Report of the 19th Session of the IOTC Working Party on Tropical Tunas

Seychelles, 17–22 October 2017

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ACRONYMS

aFAD	anchored Fish aggregating device
ASAP	Age-Structured Assessment Program
ASPIC	A Stock-Production Model Incorporating Covariates
ASPM	Age-Structured Production Model
B	Biomass (total)
BDM	Biomass Dynamic Model
BET	Bigeye tuna
B_{MSY}	Biomass which produces MSY
CE	Catch and effort
CI	Confidence Interval
CMM	Conservation and Management Measure (of the IOTC; Resolutions and Recommendations)
CPCs	Contracting parties and cooperating non-contracting parties
CPUE	Catch per unit of effort
current	Current period/time, i.e. $F_{current}$ means fishing mortality for the current assessment year.
EEZ	Exclusive Economic Zone
ENSO	El Niño–Southern Oscillation
EU	European Union
F	Fishing mortality; F_{2011} is the fishing mortality estimated in the year 2011
FAD	Fish aggregating device
F_{MSY}	Fishing mortality at MSY
GLM	Generalised linear model
HBF	Hooks between floats
IO	Indian Ocean
IOTC	Indian Ocean Tuna Commission
IWC	International Whaling Commission
K2SM	Kobe II Strategy Matrix
LL	Longline
M	Natural Mortality
MSC	Marine Stewardship Council
MSE	Management Strategy Evaluation
MSY	Maximum sustainable yield
n.a.	Not applicable
PS	Purse seine
q	Catchability
ROS	Regional Observer Scheme
RTTP-IO	Regional Tuna Tagging Project in the Indian Ocean
RTSS	RTTP-IO plus small-scale tagging projects
SC	Scientific Committee, of the IOTC
SB	Spawning biomass (sometimes expressed as SSB)
SB_{MSY}	Spawning stock biomass which produces MSY (sometimes expressed as SSB_{MSY})
SCAA	Statistical-Catch-At-Age
SKJ	Skipjack tuna
SS3	Stock Synthesis III
Taiwan,China	Taiwan, Province of China
VB	Von Bertalanffy (growth)
WPTT	Working Party on Tropical Tunas of the IOTC
YFT	Yellowfin tuna

STANDARDISATION OF IOTC WORKING PARTY AND SCIENTIFIC COMMITTEE REPORT TERMINOLOGY

SC16.07 (para. 23) The SC **ADOPTED** the reporting terminology contained in Appendix IV and **RECOMMENDED** that the Commission considers adopting the standardised IOTC Report terminology, to further improve the clarity of information sharing from, and among its subsidiary bodies.

HOW TO INTERPRET TERMINOLOGY CONTAINED IN THIS REPORT

Level 1: From a subsidiary body of the Commission to the next level in the structure of the Commission:
RECOMMENDED, RECOMMENDATION: Any conclusion or request for an action to be undertaken, from a subsidiary body of the Commission (Committee or Working Party), which is to be formally provided to the next level in the structure of the Commission for its consideration/endorsement (e.g. from a Working Party to the Scientific Committee; from a Committee to the Commission). The intention is that the higher body will consider the recommended action for endorsement under its own mandate, if the subsidiary body does not already have the required mandate. Ideally this should be task specific and contain a timeframe for completion.

Level 2: From a subsidiary body of the Commission to a CPC, the IOTC Secretariat, or other body (not the Commission) to carry out a specified task:
REQUESTED: This term should only be used by a subsidiary body of the Commission if it does not wish to have the request formally adopted/endorsed by the next level in the structure of the Commission. For example, if a Committee wishes to seek additional input from a CPC on a particular topic, but does not wish to formalise the request beyond the mandate of the Committee, it may request that a set action be undertaken. Ideally this should be task specific and contain a timeframe for the completion.

Level 3: General terms to be used for consistency:
AGREED: Any point of discussion from a meeting which the IOTC body considers to be an agreed course of action covered by its mandate, which has not already been dealt with under Level 1 or level 2 above; a general point of agreement among delegations/participants of a meeting which does not need to be considered/adopted by the next level in the Commission’s structure.
NOTED/NOTING: Any point of discussion from a meeting which the IOTC body considers to be important enough to record in a meeting report for future reference.

Any other term: Any other term may be used in addition to the Level 3 terms to highlight to the reader of and IOTC report, the importance of the relevant paragraph. However, other terms used are considered for explanatory/informational purposes only and shall have no higher rating within the reporting terminology hierarchy than Level 3, described above (e.g. **CONSIDERED**; **URGED**; **ACKNOWLEDGED**).

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EXECUTIVE SUMMARY

The 19th Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Tropical Tunas (WPTT) was held in Seychelles, from 17–22 October 2017. The meeting was opened by the Chairperson, Dr M. Shiham Adam (Maldives) who welcomed participants and Vice-Chair, Dr Gorka Merino (EU,Spain). A total of 49 participants attended the Session (44 in 2016, 44 in 2015), including the invited expert Dr. Rishi Sharma (NOAA).

The following are a subset of the complete recommendations from the WPTT19 to the Scientific Committee, which are provided at Appendix X.

Review of the statistical data available for tropical tunas

WPTT19.01 (para. 20): **ACKNOWLEDGING** the substantial gaps in reporting of mandatory IOTC datasets by many CPCs to the IOTC Secretariat, which increases the uncertainty of stock assessments and management advice based on these data, the WPTT strongly **RECOMMENDED** the Commission strengthen the penalty mechanisms adopted in *Resolution 16/06 On measures applicable in case of non-fulfilment of reporting obligations in the IOTC* to improve compliance by CPCs in terms of the submission of basic fishery data in accordance with Resolution 15/01 and 15/02.

Testing designs of Biodegradable FADs in natural conditions to mitigate the impacts of drifting FADs on the Ecosystem

WPTT19.02 (para. 73): The WPTT **NOTED** that WPEB (2017) discussed some of the challenges in conducting biodegradable FAD studies (for example the limit on the number of active FADs per purse seine vessel in the Indian Ocean that may hinder the deployment of BIOFADs following experimental sampling designs, and also engagement with the fleet to deploy BIOFADs that may not be successful for fishing), and the WPTT **RECOMMENDED** the Commission consider special allocations for experimental FADs deployed for the collection of scientific data for vessels willing to participate in biodegradable FAD testing under protocols reviewed and endorsed by the Scientific Committee.

Review of new information on the status of bigeye tuna: Nominal and standardised CPUE indices

WPTT19.03 (para. 107): The WPTT **ACKNOWLEGED** the efficiency value of making the operational logbook data available to appropriate analysts outside of the responsible CPCs, and **RECOMMENDED** that high level arrangements for sharing and confidentiality should be pursued. **NOTING** the confidentiality issues with some of the datasets, the WPTT **REQUESTED** that the IOTC Secretariat and main stakeholders explore options to facilitate future data sharing agreements which, once in place, may not necessitate face-to-face meetings and could instead include remote processes.

WPTT19.04 (para. 108): The WPTT **RECOMMENDED** that the joint longline CPUE standardization for tropical tunas should continue, and that further development work should be assigned a high priority. **ACKNOWLEDGING** that the law of diminishing returns will affect similar future analyses, the WPTT **SUGGESTED** that immediate priorities should focus on the following areas:

- develop joint CPUE indices for other IOTC species (i.e., billfish and sharks);
- explore possibilities for including CPUE data provided by other IOTC CPCs (particularly coastal fisheries);
- identify a unified approach for species targeting using simulation testing (for example, the value of cluster analysis is clear in the temperate regions, but less so in tropical regions);
- recover vessel identification details from historical data;
- further develop the work on time-area interactions. Include a detailed examination of catch rates and related data in the piracy area, comparing pre-piracy and post-piracy effects. Potentially also consider the effects of localised depletion and renewal processes on catch rates.
- conduct further size analyses to explore 1977 discontinuity (other oceans);
- develop an Indian Ocean CPUE reference manual for practitioners to use
- explore other distributions to improve model fit.

Parameters for future analyses: Yellowfin tuna CPUE standardisation and stock assessments

WPTT19.06 (paras. 227): The WPTT reiterated its previous **RECOMMENDATION** that development of the next stock assessment of yellowfin tuna should include, or be associated with, a detailed review of the existing data sources, including:

i. Size frequency data: Evaluation of the reliability of length composition from the longline fisheries (including recent and historical data), review of anomalies in the (EU) PS length composition data, and the need for a thorough review of the size frequency data held by IOTC,

in collaboration with the fleets involved, to improve the utilization of these data in tropical tuna stock assessments.

ii. Tagging data: Further analysis of the tag release/recovery data set.

iii. Alternative CPUE series: a review of the available data from the Indian tuna longline survey data.

Revision of the WPTT Program of Work (2018–2022)

WPTT19.07 (paras. 239): The WPTT **RECOMMENDED** that the SC consider and endorse the WPTT Program of Work (2018-2022), as provided at Appendix IX.

Table 1. Status summary for species of tropical tuna under the IOTC mandate.

Stock	Indicators		2009	2010	2011	2012	2013	2014	2015	2016	2017	Advice to the Commission
Bigeye tuna *Thunnus obesus*	Catch in 2016: Average catch 2012–2016: MSY (1000 t) (80% CI): F_{MSY} (80% CI): SB_{MSY} (1,000 t) (80% CI): F_{2015}/F_{MSY} (80% CI): SB_{2015}/SB_{MSY} (80% CI): SB_{2015}/SB_0 (80% CI):	86,586 t 100,455 t 104 (87-121) 0.17 (0.14-0.20) 525 (364-718) 0.76 (0.49-1.03) 1.29 (1.07-1.51) 0.38 (n.a. – n.a.)								**84 % ****		No new stock assessment was carried out for bigeye tuna in 2017, thus, the stock status is determined on the basis of the 2016 assessment and other indicators presented in 2017. On the weight-of-evidence available in 2017, the bigeye tuna stock is determined to be **not overfished** and is **not subject to overfishing**. 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. <Click here for full stock status summary>
Skipjack tuna *Katsuwonus pelamis*	Catch in 2016: Average catch 2012–2016: MSY (1000 t) (plausible range): $SSB_{Current}$ / SSB_{MSY} $E_{Current}$ / E_{msy} $Yield_{40\%SSB}$ (1000 t) (80% CI): $E_{2016}/E_{40\%SSB}$ (80% CI): $C_{2016}/C_{40\%SSB}$ (80% CI): SB_{2016} (1000 t) (80% CI): Total biomass B_{2016} (1000 t) (80% CI): $SB_{2016}/SB_{40\%SSB}$ (80% CI): SB_{2016}/SB_0 (80% CI): $E_{40\%SSB}$ (80% CI): SB_0 (80% CI):	446,723 t 407,456 t 564 (480.4-697.8) 1.61 (1.25-2.35) 0.54 (0.36-0.77) 510.1 (455.9–618.8) 0.93 (0.70–1.13) 0.88 (0.72-0.98) 796.66 (582.65-1,059.40) 910.4 (873.6-1195) 1.00 (0.88–1.17) 0.40 (0.35–0.47) 0.59 (0.53-0.65) 2,015,220 (1,651,230–2,296,135)								**47 % ****		A new assessment was carried out for skipjack tuna in 2017. The 2017 stock assessment model results differ substantively from the previous (2014 and 2011) assessments, for a number of reasons. The final overall estimate of stock status indicates that the stock is at the target biomass reference point and that the current and historical fishing mortality rates are estimated to be below the target. Thus, on the weight-of-evidence available in 2017, the skipjack tuna stock is determined to be **not overfished** and is **not subject to overfishing**. Given the current status of the fishery and assuming that catch does not exceed prescription from Resolution 16-02, it would be expected that the stock would fluctuate around the target level. However there remains considerable uncertainty in the assessment, and the range of runs analysed illustrate a range of stock status to be between 0.88 and 1.17 of SB_{2016}/SB_0 based on all runs examined. <Click here for full stock status summary>

Yellowfin tuna *Thunnus albacares*	Catch in 2016: Average catch 2012–2016: MSY (1000 t) (plausible range): F_{MSY} (plausible range): SB_{MSY} (1,000 t) (plausible range): F_{2015}/F_{MSY} (plausible range): SB_{2015}/SB_{MSY} (plausible range): SB_{2015}/SB_0 (plausible range):	412,679 t 405,741 t 422 (406-445) 0.15 (0.15-0.15) 947 (900-983) 1.11 (0.86-1.36) 0.89 (0.79-0.99) 0.29 (n.a.-n.a.)							**94%****	**68%****		No new stock assessment was carried out for yellowfin tuna in 2017, thus, the stock status is determined on the basis of the 2017 assessment and other indicators presented in 2017. On the weight-of-evidence available in 2016, the yellowfin tuna stock is determined to be **overfished** and **subject to overfishing.** The stock status determination changed in 2015 as a direct result of the large and unsustainable catches of yellowfin tuna taken over the previous three (3) years since 2012, and the relatively low recruitment levels estimated by the stock assessment model in recent years. Resolution 17/01 *On interim plan for rebuilding the Indian Ocean yellowfin tuna stock in the IOTC area of competence* implements reductions in catches (based on 2014/2015 catch levels), in response to the increased fishing pressure on yellowfin tuna and change in stock status. <Click here for full stock status summary>

** Estimated probability that the stock is in the respective quadrant of the Kobe plot (shown below), derived from the confidence intervals associated with the current stock status.

1. Opening of the Meeting

1. The 19th Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Tropical Tunas (WPTT) was held in Seychelles, from 17–22 October 2017. The meeting was opened by the Chairperson, Dr M. Shiham Adam (Maldives) who welcomed participants and Vice-Chair, Dr Gorka Merino (EU,Spain). A total of 49 participants attended the Session (44 in 2016, 44 in 2015), including an invited expert (Dr. Rishi Sharma, NOAA). The list of participants is provided at Appendix I.

2. Adoption of the Agenda and Arrangements for the Session

2. The WPTT **ADOPTED** the Agenda provided at Appendix II. The documents presented to the WPTT19 are listed in Appendix III.

3. The IOTC process: Outcomes, updates and progress

3.1 Outcomes of the 19th Session of the Scientific Committee

3. The WPTT **NOTED** paper IOTC–2017–WPTT19–03 which outlined the main outcomes of the 19th Session of the Scientific Committee (SC19), specifically related to the work of the WPTT, and **AGREED** to consider how best to progress these issues at the present meeting.

4. The WPTT **NOTED** that in 2016, the SC made a number of requests in relation to the WPTT18 report (noting that updates on Recommendations of the SC19 are dealt with under Agenda item 3.4 below). Those requests and the associated responses from the WPTT19 are provided below for reference.

- ***Report of the 18th Session of the Working Party on Tropical Tunas (WPTT18)***
  - *(Para. 89) The SC **NOTED** that the first attempt to establish a standardized CPUE series for the EU purse seine fleet was carried out in 2016 and made available to the WPTT, following results of the EU CECOFAD Project. It was NOTED that the series needs further work before being included in the assessment process, and therefore the SC **REQUESTED** that the EU scientists continue refining those series in 2017.*
  - *(Para. 90) The SC **NOTED** that both MSY and depletion-based (B0) reference points are reported in the key management quantity tables of the stock assessments. The SC also **REQUESTED** that estimates of current biomass in the absence of fishing (i.e. Bcurrent, F=0) are included in the management quantity tables for future stock assessments.*
- ***Review of the statistical data available for bigeye tuna***
  - *(Para. 91) The SC **NOTED** that in the case of many coastal fisheries, juveniles of bigeye tuna often account for an appreciable amount of the total catch but are either not reported or assigned to an 'Other' species category. The SC **REQUESTED** the IOTC Secretariat and Maldives collaborate to improve reliability of catches of bigeye tuna – particularly for historical catch series prior to the introduction of logbooks in 2010.*
- ***Collaborative study of tropical tuna CPUE from multiple Indian Ocean longline fleets***
  - *(Para. 92) The SC **REQUESTED** continued work on joint analysis of operational catch and effort data from multiple fleets, to further develop methods and to provide indices of abundance for IOTC stock assessments, and **NOTED** that ISSF would be willing to contribute support for future activities, with the aim of normalizing the process of joint analysis of the operational catch and effort data within the IOTC.*
- ***Yellowfin tuna CPUE Summary discussion***
  - *(Para. 94) The SC **REQUESTED** that efforts to develop abundance indicators using purse seine data should be continued. Given the difficulty of defining effort in purse seine fisheries (particularly in FAD fisheries), and the importance of obtaining an abundance index for skipjack, alternative methods such as those based on ratio methods and standardized species composition should also be considered.*

3.2 Outcomes of the 21st Session of the Commission

5. The WPTT **NOTED** paper IOTC–2017–WPTT19–04 which outlined the main outcomes of the 21st Session of the Commission, specifically related to the work of the WPTT and **AGREED** to consider how best to provide the Scientific Committee with the information it needs, in order to satisfy the Commission's requests, throughout the course of the current WPTT meeting.

6. The WPTT **NOTED** the 8 Conservation and Management Measures (CMMs) adopted at the 21th Session of the Commission (consisting of 8 Resolutions and 0 Recommendations) as listed below:

IOTC Resolutions

- Resolution 17/01 *On an interim plan for rebuilding the Indian Ocean yellowfin tuna stock in the IOTC Area of Competence.*
- Resolution 17/02 *Working party on the implementation of Conservation and Management Measures (WPICMM).*
- Resolution 17/03 *On establishing a list of vessels presumed to have carried out illegal, unreported and unregulated fishing in the IOTC Area of competence*.
- Resolution 17/04 *On a ban on discards of Bigeye tuna, Skipjack tuna, Yellowfin tuna, and non-targeted species caught by vessels in the IOTC Area of Competence.*
- Resolution 17/05 *On the conservation of sharks caught in association with fisheries managed by the IOTC.*
- Resolution 17/06 *On establishing a programme for transhipment by large-scale fishing vessels*
- Resolution 17/07 *On the prohibition to use large-scale driftnets in the IOTC Area.*
- Resolution 17/08 *Proposal for amendment of Resolution 15/08: Procedures on a fish aggregating devices (FADs) management plan, including a limitation on the number of FADs, more detailed specifications of catch reporting from FAD sets, and the development of improved FAD designs to reduce the incidence of entanglement of non-target species.*

7. The WPTT **NOTED** that pursuant to Article IX.4 of the IOTC Agreement, the above mentioned Conservation and Management Measures became binding on Members, 120 days from the date of the notification communicated by the IOTC Secretariat in IOTC Circular 2017–061 (i.e., **3 October 2017**).

8. **NOTING** that the Commission also made a number of general comments and requests on the recommendations made by the Scientific Committee in 2016, which have relevance for the WPTT (details as follows: paragraph numbers refer to the report of the Commission (IOTC–2017–S21–R): the WPTT **AGREED** that any advice to the Commission would be provided in the relevant sections of this report, below.

