BIGEYE TUNA

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 1** outlines some of the key life history traits of bigeye tuna relevant for management.

TABLE 1. 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 (2012–16): industrial fisheries account for the majority of catches of bigeye tuna, i.e., deep-freezing and fresh longline (≈54%) and purse seine (≈22%) (**Table 2; Fig. 1**).

In recent years catches by gillnet fisheries have also been increasing, due to major changes some fleets (e.g., Sri Lanka and I.R. Iran); notably increases in boat size, developments in 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 (2012–16):
  Indonesia (fresh longline, coastal longline, and coastal purse seine): 26%; Taiwan,China (longline): 19%; Seychelles (longline and purse seine): 12%; EU-Spain (purse seine): 12% (**Fig.2**).

- 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 3; 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.

  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 with free swimming schools 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 – mainly small juvenile bigeye (averaging around 5 kg) compared to longliners which catch much larger sized 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 has 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.

- 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.

Table 2. 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 (2006–2016), in tonnes. Catches by decade represent the average annual catch, noting that some gears were not in operation since the beginning of the fishery.

Fishery	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
BB	21	50	266	1,536	2,968	5,069	6,047	6,109	6,874	6,789	6,880	6,878	7,266	6,188	5,912	6,542
FS	-	-	0	2,340	4,824	6,196	5,672	9,646	5,301	3,792	6,222	7,180	4,662	5,000	9,627	2,356
LS	-	-	0	4,852	18,315	20,273	18,104	19,874	24,708	18,486	16,386	10,434	22,806	14,868	15,545	19,274
LL	6,488	21,861	30,413	43,079	62,350	71,462	74,531	51,882	52,077	32,419	36,156	67,449	45,632	35,134	33,662	30,476
FL	-	-	218	3,066	26,282	23,490	22,450	23,323	15,810	9,782	12,031	12,495	14,710	12,696	11,442	9,419
LI	43	295	658	2,385	4,325	6,110	7,075	7,102	8,562	8,930	9,719	9,897	8,984	9,756	10,961	10,343
OT	38	63	164	858	1,355	3,590	4,374	4,580	5,469	5,170	6,980	6,085	6,783	6,918	6,706	8,180
Total	**6,589**	**22,269**	**31,720**	**58,118**	**120,418**	**136,191**	**138,255**	**122,516**	**118,801**	**85,368**	**94,374**	**120,418**	**110,844**	**90,561**	**93,854**	**86,589**

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 3. 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 (2007–2016), in tonnes. Catches by decade represent the total annual catch.

Fishery	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
A1	2,496	12,077	17,712	35,056	59,011	78,193	81,225	68,381	58,717	39,305	42,001	74,092	64,095	51,519	56,379	51,211
A2	3,889	7,171	10,168	18,445	43,964	43,802	50,955	47,673	55,339	40,184	44,376	38,039	39,465	32,070	29,491	28,979
A3	204	3,021	3,839	4,617	17,443	14,196	6,074	6,462	4,745	5,879	7,997	8,287	7,284	6,972	7,985	6,399
Total	**6,589**	**22,269**	**31,720**	**58,118**	**120,418**	**136,191**	**138,255**	**122,516**	**118,801**	**85,368**	**94,374**	**120,418**	**110,844**	**90,561**	**93,854**	**86,589**

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.

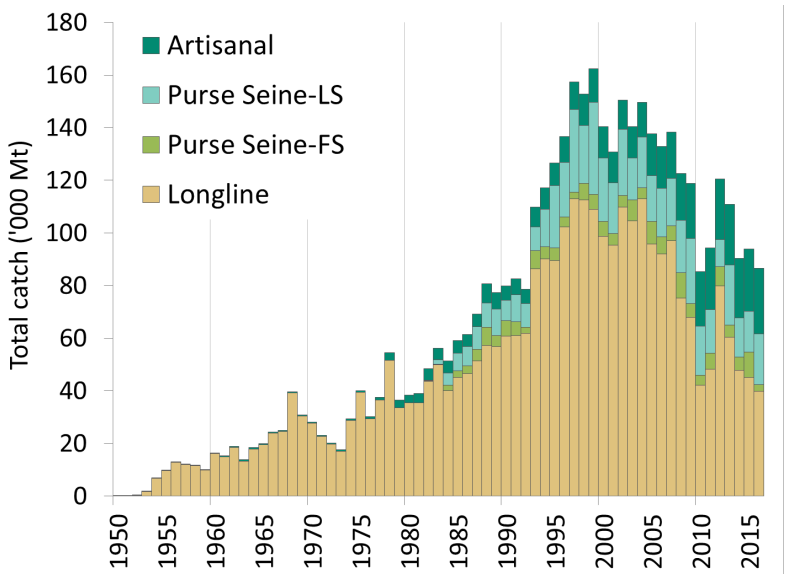


Fig. 1. Annual catches of bigeye tuna by gear (1950–2016).

Gears (as agreed by WPTT): Longline **(including Taiwan,China, Japan and other associated fleets);** 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**).

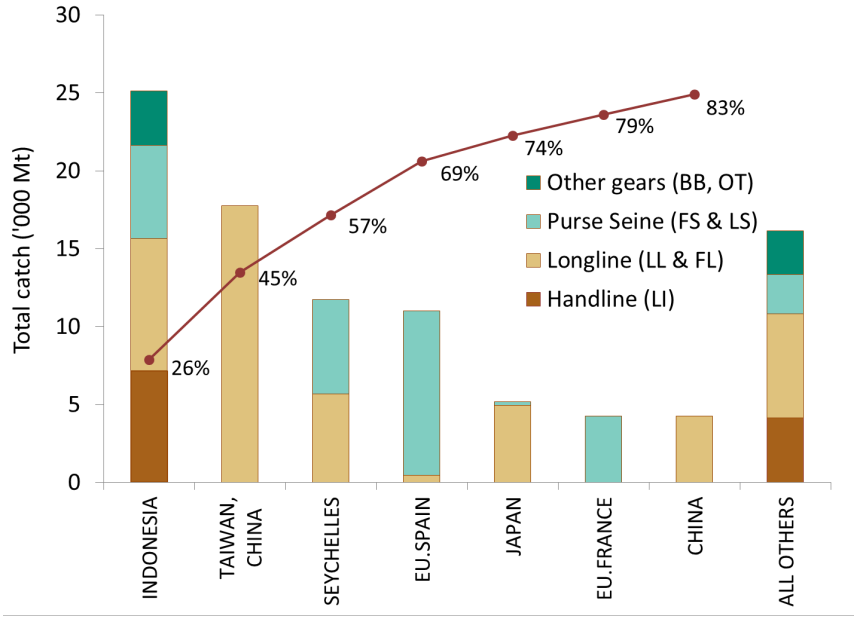


Fig.2. Bigeye tuna: average catches in the Indian Ocean over the period 2012–16, by country. Countries are ordered from left to right, according to the importance of catches of bigeye reported. The red line indicates the (cumulative) proportion of catches of bigeye for the countries concerned, over the total combined catches of this species reported from all countries and fisheries.

