
B_{2012}/B_{1952}	n.a.
SB_{2012}/SB_{1952} [plausible range]	0.40 [0.27–0.54]
$B_{2012}/B_{2012,\ F=0}$	n.a.
$SB_{2012}/SB_{2012,\ F=0}$	0.40 [0.27–0.54]

LITERATURE CITED

Froese R, Pauly DE (2009) *FishBase*, version 02/2009, FishBase Consortium, <www.fishbase.org>
Nootmorn, P (2004) Reproductive biology of bigeye tuna in the eastern Indian Ocean. IOTC–2004–WPTT04–05.