- ***Report of the 19th Session of the Scientific Committee***
  - *(Para 22) The Commission **CONSIDERED** the list of recommendations made by the SC19 in 2016 (IOTC–2016–SC19–R) that related specifically to the Commission. The Commission **ENDORSED** the list of recommendations as its own, while taking into account the range of issues outlined in this Report (IOTC-2017-S21-R) and incorporated within Conservation and Management Measures adopted during the Session and as adopted for implementation as detailed in the approved annual budget and Program of Work.*
- ***On the status of tropical tunas.***
  - *(Para. 23) The Commission noted that the current status of tropical and temperate tunas is as follows:*

    ***Bigeye tuna**: a bigeye assessment was carried out in 2016. The stock is not overfished and not subject to overfishing. If catch remains below the estimated MSY levels estimated for the current mix of fisheries, then immediate management measures are not required.*

    ***Yellowfin tuna**: a yellowfin assessment was carried out in 2016. The stock is overfished and subject to overfishing. The stock status is driven by unsustainable catches of yellowfin tuna taken over the last four years, and the relatively low recruitment levels estimated by the model in recent years. The Commission has an interim plan for the rebuilding of this stock (Resolution 16/01), with catch limitations beginning January 1 2017. The possible effect of this measure can only be assessed once estimates of abundance in 2017 would be available at the 2019 assessment.*

    ***Skipjack tuna**: a skipjack assessment was carried out in 2014. The stock is not overfished and not subject to overfishing. The adoption of Resolution 16/02 requires that an estimate of spawning biomass relative to virgin spawning biomass from future skipjack assessments is used to parameterise the Harvest Control Rule (HCR). The next assessment for skipjack will be conducted in 2017, at which time the HCR will be applied and a total allowable catch for skipjack will be established for 2018. No* *additional management measures are required at this time, however continued monitoring and improvement in data collection, reporting and analysis (including fishery indicators) is required to reduce the uncertainty in assessments.*

- ***Consideration of management measures to tropical and temperate tunas**.*
  - *(Para. 24) The Commission **ADOPTED** Resolution 17/01 On an interim plan for rebuilding the Indian Ocean yellowfin tuna stock in the IOTC Area of Competence.*
  - *(Para. 25) The Commission **NOTED** the following statement from Seychelles: "A number of compromises were made to reach a consensus, which include: 1) changing the number of FADs from 300 to 350 and 2) move to a gradual reduction of supply vessels to accommodatee the concerns of some CPCs."*
  - *(Para. 28) The Commission **ADOPTED** Resolution 17/08 Procedures on a fish aggregating devices (FADs) management plan, including a limitation on the number of FADs, more detailed specifications of catch reporting from FAD sets, and the development of improved FAD designs to reduce the incidence of entanglement of non-target species.*

*3.3 **Review of Conservation and Management Measures relating to tropical tunas***

9. The WPTT **NOTED** paper IOTC–2017–WPTT19–05 which aimed to encourage participants at the WPTT19 to review some of the existing Conservation and Management Measures (CMM) relevant to tropical tunas, noting the CMMs contained in document IOTC–2017–WPTT19–04; and as necessary to 1) provide recommendations to the Scientific Committee on whether modifications may be required; and 2) recommend whether other CMMs may be required.

10. The WPTT **AGREED** that it would consider proposing modifications for improvement to the existing CMMs following discussions held throughout the current WPTT meeting.

3.4 Progress on the Recommendations of WPTT18

11. The WPTT **NOTED** paper IOTC–2017–WPTT19–06, which provided an update on the progress made in implementing the recommendations from the previous WPTT meeting that were endorsed by the Scientific Committee, and **AGREED** to provide alternative recommendations for the consideration and potential endorsement by participants, as appropriate, given any progress.

12. The WPTT **RECALLED** that any recommendations developed during a Session, must be carefully constructed so that each contains the following elements:
    - a specific action to be undertaken (deliverable);
    - clear responsibility for the action to be undertaken (i.e. a specific CPC of the IOTC, the IOTC Secretariat, another subsidiary body of the Commission or the Commission itself);
    - a desired time from for delivery of the action (i.e. by the next working party meeting, or other date);
    - if appropriate, an approximate budget for the activity, so that the IOTC Secretariat may be able to use it as a starting point for developing a proposal for the Commission's consideration.

4. NEW INFORMATION ON FISHERIES AND ASSOCIATED ENVIRONMENTAL DATA RELATING TO TROPICAL TUNAS

4.1 Review of the statistical data available for tropical tunas

13. The WPTT **NOTED** paper IOTC–2017–WPTT19–07 which summarised the standing of a range of data and statistics received by the IOTC Secretariat for tropical tuna, in accordance with IOTC Resolution 15/02 *Mandatory statistical reporting requirements for IOTC Contracting Parties and Cooperating Non-Contracting Parties (CPC's)*, for the period 1950–2016. The paper also provided a range of fishery indicators, including catch and effort trends, for fisheries catching tropical tunas in the IOTC area of competence. It covers data on nominal catches, catch-and-effort, size-frequency and other data, in particular release and recapture (tagging) data. A summary of the supporting information for the WPTT is provided in Appendix IV.

14. The WPTT **THANKED** the IOTC Secretariat for the continuing efforts in the data collation and assessment of the quality of core IOTC datasets, and **ACKNOWLEDGED** the importance of the IOTC Secretariat's role in strengthening the capacity of CPCs in facilitating improvements in the collection, validation and reporting of data to the IOTC.

15. The WPTT **ACKNOWLEDGED** the progress of some CPCs in recent years (e.g., Pakistan, Kenya, and Sri Lanka) in terms of improvements in the collection and reporting of basic fisheries data to the IOTC, with the support of the IOTC Secretariat, but **NOTED** that overall improvements in levels of quality in the IOTC datasets are largely determined by the small number of CPCs which account for the majority of Indian Ocean catches.

16. The WPTT **NOTED** the main tropical tuna data issues that are considered to negatively affect the quality of the statistics available at the IOTC Secretariat, by type of dataset and fishery, which are provided in Appendix IV, and **REQUESTED** that the CPCs listed in the Appendix, make efforts to remedy the data issues identified and to report back to the WPTT at its next meeting.

17. The **WPTT NOTED** with concern the lack of information submitted by CPCs on total catches, catch and effort and size data for IOTC tropical species, despite their mandatory reporting status. For many IOTC stocks the IOTC Secretariat is required to estimate (or partially estimate) the level of catches – by as much as 50% or higher in the case of some of some IOTC species – which increases the uncertainty of the stock assessment results using these data.

18. The WPTT **REITERATED** its request that CPCs comply with IOTC data collection and reporting requirements in accordance with Resolution 15/01 and 15/02, given the gaps in available information in the IOTC database and the importance of basic fishery data for assessing the status of stocks and developing sound management advice.

19. The WPTT **NOTED** with concern that many CPCs utilizing MPF funds to participate in IOTC Working Parties present detailed information on nominal catches, catch and effort, and size data, but do not officially submit these data to IOTC. In some cases this may reflect a fundamental lack of willingness (or lack of awareness) to comply with IOTC mandatory data reporting requirements.

20. **ACKNOWLEDGING** the substantial gaps in reporting of mandatory IOTC datasets by many CPCs to the IOTC Secretariat, which increases the uncertainty of stock assessments and management advice based on these data, the WPTT strongly **RECOMMENDED** the Commission strengthen the penalty mechanisms adopted in *Resolution 16/06 On measures applicable in case of non-fulfilment of reporting obligations in the IOTC* to improve compliance by CPCs in terms of the submission of basic fishery data in accordance with Resolution 15/01 and 15/02.

21. The WPTT **AGREED** that all species specific discussion would be placed within the individual species sections below.

4.2 Review new information on fisheries and associated environmental data

Climate and oceanographic conditions

22. The WPTT **NOTED** paper IOTC–2017–WPTT19–09 which provided an update of the climate and oceanographic conditions in the Indian Ocean up to 2017, including the following abstract provided by the author:

    "After a strong positive Indian Ocean Dipole (IOD) during the 2nd semester 2015, coinciding with ENSO warm phase and negative Indian Oscillation Index (IOI), the situation reversed into a negative IOD (positive IOI) in Jan 2016, becoming mature in July 2016. The situation returned to normal during the 2nd quarter 2017. Most models predict a continuation of neutral IOD through the 1st quarter 2018. Elevated sea surface temperature (SST) anomalies developed over the whole ocean basin during Jun 2015-May 2016 (+1.5° to +2°C) and surface chlorophyll (SSC) was below normal in the West and Central IO, whereas normal conditions prevailed in the East IO. The 2016 SW monsoon (Jun to Sep) had negative SST anomalies (-1° to -2°C) with a strong Somali upwelling, shallower than normal thermocline depth in the WIO (30-40 m rise) and deeper than normal thermocline in the East IO (40-50 m deepening). SSC was high in the West IO, notably during July-Aug 2016, and depleted in the East IO, off Sumatera (Indonesia). Overall SST was normal during the 4th quarter 2016 Thermocline depth became shallower than normal in the West and Central IO during Jan-Jun 2017, potentially enhancing catchability for the PS fishery. SSC was considerably high (>0.4 mg.m-3) in the North Indian Ocean during Sep 2016- Mar 2017. SSC hot spots were located in the Gulf of Aden, along the coast of Iran, Pakistan, along the west coast of India and Sri Lanka. The whole Arabian Sea had elevated SSC in Feb-Mar 2017. Overall, SSC has been increasing gradually since 2014 in the IO. Foraging conditions would have been promoted for mid- and high-trophic levels in 2016 and potentially in 2017."

23. The WPTT **NOTED** that oceanic climate indices are potentially useful additions alongside the stock status advice as ecosystem indicators for management. One option could be through the addition of a 'Climate Page' on the

IOTC website and the addition of environmental/climate indicators in an ecosystem report card being developed to progress on ecosystem based fisheries management, where climatic and oceanographic indicators would be presented and regularly updated. The WPTT **ENCOURAGED** the authors to develop such an initiative before the WPTT-20 meeting in 2018, in conjunction with those developing report cards. This issue is also of particular relevance for WPEB.

24. The WPTT **NOTED** that dissolved oxygen content should be added to the current set of environmental indicators. Because of gaps in time and space distribution of *in situ* observations, products of high-resolution assimilated biogeochemical models should also be presented.

25. The WPTT **RECALLED** the difficulty in including environmental variables in CPUE standardisations, especially because of temporal and spatial autocorrelation and subsequent confounding effects and **SUGGESTED** that a range of approaches should be explored (e.g., mixed effect models).

I.R. Iran tropical tuna fisheries

26. The WPTT **NOTED** paper IOTC–2017–WPTT19–10 which provided an overview of the tropical tuna catch in I.R. Iran, including the following abstract provided by the author:

"Iran fishing grounds in Northern and southern waters of the country are located in the Caspian Sea and Persian Gulf and Oman Sea. Fishery for tuna and tuna-like species is a major component in large pelagic fisheries in Iran and one of the most important activities in the Persian Gulf, Oman Sea and offshore waters. The long Iranian coastline about 193 port and landing places and about 142 thousand fishermen individuals which are directly engaged in fishing activities and Around 11500 thousand fishing crafts consist of fishing boats, Dhows and vessels using different fisheries including: Gillnet, Purse seine, Trolling, Trawl and Wire-trap which are engaged in fishing operation according to a time schedule during different fishing seasons in the coastal and offshore waters. Gillnet and purse seine are two main fishing methods used by Iranian vessels to target large pelagic species in the IOTC area competency and also some of small boats used trolling and traditional longline in coastal fisheries." – see paper for full abstract.

27. The WPTT **NOTED** that the size-frequency data reported by I.R. Iran for some strata indicate larger sized specimens of tropical tunas (i.e., around 10kg heavier) compared to similar gears operating in the same area, and **REQUESTED** that scientists from I.R. Iran confirm whether the recorded sizes are not the result of sampling errors.

28. The WPTT **ACKNOWLEDGED** that skipjack tuna are likely to have different growth rates depending on the area of sampling (e.g., North and South Arabian sea where seasonal upwelling and increased productivity is observed) although this is not evident from the currently available size-frequency data from I.R. Iran.

29. The WPTT **NOTED** issues with the catch and effort and size data submitted by I.R. Iran, which are not reported to IOTC according to the standards of Resolution 15/02 (e.g., size of size bins), and that the IOTC Secretariat has scheduled a Data Compliance and Support mission to Iran in November 2017 to assist with the reporting of mandatory datasets.

Status of gillnet fisheries and data reconstruction of tropical tunas in Pakistan

30. The WPTT **NOTED** paper IOTC-2017-WPTT19-12 which provided a description of the work undertaken by WWF-Pakistan and the Government of Pakistan on the data reconstruction of Tropical Tuna catches in Pakistan and the status of its gillnet fisheries, including the following abstract provided by the authors:

"Tropical tuna forms important component of commercial fish landings of Pakistan. Yellowfin and skipjack tunas are two important species that are caught in the coastal, offshore and from area beyond national jurisdiction (ABNJ). Government of Pakistan regularly provides the statistical data of tropical tuna along with other species of tuna and tuna like species to IOTC which was considered to be under reported and has other anomalies. WWF-Pakistan started a crew based observer programme in 2012 which includes collection of information about tuna (including tropical tuna) landings. This data was used for calculating annual tuna landings for Pakistan. A major difference in the two set of data (Government data and WWF-Pakistan's data) was observed. In order to reconcile the two data, a catch reconstruction exercise of catches of tuna and tuna like species was done in consultation with the Government of Pakistan. The exercise confirmed that the catch of tuna species in most cases is underreported and has other disparities. The major difference was found to be in the case of skipjack tuna whose annual landings was reported to be much higher by Government of Pakistan whereas data collected by the observers indicates its landings to be comparatively lower than reported figures. In case of yellowfin the data of annual catches provided to IOTC was much lower than reconstructed data. Such disparities are now resolved in the two data sets and reconstructed data is now submitted to IOTC by Government of Pakistan which will resolves issues

related with tuna statistical data. Bigeye tuna is caught in commercial quantities by the gillnet fleet of Pakistan, therefore, not reported in the data. Length frequency data for tropical tuna is being compiled by WWF-Pakistan in consultation with Government of Pakistan and will be supplied to the Secretariat in next few months."

31. The WPTT **NOTED** the serious shortcomings in the fisheries data compiled by Pakistan's Provincial governments including: lack of port sampling or systematic data collection systems in provinces, missing or under-reporting of catches recorded at landing centres in the compilation of annual catch statistics, as well as aggregation of catches of multiple species and lack of length frequency sampling.

32. The WPTT **ACKNOWLEDGED** WWF-Pakistan's assistance to the Government of Pakistan in terms of compliance with IOTC CMMs, particularly through the implementation of the crew-based observer program, funded by the ABNJ Project, and **NOTED** that the Government of Pakistan may adopt the observer scheme as a national program under the Federal government so that the scheme will continue beyond the lifetime of the ABNJ project.

33. The WPTT also **CONGRATULATED** WWF's efforts in facilitating improvements in the quality and reporting of fisheries data by Pakistan to the IOTC, as a direct result of the crew-based observer project, which should result in an improvement in Pakistan's compliance with IOTC data reporting requirements in 2017.

34. The WPTT **ACKNOWLEDGED** Pakistan's recent efforts to reconcile catch estimates available from the Government of Pakistan and data collected by WWF-Pakistan, resulting in an overall increase in catch estimates for all species for the 1999-2016 period – with the exception of skipjack tuna, that shows a marked decrease compared to the previous estimates for the same period.

35. The WPTT further **NOTED** that the 2016 skipjack catches presented during the WPTT are significantly higher than the official, reconciled quantities recently submitted by Pakistan to IOTC and **REQUESTED** that the IOTC Secretariat provide assistance to Pakistan to validate the new catch series – including discrepancies between the catches estimated by the Government of Pakistan and WWF-Pakistan.

36. The WPTT further **REQUESTED** that the IOTC Secretariat continues to support the work of WWF-Pakistan and the Government of Pakistan in the evaluation and reporting of the crew-based observer program, and facilitate the reporting of length and catch-and-effort data collected by the observer log-books.

37. The WPTT further **NOTED** that Pakistan's estimates of catches for tuna and tuna-like species prior to 1999 are derived from the IPTP program, and are considered to be relatively reliable and therefore unlikely to be revised further.

38. The WPTT **NOTED** that Pakistan has proposed several initiatives to improve the quality of fisheries data collection, including: the acquisition and incorporation of AIS data, development of data validation systems, installation of CCTV on selected vessels, adoption of Flywire electronic monitoring systems (already trialled in Indonesian gillnet fisheries), in addition to negotiations between WWF-Pakistan and the Government of Pakistan to adopt a crew-based observer scheme, to facilitate compliance with IOTC mandatory data reporting requirements.

Mauritius tropical tuna fishery

39. The WPTT **NOTED** paper IOTC–2017–WPTT19–13 which provided a review of the catch of tropical tunas from purse seine vessels licensed in Mauritius, including the following abstract provided by the author:

"*The purse seine fishery in Mauritius restarted in 2013 after an absence of 12 years. In 2016, the Mauritian purse seine fishery produced 11721.95 tons of fish with a fleet having a carrying capacity of 5334t. The lowest catch was recorded in 2013 with a production of 855 t and was due to starting of fishing operations of only one vessel in the month of October. Two categories of purse seiners were in operation: there were three small purse seiners with a GT of 678 each and two large freezer purse seiners with a GT of 2667 each. The average catch for these small purse seiners decreased to 75 tonnes per vessel in 2015 due to a decrease in the number of small purse seiners in operation. The majority of the catch of these small purse seiners was skipjack (81.23%), followed by yellowfin (8.91%) and albacore tuna (0.10%). The miscellaneous species represented 9.76 % of the total catch and comprised mainly of mackerel (Decapterus spp) and rainbow runner. This paper focuses mainly on the catch records between 2014 and 2016 for the two large purse seiners. Yellowfin tuna was the predominant species varying between 56-63 % of the total catch followed by lower skipjack tuna catches (29-32%). The proportion of bigeye tuna was the lowest among the tropical species with a percentage varying between 4-14%. The catch obtained on log school was slightly higher (51.57-56.74%) as compared to that obtained on free schools (43.26-48.43and the* *number of sets deployed on free school was lower (30.23-42.79%) than those deployed on log schools (57.21-69.77%). Furthermore the high occurrence of yellowfin tuna in the total catch may be attributed to the harvesting of both large yellowfin tuna on free school and large catches of smaller yellowfin on log associated schools. A breakdown of the size composition of yellowfin tuna showed that, on average, 42.64 % of the catch comprised of yellowfin of size 10-40 kg and were harvested on log associated schools. 27.72 % of the yellowfin catch comprised of fish size greater than 60 kg and was obtained on free school. The remaining 29.36 % of yellowfin comprised of fish of size 40-60 kg and was harvested from both log associated and free school with the majority being from free school (60 %). A total effort 1383 sets were deployed with 1146 positive sets for the period 2014-2016. Null sets on free swimming fish schools had a higher representation (28.09%) as compared to those on log associated school (10%).".*

40. The WPTT **NOTED** the statement made by the participant from the Republic of Mauritius, which reiterates the position conveyed in the statements made by the Republic of Mauritius at the 21st Session of the Indian Ocean Tuna Commission and contained in Report IOTC-2017-S21-R at Appendix 2.

41. The WPTT **NOTED** the changes to the fleet composition of purse seiners registered to Mauritius between 2013 to 2016, actively fishing for tuna and tuna-like species, which are classified into two distinct categories (super freezers and smaller-sized purse seiners) based on the tonnage and LOA of the vessels.

42. The WPTT **NOTED** the different size-frequency distributions recorded by Mauritius for the three tropical tuna species, and that the increase in catches between 2014 and 2016 might be partially explained by the capture of larger yellowfin tuna by the industrial purse seiners.

Thailand tuna fisheries

43. The WPTT **NOTED** paper IOTC–2017–WPTT19–14 which provided an overview of foreign tuna longline fishery in the east Indian Ocean, including the following abstract provided by the author:
"Foreign tuna longliners in Indian Ocean have landed their catch in Phuket Province since 1994. The supporting infrastructure and directed flight from Phuket to Narita airport of Japan are the main factor of their decision to landing there. So, this paper summarizes tropical tunas landing in the ports of Phuket Thailand in the last 23 years, 1994-2016. The catch from IOTC area was mainly from foreign fishing vessels including from Taiwan, Belize, Malaysia, India and Indonesia. The number of entry was highest in 1999 of 883 entries. However, it has gradually decreased, and there were only 204 entries in 2016. The landing retained catch included the four majority groups of tunas, billfish, sharks and bycatch. The majority of tunas were yellowfin and bigeye tunas while skipjack tuna was rarely found in the catch composition. The catch trend and species composition during this period have been figured."

44. The WPTT **NOTED** inconsistencies between the decrease in the number of foreign longline entries and the increase in catches, and **ENCOURAGED** Thailand to continue to collect and report the data to the IOTC Secretariat to determine the reasons for the inverse trend between the number of foreign vessel entries and catches landed. The WPTT **REQUESTED** the IOTC Secretariat to investigate whether the data submitted by Thailand is consistent with the data submitted by the flag states of the foreign longline vessels.