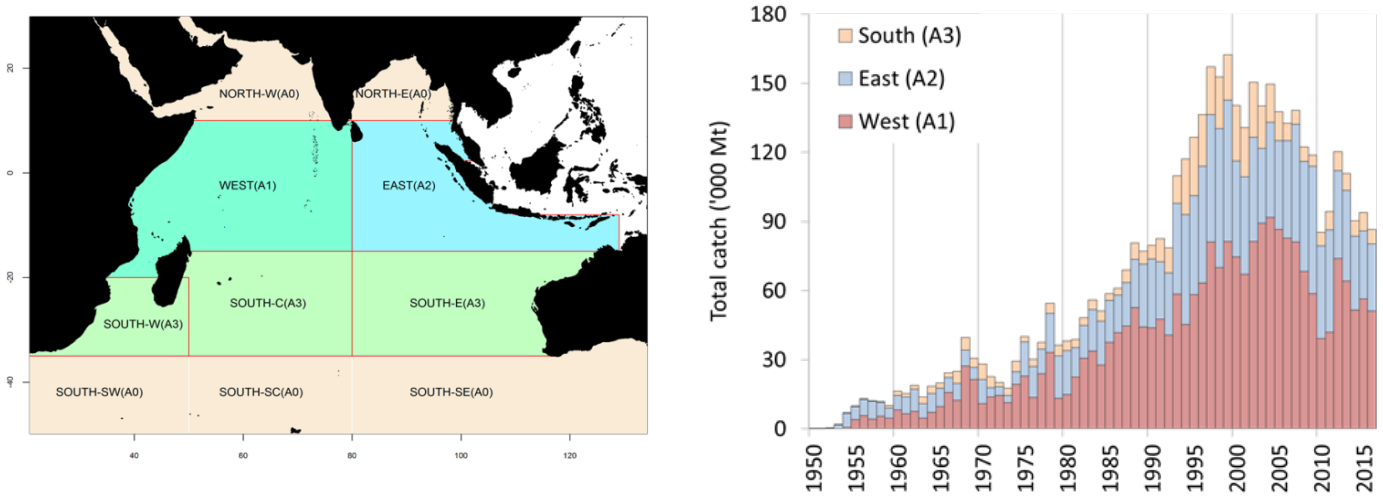


Fig. 3(a-b). Bigeye tuna: Catches of bigeye tuna by (SS3) stock assessment area by year (1950–2016). Catches outside the areas presented in the map were assigned to the closest neighbouring area for the assessment.

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.

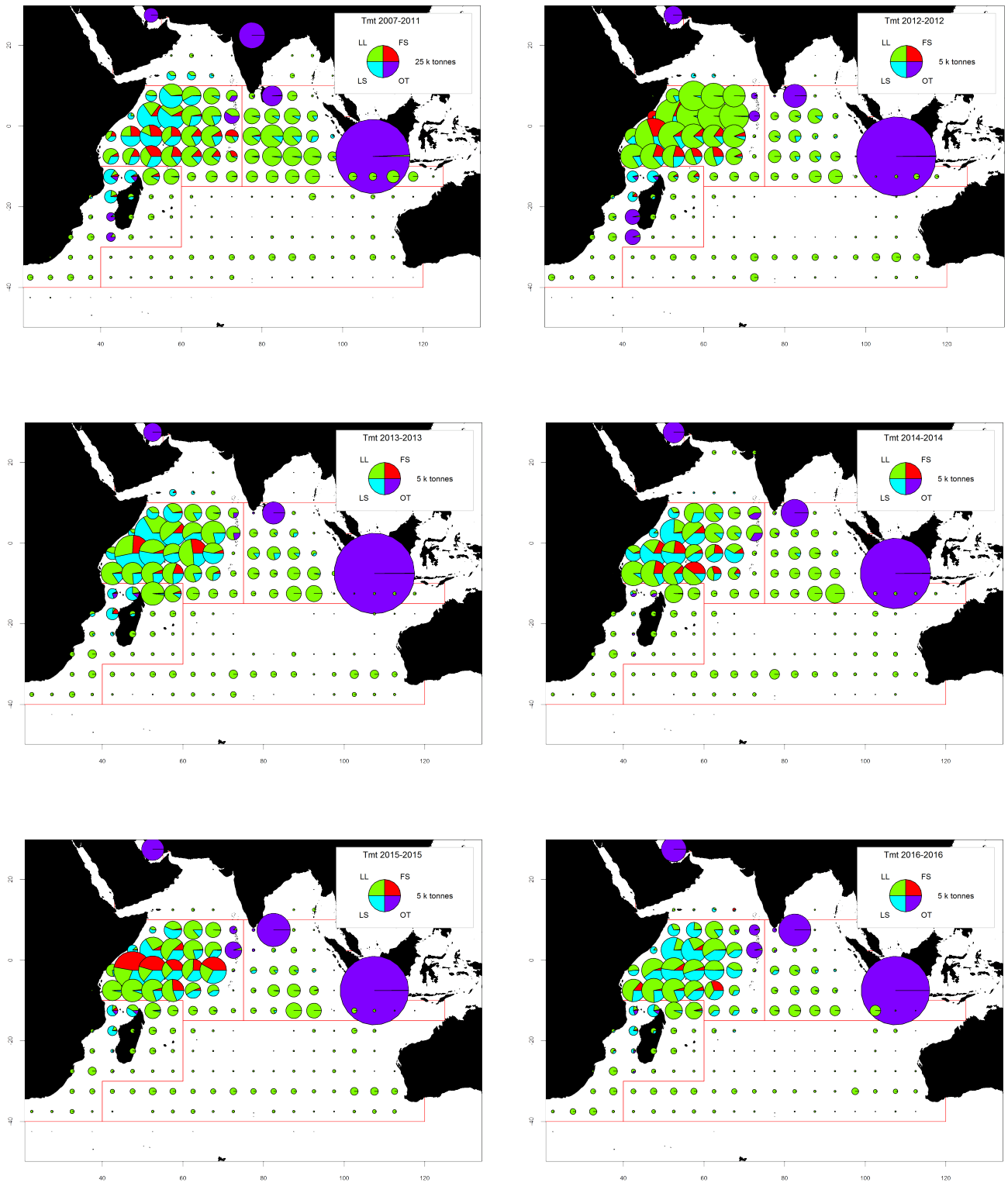


Fig. 4(a-f). Time-area catches (total combined in tonnes) of bigeye tuna estimated for the period 2007–2011 by type of gear and for 2012–16, by year and type of gear. Longline (**LL**), Purse seine free-schools (**FS**), Purse seine associated-schools (**LS**), and other fleets (**OT**), including pole-and-line, 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 relatively reliable for the main industrial fleets targeting bigeye tuna, with the proportion of catches estimated or adjusted by the IOTC Secretariat relatively low (**Fig.5a**).
- 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, Sri Lanka (gillnet-longline fishery) and the artisanal fisheries in Indonesia, Comoros (before 2011) and Madagascar.

Catch-per-unit-effort (CPUE) trends

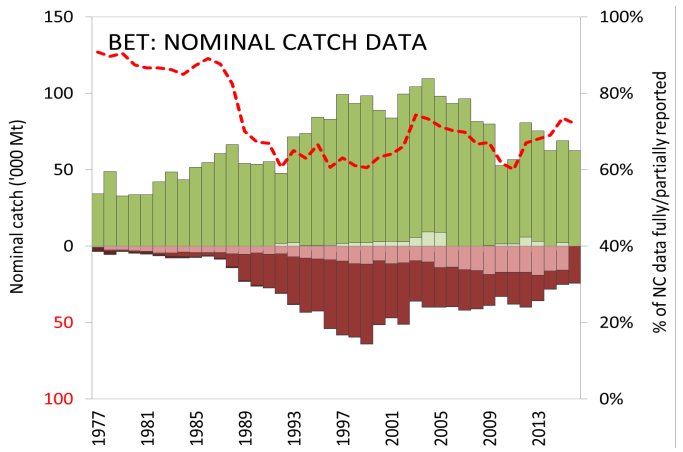
- Availability: Standardized CPUE series are available for the major industrial longline fisheries (i.e., Japan, Rep. of Korea, Taiwan,China).

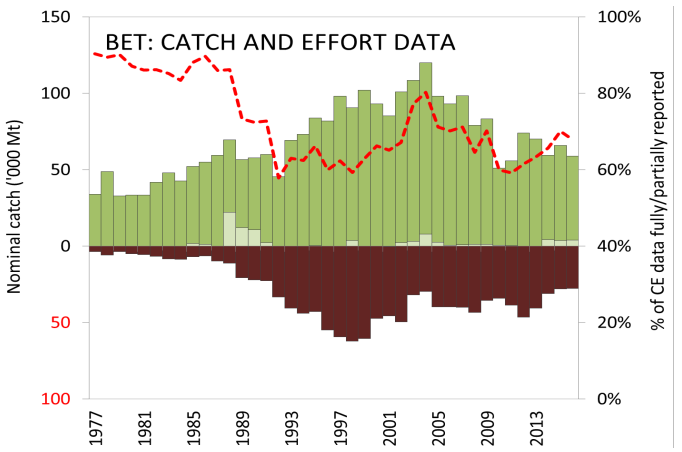
  For most other fisheries, catch-and-effort are either not available (**Fig.5b**), or are considered to be of poor quality – especially since the early-1990s and for the following fisheries/fleets:

  - NEI purse seine and longliners: no data available.
  - Fresh-tuna longline fisheries: no data are available for the fresh-tuna longline fishery of Indonesia, while data for the fresh-tuna longline fishery of Taiwan,China are only available since 2006;
  - Other industrial fisheries: uncertain data from significant fleets of industrial purse seiners from I.R. Iran, and longliners from India, Indonesia, Malaysia, Oman, and Philippines;
  - Artisanal/coastal fisheries: 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.5c**) 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) .
- Catch-at-Size (Age) table: data are available, but the estimates are more uncertain for some years and some fisheries due to:
  i. lack 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. lack of size data available for some industrial fleets (NEI, India, Indonesia, I.R. Iran, Sri Lanka).





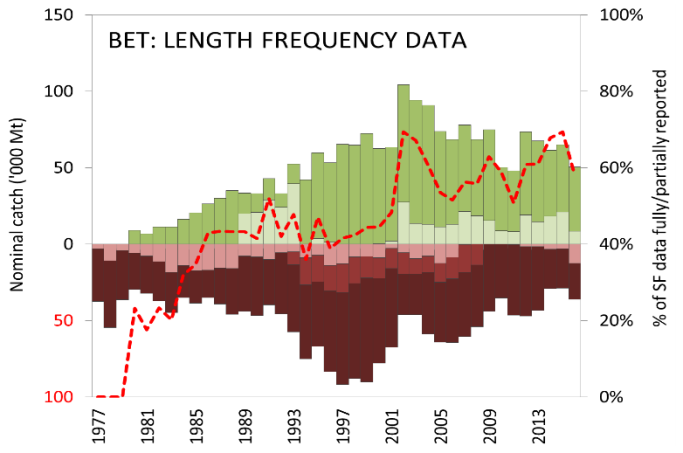


Fig.5a-c. Bigeye tuna: data reporting coverage (1977–2016).

Each IOTC dataset (nominal catch, catch-and-effort, and length frequency) are assessed against IOTC reporting standards, where:

- *Score 0: indicates the amount of nominal catch associated with each dataset that is fully reported according to IOTC standards;*
- *Scores: 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;*
- *Score: 8 refers to the amount of nominal catch associated with catch-and-effort or size frequency data that is not available.*

The red dotted line indicates the proportion of data (in terms of total catches) fully or partially reported for each dataset.