Catches of yellowfin tuna and bigeye tuna from longline in Kenya EEZ during the year 2016

45. The WPTT **NOTED** paper IOTC–2017–WPTT19–15 which provided an overview of catches from yellowfin and bigeye tuna from the longline fishery in the Kenya EEZ in 2016, including the following abstract provided by the author:
"Yellowfin tuna (Thunnus albacares), and bigeye tuna (Thunnus obesus) are the main target pelagic species caught by a Kenyan longliner in the Kenyan EEZ during the year 2016. The total landings recorded were 150 tons. Yellowfin tuna landings were 50 tons representing 33% of the total catch. Bigeye tuna was the second most landed species with 28 tons representing 19% of the total catch. The two tuna species represented 52% of the total catches landed from the Kenya longliner. Other major species landed were swordfish and black marlin representing 13% and 7% of the total catch respectively. A look at the temporal distribution of the catches showed the month of May recording the highest catches with nearly 36.9 tons reported while the lowest catches were recorded in August standing at 9.7 tons. The yellowfin tuna catches were highest in the month of May with 22.4 tons recorded while the lowest was in September with 0.7 tons recorded. The highest catch for bigeye tuna was reported in September with 10.7 tons recorded while the lowest was in July with no catches of bigeye reported. The average size of Bigeye tuna was 47.2 ± 7.3 kgs while the yellowfin tuna recorded an average weight of 39.2 ± 13.7 kgs. The size frequency of the catches showed a unimodal distribution in bigeye catches and two distinct length classes in yellowfin tuna. The catches of 2016 are also compared with the 2007 longline catches in Kenya EEZ."

46. The WPTT **NOTED** the increased catch rate of yellowfin tunas between 2007 and 2016, following the return of longliners after the reduced threat of piracy.

47. The WPTT **NOTED** the species composition of longline catches, with yellowfin tuna catches dominating in the first part of the year compared to bigeye tuna catches between September to December, and **REQUESTED** Kenya to consider any additional information collected by logbooks that might explain the differences in species composition in terms of changes in the vessel operations (e.g., number of hooks and depth of setting).

48. The WPTT **NOTED** that the Kenyan observer programme operates only on board Kenyan flagged vessels, as per the IOTC requirements for Kenya under Resolution 11/04.

Colonization of drifting fish aggregating devices (DFADs) in the Western Indian Ocean, assessed by fishers' echo-sounder buoys

49. The WPTT **NOTED** paper IOTC–2017–WPTT19–16 which provided an overview of the main trends of data collected from drifting fish aggregating devices in the Western Indian Ocean equipped with echo-sounder buoys, including the following abstract provided by the author:

    "Floating objects drifting in the surface of tropical waters attract hundreds of marine species including tuna and other species. Taking advantage of this associative behavior, industrial tropical tuna purse seiners have been increasingly deploying artificial man-made DFAD. Yet, the reasons driving this associative behavior are not fully understood. Currently, most of the DFADs are equipped with satellite linked echo-sounder buoys, which provide information on the accurate geo-location and rough estimates of the aggregated fish biomass underneath along the trajectory of the DFAD. This study investigates the colonization process of DFADs in different periods in the Western Indian Ocean, using information from 962 echo-sounder buoys of DFADs deployed between 2012 and 2015 by the Spanish fleet (67716 day observations). It was found that tuna species arrived at DFAD before non-tuna species (13.49±8.35 and 21.69±15.06 days, respectively). Results provided evidences on the relation between object depth and colonization process, finding that tunas arrive earlier to deeper objects. The analysis revealed period and species-specific colonization patterns, suggesting that both non-tuna species and tuna may have different behaviors depending on the period. This study will contribute to the understanding of the ecology and behavior of target and non-target species which are necessary to assure the sustainability of tuna resources."

50. The WPTT **NOTED** that the aggregation of fish to a FAD is a dynamic process as fish may initially congregate around a FAD, which can be followed by the departure of some fish and the arrival of others. The paper also presented the dynamics of biomass in the first 60 days. The WPTT **AGREED** that it is important to investigate trajectories over time in relation to environmental parameters, amongst others.

51. The WPTT **NOTED** that the non-target species are generally located in the shallower surface waters, while tunas are found in deeper water (>25m), however, this may vary with environmental factors such as the depth of the thermocline and the time of day, etc.

52. The WPTT **NOTED** the buoys used in this study have an acoustic 'blank' zone in the surface waters beneath a FAD that extends to approximately 3m depth. Given that the detection probability is likely to be lower for shallower distributed species (non-target species), this might potentially account for some of the differences in arrival time observed between tuna and non-tuna species. However, it was also noted that these non-target shallower distributed species do not generally undertake such extensive excursions as tunas and can also move into waters below 3m depth.

53. The WPTT **NOTED** that the initial colonisation time of a dFAD is around 14 and 21 days for tuna and non-tunas respectively, where colonisation is defined as time detectable biomass begins to appear beneath the FAD.

54. The WPTT **NOTED** the results indicate that the maximum possible density of biomass around a FAD is reached at approximately 30-40 days, after which time the biomass beneath the FAD does not increase further but instead plateaus. It is unclear as to whether this biomass comprises the same original fish or whether some depart while others arrive. The WPTT **REQUESTED** the authors investigate the results further to attempt to disentangle these events.

55. The WPTT **ENCOURAGED** the authors to investigate the results further to evaluate the following hypotheses: (i) the ecological trap hypothesis where the entrained fish compromise its normal life-history pattern and (ii) the meeting point hypothesis where a school assembles around a dFAD and when the biomass becomes larger than the associative capacity of the FAD, a sizeable mass separates to form another school elsewhere. It was also **ENCOURAGED** to explore the use of a hierarchical models with individual dFADs incorporated as random

effects to help explain the situation with respect to the arrival and removal of tuna in relation to mesoscale processes.

Spanish Best Practices program: evolution of the use of non-entangling FADs, interaction with entangled animals, and fauna release operations

56. The WPTT **NOTED** paper IOTC–2017–WPTT19–17 which provides a summary of Spanish Best Practices in the use of non-entangling FADs, including the following abstract provided by the author:

    "About half of the tropical tuna caught worldwide annually is fished by purse seiners mainly using fish aggregating devices (FADs). These devices, although being a very effective fishing tool, are also controversial due to their potential impacts on the ecosystem. Since 2012, Spanish tuna freezer organizations OPAGAC and ANABAC have and voluntary self-regulated code for responsible tuna fishing. This agreement aims to decrease impacts and improve the long-term sustainability of the tuna fishery, with particular emphasis on FAD-related issues. The code promotes best fishing practices by reducing mortality of incidental catch of sensitive species (sharks, rays, mantas, whale sharks, and sea turtles) and the use of non-entangling FADs. In addition to that, the agreement is based on the following points: 100% observer coverage, continuous training of fishing crew and scientific observers, implementation of a FAD logbook, creation of a Steering Committee and continuous monitoring and data analysis by the independent scientific body AZTI.".

57. The WPTT **NOTED** that the best practice programme has been implemented by the French purse seine fleet for several years, and **ENCOURAGED** the other fleets to adopt similar practices.

58. The WPTT further **NOTED** that while larger sharks and rays remain difficult to handle, there are a number of tools and protocols that have been developed as part of the programme to assist with the safe release of larger animals.

Monitoring the number of active FADs used by the Spanish and associated Purse Seine fleet in the IOTC and ICCAT Convention Areas

59. The WPTT **NOTED** paper IOTC–2017–WPTT19–18 which presented an overview of the monitoring of the number of active FADs used by the Spanish and associated purse seine fleet in the IOTC and ICCAT Convention Areas, including the following abstract provided by the author:

    "The purse seine vessels of the Spanish ANABAC and OPAGAC fleet owners organizations agreed in late 2014 to freeze the number of DFADs by 1st of January 2016. According to that agreement, each purse seine vessel could use simultaneously a maximum of 550 Drifting Fishing Aggregating Devices (dFDAs) at any time of the year. This limit to be evaluated through the number of active instrumented buoys, which implicitly established the prohibition of the use of DFADs without buoys. This voluntary agreement also established that the verification of the volume of the daily active beacons used by each purse seiner would be carried out by the independent scientific body AZTI and sanctions were also included in the agreement. Furthermore, in 2015 IOTC adopted the Resolution 15-08 Procedures on a Fish Aggregating Devices (FADs) Management Plan that sets the maximum number of instrumented buoys active and followed by any purse seine vessels at 550 at any one time (and 1100 acquired purchased annually). In 2016, Resolution 16-01 on interim plan for rebuilding the Indian Ocean Yellowfin tuna stock in the IOTC area of competence decreased the limit to no more than 425 daily active instrumented buoys per purse seine vessel (and 850 purchased annually)… Since September 2015 AZTI is carrying out the verification of the compliance with the different FAD limit measures adopted; initially as a voluntary agreement and later as agreed IOTC Resolutions 15/08 and 16/01 and ICCAT Recommendation 15-01. The procedure and mechanisms developed to verify the compliance are briefly outlined in the present document."

60. The WPTT **NOTED** that the high resolution FAD data available to AZTI Tecnalia, Spain, used for this study should be considered for scientific research too, rather than only for compliance purposes.

Moving away from synthetics used in FADS: Evaluating biodegradable ropes' degradation

61. The WPTT **NOTED** paper IOTC–2017–WPTT19–50 describing a pilot project to test the use of non-synthetic materials used in FAD construction, including the following abstract provided by the author:

    "The present study summarizes the results of a project to test biodegradable ropes, to be used at FADs, in a controlled environment. Three types of biodegradable ropes were tested following their evolution for oneyear at sea: (i) twisted 100 % cotton rope; (ii) twisted 50% cotton and 50% sisal rope; and (iii) cotton sisal and linen rope with loops. Samples were deployed in June 2016 in 2 different sites simultaneously, in offshore waters attached to a mooring rope, simulating a FAD in oceanic waters and in a shallow lagoon close to the reef in Maniyafushi island, simulating the arrival of a FAD to the coast. Results show different

robustness of the ropes, being the strongest the one made of sisal and cotton. Other considerations for the successful use of biodegradable ropes at FADs are discussed."

62. The WPTT **NOTED** that only biodegradable subsurface material for FADs was trialled through this project. This is the first phase of the study designed to lessen the environmental impacts by starting with the hanging structure.

63. The WPTT further **NOTED** that increased opportunities for biofouling on some rope structures might potentially increase the sinking rate of the FAD, which is not necessarily desirable for fishers, nor for the environment.

Pilot Project to test biodegradable ropes at FADs in real fishing conditions in Western Indian Ocean

64. The WPTT **NOTED** paper IOTC–2017–WPTT19–51 which provided an overview of a pilot project to test biodegradable ropes in FADs in real fishing conditions, including the following abstract provided by the author:
"The present study summarizes the results of a pilot project to test biodegradable ropes at FADs in real fishing conditions. One of the difficulties when testing experimental FADs in purse seine fishery is that fishers fish on any FAD found at sea, so that FADs change hands very often making difficult to revisit experimental FADs to collect data and get significant results. The main objective of the pilot was learning from this experience to develop a large-scale deployment of biodegradable FADs at sea, by detecting potential difficulties and issues related mainly to effective data gathering on FADs under test. In order to compare the performance of biodegradable and non-biodegradable FADs, International Seafood Sustainability Foundation (ISSF) deployed in collaboration with 6 purse seiners from INPESCA fleet in Western Indian Ocean, a total of 174 FADs, 89 non-biodegradable and 85 biodegradable. Two different FAD designs were tested working at different depths (10m, 30m, 50m and 70 m). A total of 74.913 biomass samples were collected using echo-sounder buoys attached to those FADs. Our results show similar aggregative patterns of fish (tuna and non-tuna species) for non-biodegradable and biodegradable FADs. Life-time of FADs and implications of our results for future experiments are discussed."

65. The WPTT **NOTED** that although the results appear to suggest that there is more rapid accumulation of biomass to a FAD with biodegradable materials the number of observations is currently too low to make this type of inference.

66. The WPTT **NOTED** and **ACKNOWLEDGED** the activity undertaken by ISSF and partners is important to minimize the environment footprint of FAD fishing and also **ENCOURAGED** further, large scale testing of biodegradable FADs in the Indian Ocean.

67. The WPTT **NOTED** that a larger scale experiment in real conditions with the collaboration of the whole purse seiner fleet will be required to ensure tracking the experimental BIOFAD during its lifetime (i.e. follow the BIOFAD when buoy of the BIOFAD is changed by other vessel).

68. The WPTT **NOTED** that in these trials only the underwater section of the FAD uses biodegradable material and that rafts used in this experiment were the same as those used in non-biodegradable FADs. Further experimentation should investigate the use of biodegradable ropes for submerged structure of FADs as well as biodegradable materials in the construction of the FAD raft.

69. The WPTT also **NOTED** that the limit on the number of active FADs at sea in the Indian Ocean is affecting the deployment of additional FADs to follow the protocol of the experiment, as fishers with a given number of active FADs at sea need to wait until one of their own FADs is lost before they are able to activate a new one.

Testing designs of Biodegradable FADs in natural conditions to mitigate the impacts of drifting FADs on the Ecosystem

70. The WPTT **NOTED** paper IOTC–2017–WPTT19–19 which provided an overview of different designs of Biodegradable FADs to mitigate the impacts of drifting FADs on the ecosystem, including the following abstract provided by the author:
"Despite most of the currently used FADs designs have eliminated their entangling characteristic, these are made by non-biodegradable materials contributing to increase marine debris, and with other negative impacts in the ecosystem like FADs beaching and ghost fishing. IOTC together with other RFMOs have made recommendations and published resolutions to promote the reduction of the amount of synthetic marine debris, by the use of natural or biodegradable materials for drifting FADs. However, there are some practical aspects that needs to be clarified for the operationalization of this type FADs construction and effective replacement of materials. The Specific Contract N0 7 under the Framework Contract EASME/EMFF/2016/008 provisions of Scientific Advice for Fisheries Beyond EU Waters addresses the current impediments and provides solutions that shall support the implementation of non-entangling and

biodegradable FADs in the IOTC Convention Area through the collaboration with the EU purse seine tropical tuna fishery and International Seafood Sustainability Foundation. This Specific Contract has three main objectives: (1) to test the use of specific biodegradable materials and designs for the construction of drifting FADs in natural environmental conditions; (2) to identify options to mitigate drifting FADs impacts on the ecosystem; and (3) to assess the socio-economic viability of the use of biodegradable FADs in the Purse Seine tropical tuna fishery. The results of this contract will create fruitful discussions and provide solutions that shall support and help IOTC defining the process of the implementation of non-entangling and biodegradable FADs."

71. The WPTT **ACKNOWLEDGED** the implementation of this large scale project in the Indian Ocean to test biodegradable FADs in real conditions in order to minimize the ecological impact of FADs in the region. The WPTT **NOTED** that this is an advance on previous experiments as biodegradable materials will be used to construct the submerged part and raft of the drifting FADs.

72. The WPTT **NOTED** that most of the purse seiner fleet (EU, Seychelles and Mauritius) will collaborate with the project which will assure tracking the experimental BIOFAD during its lifetime (i.e. follow the BIOFAD when buoy of the BIOFAD is changed by other vessel) and the WPTT **ENCOURAGED** other fleets to also collaborate with the project in the collection of information.

73. The WPTT **NOTED** that WPEB (2017) discussed some of the challenges in conducting biodegradable FAD studies (for example, the limit on the number of active FADs per purse seine vessel in the Indian Ocean may hinder the deployment of BIOFADs to follow experimental sampling designs, and also; the co-operation of the fleet to deploy BIOFADs that may not be successful for fishing), and the WPTT **RECOMMENDED** the Commission consider special allocations for experimental FADs deployed for the collection of scientific data for vessels willing to participate in biodegradable FAD testing under protocols reviewed and endorsed by the Scientific Committee.

The Dynamic Simulation of Pelagic Longline Retrieving

74. The WPTT **NOTED** paper IOTC–2017–WPTT19–20 which provided a description of the dynamic simulation of pelagic longline retrieval and interaction with covariates such as sea current and gear configuration, including the following abstract provided by the author:

"It is important to understand the interactions among sea current, fishing vessel, line hauler, and catches during the pelagic longline gear retrieving for improving fishing gear performance and efficiency. In this study, fishing gear configuration parameters, operational parameters and three-dimensional (3D) ocean current data were collected in the Indian Ocean. Dynamic models of pelagic longline gear retrieving were built using the lumped mass method, and solved using the Euler-Trapezoidal method. The results are: (1) pulling force of line hauler exerted on the gear was 2800N～3600N; (2) there were no significant differences (P > 0.05) between the time of the hook retrieving measured at sea and that of simulated; and (3) the absolute value of moving velocity at representative nodes along the X, Y and Z axes was 0.01～25.5m/s. These results suggest that the dynamic model of longline fishing gear retrieving could be used: (1) to understand the interaction among the sea current, fishing vessel, line hauler, longline gear and the catches; (2) to provide basic data for optimizing the design of the line hauler; and (3) to serve as a reference to study the hydrodynamic performance of other fishing gears during the hauling process."

75. The WPTT **NOTED** that the main purpose of this study is to serve as a reference guide to assess the hydrodynamic performance of longline fishing gears.

Preliminary findings of AFAD research project in the Maldives

76. The WPTT **NOTED** paper IOTC–2017–WPTT19–21 which provided an analysis of Anchored fish aggregating devices in the Maldives, including the following abstract provided by the author:

"Anchored fish aggregating devices (AFADs) are widely used in the Maldives tuna fishery since its deployment began in the early 1980s. There are a total of 55 AFADs in the Maldives. The associative behavioral patterns of tuna has not yet been studied on a large scale at AFADs in the Maldives. This research project attempts to study behavior of two important commercial species of tuna, Katsuwonus pelamis and Thunnus albacares, in the Maldivian AFADs array. Echo-sounders buoys are used to study the biomass under the AFADs. Acoustic and conventional tagging is conducted to investigate the movement of tuna among the AFADs but also movement to Drifting FADs (DFADs) and free schools. Fisher interviews are conducted to gather local ecological knowledge on the AFAD fishery in the Maldives. Preliminary findings indicate that there is no apparent movements of tuna between AFAD in the Maldives. Preliminary investigation of Echo-sounder buoy data suggests that biomass at neighboring AFADs can vary in size and

that there is no clear East to West gradient in biomass across the Maldives. The combination of echo-sounder buoy and acoustic tagging data suggest that there is a continuous turnover of fish at FADs. Additional experiments are planned for 2018 in order to increase current datasets."

77. The WPTT **NOTED** that while exchange of tuna takes place between aFADs in Hawai'i, this phenomenon is not apparent in the Maldives. This may be due to the extensive distances (e.g., often >20miles) between aFADs in the Maldives, resulting in lack of connectivity that prevents the tuna from moving between aFAD arrays. The WPTT further **NOTED** that the results suggest that tuna may show little residency in the Maldives tending towards an open population assumption.

78. The WPTT **NOTED** that further studies are needed to evaluate fragmentation effects, considering that aFADs are anchored around an island and not floating in the open ocean as opposed to dFADs.

Derivation of abundance indices for tropical tuna: Recent progress in the analysis of echo-sounder buoys

79. The WPTT **NOTED** paper IOTC–2017–WPTT19–22 which provided an overview of analysis of echo-sounder buoys taken from the French purse seine fleet, including the following abstract provided by the author:

"Currently, the whole of the drifting FADs deployed by the purse seiners are equipped with echo-sounder buoys to remotely locate the FADs and to assess the amount of associated tuna. The acoustic signals provided by the buoys constitute an unprecedented, wide-scale database that can potentially provide real-time indicators on the dynamics of tuna populations, as well as local and regional abundance indices of tropical tunas for their stock assessments. We present the current progress in the treatment of the echo-sounder buoys database provided by the French fleet. We show results obtained through two novel algorithms developed in order to (i) filter-out erroneous and non-valid data from the echo-sounder buoys database (wrong positions, wrong biomass estimation, on-board positions); (ii) improve biomass estimates for tropical tuna species at the FAD level, by comparing their outputs with the data collected from onboard observers."

80. The WPTT **THANKED** the authors for the encouraging work undertaken to derive a fisheries-independent index of abundance from echo-sounder buoy data, and **NOTED** that the indices developed do not have to match the catch exactly, but only need to be proportional to the magnitude of catches in order to provide a relative abundance index – provided there is no systematic bias.

Proposals to revisions of the Supplementary Information to the IOTC Tropical Tuna Executive Summaries

81. The WPTT **NOTED** paper IOTC–2017–WPTT19–23_Rev3 and **THANKED** the author for the comprehensive presentation which detailed proposals for alternative (or additional) figures and information in the tropical tunas Executive Summaries (supplementary information).