IOTC Data reporting score:

Nominal Catch	By species	By gear
Fully available according the minimum reporting standards	0	0
Partially available (part of the catch not reported by species/gear)*	2	2
Fully estimated (by the IOTC Secretariat)	4	4

*E.g., Catch assigned by species/gear by the IOTC Secretariat; or 15% or more of the catches remain under aggregates of species

Catch-and-Effort	Time-period	Area
Fully available according to the minimum reporting standards	0	0
Partially available according to the minimum reporting standards*	2	2
Low coverage (less than 30% of total catch covered through logbooks)	2	
Not available at all	8	

* E.g., Catch-and-effort not fully disaggreaged by species, gear, area, or month.

Size frequency data	Time-period	Area
Fully available according to the minimum reporting standards	0	0
Patially available according to the minimum reporting standards*	2	2
Low coverage (less than 1 fish measured by metric ton of catch)	2	
Not available at all	8	

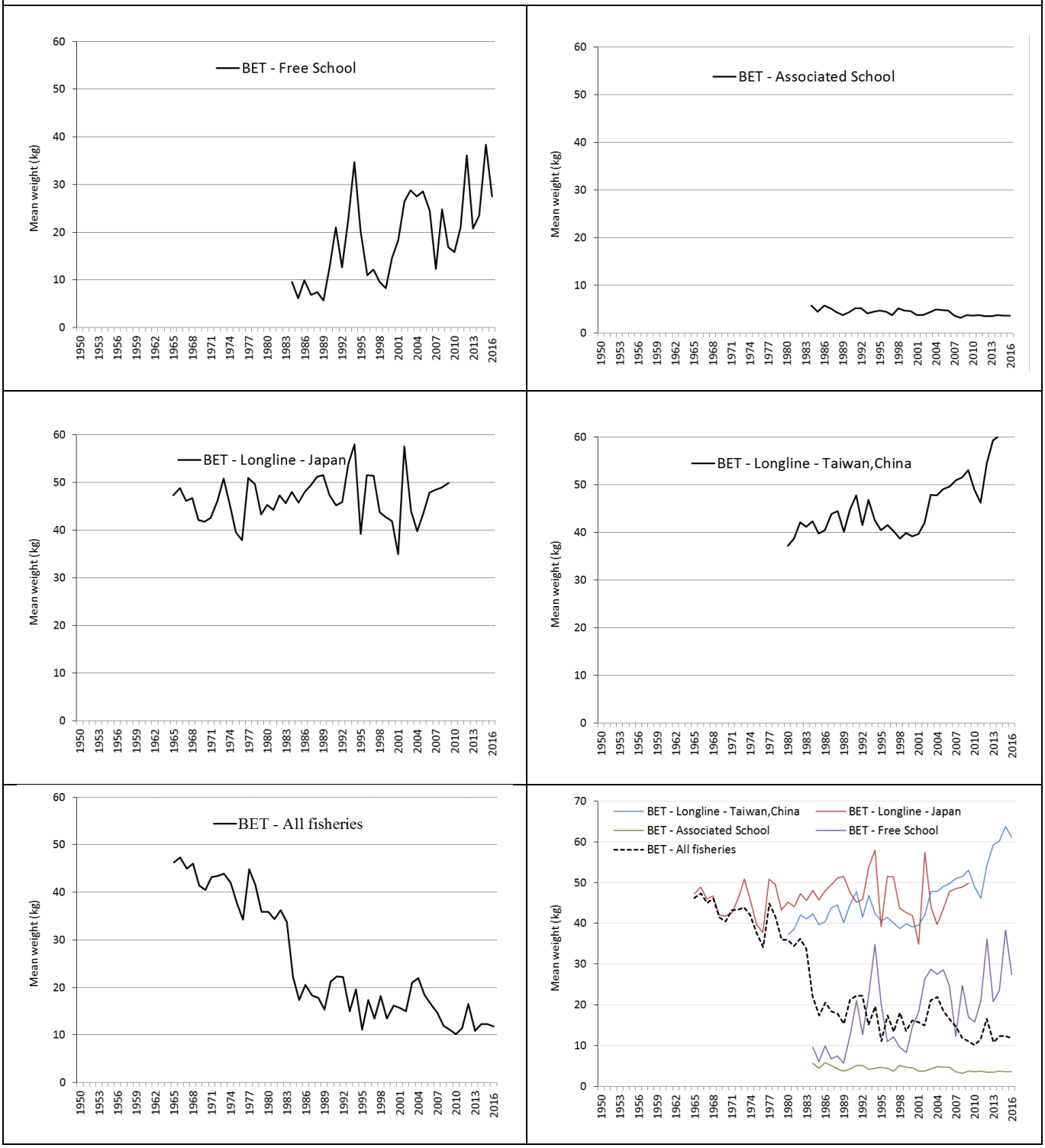
* E.g., Size data not fully available by species, gear, gear, month, or recommended size interval.

Key to colour coding

- Total score is 0 (or average score is 0-1)
- Total score is 2 (or average score is 1-3)
- Total score is 4 (or average score is 3-5)
- Total score is 6 (or average score is 5-7)
- Total score is 8 (or average score is 7-8)

Fig.6 Average weight of bigeye tuna (BET) taken by:

- Purse seine on free (top left) and associated (top right) schools,
- Longlines from Japan (second row left) and Taiwan,China (second row right)
- All fisheries (bottom row left), and all fisheries and main gears (bottom row left)



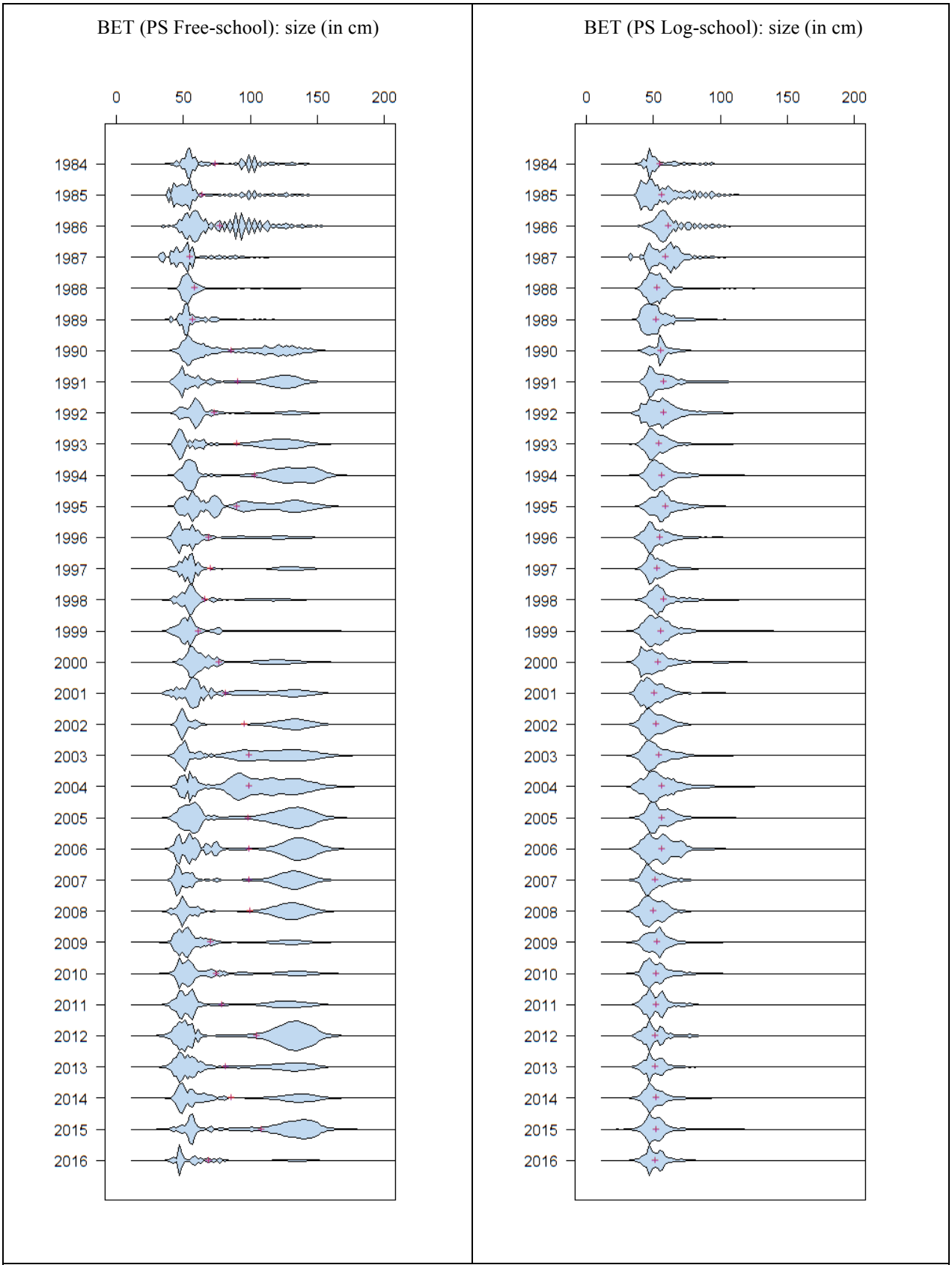


Fig.7 Bigeye tuna (purse seine): **Left:** length frequency distributions for BET PS Free school fisheries (by 2 cm length class). **Right**: Length frequency distributions for BET PS Associated (log) school fisheries (by 2 cm length class). Source: IOTC database.

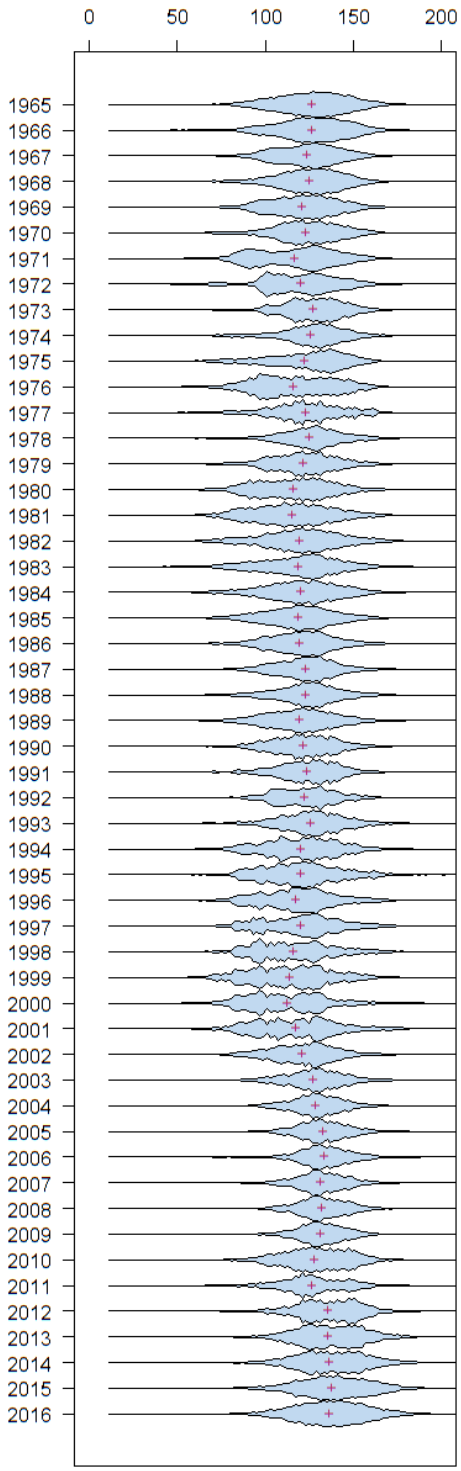


Fig.8. Bigeye tuna (longline): **Left:** length frequency distributions for longline fisheries (by 2 cm length class) derived from data available at the IOTC Secretariat. **Right**: Number of bigeye tuna specimens sampled for lengths, by fleet (longline only).

Bigeye tuna: 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. 9**). The remaining were tagged during small-scale projects, and by other institutions with the support of the IOTC Secretariat, in the Maldives, 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.