82. The WPTT **NOTED** the discussions following the presentation by the author, however, no consensus could be agreed on the proposals for the addition of new charts or changes to the existing format of the existing Executive Summaries (supplementary information). The WPTT **REQUESTED** that the proposed changes to the figures be discussed at the next session of the WPDCS to be considered by the SC prior to inclusion into the supplementary information to the Executive Summaries posted on the IOTC website.

5. BIGEYE TUNA – REVIEW OF NEW INFORMATION ON STOCK STATUS

5.1 Review of the statistical data available for bigeye tuna

83. The WPTT **NOTED** paper IOTC–2017–WPTT19–07 which summarised the standing of a range of data and statistics received by the IOTC Secretariat for bigeye tuna, in accordance with IOTC Resolution 15/02 *Mandatory statistical reporting requirements for IOTC Contracting Parties and Cooperating Non-Contracting Parties (CPC's)*, for the period 1950–2016. The paper also provided a range of fishery indicators, including catch and effort trends, for fisheries catching bigeye tuna in the IOTC area of competence. It covers data on nominal catches, catch-and-effort, size-frequency and other data, in particular release and recapture (tagging) data. A summary of the supporting information for the WPTT is provided in Appendix IVb.

84. The WPTT **RECALLED** that catches of bigeye tuna from coastal fisheries may be underestimated, in particular for the coastal fisheries of Indonesia (juvenile tunas) and driftnet gillnet fisheries, due to the lack of data or poor reporting of bigeye tuna catches for some coastal fisheries.

85. The WPTT **NOTED** that catches of bigeye tuna are likely to be underestimated, particularly gillnet vessels of some countries which operate in offshore waters (and landing elsewhere), and **REQUESTED** the IOTC Secretariat to address this issue during the Data Compliance and Support missions scheduled for 2018.

86. The WPTT further **NOTED** that the on-going issues with the reliability of the size-frequency data reported by the distant-water longline fleets (i.e., particularly the increase in average weights of bigeye and yellowfin tuna specimens sampled since the early-2000s by Taiwan,China) will be addressed through a dedicated project by the IOTC Secretariat in 2018.

5.2 Review new information on the biology, ecology, stock structure, their fisheries and associated environmental data for bigeye tuna

87. The WPTT **NOTED** paper IOTC–2017–WPTT19–25 which provides a summary of the movements and behaviour of yellowfin and bigeye tuna associated with oceanic structures in the Western Indian Ocean, including the following abstract provided by the author:

"We present here preliminary results of PSAT tagging experiments conducted on bigeye tuna Thunnus obesus and yellowfin tuna Thunnus albacares in the western Indian Ocean. We analysed in this paper the horizontal movements and behaviour of the both tuna species associated to oceanic structures such as mesoscale eddies and fronts."

88. The WPTT **NOTED** that the horizontal movements were obtained through light-based geolocation and that the trajectories were estimated using a hidden Markov movement model constrained by bathymetry and land, as well as sea surface temperature.

89. The WPTT **NOTED** that of the bigeye and yellowfin tuna monitored, at least one yellowfin specimen exhibited a very strong site-identity, with very limited movement around the area, whereas another specimen showed marked displacements during the analysis period.

90. The WPTT **NOTED** that the final results are still preliminary in terms of analysis of the activity of the sampled specimen with respect to the mesoscale structures and that at the present stage no accurate conclusion could be provided on the tropism of yellowfin and bigeye tuna with respect to cyclonic eddies and fronts.

5.3 Review of new information on the status of bigeye tuna

5.3.1 Nominal and standardised CPUE indices

91. The WPTT **NOTED** paper IOTC–2017–WPTT19–26 which provided an overview of the CPUE standardization of bigeye tuna for the South African longline fishery in the Indian Ocean, including the following summary provided by the authors:

"*Bigeye tuna (Thunnus obesus) and yellowfin tuna (Thunnus albacares) are important target species for the Japanese flagged vessels, which operate under South African joint-venture agreement in the IOTC region of the South African EEZ. The standardization of catch per unit effort (CPUE) from the joint-venture fleet segment for the period 2004-2016 was carried out using Generalized Additive Mixed Models (GAMMs) with a Tweedie distributed error. Explanatory variables of the final model included year, month, geographic position and a targeting factor with 2 levels, derived by clustering of PCA scores of the root-root transformed, normalized catch composition. Vessels that fished for at least two years were included as a random effect. Standardized bigeye tuna CPUE showed a strong seasonal trend, with catch rates highest between April and July. The standardized CPUE index showed a decline between 2005 and 2008, a slight increase between 2008 and 2010 and a fairly stable trend between 2010 and 2015 and a slight increase again in 2016. Yellowfin tuna showed less pronounced seasonal trend, which peaked in between July and August. The standardised CPUE index for yellowfin tuna showed a sharp decline between 2004 and 2012, followed by a slight increase until 2016. We anticipate that the here presented standardized abundance indices for bigeye tuna and yellowfin tuna could be useful for corroborating other abundance indices for the South-West Indian Ocean.*"

92. The WPTT **THANKED** the author for the paper and **NOTED** that these detailed analyses of local fleet CPUE are helpful for interpreting and corroborating the DWFN CPUE series.

93. The author **NOTED** that further work can be done on species targeting by using the observer data which covers 100% of Japanese flagged longline vessels operating under the South African Joint Venture agreement (in which sharks are only fully captured in logbooks if retained). In addition, observers also fully record sharks that are released, including prohibited shark species, and if the precautionary catch limit of 10% sharks relative to the total catch is exceeded).

94. The WPTT **NOTED** that the transition period from the South African-Japanese Joint Venture might result in some double counting of catches in both the South African and Japanese databases, although meeting participants

familiar with Japanese distant water fishing confirmed that Joint Venture vessel logbooks are not usually uploaded to the distant water fishing databases.

95. The WPTT **NOTED** that the Tweedie distribution generally made little difference to the estimates, but gave more stable variance estimates in multi-species simulation testing compared to the delta-lognormal in the 10% of troublesome cases.

96. The WPTT **NOTED** paper IOTC–2017–WPTT19–27 which provided a discussion of the large increases in Japanese longline CPUE for bigeye and yellowfin tuna in the late-1970s in the Indian Ocean, including the following summary provided by the authors:
"*High jump of Japanese longline CPUE for bigeye and yellowfin tuna in the late 1970s has been a concern. One possibility was due to error in inputting or compiling logbook data, and so original logbook sheets were sampled and checked. As a result, there is almost no difference of catch and effort data between in the original logbook sheets and logbook database. Sharp increase in CPUE in the late 1970s was partly observed in other ocean as well including other longline fleets, although it was not universal. These implies that something happened for the stock or catchability, but the reason is still unclear.*"

97. The WPTT **NOTED** that comparing logbook samples with the general trends in the Japanese longline CPUE did not reveal any explanation for the CPUE spike occurring around 1978 for yellowfin and bigeye tuna, however, it was further **NOTED** that only 1% of records were compared and may not be representative of changes in the fleet as a whole.

98. The WPTT **NOTED** paper IOTC–2017–WPTT19–28 which provided an update of the Japanese longline standardized CPUE for bigeye tuna in in the Indian Ocean, including the following summary provided by the authors:
"*Standardization of Japanese longline CPUE for bigeye tuna was conducted for 1960-2016 by using GLM (generalized linear model, log normal error structured). Methods of standardization are the same as or similar to those provided at IOTC WPTT in 2016 or before. The effects of season (month or quarter), subarea or LT5LN5 (five degree latitude-longitude block), SST (sea surface temperature), NHF (number of hooks between floats) and material of main line, and several interactions between them were used for standardization. The trend of CPUE slightly differed by area, but high jump in 1977 and 1978, slight decrease after that, and increasing trend in the recent few years, but decrease in the latest year are seen as for each area.*"

99. The WPTT **NOTED** paper IOTC–2017–WPTT19–29 which provided an overview of the Japanese longline standardized CPUE for bigeye tuna and yellowfin tuna in the Indian Ocean using cluster analysis, including the following summary provided by the authors:
"*Standardizations of Japanese longline CPUE for bigeye and yellowfin tuna in multiple Indian Ocean regions were conducted using generalized linear models (GLM) with log normal errors. The models incorporated fishing power based on vessel ID where available, and used cluster analysis to account for targeting. The variables year-quarter, vessel ID, latlong5 (five degree latitude-longitude block), cluster and number of hooks were used in the standardization. The numbers of clusters selected varied among regions and species, but in all cases were either 4 or 5. Dominant species differed depending on clusters. The effects of each covariate differed depending on species and region. The CPUE trends were similar to those estimated last year, though with some differences due to the inclusion of vessel effects and cluster variables.*"

100. The WPTT **NOTED** the combined presentation (and discussion points below) for papers IOTC–2017–WPTT19–28 and IOTC–2017–WPTT19–29.

101. The WPTT **NOTED** that the bigeye tuna cluster analysis appeared to remove recent spikes in areas 1 and 2, but suggested that this might really be a vessel effect since vessels left due to piracy and **SUGGESTED** that including the variance in the CPUE plots would illustrate small sample size effects.

102. The WPTT **NOTED** paper IOTC–2017–WPTT19–31 which provided an update of the Taiwanese longline standardized CPUE for bigeye tuna and yellowfin tuna in the Indian Ocean, including the following summary provided by the authors:
"Updated Taiwanese longline fishery data to 2016 was used in this analysis. Cluster analysis was used to classify longline sets in relation to species composition of the catches to understand whether cluster analysis could identify distinct fishing strategies. Bigeye and Yellowfin tuna CPUE standardization were presented. All analyses were based on the approaches used by the collaborative workshop of longline data and CPUE standardization for bigeye and yellowfin tuna held in March 2017 in Taipei and in April 2017 in Busan."

103. The WPTT **NOTED** that the CPUE influence plots were very useful for interpreting the impact of each variable included in the CPUE standardization and **ENCOURAGED** that these plots should be routinely provided for all CPUE analyses (**Fig.1**).

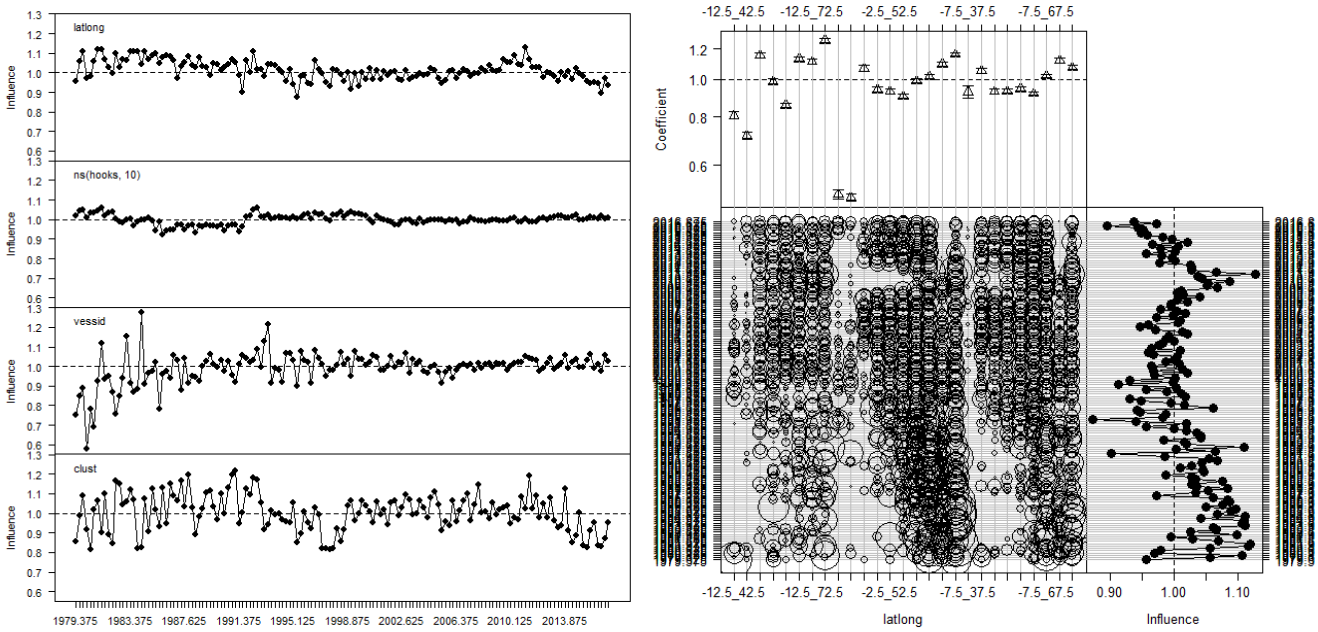


Fig.1 Influence plots for bigeye tuna CPUE in region 1S by the Taiwanese fleet. The top left plots shows the change in the CPUE time series caused by each covariate. The top right plot shows the influence of the latlong effect.

104. The WPTT **NOTED** paper IOTC–2017–WPTT19–32 which described the collaborative study of tropical tuna CPUE from multiple Indian Ocean longline fleets in 2016, including the following abstract provided by the authors:

"*We describe a collaborative study between national scientists with expertise in Japanese, Korean, Seychelles, and Taiwanese longline fleets, an independent scientist, and an IOTC scientist. Terms of Reference covered issues related to bigeye and yellowfin tuna CPUE indices in the Indian Ocean. A series of workshops in June and July 2017 developed joint indices of abundance for bigeye and yellowfin tunas, provided support and training to national scientists in their analyses of catch and effort data, and further developed CPUE analysis methods. National indices and results of data preparation and cluster analysis are provided in related papers, while this paper IOTC-2017-WPM08-18 reports detailed methods and joint indices. New developments covered in this paper include addition of data from the Seychelles, splitting the western tropical areas into northern and southern sub-regions for both species, and testing the inclusion of time-area interactions in the model. Figures and tables are provided for each set of indices, including both quarterly and annual indices. Diagnostic plots are also presented*".

105. The WPTT **THANKED** the authors for the successful progress of the joint-CPUE group, and **REITERATED** the importance of the joint-LL CPUE work in terms of providing robust estimates of abundance.

106. The WPTT **NOTED** that the spatial structure for future CPUE standardizations has been aligned in terms of the assessment for both bigeye and yellowfin tuna.

107. The WPTT **ACKNOWLEGED** the efficiency value of making the operational logbook data available to appropriate analysts outside of the responsible CPCs, and **RECOMMENDED** that high level arrangements for sharing and confidentiality should be pursued. **NOTING** the confidentiality issues with some of the datasets, the WPTT **REQUESTED** that the IOTC Secretariat and main stakeholders explore options to facilitate future data sharing agreements which, once in place, may not necessitate face-to-face meetings and could instead include remote processes.

108. The WPTT **RECOMMENDED** that the joint longline CPUE standardization for tropical tunas should continue, and that further development work should be assigned a high priority. **ACKNOWLEDGING** that the law of

diminishing returns will affect similar future analyses, the WPTT **SUGGESTED** that immediate priorities should focus on the following areas:

- develop joint CPUE indices for other IOTC species (i.e., billfish and sharks);
- explore possibilities for including CPUE data provided by other IOTC CPCs (particularly coastal fisheries);
- identify a unified approach for species targeting using simulation testing (for example, the value of cluster analysis is clear in the temperate regions, but less so in tropical regions);
- recover vessel identification details from historical data;
- further develop the work on time-area interactions. Include a detailed examination of catch rates and related data in the piracy area, comparing pre-piracy and post-piracy effects. Potentially also consider the effects of localised depletion and renewal processes on catch rates.
- conduct further size analyses to explore the 1977 discontinuity (other oceans);
- develop an Indian Ocean CPUE reference manual for practitioners to use
- explore other distributions to improve model fit.

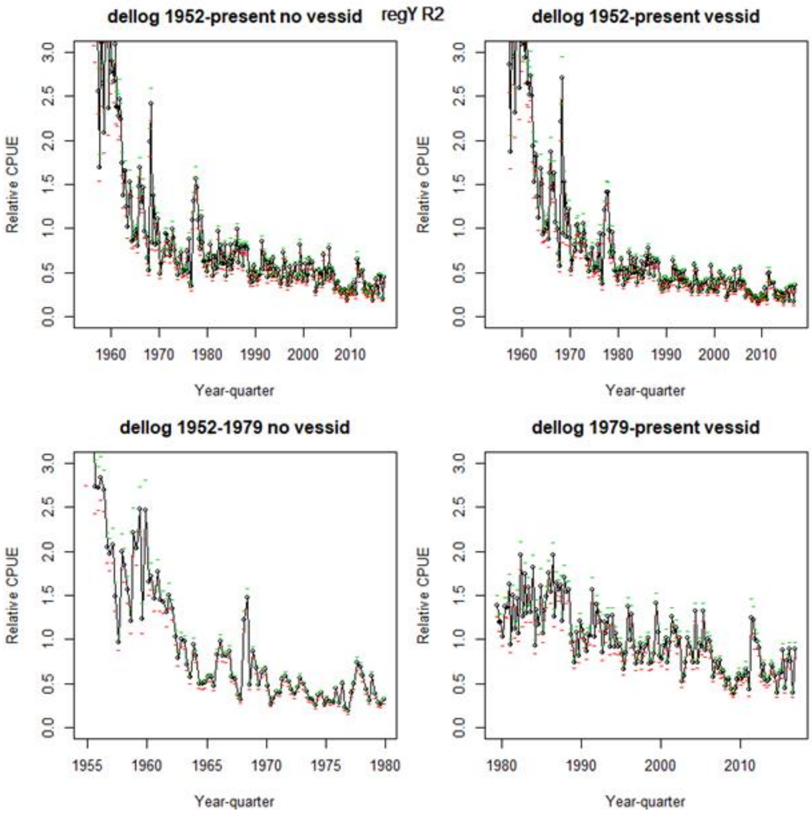


Fig.2. Estimated CPUE series for yellowfin in regions 2 (western tropical) and 5 (eastern tropical), in each case including time series for all years (top) both with (right) and without (left) vessel effects, and time series for 1952-79 without vessel effects, and 1979-2015 with vessel effects.

109. The WPTT **NOTED** paper IOTC–2017–WPTT19–33 which described the possible causes of discontinuities in the Japanese longline CPUE series, including the following abstract provided by the authors:

"The Indian Ocean Tuna Commission's 7th Working Party on Methods (IOTC-2016-WPM07-R) noted concern about a step change in the Japanese CPUE in the late 1970s, which affects the joint indices and therefore the assessments. The WPM recommended work to improve the understanding of the fishery, including the factors that created the discontinuity in the bigeye (and to a lesser extent yellowfin) CPUE 1976-80, and the associated size data. We explored the characteristics of the 1977 discontinuity, and found that it occurred in all datasets examined, which included Japanese data for all oceans, and Taiwanese and Korean data for the Indian Ocean. It occurred for both bigeye and yellowfin to differing degrees, and in multiple regions in each ocean. We also analysed Japanese size data, and found no contemporary changes in that dataset. We discuss some possible explanations, and suggest that changes to the population or catchability (oceanography, introduction of deep setting) are unlikely. Explanations associated with catch reporting appear more plausible, partly due to elimination of alternatives, but we have not identified any evidence of such effects. We suggest some options for further exploring the issue."

110. The WPTT **AGREED** that the bigeye tuna and yellowfin tuna CPUE spikes around 1977 were not likely to be indicative of abundance, and **SUGGESTED** future consideration of splitting CPUE series at this date.

111. The WPM **NOTED** paper IOTC–2017–WPTT19–34 which described selectivity changes and spatial size patterns of bigeye and yellowfin tuna in the early years of the Japanese longline fishery, including the following abstract provided by the authors:
"*Stock assessment requires an understanding of the fisheries that provide the data, and the biology and ecology of the species assessed. We standardized the size data to reveal spatial and temporal patterns. There were significant changes in mean sizes through time, with a substantial decline during the 1950s, consistent with the juvenilisation hypothesis. The decline was too rapid to represent change in the population size structure due to fishing, which is reflected in the inability of the yellowfin stock assessment to fit the early size data. Spatial size variation is common in tunas but has not previously been reported for Indian Ocean bigeye and yellowfin tuna. We found significant spatial variation in both yellowfin and bigeye tunas, across datasets collected in different ways. The Japanese spatial patterns contrast with the Taiwanese length frequency data, which show relatively little spatial size variation. It would be useful to review the spatial location information associated with the Taiwanese size data. We recommend further analyses that include bigeye size data starting in 1952. It would also be useful to compare early size changes across oceans and fleets, and for other species such as billfish; and to investigate size changes after the resumption of fishing in the piracy area near Somalia".*

112. The WPTT **THANKED** the authors for the investigation of selectivity changes and spatial size patterns of bigeye and yellowfin tuna in the early years of the Japanese longline fishery and **AGREED** that this work is important in terms of improving understanding of the trends in the Japanese longline CPUE. **NOTING** that various issues have been identified that could be explored further, the WPTT **REQUESTED** that this work is continued.

113. The WPTT **NOTED** that selectivity changes are a potentially important influence on most stock assessments and that this needs further exploration.

114. The WPTT **NOTED** paper IOTC–2017–WPTT19–35 exploring Japanese size data and historical changes in data management, including the following abstract provided by the authors:
"*The 2016 IOTC Working Party on Methods recommended work to improve understanding of the size data used in tuna assessments. The Japanese longline fishery provides the longest and most valuable size dataset for the bigeye and yellowfin tuna assessments. We explored this dataset in order to describe and characterise the types and sources of size data, so that analysts can understand the patterns in the data; and to check the validity of assumptions used in preparing the data for assessments. We provide figures showing the types of data available (spatial resolution, commercial vs research & training, measurement unit, and sampling type), for each species and by time period and location. We also describe a previously unsuspected change in 1970 from rounding up to rounding down. The current practice is to round up, so there must have been a further change after 1988. Further investigation is recommended to determine when the later change occurred. We recommend exploring the implications of these changes for other size datasets used by IOTC and other RFMOs. We further recommend exploring how size data biases noted by Satoh et al (2016) in the Eastern Pacific may affect Indian Ocean data."*

115. The WPTT **NOTED** that the analysis is based on fine scale data whereas the size frequency data submitted by Japan to the IOTC Secretariat (up to 2008) is by 10 by 20 degree grid areas. The WPTT **REQUESTED** Japan to submit the historical size frequency data in 5 by 5 degree grids for all IOTC species, including billfish, for the period 1965-2008, in accordance with Resolution 15/02 mandatory data reporting requirements.

116. The WPTT **NOTED** paper IOTC–2017–WPTT19–36 describing regional scaling factors for Indian Ocean stock assessments, including the following abstract provided by the authors:
"In stock assessments with multiple regions it is important to determine the relative abundances among the regions. Relative abundances can be estimated using CPUE data, using the relative catch rates among regions as a proxy for density, and also allowing for the size of each region. The method has been used for Indian Ocean yellowfin assessments since 2005, and is similar to the method used in WCPO bigeye and yellowfin assessments. This paper describe several modifications to the approach and compares the results. First, I use standardized catch rates rather than mean values. Second, I use the period 1980-2000 rather than 1963-1975 as the base period. Finally, in all analyses I use Japanese and Korean aggregated data, rather than Japanese data only. Both changing the time period and using standardized CPUE had moderate impacts on the regional scaling parameters. Further development using operational data is recommended, so as to allow for the effects of targeting on catch rates. We also suggest exploring other datasets to allow for far northern areas not sampled by Japanese and Korean effort."

117. The WPTT **NOTED** that regional scaling factors are dynamic, and **SUGGESTED** that more analysis should be undertaken to account for seasonal effects, and possibly inter-annual changes in biogeographical province.

118. The WPTT **NOTED** paper IOTC–2017–WPTT19–37 which provided an overview of the CPUE standardization of the Seychelles longline fleet, 2001-2015, including the following abstract provided by the authors:
"We analysed Seychelles' industrial longline operational catch and effort data to describe and characterize the temporal and spatial patterns of the fishery. The focus is on the tropical tuna species bigeye and yellowfin tuna, but information on other species is included.. We conducted standardised CPUE analysis for Seychelles industry longline fishery data from 2001 to 2015. Cluster analysis was used to classify longline sets in relation to species composition of the catches to understand whether cluster analysis could identify distinct fishing strategies. Bigeye and Yellowfin tuna CPUE standardization for core regions were presented. All analyses were based on the approaches used by the collaborative workshop of longline data and CPUE standardization for bigeye and yellowfin tuna held in July 2016 in Busan. For bigeye tuna, CPUE Standardisations were conducted to the western tropical regions 1N and 1S separately. The lognormal models fitted to the non-zeros sets resulted in very similar trends in both regions, and the standardised CPUE index has declined between 2004 and 2010 with strong inter-annual fluctuations. The standardised catch rates peaked around 2012 when the fleet returned to the fishing ground in the western Indian Ocean, and the catch rates between 2013 and 2015 were on average lower than those in the mid-2000s (before the piracy threat period (2008 -2011). For yellowfin tuna, CPUE standardisations were conducted in region 1b. The delta-lognormal model was applied and the YFT region 1S appears adequate and consistent trends were estimated from both the binomial and lognormal part of the model, suggesting that the population in the region may have declined between 2004 and 2010."

119. The WPTT **ACKNOWLEGED** the importance of the Seychelles longline CPUE, but **NOTED** that cluster analyses can be misleading if species abundance is changing, particularly for high value species.

5.3.2 Stock assessments

Online tool for stock assessment models

120. The WPTT **NOTED** paper IOTC–2017–WPTT19–39 which described an online tool to easily run stock assessment models, using SS3 and YFT as an example, including the following abstract provided by the authors:
"Stock assessment software are complex and advanced technical skills are required to develop the models. Producing output becomes time-intensive and even more complex as thousands of simulations must be run on super-computers in order to include the multiple sources of uncertainty in assessment results. As few stock assessment participants have the specific technical skills required to reproduce these outputs, our aim has been to develop a Virtual Research Environment (VRE) that enables any user to easily parameterize, execute and edit online various steps of the stock assessment work flow using SS3 (a widely-used statistical catch-at-age model), with standardized data outputs. Here, we illustrate the stock assessment work flow through the VRE, using the last stock assessment of yellowfin, provided by the IOTC, as an example."

121. The WPTT **WELCOMED** this contribution and **NOTED** the tool as a mechanism for further engagement of CPC scientists in understanding the SS3 assessment framework, and also **NOTED** that a similar shared platform initiative in ICES (stockassessment.org) was initially used for collaboration, but eventually became a tool primarily for archiving data and improving reproducibility.

122. The WPTT **ENCOURAGED** the team to make plans for how this project will be maintained and updated after 2018 when the funding for personnel ends with the BlueBridge project, and after 2020 when the availability of the infrastructure will depend on alternative funding. The WPTT further **NOTED** that the lack of long-term funding, in some cases, might reduce the likelihood of people investing in the initial learning curve.

123. The WPTT **SUGGESTED** that adding simulation capacity to the platform may be very valuable.

124. The WPTT also **ENCOURAGED** continued development of the tool with an eye to increasing CPC understanding of the SS3 assessment methodology and to help to overcome limitations in characterizing uncertainty in assessment outcomes by WPTT and WPM. The WPTT **NOTED** the intention to carry out further work on the Maldives data using this VRE to test its ability to facilitate collaborative projects.

125. The WPTT **NOTED** paper IOTC–2017–WPTT19–40 which provided a description of the stock assessment of Indian Ocean bigeye tuna using an Age Structured Assessment Program (ASAP), including the following abstract provided by the authors:

"Bigeye tuna (BET), Thunnus obesus distributes in the tropical and subtropical waters of Indian Ocean. Because of a variety of fishing gears and fishing fleet structures, there remain statistical biases in the historical nominal catches of the Indian Ocean BET. However, the impact of this bias on stock assessment has been neglected in recent years' assessments. This paper investigated the impacts of observation error and statistical bias of catch on the stock assessment of Indian Ocean BET, using Age Structured Assessment Program (ASAP) based on fishery-specific catch, catch-at-age, and standardized catch-per-unit-effort data. The results showed that the current stock of BET was not overfished and overfishing was not likely occurring at the beginning of 2015 (base case model). However, the results of base model and sensitivity analysis models showed that both the observation error and the statistical bias associated with catch data can have impacts on assessment results, with the latter being more influential. Thus, this study highlights the importance of considering both the assumptions of observation error and statistical bias in catch data for tuna fishery stock assessment, with the latter often being neglected."

126. The WPTT **NOTED** that the under and over reporting rates were assumed across all fisheries for different periods and **SUGGESTED** that future evaluations should consider the likelihood that the tendency to under report catch or have different levels of reliability depends upon the fisheries by which the catches are made.

127. The WPTT also **SUGGESTED** that future versions might include trends in catch reporting error, where the magnitude of the error could be linked to the individual fisheries – for example in terms of the evaluation of the quality of catches reported to the IOTC Secretariat.

128. The WPTT **NOTED** the key assessment results for the ASAP model as shown below (Table 2).

Table 2. Indian Ocean Bigeye tuna stock status summary based on the ASAP analysis.

Management Quantity	Estimate
Most recent catch estimate (t) (2016)	86589
Mean catch over last 5 years (t) (2012-2016)	100455
MSY (1000 t) (80%CI)	102.2 (NA）
Current data period	1979-2016
F(Current)/F(MSY) (2016) (80% CI)	1.02 (NA）
B(Current)/B(MSY)(2016) (80% CI)	1.18 (NA)
B(Current)/B(0)(2016) (80% CI)	0.38 (NA)

Bigeye tuna: Summary of stock assessment models in 2016

129. **NOTING** that no new formal stock assessments were carried out on bigeye tuna in 2017, the WPTT **RECALLED** that a range of quantitative modelling methods (ASAP, BDM, ASPIC, SCAA, BSPM and SS3) were applied to bigeye tuna in 2016 and readers are requested to refer to the report of the 18th Session for details (IOTC–2016–WPTT18–R).

Parameters for future analyses: Bigeye tuna CPUE standardisation and stock assessments

130. The WPTT **RECALLED** that in order to obtain comparable CPUE standardisations, the analyses should be conducted with similar parameters and resolutions when the stock is next assessed. The improved methods recommended by the CPUE workshop should also be applied. Table 3 provides a set of parameters that give guidelines for the standardisation of CPUE.

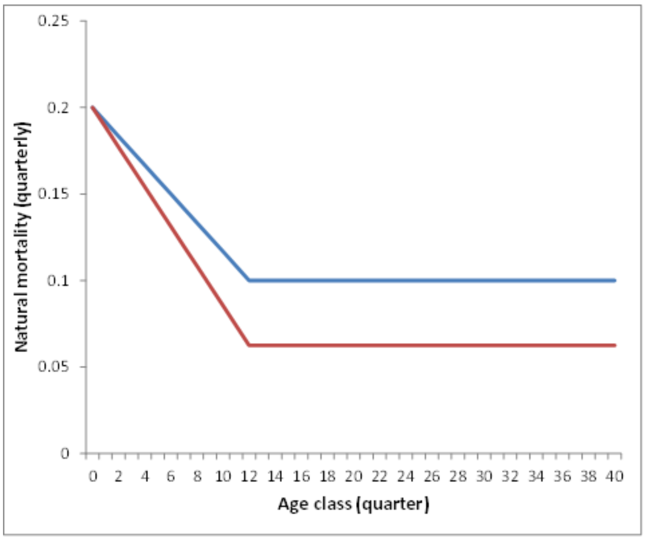
Table 3. Bigeye tuna: Parameters for the future standardisation of CPUE series.

CPUE standardisation parameters	2016 CPUE standardisations for consistency
Area	By region, 4 regions
CE Resolution	Operational data
Data preparation	Cluster analysis or related approaches to select data or add cluster parameters
GLM Factors	Year-Quarter, 5 degree cells, HBF or cluster, vessel
Model	Delta lognormal, lognormal + constant
	Proposed updates to standardisation methods
Area	By region, 5 regions
CE Resolution	As above
Data preparation	As above
Factors	As above, plus sub-area * time interaction
Model	As above
Other possible changes	Transform response variable

131. The WPTT **RECALLED** that the model parameters contained in Table 4 could be considered appropriate for future bigeye tuna stock assessments preliminary base case analysis, with appropriate sensitivity runs.

Table 4. Bigeye tuna: Model parameters for use in future base case and sensitivity stock assessment runs.

Biological parameters	Value for assessments
Sex ratio	1:1
Age (longevity)	10 years
Natural mortality	Age specific, quarterly M. 2 alternative M options (base low, sensitivity high).



Growth formula	VB log K 2-stanza growth (Eveson et al. 2012 IOTC–2012–WPTT14–23) or appropriate re-analysis based on more recent data
Weight-length allometry	$W=aL^b$ with $a= 2.7^{-05}$ and $b=2.951$ common to sex[1]

[1] Updated length-weight allometry equation, as adopted by IOTC WPDCS (Source: Chassot, E. et al, in IOTC-2016-WPDSC12-INF05).

Maturity	Length-specific (50% mature at length 110 cm) – or age-based equivalent[2]
Fecundity	Proportional to the spawning biomass
Stock-recruitment	B&H, h=0.8 (plus sensitivity e.g. 0.7 and 0.9), sigma_R=0.6
Other parameters	
Spatial structure	As in previous assessment, or harmonize with yellowfin tuna spatial structure if possible (4 model regions, similar to YFT tuna)
Fisheries	15 (Longline (6); Baitboat (pole-and-line); Purse seine free school (3); Purse seine log school (3); Other (2))
Abundance indices	Composite longline indices, region-specific.
Selectivity	Age based, fishery specific

5.3.3 Selection of Stock Status indicators for bigeye tuna

132. The WPTT **AGREED** that as no new stock assessment was carried out for bigeye tuna in 2017, management advice should be based on the range of results from the SS3 model in 2016, as well as the updated CPUE series presented at the WPTT19 meeting.

5.4 Development of management advice on the status of bigeye tuna & update of the bigeye tuna Executive Summary for the consideration of the Scientific Committee

133. The WPTT **ADOPTED** the management advice developed for bigeye tuna (*Thunnus obesus*), as provided in the draft resource stock status summary and **REQUESTED** that the IOTC Secretariat update the draft stock status summary for bigeye tuna with the latest 2016 catch data (if necessary), and for the summary to be provided to the SC as part of the draft Executive Summary, for its consideration:
    - Bigeye tuna (*Thunnus obesus*) – Appendix VI

5.5 Bigeye tuna Management Strategy Evaluation process update

134. The WPTT **NOTED** paper IOTC–2017–WPTT19–49, which provided an update on the tropical tunas management strategy evaluation development framework. A summary of this document and discussion is presented in Agenda item 8 below.

6. Skipjack Tuna – Review of New Information on Stock Status

6.1 Review of the statistical data available for skipjack tuna

135. The WPTT **NOTED** paper IOTC–2017–WPTT19–07 which summarised the standing of a range of data and statistics received by the IOTC Secretariat for skipjack tuna, in accordance with IOTC Resolution 15/02 *Mandatory statistical reporting requirements for IOTC Contracting Parties and Cooperating Non-Contracting Parties (CPC's)*, for the period 1950–2016. The paper also provided a range of fishery indicators, including catch and effort trends, for fisheries catching skipjack tuna in the IOTC area of competence. It covers data on nominal catches, catch-and-effort, size-frequency and other data, in particular release and recapture (tagging) data. A summary of the supporting information for the WPTT is provided in Appendix IVc.

136. The WPTT **RECALLED** that the EU is in the process of recalculating the estimated weight of catches of skipjack tuna from 1991 onwards, based on revisions to the IOTC length-weight conversion factors (used to estimate the total weight of catches by species for European purse seiners), which will impact estimates of the species composition reported from EU-PS samples – with a likely increase in overall skipjack tuna catches for purse seiners (of approximately 4 per cent).

137. The WPTT **NOTED** the relatively low quality of catch estimates prior to the arrival of industrial fisheries (i.e., from the 1980s), due to the predominance of small-scale artisanal fisheries, but **ACKNOWLEDGED** the range of uncertainty in catches was difficult to quantify.

[2] Updated ogive taken from Zudaire, et al., 'Sex-ratio, size at maturity, spawning period and fecundity of bigeye tuna (Thunnus obesus) in the western Indian Ocean', IOTC–2016–WPTT18–37.

6.2 Review new information on the biology, ecology, stock structure, their fisheries and associated environmental data for skipjack tuna

Reconstruction of Maldives Historic Fleet Size Composition from Partial Register Data 1970-2004

138. The WPTT **NOTED** paper IOTC–2017–WPTT19–41 which provided an overview of the reconstruction of the Maldives fleet-size composition between 1970-2007, and included the following abstract by the authors:
"Maldives pole and line fleet's vessel length composition was reconstructed for 1970-2007 in order to standardize non-vessel-specific CPUE from this period. The Indian Ocean skipjack stock assessment has been using Maldivian pole and line CPUE data to derive a skipjack abundance index, with vessel length used as an important covariate in the standardization. Unfortunately information on fleet size composition is missing before 2004. To develop an abundance index covering the period 1970-2003 will require an estimate of the size composition of the vessels during this period. "Survival" of vessels was estimated from the 2004-2015 effort data using a simple survival analysis regression based on the Weibull probability density. The model was fitted to vessel-specific data 2004-2015 to estimate how long vessels remained active as they age. Two models were explored with survival dependent or not dependent on vessel length. The survival model was used with year of registration to estimate fleet length composition at each quarter 1970-2007."

139. The WPTT **ACKNOWLEDGED** the importance of the paper, and **NOTED** that the motivation for this work was to extend the Maldives pole and line CPUE standardisation to include data prior to 2004.

Preliminary stock structure study of skipjack tuna from South Java using otolith shape analysis

140. The WPTT **NOTED** paper IOTC–2017–WPTT19–42 which provided a description of the stock structure of skipjack in southern Java, , including the following abstract by the authors:
"Skipjack tuna (Katsuwonus pelamis) regarded as cosmopolitan species and distributed vastly along the Indian Ocean south of Java, Bali and Nusa Tenggara. Known to have high exploitation by various fishing gear but yet it always managed as a single stock, not because of scientific evidence but merely based on "a scientific assumption", so that vulnerable to subject of overfishing. The objective of this study was to find alternative tool for identifying the stock structure based on the otolith shape. Otolith samples were collected from four areas, namely: Binuangeun, Sadeng, Prigi and Labuhan Lombok during April, August, and September 2016. The otolith shape was reconstructed using outline analysis with discrete wavelet transformation technique. Multivariate statistic with cluster analysis using canonical analysis of principal (CAP) and ANOVA-like permutation test were also implemented to determine the signification among populations. The result showed that skipjack's otolith shape was varied from one and another, especially in rostrum. But it wasn't statistically different among regions ($p>0.001$), which means a single stock for skipjack was defined in the Indian Ocean (Indonesian territory of FMA 573). This study also proved that otolith shape can be useful marker tool to identify stock structure for management purpose."

141. The WPTT **ACKNOWLEDGED** that the value in this research can be increased when complementary techniques, such as genetics, parasite/symbion, otolith microchemistry and life history information are used to better inform stock structure and management units, but that it was unclear how the results from this work will be used to define the stock structure and delineate distinct management units for skipjack tuna.

142. The WPTT **NOTED** that techniques such as genetics and microchemistry will be explored in the IOTC Stock Structure project funded by the EU and led by CSIRO with the participation of AZTI, IRD, and RITF. This project will also include additional species and expand the geographical range of sample collection.