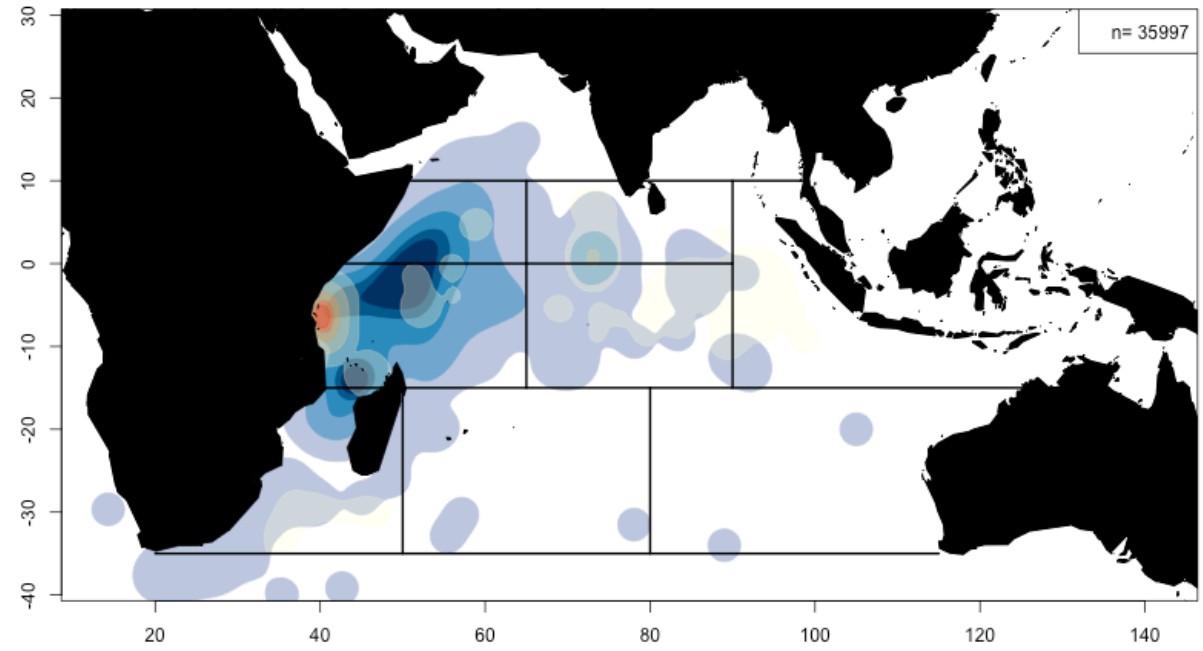


Fig. 9. Bigeye tuna: densities of releases (in red) and recoveries (in blue). The black line represents the stock assessment areas. Includes specimens tagged during the IOTTP and also Indian Ocean (Maldivian) tagging programmes during the 1990s.

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

Fishing effort trends

Total effort from longline vessels flagged to Japan, Taiwan,China and EU,Spain by five degree square grid in 2015 and 2016 are provided in **Fig. 10**, 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 in 2015 and 2016 are provided in **Fig. 11**.

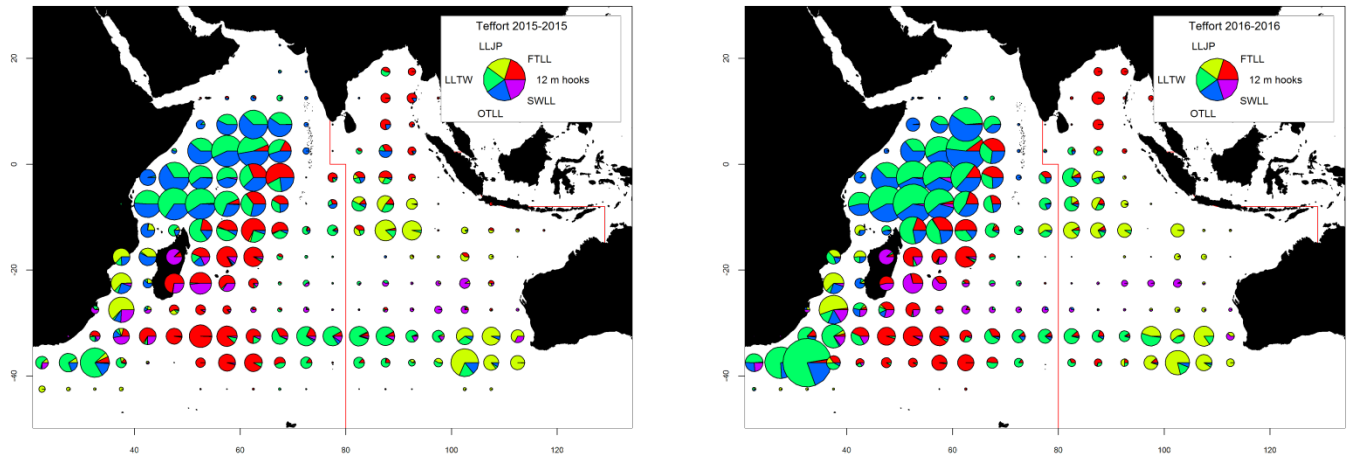


Fig.10. Number of hooks set (millions) from longline vessels by five degree square grid and main fleets, for the years 2014 (left) and 2015 (right). Definition of fisheries:

- **LLJP** (light green): deep-freezing longliners from Japan
- **LLTW** (dark green): deep-freezing longliners from Taiwan,China
- **SWLL** (purple): 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, South Korea and various other fleets)