Data-derived stock status indicators for skipjack tuna of the Indian Ocean

143. The WPTT **NOTED** paper IOTC–2017–WPTT19–43 which provided a description of data-derived stock status indicators for skipjack tuna in the Indian Ocean, including the following abstract by the authors:
"This paper is presenting a set of indicators that inform on trends on fisheries and potential status of the skipjack stock in the Indian Ocean. We present six categories of indicators: i) fishing power and FAD use, ii) catch-related trends, iii) catch rates, iv) size-based indicators, v) tag-recovery indicators and vi) environmental indicators. The FAD-specific fishing power has greatly increased since 2014, in terms of number of active buoys attached to FADs and number of support vessels. The FAD fishery has spatially expanded in 2016 and the proportion of catches on FADs has reached unprecedented record levels. CPUEs have declined for both purse seine (-43% for 1991-2016) and baitboats (-43% for 2005-2015). The average weight of skipjack caught by PS at FADs has been reduced by 19% (1984-2016) and by 11% for baitboats, after 2006. The proportion of immature skipjack has greatly increased in the PS FAD catches (14.5%). Among the most striking features are the anomalously low abundance of skipjack on free schools and the large dominance of small sets at FADs, suggesting a fragmentation of schools. CPUE are likely affected by ambient

conditions, with low CPUEs during El Niño and Indian Ocean Positive dipole events. Most of the indicators portray a situation where the Indian Ocean skipjack stock would be fully exploited. Moreover, this analysis underlines potential concern of future overfishing since increasing catch levels, including those of immature fish, and overall trend in fishing effort and strategy as seen in the last two years, might not be sustainable."

144. The WPTT **ACKNOWLEDGED** the value of the indicators presented for stimulating discussion about the factors that should be explored further in the stock assessment.

145. The WPTT **NOTED** that the indicators contain some information that could be useful in developing appropriate indices to account for efficiency changes in the purse seine FAD and free school fisheries. However, there are difficulties in quantifying information from such fishery indicators, and further exploration and analyses of the data would be required.

146. The WPTT **NOTED** the decline in the number of large FAD sets (i.e. sets with catches >60 t) and the increase in the number of small FAD sets (i.e. sets with catches <30 t) that may be caused by the combination of various factors, such as decline of the average weight of individuals, abundance, school fragmentation and fishing tactics leading to sets on the FAD before being fully colonised. The WPTT **ENCOURAGED** further analyses to better understand the relationship between these indicators to improve future standardisations of purse seine CPUE.

147. The WPTT **NOTED** the absence of some indicators that were presented in previous years in the EU purse seine statistics working papers (e.g., the number of fishing sets, etc.), which would provide additional indications of how fishing strategies have evolved over time. The WPTT **REQUESTED** that the EU scientists prepare this document for the next WPTT meeting in 2018.

148. The WPTT **NOTED** that the knife-edge maturity schedule used to assign fish <40 cm as immature should be replaced with the updated maturity ogive which would provide a more accurate estimate of the proportion of immature fish in the catch. The WPTT **NOTED** in the skipjack stock assessment working document (IOTC–2017–WPTT19–47), which included all gear types, that applying the maturity ogive to the catch at size matrix, indicates that most catches are mature fish.

149. The WPTT **NOTED** that the correlation between environmental variables and catch of skipjack tuna resulted in catch rates that fluctuated around the long-term average, and **AGREED** that it is difficult to disentangle changes in catchability from changes in productivity, and that such variability should be retained in the assessment model.

150. The WPTT **NOTED** that distances travelled by PS vessels has increased over time, that may be related to FADs fished far away from the core FAD fishing zone. However, the reasons for this increase require additional analyses of the disaggregated data.

6.3 Review of new information on the status of skipjack tuna

6.3.1 Nominal and standardised CPUE indices

Maldives pole and line skipjack tuna CPUE standardization 2004-2015

151. The WPTT **NOTED** paper IOTC–2017–WPTT19–44 which provided an overview of the Maldives pole and line skipjack tuna CPUE standardization between 2004-2015, including the following abstract by the authors:
"Abundance indices are an important requirement for reliable stock assessment. Maldives pole and line fishery provides a CPUE-based abundance index for the Indian Ocean skipjack stock assessment. The CPUE index needs standardization because the fishery has improved its efficiency over time. Generalized linear models are fitted consistent with previous standardization models using new data which has been carefully reviewed and corrected. The model was restructured based on a review of the available categorical and covariate variables. The final recommended index was produced from the new linear model fitted using a Markov chain Monte Carlo to the available data, with numbers of skipjack caught as the response variable."

152. The WPTT **NOTED** the rationale for excluding zero catch trips. It was pointed out that there were very few pole and line trips reporting zero skipjack catch, and that it may be these were not real pole and line trips due to gear misreporting. In addition, not all trips are necessarily recorded if no catch is taken. Overall, only positive trips were considered to be reliable.

153. The WPTT **NOTED** that the CPUE plots suggested that fishing power of the fleet has decreased in relative terms (MCMC plot) and it was suggested that this was unlikely, and that generally fishing power should increase over time. The WPTT **REQUESTED** that this issue should be looked at in more detail, but **NOTED** that a decrease in fishing power in the Maldives was possible (e.g., redirection of effort to other fisheries, fuel, bait collection).

Also the sample used in the study did not cover the complete fleet and may not be representative of changes in the overall fleet.

154. The WPTT **NOTED** that the MCMC fit gave different indices to the maximum likelihood estimates, but the reason for the difference could not be identified.

155. The WPTT **SUGGESTED** that plots of covariates over time may show possible causes of change; as well, indices by region may indicate potential spatial problems.

156. The WPTT also **SUGGESTED** the use of random effects to account for vessel and atoll effects to improve the model, however, the very large number of vessels presents practical difficulties for this approach. There is also a potential bias due to an unbalanced design, with effort not distributed across atolls evenly. However, it is not clear that atolls should be interpreted as different fishing areas, so dealing with this type of bias may need more information.

157. The WPTT **NOTED** that using atolls could possibly be the reason why FADs were not significant as area-FAD interactions were significant in previous years.

Relationship between skipjack tuna CPUE and fishing operation related parameters: A case study for the gillnet fishery of Sri Lanka

158. The WPTT **NOTED** paper IOTC–2017–WPTT19–45 which provided an overview of the Sri Lanka gillnet CPUE and relationship between the fishing operation parameters, including the following abstract by the authors:
"The fishing operations in tuna fishery of Sri Lanka are conducted by single day and multiday fishing crafts and fishing activities are taken place from coastal waters up to the high seas. Gillnet is the main fishing gear used in tuna fishery of Sri Lanka. Mostly multiday fishing boats use this fishing gear. Gillnet is sometimes operated as a supplementary fishing gear in longline fishery. The popular gear combinations operated with gillnets are gillnet-longline (GL), gilllnet-handline (GH) and gillnet-ringnet (GR). The key target species in gillnet fishery is skipjack tuna (Katsuwonus pelamis). Skipjack tuna landed by Sri Lankan fishing vessels were monitored from January 2005 – December 2012 at the major tuna landing sites and fishery harbours in Sri Lanka. The unloaded skipjack tuna catch by the vessels was recorded. Other parameters in relation to fishing operations were also recorded: boat type, gear type, trip duration and number of net panels used. A Gamma based Generalized Additive Model (GAM) was fitted using log link function to describe the relationship between skipjack tuna CPUE and fishing operation related parameters. The fitted GAM model explains 75.4% of the deviance. Catch rates of skipjack tuna increased in association with increases in trip duration and increases in gillnet panels. Results from this case study can have few management implications."

159. The WPTT **ACKNOWLEDGED** the value of this paper as it represents the first attempt towards a CPUE standardisation by Sri Lanka, and also for gillnet fisheries, and **ENCOURAGED** Sri Lanka to continue to refine and improve the CPUE standardisation with a view to incorporating the CPUE series in future IOTC stock assessments, ideally using detailed logbook data available since 2014.

160. The WPTT **NOTED** that information on mesh size was not available for this analysis (2005-2012), but will be collected in the future. Nets are <2.5km in length.

161. The WPTT **NOTED** that the annual variation in CPUE is only shown for positive trips, while zero catch trips were not described. However, zero catch trips represent less than 2% of trips, which should make little difference to the results presented.

Standardization of skipjack tuna CPUE for the EU purse seine fleet operating in the Indian Ocean

162. The WPTT **NOTED** paper IOTC–2017–WPTT19–38 which provided an update to CPUE for the EU purse seine fleet in the Indian Ocean for skipjack tuna, including the following abstract by the authors:
"The EU purse seine fleet catches of skipjack tuna (SKJ; Katsuwonus pelamis) from the Indian Ocean were standardized using the framework described in Katara et al (2016). The analysis was restricted to fishing sets related with floating objects (FOBs), due to the strong associative behaviour of species and the FOB-oriented strategy of the fleet. Two definitions for Catch per unit of Effort (CPUE) were explored, i) a more traditional catch per fishing hour and ii) an alternative catch per fishing set. The time series for both CPUEs were standardised for two different periods: one for the whole time series (1985-2016), and one for the more recent years (2004-2016), because the length of the time series of available covariates, differed. In the latter case (2004-2016), the lasso – least absolute shrinkage and selection operator- method was applied for data mining and model selection. The results are four standardised skipjack CPUE time series for floating object fishing, all of them showing similar trends. The time series for the two CPUEs based on different definitions of effort

(fishing hours vs fishing set) are comparable, both showing a decreasing trend. The values are lower than the nominal CPUE values, possible due to accounting for unfished areas."

163. The WPTT **ACKNOWLEDGED** the results presented at the meeting represent a major step forward in developing a CPUE abundance index for purse seiners. It is recognised that technology changes, in particular in the purse seine fishing fleet have been significant. Despite the inclusion of several relevant FAD related factors derived from observer data, the standardized CPUE series was similar to the nominal CPUE, which meant the standardization did not effectively incorporate the effects of technology change. In addition, the CPUE index would benefit from more accurate historic and current FAD numbers.

164. The WPTT **NOTED** that echo-sounders on FADs was recognised as one of the most important factors in terms of recent technological changes. The WPTT **SUGGESTED** that covariates relating to fishing efficiency be effectively incorporated into future time series of CPUE standardisation (i.e., as a time dependent addition) (e.g. number of FADs, etc.).

165. The WPTT **NOTED** that the inclusion of echo-sounder buoys in the standardisation resulted in a decline in efficiency over time, probably due to confounding with the year effect, contrary to the expected trend, and **ENCOURAGED** further work to better capture efficiency changes in future standardisations of purse seine CPUE.

166. The WPTT **NOTED** that other units of effort may be more appropriate for catch rate standardization and should be explored in the future.

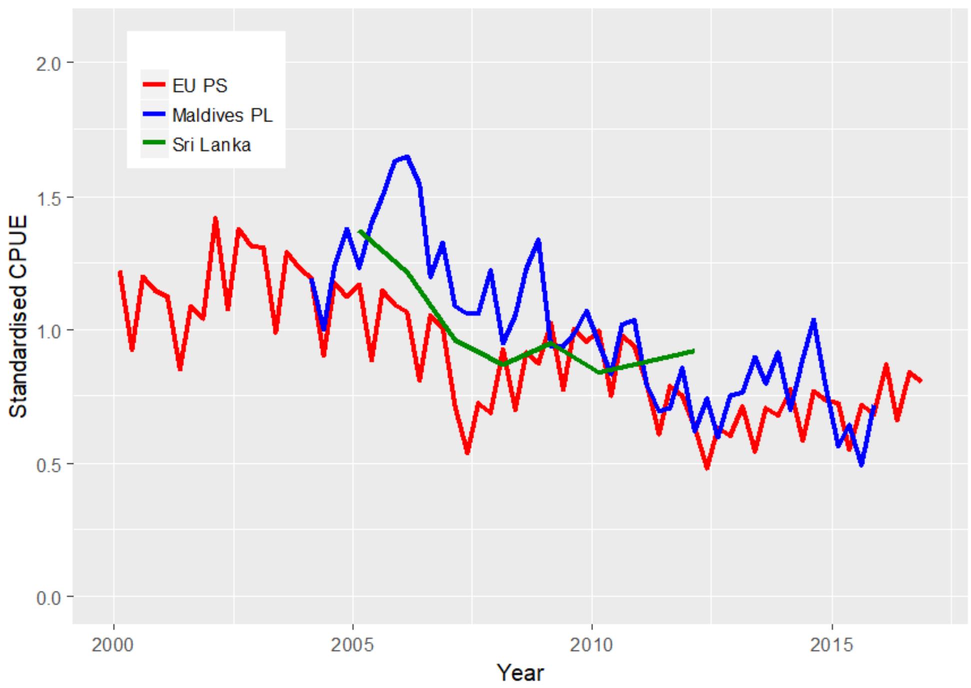


Fig. 3 Skipjack tuna: comparison of standardized CPUE indices for EU-purse seiners (FAD associated sets), Maldives pole-and-line, and Sri Lanka gillnet, 2000-2016.

6.3.2 Stock assessments

Skipjack tuna: Summary of stock assessment models in 2017

167. The WPTT **NOTED** that two (2) modelling methods (BDM (APSIC) and SS3) were applied in documents IOTC-2017-WPTT19-46 and IOTC-2017-WPTT19-47 submitted to the WPTT in 2017 for the assessment of skipjack tuna. Each model is summarised in the sections below. An additional modelling framework (JABBA) was also applied at the WPTT meeting, but no document was provided. The WPTT **NOTED** that the BDM (ASPIC) model was only preliminary and work in progress and therefore the results should be not be considered in determining stock status.

168. The WPTT **NOTED** Table 5, which provide an overview of the key features of each of the stock assessments presented in 2017 for the Indian Ocean-wide assessments (2 model types).

Table 5. Skipjack tuna: Indian Ocean-wide assessments. Summary of final stock assessment model features as applied to the Indian Ocean skipjack tuna resource in 2017.

Model feature	**BDM (ASPIC) (Doc#46)**	**SS3 (Doc# 47)**
Software availability	mpb (R-package)	NMFS toolbox
Population spatial structure / areas	Aggregated	1
Number CPUE Series	2	2
Uses Catch-at-length/age	No	Yes
Uses tagging data	No	Yes
Age-structured	No	Yes
Sex-structured	No	No
Number of Fleets	1	4
Stochastic Recruitment	No	Yes

Biomass Dynamic Model (BDM (APSIC)) assessment of skipjack tuna

169. The WPTT **NOTED** paper IOTC–2017–WPTT19–46_Rev1 which provided a stock assessment of skipjack tuna in the Indian Ocean by using Biomass Dynamic Model (ASPIC), including the following abstract provided by the authors:
"In this paper we presented a stock assessment for Indian Ocean skipjack tuna using biomass dynamic model. The estimated parameters include MSY (maximum sustainable yield), F_{MSY} (fishing mortality at MSY), q (catchability coefficient), K (carrying capacity) and B1/K (Initial biomass over carrying capacity). The estimated median MSY based on Logistic production model was 758 (1000 tons) and based on Fox production model was 1,110 (1000 tons), respectively. The results also showed that catch bias had influences on the assessment results. When the bias of nominal catch was adjusted by 20%, 15%, 10%, 5% (i.e. the historical catch was underestimated), the assessment results were significant differences. Overall, it is difficult to determine the stock status due to the high uncertainties in the derived management quantities. Therefore, this assessment still needs to be improved by covering more uncertainty sources."

170. The WPTT **NOTED** that this model was presented for exploratory purposes only and that it still needs to be improved to cover a broader range of sources of uncertainty.

171. The WPTT **NOTED** the key assessment results for the BDM (ASPIC) model as shown below (Table 6).

Table 6. Skipjack tuna: Key management quantities from the BDM (ASPIC) stock assessment, for the Indian Ocean.

Management Quantity	**Estimate**
Most recent catch estimate (t) (2015)	396,522
Mean catch over last 5 years (t) (2011-2015)	394,725
MSY (1000 t) (80%CI)	111.6 (65.5~179.6）
Current data period	2004-2015
F(Current)/F(MSY) (2015) (80% CI)	0.983（0.93~1.62）
B(Current)/B(MSY)(2015) (80% CI)	1.068 (0.39~2.8)
B(Current)/B(0)(2015) (80% CI)	NA

Stock Synthesis III (SS3) assessment of skipjack tuna

172. The WPTT **NOTED** paper IOTC–2017–WPTT19–47 which provided a stock assessment of skipjack tuna in the Indian Ocean using Stock Synthesis III, including the following abstract provided by the author:

"This paper presents a stock assessment for Indian Ocean Skipjack (Katsuwonus pelamis) using Stock Synthesis 3 (SS3). The assessment uses a spatially aggregated, age structured model that integrates multiple datasets into a unified framework. The assessment includes catch data grouped into four separate fisheries covering the period from 1950 through to 2016, two CPUE series, length composition data, and tag-recapture data."

173. The WPTT **NOTED** the key assessment results for the SS3 model as shown below (**Table 7; Fig.4**).

Table 7. Skipjack tuna: Key management quantities from the SS3 stock assessment, for the Indian Ocean.

Management Quantity	Indian Ocean
Catch in 2016	446,723 t
Average catch 2012–2016	407,456 t
MSY (1000 t) (plausible range):	564 (480.4-697.8)
$SSB_{Current}$ / SSB_{MSY}	1.61 (1.25-2.35)
$E_{Current}$ / E_{msy}	0.54 (0.36-0.77)
$Yield_{40\%SSB}$ (1000 t) (80% CI)	510.1 (455.9–618.8)
$E_{2016}/E_{40\%SSB}$ (80% CI):	0.9259 (0.70–1.13)
$C_{2016}/C_{40\%SSB}$ (80% CI)	0.88 (0.72-0.98)
SB_{2016} (1000 t) (80% CI)	796.66 (582.65-1,059.40)
Total biomass B_{2016} (1000 t) (80% CI)	910.4 (873.6-1195)
$SB_{2016}/SB_{40\%SSB}$ (80% CI)	1.00 (0.88–1.17)
SB_{2016}/SB_0 (80% CI)	0.40 (0.35–0.47)
$E_{40\%SSB}$ (80% CI)	0.59 (0.53-0.65)
SB_0 (80% CI)	2,015,220 (1,651,230–2,296,135)

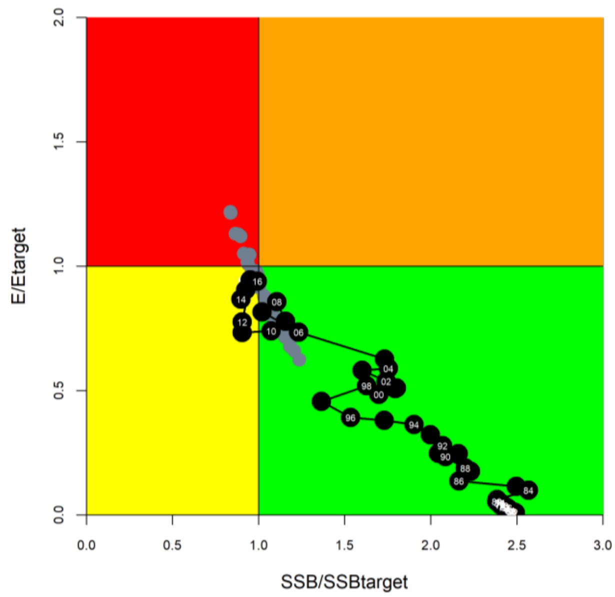


Fig.4. Skipjack tuna: SS3 Aggregated Indian Ocean assessment Kobe plot. Black circles indicate the trajectory of the median estimates for the SB/SB_{target} ratio and E/E_{target} ratio across all models of the 2017 uncertainty grid for each year 1950–2016; grey dots are the estimates for year 2016 from individual models..

174. The WPTT **NOTED** the following key elements and core assumptions in the SS3 assessment model, summarised below:
- Catch is assumed to be known, without error.
- The population model is age based, spatially disaggregated (1-2 region(s)), and seasonally structured

(iterated on an annual cycle consisting of four seasons).
- The model assumes that there is a shared spawning stock and total recruitment follows a Beverton-Holt relationship, with annual deviates and temporal variability in the proportional distribution of recruits among four seasons.
- There are four fisheries consisting of Maldives Pole and Line (PL) fleet, FAD/log associated Purse Seine (PS) sets from the EU/Seychelles fleets, unassociated PS sets from the EU/Seychelles fleets, and coastal fisheries including the gillnet fisheries, PS from other nations all categorized as Other fisheries.
- Standardised CPUE series are available from Maldives PL fleet and EU-PS (FAD-associated) sets. Length composition data are available for all four fisheries. Tagging data are available from the RTTP-IO and RTSS (regional tuna - small-scale tagging programmes).
- The model estimated non-parametric (cubic spline) length-based selectivity for each fleet independently (with sufficient flexibility to describe logistic, dome-shaped or polymodal functions).
- Estimated parameters include virgin recruitment, selectivity functions, recruitment deviations, and the seasonal pattern of recruitment, natural mortality (in some models), and the tag recovery reporting rate for the PL fleet (for models using RTTP-IO and RTSS tagging data).
- Fixed parameters include stock recruit steepness and life history parameters describing growth and the maturity schedule.

175. The WPTT **NOTED** a range of exploratory models were presented to explore the impact of key data and model assumptions on the stock assessment conclusions. A systematic approach was undertaken to evaluate interactions of model assumptions and to develop management advice. Possible combinations of model options considered in the exploratory phase were included in a final grid of model runs. Stock status was estimated for 144 models running a permutation of the parameters, including combinations of the following options:
    - 2 CPUE options: Maldives PL indices + EU PS indices, and Maldives PL only
    - 2 growth options: a Richards curve approximating the 2 stanza curve of Eveson et al. (2012), a von Bertalanffy curve of Eveson (2011) with Linf fixed at 83cm
    - 3 values of stock recruit steepness: h=0.7, 0.8, 0.9
    - 2 tagging program release/recovery options: i.) RTTP-IO, ii.) RTTP-IO plus small-scale tagging programme (RTSS)
    - 2 tag mixing period options: (t = 2, 4 quarters)
    - 2 tag recovery negative-binomial overdispersion options (τ = 2, 20)
    - 2 M options: estimated (age-specific), a constant value of 0.8

176. The WPTT **NOTED** that IOTC Resolution 16/02 adopted a harvest control rule (HCR) for skipjack tuna, which shall recommend a total annual catch limit based on a relationship between stock status (spawning biomass relative to unfished levels) and fishing intensity (exploitation rate relative to target exploitation rate), estimated from a model-based stock assessment. Therefore this assessment reported depletion-based reference points including $SSB_{40\%}$ (40% of unfished spawning biomass) and $F_{40\%SSB}$ (Fishing mortality corresponding to an equilibrium spawning biomass of 40% unfished level).

177. The WPTT **NOTED** that additional models based on alternative temporal and/or spatial structures were investigated to assess robustness of assessment conclusions, including a quarterly-based model in which calendar seasons are configured as model years, and a two-area model in which the stock is partitioned into the East and West Indian Ocean.

178. The WPTT **NOTED** that the alternative temporal configuration allows seasonal recruitment to be generated from the stock-recruitment relationship (rather than apportioned among four seasons from a single recruitment event), and also allows the tag release to be grouped by finer age classes (however, our investigation showed this is not influential). Overall the quarterly-based model had a similar performance to the original year-season model. A grid of 144 models (Grid-Q0, with the afore-mentioned parameter options) was also run using this alternative temporal structure.

179. The WPTT **NOTED** that the two area model allows differential depletion by area, and potentially accounts for spatial heterogeneity in tag mixing rate. However, the two-area models examined so far across a range of model options did not appear to provide credible estimates of relative biomass distribution between the two regions. Further investigation and improvement are required to assess this model's ability to estimate stock status and its applicability to provide management advice.

180. The WPTT **ACKNOWLEDGED** the excellent work carried out by the Secretariat and thanked the author for the clarity and precision of the working paper and presentation.

181. The WPTT **NOTED** the results of the set of runs with SS3 produced for the assessment of this stock (**Fig.5**). With regards to this first set of results (Grid-Q0, 144 models), the WPTT **NOTED** the following:

- The IO grid model structure in the document is very similar to previous stock assessments in terms of model configurations. However in the 2011 assessment (Kolody *et.al.*, 2011) the EU-PS fishery abundance index was taken from the free school fleet, compared to the 2014 assessment (Sharma and Herrera 2014) which was a FAD associated CPUE (but not standardized in the manner used this year).
- The profile likelihood on R_0 for the model IO confirmed that the global minimum was obtained by the maximum likelihood estimate.
- There were no major conflicts among various sources of likelihood components in the model, in particular between the abundance indices, size frequency, and tag recoveries data.
- There is also reasonable contrast in the profile, indicating sufficient information existed in the data for estimating absolute abundance.
- The model fitted Maldives-PL (2004-2015) and EU-PS-FAD (1986-2016) CPUE indices reasonably well, and captured the inter-annual variability of both time series.
- The models provided a reasonable fit to the aggregate size composition data. However, the fit to individual years is much less impressive for PL-FS and the Other fishery category, where the size distribution varied greatly between years. There appears to be some seasonality to the selectivity (particularly for the PS-FS fleet), which is not captured in the Reference Case model that was presented.
- As expected, the selectivity estimates show that larger fish are caught in the Maldives-PL and Other fisheries, and that the youngest ages (including the 38cm maturity threshold) are only weakly vulnerable to the fisheries.
- The WPTT **NOTED**, however, that the selectivity was assumed to be 0 for the first three quarters of age (as modelled in the 2014 stock assessment) so that the model would not expect that fish of that size are caught, even though the catch at size indicated reasonable catches of those size categories. Therefore, the specification of selectivity for small fish was corrected to allow the model to estimate selectivity for the size of fish found in the catch at size in the final runs.
- There were problems in the fit to the tag recoveries, and it was questioned whether the tag mixing assumption of 2 quarters is sufficient. Therefore, this assumption was replaced using 3 quarters for tag mixing in the final runs.
- With regards to the model biomass trajectory, the WPTT **NOTED** that it showed two steep declines, one in the late-1990s and the other in the mid-2000s, possibly explained by catch removals and recruitment variability, and that the biomass has increased over the last four years.
- The results after the correction of the error detected for the yearly model structure (i.e. selectivity fixed at 0 for the 3 first quarters of age) are very similar to the Quarterly model (QO grid), which estimates a lower biomass than before the correction.
- At the beginning of the Maldivian PL CPUE series (i.e., year 2004) there were high catch rates for all fisheries, and the WPTT **SUGGESTED** that if this was attributed to increased catchability rather than abundance, the index would decline at a lower rate than the current abundance indices. However, the WPTT also **NOTED** that this should be captured as a source of variability around the abundance indices.
- The CPUE series used in the IO Grid and Sensitivity runs do not account for the impact of the effort creep; in particular for the EU-PS-FAD fishery, there has been, but yet to be fully quantified, increase in fishing power that should be accounted for in the abundance index. The WPTT also **NOTED** that the Maldivian-PL fishery index may also be subject to effort creep, but perhaps at a different scale, as the frequency of drifting FADs entering the Maldives zone and other features not yet accounted for in the standardization could potentially have increased catchability. However, the increase in efficiency is less clear in such a short period since there have also been descriptions of lower efficiency due to problems with fuel price, bait availability, etc.
- With regards to the runs presented, the WPTT **NOTED** that the EU-PS-FAD indices are consistent with Maldives CPUE for the overlapping period, and that the longer EU indices help to stabilize estimates of abundance in the early fishery period.
- The assumed CV for the abundance indices is around 0.1, which it considered to be low.
- The uncertainty on catch was not addressed in the model and the WPTT **SUGGESTED** that future modeling should take catch uncertainty into account, to the degree it can be characterized.

- Exploring temporal structuring with the so-called, SSYS formulation, appears to allow modeling finer-scale temporal processes at least as well as the CYMS model.
- With regards to the differences between one or two area models, with the two area models the depletion between regions and the heterogeneity in tag mixing are accounted for. However, it was also **NOTED** the large uncertainty in East/West biomass allocation, which could not be resolved at the current meeting. The WPTT therefore **SUGGESTED** that the two-area model should not be included in the Reference Grid of models until the reasons for this could be better understood.

182. The WPTT **NOTED** an alternative model result developed at the WPTT meeting (JABBA, Winker IOTC-WPM08-11) that produced very similar results to the IO Grid from IOTC-2017-WPTT19-47. The WPTT **ACKNOWLEDGED** that obtaining similar results from different model structure and assumptions provided a degree of comfort in that the assessment outcomes appear robust for these alternative model structures and data requirements, in this case.

183. WPTT **NOTED** that the JABBA model was used at the WPTT meeting to explore implications of assuming alternative levels of effort creep on stock status evaluations. The runs explored over the range of effort creep increases (1% - 3% per annum) applied to the purse seine abundance index resulted in similar model fit diagnostics when compared to the JABBA reference case with no effort increase.

184. The WPTT also **NOTED** that given similar outcomes as the SS3 IO Grid, a simpler modelling framework approach like JABBA could be used which would make the stock assessment easier to implement and less time-intensive, without hindering the WPTT's ability to provide management advice, and **SUGGESTED** that this should be considered for the future. The downside is that these relatively simple models cannot explicitly include biological details, including tagging and recapture data.

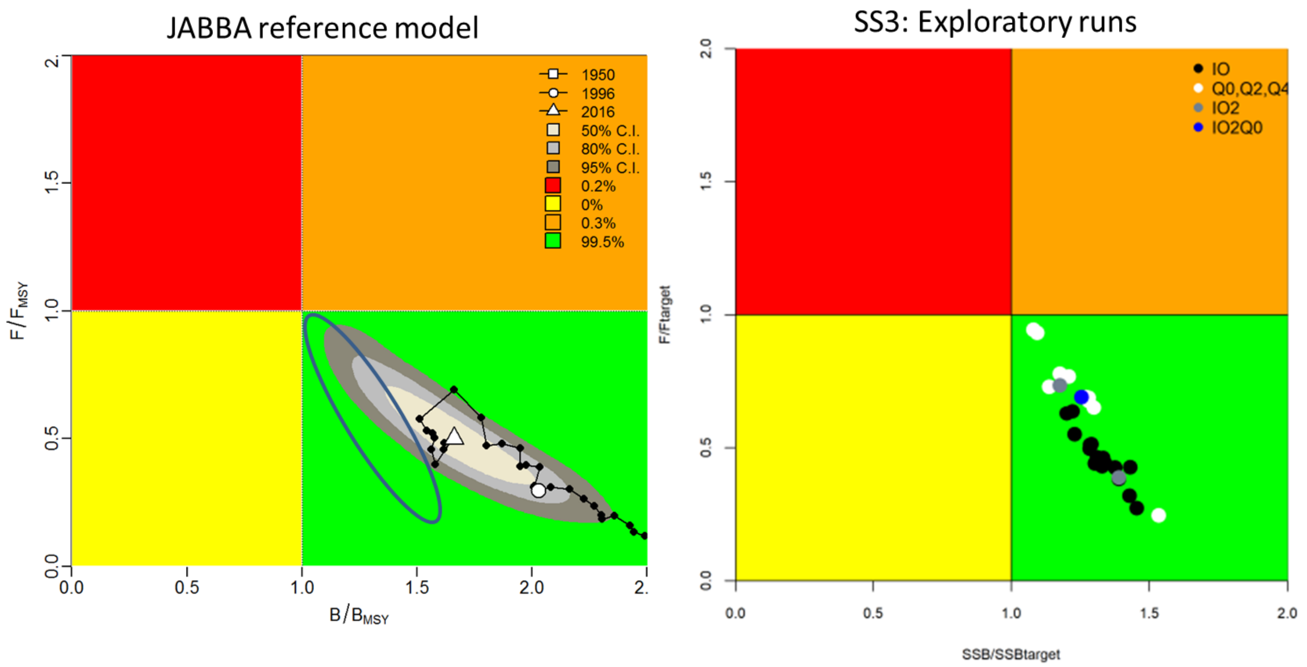


Fig.5. A comparison of the outcomes of the IO-grid described in IOTC-2017-WPTT19-47 (right panel) with the outcome of a JABBA model application using the same catch rate inputs (left panel) made at WPTT19. The blue ellipse in the left panel is an approximation of the range of outcomes from the IO-grid.

Modifications to the IO Grid and sensitivity runs

185. Following extensive discussions, the WPTT **AGREED** on a series of modifications to the IO Grid and Sensitivity runs to further examine the implications of model assumptions and to guide selection of plausible models to be used for characterizing uncertainty in the stock assessment. These initial modifications are summarized below:
    a. Remove from the grid (or change)
        i. Add mixing period of 3 quarters to the existing case with 4 quarters and remove 2 quarter mixing period runs.
        ii. Remove slow growth scenarios

        iii. Remove estimated natural mortality scenarios
    b. Add to the grid
        i. Add effort creep of 1% (annual increase in q) for EU-PS-FAD starting in 1995.
        ii. Natural mortality vector used in the WCPFC and constant M (instead of estimated M)
    c. Change in all models
        i. Tagging induced mortality to match the values used in bigeye stock assessment (2016) to 25% which was estimated from RTTP / RTSS date set
        ii. Correct specification for selectivity for fish < 4 quarters of age for the model to detect catch of these fish.
    d. Sensitivity Runs
        i. Use weight of 10 on LFSS (size data)
        ii. Sri Lankan CPUE added to the others
        iii. Remove all tagging data (lambda=0.1)
        iv. Asymptotic selectivity on 1 fishery (Free School or Others, double normal)
        v. 2% of annual increase in q (effort creep).

186. The WPTT **NOTED** the benefit of exploring the impact of each of the changes proposed first individually and subsequently in combination.

187. The WPTT **NOTED** that diagnostics of the model fit to data need to guide the selection of alternative hypotheses for model structure and model assumptions and proceeded to evaluate the impacts of these alternatives on the fits to data.

188. The WPTT also **NOTED** that it was unclear whether a single case or an uncertainty grid should be used to produce stock status summaries for this stock. The WPTT **NOTED** that this will depend upon plausible uncertainty characterization in the new grid of models. This would be particularly important in terms of MSE and how it should be implemented with a clear MP.

189. The WPTT **CONSIDERED** the results of the new set of runs requested with SS3 and **NOTED** the following:
- The diagnostics examined, with the possible exception of the M and tag release mortality assumptions impacts on fits to the tagging data, did not reveal any substantial discrepancies between the different model formulations identified above.
- Change in the tag release mortality rate to 25% (from 0%) had a notable effect.
- M assumptions also have impact on fits to the tag data.

190. The WPTT **AGREED** that, after reviewing and discussing the new sets of runs, the following specifications for the model grid be used to characterize uncertainty in the assessment and for provision of management advice. The details of the final grid are the following (48 model runs specified):
- 1 Growth scenario (fast growth - LR)
- 1 CPUE option: Maldivian standardized CPUE and EU-PS-FAD standardized CPUE with a 1% annual catchability increase since 1995 (PS only).
- 2 mixing periods (3 and 4 quarters).
- 2 tagging programs options (i) RTSS (RTTP plus small-scale tagging), (ii) RTTP)
- 2 Natural Mortality options (Constant M and estimated M)
- 3 Steepness options (h=0.7, 0.8, 0.9)
- 2 options for release tag mortality (15% and 25%).

Final model specification

191. The WPTT **CONSIDERED** the final results of the grid of runs requested with SS3.

192. The WPTT **NOTED** that from the initial grid that consisted of 48 model runs, the number of runs was reduced to 36, since 12 scenarios with all combinations of estimated natural mortality and the option (RTTP only) for the tagging programs yielded unacceptable fits.

193. The WPTT further **DISCUSSED** the range of steepness assumptions applied and, although there was some concern expressed that a steepness value of 0.7 could be considered too low, the WPTT **AGREED** on using the new grid of results to characterize stock status for skipjack in the Indian Ocean and to provide the necessary parameters for establishing TAC under the terms of Resolution 16/02.

194. The WPTT **CONCLUDED** the assessment outcomes as indicated in **Table 7** and **Fig. 5**.

195. WPTT also **NOTED** that the history of Skipjack stock status and uncertainty in current (beginning of 2017) status is depicted in the Kobe plot.

196. Considering the requirements of Resolution 16/02 regarding TAC setting for the subsequent 3 year period, the WPTT **AGREED** that forward projections and corresponding Kobe 2 Strategy Matrices would not be produced, since historically these have been produced to provide guidance to the Commission on management alternatives.

197. The WPTT **AGREED** on showing stock status and other indicators for management using medians and 80% confidence intervals considering the advice offered by WPM on this topic.

198. The WPTT **CONSIDERED** the specifications for computing the TAC based on Resolution 16/02 and **NOTED** a possible contradiction in the TAC calculation based on the method specified by the Resolution and the method used in the simulation tested in the Harvest Control Rule. The WPTT therefore **REQUESTED** clarification from the authors of the simulation tests and the stock assessment scientist.

199. The WPTT **NOTED** that the fishing mortality shown in the management quantities of **Table 7** has been adapted to reflect the exploitation rate.

Future skipjack assessments: issues for consideration

200. The WPTT **AGREED** on the grid of assessment models as a pragmatic path forward, but **NOTED** several concerns that the next iteration of the assessment needs to consider, with some possible avenues for exploration:

   a. The standardized CPUE indices of relative abundance were very similar to the nominal series, which means that either the standardization has failed to account for years of technological development, or these developments are not relevant to efficiency in the context of relative abundance estimation. The group thought that stationary catchability for these fleets was unlikely, despite competing mechanisms which could decrease catchability, i.e. bait competition in the PL fishery, and decreasing set times in the PS fishery due to competition. However, assuming arbitrary catchability increases was also not a satisfactory solution.

   b. Avenues for exploration include:

      i. using PS catchability estimates from YFT and BET assessments to estimate the catchability trends in a manner that is internally consistent with those assessments
      ii. using species composition from PS sets to estimate SKJ abundance using the ratio of the SKJ/YFT multiplied by the (fishery selected) YFT assessment abundance.

201. The WPTT **NOTED** that some participants considered the steepness value of 0.7 to be implausibly low for skipjack life history. Others considered that h=0.7 was consistent with a lower range that several tuna-RFMOs considered plausible, and there were not enough tuna stocks sufficiently depleted to provide compelling evidence one way or the other.

202. The WPTT **NOTED** that the inclusion of the tagging data in the current model structure is problematic because of the low mixing rates which break a key model assumption, i.e. that tagged and untagged individuals are equally vulnerable to exploitation. Independent analyses of RTTP tag data have shown strong evidence of poor mixing for 3 quarters, but proper mixing might never occur at the basin scale. It was recognized that the mixing problem with the small-scale tagging data may positively bias the biomass estimate, but the effects of the mixing problem in the RTTP-IO data are not easy to predict. Two possible approaches were considered to reduce the problem:

   - Spatially disaggregate the assessment model. This introduces other problems of over-parameterization, e.g. tagging data are not sufficient to estimate movement.
   - Use independent, high resolution spatial models to provide independent estimates of tag bias (or abundance, etc.). These estimates could potentially be introduced to the assessment as priors or through the external manipulation of tag releases/recoveries.

203. The WPTT **NOTED** that there was a lack of fit to the tag recoveries, with predicted recoveries of tags shortly after the mixing period systematically underestimated, and predicted recoveries over longer periods systematically overestimated. The underestimation of short term recoveries is consistent with tags not being well mixed as discussed above, while overestimation of long term recoveries is consistent with natural mortality being underestimated. Several approaches could be explored to address the latter problem:

   - Apply higher levels of natural mortality (senescence) to older skipjack.
   - Use a higher level of natural mortality, closer to the level used in the WCPO.

204. The WPTT **NOTED** that all of the SKJ assessment grid models estimated that recent recruitment had been low relative to the stock recruit relationship, and this may reflect a systematic lack of fit to the stock recruit relationship. This could be an artefact of the model attempting to explain declining abundance through a recruitment trend rather than a declining abundance trend (i.e. F under-estimated). Model scenarios that explain declining abundance as a function of fishing depletion should be explored (e.g. possibly catchability trend scenarios)

205. The WPTT **NOTED** that the model was unable to predict the lower average sizes observed in a number of recent years in the PSLS, PSFS, and PL fisheries, since the maximum catch in about 2007. The group was unable in the available time to identify model scenarios that could predict these size changes. Approaches that may help identify how to resolve the problem include running multiple model scenarios without the tagging data (so that the biomass level is able to adjust) while prioritising the fit of one size dataset in each scenario, using the effective sample sizes.

206. The WPTT **NOTED** that the 'other' fishery is a composite of multiple fleets that take different sizes of fish and with inconsistent/irregular size sampling, and the size distribution changes repeatedly though time. The effective sample sizes are 1/10th of the PS fleets, but it may be advisable to reduce them further so as to avoid unwanted data conflict and possible effects on biomass estimates. It may also be useful to split the fishery into small and large fish fisheries, which could improve the predicted sizes in the catch.