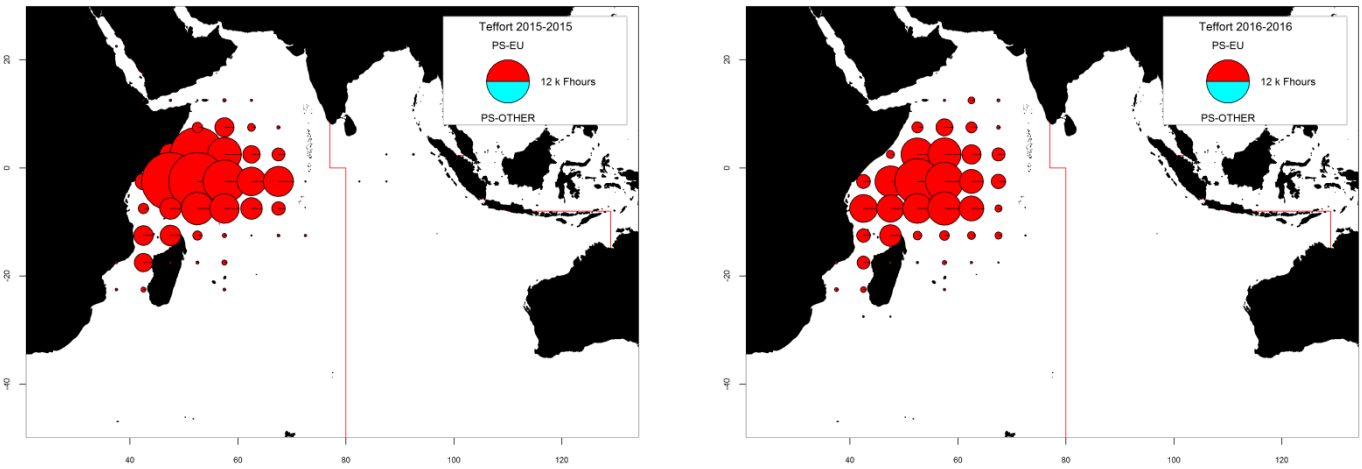


Fig.11. Number of hours of fishing (Fhours) from purse seine vessels by 5 degree square grid and main fleets, for the years 2015 (left) and 2016 (right). Definition of fisheries:

- **PS-EU** (red): Industrial purse seiners monitored by the EU and Seychelles (operating under flags of EU countries, Seychelles and other flags)
- **PS-OTHER** (light blue): 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, and days-at-sea recorded for Australia)

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

The CPUE series presented at the WPTT18 meeting in 2016 are listed below. The joint longline CPUE Japanese longline CPUE index by region (1979–2015) was utilised for the final stock assessment model runs and in the development of management advice, noting that the Japanese and Taiwanese series from the tropical areas and the Indian Ocean as a whole, showed very similar trends (**Figs. 12 & 13**).

- Joint longline CPUE (1979-2015): Series (regions 1 to 4) from document IOTC-2016-WPTT18-14.
- Taiwan,China data (1979–2015): Series (core, core east, core west, south) from document IOTC–2016–WPTT18–34.
- Japan data (1960–2015): Series (whole Indian Ocean, tropical area, temperate area) from document IOTC–2016–WPTT18–18.
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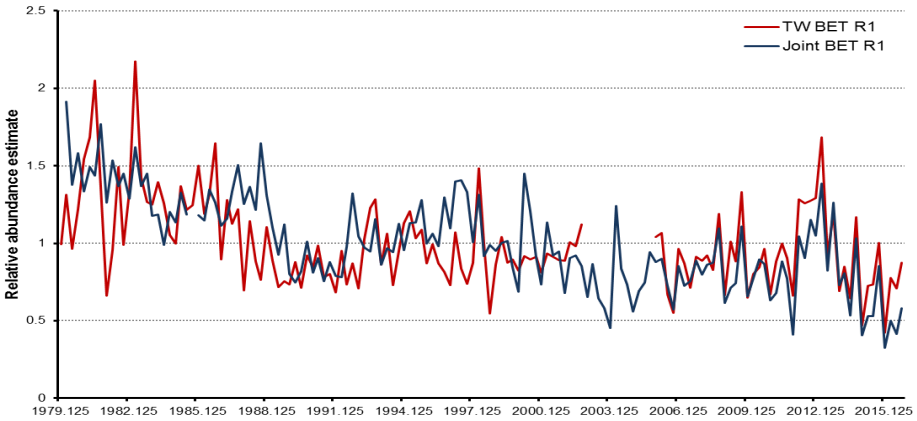

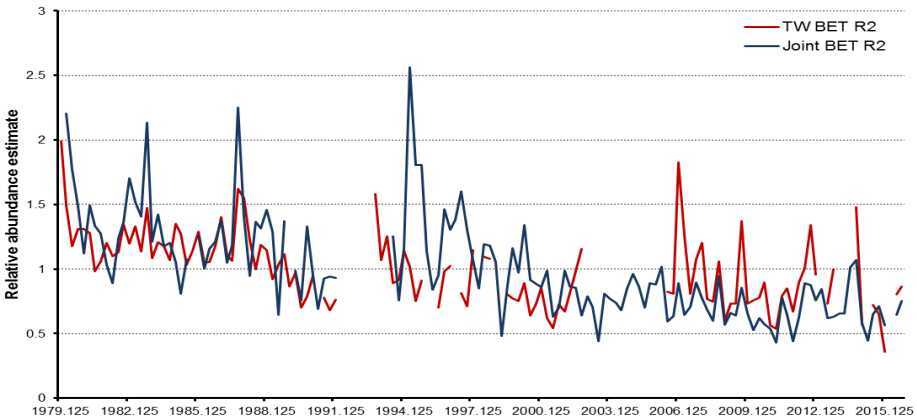

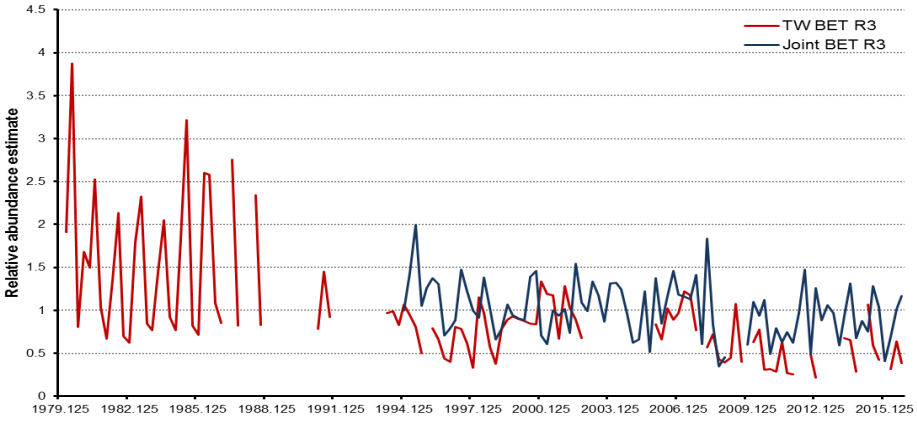

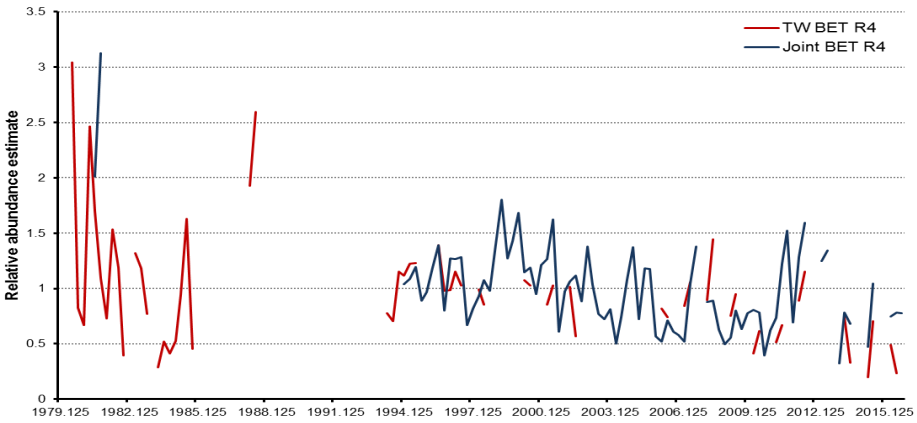

Fig. 12. Comparisons of Taiwan,China bigeye tuna CPUE time series (red) with those estimated during the 2016 collaborative project (blue) by region.

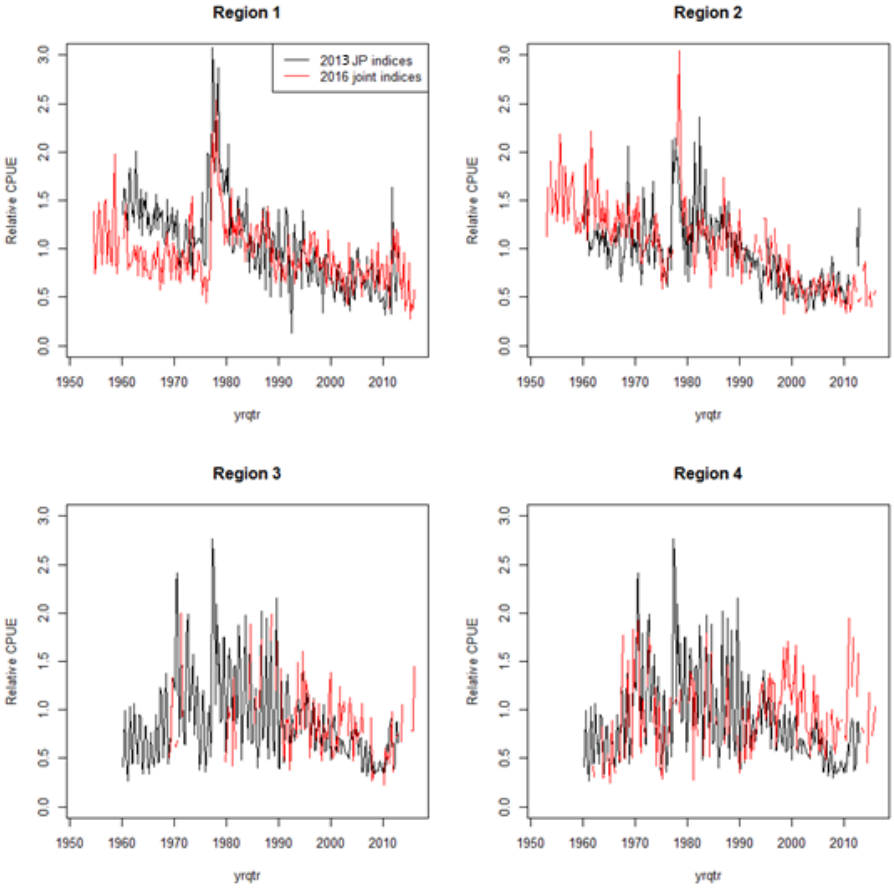

Fig. 13. Comparison of the 2016 joint indices described in this paper (red), with the Japanese indices developed in 2013 and used in the 2013 bigeye stock assessment (black).

STOCK ASSESSMENT

An assessment of bigeye tuna was carried out in 2016, using a range of quantitative modelling methods (ASAP, ASPIC, BDM, BSPM, SCAA and SS3). Management advice for bigeye tuna is based on the range of results from the SS3 models – although the other models were discussed as supporting evidence.

The SS3 results were preferred to the other assessment platforms 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.

A range of plausible SS3 model options were considered to adequately represent the range of uncertainty in the assessment, including:

i. model options with different weightings associated with the tagging data.
ii. A model option that commenced in 1950 and partitioned the longline CPUE indices into two time periods (1953-1975 and 1979-2015) with different catchability coefficients estimated for each time period. The model estimated recruitment deviates for the entire time period. Recruitment was estimated to be lower during the earlier period compared to the latter period. The WPTT was concerned that the change in the level of recruitment between the two periods may be due to model mis-specification rather than a regime shift. On that basis, the model scenario that commenced in 1950 was not used for the provision of management advice.

Integrating across all outcomes, the 2016 stock assessment model results did not differ substantively from the previous (2013 and 2011) assessments – 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 – and indicate that current that current fishing mortality is below the MSY-based reference level (i.e. $F_{2015}/F_{MSY} < 1$).

Key assessment results for the SS3 stock assessment conducted in 2016 are shown in **Table 4**.

Table 4. Bigeye tuna: Key management quantities from the 2016 SS3 assessment, for the aggregate Indian Ocean.*

Management Quantity	Aggregate Indian Ocean
Most recent catch estimate (t) (2015)	93,040
Mean catch over last 5 years (t) (2011–2015)	101,483
h (steepness)	0.7, 0.8, 0.9
MSY (1,000 t) (80% CI)	104 (87-121)
Data period (catch)	1975-2015
CPUE series/period	1979-2015
F_{MSY} (80% CI)	0.17 (0.14-0.20)
SB_{MSY} or $*B_{MSY}$ (1,000 t) (80% CI)	525 (364-718)
F_{2015}/F_{MSY} (80% CI)	0.76 (0.49-1.03)
B_{2015}/B_{MSY} (80% CI)	n.a.
SB_{2015}/SB_{MSY} (80% CI)	1.29 (1.07-1.51)
B_{2015}/B_{1950} (80% CI)	n.a.
SB_{2015}/SB_{1950} (80% CI)	0.38 (n.a.-n.a.)
$SB_{2015}/SB_{current, F=0}$ (80% CI)	n.a.

* The management quantities refer to the data used in the last assessment, conducted in 2016.

LITERATURE CITED

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