207. The WPTT **NOTED** that additional diagnostics such as more detailed virgin recruitment profiling and retrospective analyses should be applied to possibly the reference model from the new grid.

Parameters for future analyses: Skipjack tuna CPUE standardisation and stock assessments

208. The WPTT **RECALLED** its previous agreement that in order to obtain comparable CPUE standardisations, the analyses shall be conducted with similar parameters and resolutions. Table 8 provides a set of parameters, discussed during the WPTT18 that give guidelines, if available, for the standardisation of CPUE, to be used as indices of abundance for the next scheduled stock assessment of skipjack tuna.

Table 8. Skipjack tuna: Parameters for the future standardisation of CPUE series.

CPUE standardisation parameters	Value for next CPUE standardisation
Area	*To be defined (possible eastern and western Indian Ocean).* Explore core area(s)
CE Resolution	Operational data
Factors	Year, Quarter, Area, vessel characteristics, environmental + interactions, number of FADs and species composition
Model	Negative binomial, zero-inflated or delta-lognormal models

209. The WPTT **RECALLED** that the model parameters contained in Table 9 could be considered appropriate for future skipjack tuna stock assessments preliminary base case analysis, with appropriate sensitivity runs.

Table 9. Skipjack tuna: Model parameters agreed to by the WPTT for use in future base case stock assessment runs.

Biological parameters	**Value for assessments**
Stock structure	1 and 2 areas
Sex ratio	1:1
Age (longevity)	8+ years
Natural mortality	M=0.8 (/year) constant over ages (or estimated within the model)
Growth formula	VB log K 2-stanza growth (Eveson et al. 2015) *
Weight-length allometry	$W=aL^b$ with $a= 4.97*10^{-6}$ and $b=3.39292$ common to sex **
Maturity	Length-specific (50% mature at length 38 cm, fully mature at 44 cm)
Fecundity	Proportional to the spawning biomass
Stock-recruitment	B&H, h=0.8 (plus sensitivity e.g. 0.7 and 0.9), sigma_R=0.6
Other parameters	
Fisheries	4 (Maldives PL, Purse Seine FS, Purse Seine LS, Other)
Abundance indices	PSFS/PSLS combined, Maldives PL with SRL GL CPUE
Selectivity	Fishery specific. Cubic splines

* Eveson J P, Million J, Sardenne F & Le Croizier G (2015) Estimating growth of tropical tunas in the Indian Ocean using tag-recapture data and otolith-based age estimates. Fisheries Research: Indian Ocean Tuna Tagging Programme special issue.

** Updated length-weight allometry equation, as adopted by IOTC WPDCS (Source: Chassot, E. et al, in IOTC-2016-WPDSC12-INF05).

6.3.3 Selection of Stock Status indicators for skipjack tuna

210. The WPTT **AGREED** that the final grid of 36 model runs from the SS3 stock assessment would be used for development of management advice for the Scientific Committee's consideration.

6.4 Development of management advice for skipjack tuna & update of skipjack tuna Executive Summary for the consideration of the Scientific Committee

211. The WPTT **ADOPTED** the management advice developed for skipjack tuna as provided in the draft resource stock status summary and **REQUESTED** that the IOTC Secretariat update the draft stock status summary for skipjack tuna with the latest 2016 catch data (if necessary), and for the summary to be provided to the SC as part of the draft Executive Summary, for its consideration:
    - Skipjack tuna (*Katsuwonus pelamis*) – Appendix VII.

212. The WPTT **NOTED** that when providing advice on stock status, IOTC stocks are considered to be overfished and subject to overfishing when the target reference points are breached, and there is no change to stock status when limit reference points are breached.

213. The WPTT **NOTED** that this may not always be consistent with the intended application of target and limit reference points. For example, when managing stocks to a specific target reference point, the stock can breach the target in some years due to natural fluctuations in stock abundance or other sources of variability. In these years, the stock would be assessed as being overfished and/or subject to overfishing.

214. The WPTT therefore **RECOMMENDED** that the Scientific Committee review the approach used to provide management advice, particularly in relation to how the outcomes from stock assessments are reported against target and limit reference points.

6.5 Update of the skipjack tuna Skipjack tuna Management Strategy Evaluation process update

215. The WPTT **NOTED,** as indicated in IOTC-2017-WPTT19-05, that the Commission adopted Resolution 16/02 *On harvest control rules for skipjack tuna in the IOTC Area of Competence,* which was informed by the MSE process undertaken and endorsed by SC18.

7. YELLOWFIN TUNA – REVIEW OF NEW INFORMATION ON STOCK STATUS

7.1 Review of the statistical data available for yellowfin tuna

216. The WPTT **NOTED** paper IOTC–2016–WPTT19–07 which summarised the standing of a range of data and statistics received by the IOTC Secretariat for yellowfin tuna, in accordance with IOTC Resolution 15/02 *Mandatory statistical reporting requirements for IOTC Contracting Parties and Cooperating Non-Contracting Parties (CPC's)*, for the period 1950–2016. The paper also provided a range of fishery indicators, including catch and effort trends, for fisheries catching yellowfin tuna in the IOTC area of competence. It covers data on nominal catches, catch-and-effort, size-frequency and other data, in particular release and recapture (tagging) data. A summary of the supporting information for the WPTT is provided in Appendix IVd.

217. The WPTT **RECALLED** that catch-and-effort and size data for yellowfin tuna (and for other tropical tuna species) is either unavailable or is not reported to IOTC standards for many coastal fisheries which account for over half of total tropical tuna catches in recent years, including gillnet and fresh-tuna longline fleets operating on the high seas, and **ENCOURAGED** coastal fleets to improve their data collection and reporting systems required to meet the mandatory reporting obligations of IOTC Resolution 15/02.

218. The WPTT **NOTED** the very low coverage level of size frequency samples for the Japanese longline fleet, and **ACKNOWLEDGED** that this is due to current sampling protocols applied by the Japanese longline fleet that seem to focus more on the sampling of albacore tuna, rather than tropical tuna species.

219. The WPTT also **NOTED** that recent revisions in Pakistan's nominal catch data (submitted but not yet incorporated within the IOTC official data sets) seem to positively affect the quality of the time series and **ACKNOWLEDGED** that the Secretariat is awaiting the completion of a future (Q1 2018) Data Compliance and Support Mission to Pakistan to assess the provided updates before their finalization.

220. The WPTT **NOTED** the update provided by the Secretariat about future Data Compliance and Support missions planned from the end of 2017 until Q1 2018, and **RECOGNIZED** the importance of these data compliance missions in the improvement of the statistical information available to scientists.

7.2 Review new information on the biology, ecology, stock structure, their fisheries and associated environmental data for yellowfin tuna

221. The WPTT **NOTED** that as yellowfin tuna was not the priority species at WPTT19, no papers were submitted for this agenda item in 2017.

7.3 Review of new information on the stats of yellowfin tuna

7.3.1 Nominal and standardised CPUE indices

Japan longline – Catch-per-unit-of-effort (CPUE) for yellowfin tuna standardized by generalized linear model

222. The WPTT **NOTED** paper IOTC–2017–WPTT19–48 which provided an update on the standardized Japanese longline CPUE for yellowfin tuna in the Indian Ocean (**Fig.6**), including the following abstract provided by the author:

"*Japanese longline CPUE for yellowfin tuna in the Indian Ocean (area aggregated and area-specific) was standardized up to 2016 by GLM based on similar method to those in the previous studies. Basically, standardized CPUEs showed similar trends among areas. CPUE continuously decreased from early 1960s to 1974, and kept in the same level until 1990. Thereafter, it declined to historical low level in recent years. The stable trend in recent years at all models indicates decreased effort caused by piracy activity in area 2 (northwest) has little effect on overall CPUE trends. Applying 5 degree latitude/longitude effect showed large effect on the CPUE trend for Area 3 (southwest) and 4 (south). There was some difference of area aggregated CPUE between the model with subarea and with 5 degree latitude/longitude.*"

223. The WPTT **WELCOMED** the updated catch rate standardisation for the Japan fleet in the Indian Ocean for yellowfin tuna (**Fig.6**) and **ENCOURAGED** the authors to continue their analyses as part of the multi-nation collaborative effort to improve CPUE standardisations.

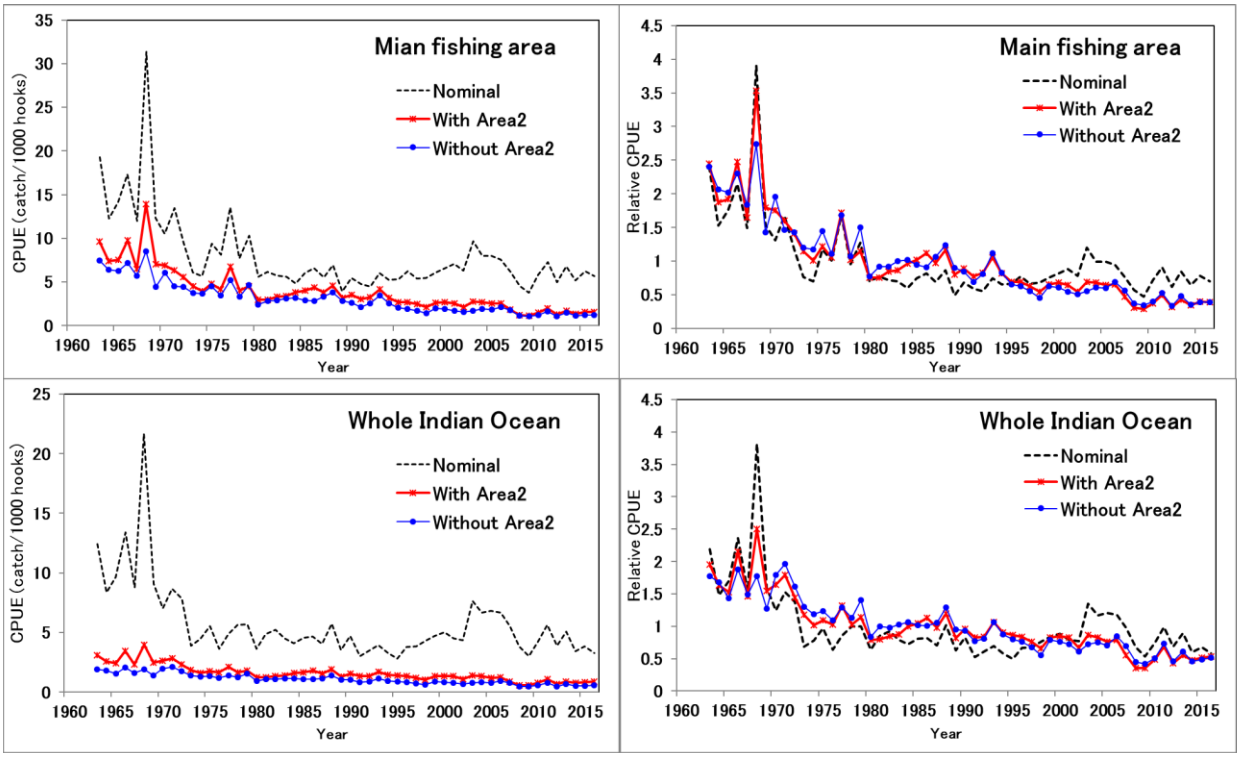


Fig.6. Annual based area aggregated CPUE in number for 1963-2016 standardized for main (top) and whole (bottom) fishing grounds expressed in real (left figure) and relative (right figure) scale overlaid with nominal CPUE.

7.3.2 Stock assessments

Yellowfin tuna: Summary of stock assessment models in 2016

224. **NOTING** that no new formal stock assessments were carried out on yellowfin tuna in 2017, the WPTT **RECALLED** that two quantitative modelling methods (ASPIC and SS3) were applied to yellowfin tuna in 2016 and readers are requested to refer to the report of the 18th Session for details (IOTC–2016–WPTT18–R).

Parameters for future analyses: Yellowfin tuna CPUE standardisation and stock assessments

225. The WPTT **RECALLED** that in order to obtain comparable assessments, the CPUE standardisations should be conducted with similar parameters and resolutions. However the improved methods recommended by the CPUE workshop should also be applied so that standardisation procedures can make progress. **Table 10** provides a set of parameters, discussed during WPTT meetings that give guidelines, if available, for the standardisation of CPUE in the unimproved state.

Table 10. Yellowfin tuna: Parameters for the future standardisation of CPUE series.

CPUE standardisation parameters	CPUE standardisations for consistency
Area	By region
CE Resolution	Operational data
Data preparation	Cluster analysis or related approaches to select data or add cluster parameters
Factors	Year, Quarter, 5 degree squares, HBF or cluster, vessel
Model	Delta lognormal, lognormal + constant
	Proposed updates to standardisation methods
Area	As above
CE Resolution	As above
Data preparation	As above
Factors	As above, plus sub-area * time interaction
Model	As above
Other possible changes	Transform response variable

Table 11. Yellowfin tuna: Model parameters agreed to by the WPTT for use in future base case stock assessment runs.

Biological parameters	**Value for assessments**
Spatial structure	4 regions
Sex ratio	Sex aggregated
Age (longevity)	60 quarterly age classes with the last representing a plus group.
Natural mortality	Age-specific. Relative variation amongst ages based on WCPO yellowfin assessment and overall scale of natural mortality estimated in 2012 Indian Ocean yellowfin tuna assessment (see Figure 16 in SS3 assessment). Constant over time and among regions.
Growth formula	Estimates in Fonteneau 2008 (Replace with Eveson et al. 2015 and/or Dortel et al. 2015, but not for 2016 update). SD of length-at-age based on a constant coefficient of variation of average length-at-age.
Weight-length allometry	a = 1.7665e-05, b = 3.03542
Maturity	age-class 0-4: 0; 5: 0.1; 6: 0.15; 7: 0.2; 8: 0.5; 9: 0.5; 10: 0.7; 11: 0.9; 12-28: 1.0 (based on Zudaire et al. 2013)
Fecundity	Assume constant, since results are based on spawning biomass rather than egg production. (Potential to change this post-2016.)
Stock-recruitment	Beverton-Holt steepness of 0.8 with sensitivities at 0.7 and 0.9.
Other parameters	
Fisheries	25 fisheries defined by region and gear type, with temporal splits to reflect selectivity change in the region 1b PS fisheries.
Abundance indices	Regional standardised longline CPUE indices estimated jointly across flags
Selectivity	Age specific, constant over time. Principal longline fisheries share logistic selectivity parameters. Common selectivity for all PSLS fisheries. Common selectivity for all PSFS fisheries. LF4 fishery logistic selectivity. All other fisheries: double normal selectivity. OT 1a & 4 and TR 1b & 4 share selectivity parameters.

226. The WPTT **RECALLED** that the model parameters contained in **Table 11** could be considered appropriate for future yellowfin tuna stock assessments preliminary base case analysis, with appropriate sensitivity runs.

227. The WPTT reiterated its previous **RECOMMENDATION** that development of the next stock assessment of yellowfin tuna should include, or be associated with, a detailed review of the existing data sources, including:
   i. Size frequency data: Evaluation of the reliability of length composition from the longline fisheries (including recent and historical data), review of anomalies in the (EU) PS length composition data, and the need for a thorough review of the size frequency data held by IOTC, in collaboration with the fleets involved, to improve the utilization of these data in tropical tuna stock assessments.
   ii. Tagging data: Further analysis of the tag release/recovery data set.
   iii. Alternative CPUE series: a review of the available data from the Indian tuna longline survey data.

7.3.3 Selection of Stock Status indicators for yellowfin tuna

228. The WPTT **AGREED** that as no new stock assessment was carried out for yellowfin tuna 2017, management advice should be based on the range of results from the SS3 model in 2016, as well as the updated CPUE series presented at the WPTT19 meeting.

7.4 Development of management advice for yellowfin tuna & update of yellowfin tuna Executive Summary for the consideration of the Scientific Committee

229. The WPTT **ADOPTED** the management advice developed for yellowfin tuna as provided in the draft resource stock status summary and **REQUESTED** that the IOTC Secretariat update the draft stock status summary for the

yellowfin tuna with the latest 2016 catch data (if necessary), and for the summary to be provided to the SC as part of the draft Executive Summary, for its consideration:

- Yellowfin tuna (*Thunnus albacares*) – Appendix VIII.

7.5 Yellowfin tuna Management Strategy Evaluation process update

230. The WPTT **NOTED** paper IOTC–2017–WPTT19–32, which provided an update on the tropical tunas management strategy evaluation development framework. A summary of this document and discussion are presented below in Agenda item 8 below.

8. Development of options for alternative management measures for tropical tunas in the IOTC area of competence

231. The WPTT **NOTED** IOTC–2017–WPTT19–49 was presented, which describes progress on the development of Management Strategy Evaluation (MSE) for Indian Ocean yellowfin and bigeye tunas, and solicits feedback from the WPTT for the next iteration. Financial support was unavailable for this work over the preceding year. ABNJ/FAO and CSIRO recently signed a contract to support the work from Oct 2017 to Dec 2018. The update consisted primarily of a "mechanical" implementation of the yellowfin tuna reference and robustness OM requests made in 2016 (no progress has yet been made on bigeye tuna under the phase 2 project). The results indicate that the reference set OM needs further development, as many of the scenarios suggested implausibly high productivity. The robustness scenarios proposed (temporal variability in longline selectivity, and over-weighting the tagging data) did not appear to add a challenge for the MPs that was substantially outside of the current reference set OM.

232. The WPTT **AGREED** on the general specification of the reference case OM as defined by the WPTT and WPM in 2016. Noting that it was difficult to specify explicit new scenarios outside of the context of a recent assessment, the following scenarios were suggested for further consideration in the OM robustness tests (with potential inclusion in the OM reference set, subject to review by WPM):
    - Ricker stock recruitment curve.
    - Recruitment shock (sustained poor recruitment consistent with the worst outcomes in the historical record).
    - Alternative options for growth (among those considered plausible in recent YFT growth analyses).
    - Alternative selectivity (e.g. dome-shaped vs: asymptotic, and region-specific).
    - Alternative catchability increase scenarios (e.g. 3 or 5%).
    - Explore options for temporal variability in biological parameters (e.g. natural mortality, growth, recruitment and migration) in relation to climate change. It was noted that these sorts of effects might not be important over the time-scale which an MP might be expected to operate without a thorough review (e.g., 5-10 years), and if they are important, they might undermine a lot of the stationary dynamics assumptions that underpin the modern fisheries assessment and management paradigm.

233. The WPTT **SUGGESTED** using a partially confounded design to increase the number of dimensions that could be included in the reference OM.

234. The WPTT **NOTED** that the 2018 yellowfin tuna assessment should not influence the specification of the YFT OM or the MSE process, unless there are new insights that dramatically change the perception of the stock status and associated uncertainties.

9. WPTT Program of Work

9.1 Revision of the WPTT Program of Work (2018–2022)

235. The WPTT **NOTED** paper IOTC–2017–WPTT19–08 which provided the WPTT19 with an opportunity to consider and revise the WPTT Program of Work (2018–2022), by taking into account the specific requests of the Commission, Scientific Committee, and the resources available to the IOTC Secretariat and CPCs.

236. The WPTT **RECALLED** that the SC, at its 18th Session, made the following request to its working parties:

> "*The SC **REQUESTED** that during the 2016 Working Party meetings, each group not only develop a Draft Program of Work for the next five years containing low, medium and high priority projects, but that all High Priority projects are ranked. The intention is that the SC would then be able to review the rankings and develop a consolidated list of the highest priority projects to meet the needs of the*

Commission. Where possible, budget estimates should be determined, as well as the identification of potential funding sources." (SC18. Para 154)

237. The WPTT **REQUESTED** that the Chairperson and Vice-Chairperson of the WPTT, in consultation with the IOTC Secretariat, develop Terms of Reference (TOR) for each of the high priority projects that are yet to be funded, for circulation to potential funding sources.

238. **NOTING** that the current IOTC *Guidelines for the presentation of CPUE standardisations and stock assessment models* (IOTC–2015–WPTT17–INF01) may need revising, as it was felt that the current Stock Status summary table, which is the principal communication tool regarding stock status used on the IOTC website, understates uncertainty in stock status evaluations, the WPTT **REITERATED** that the following be reviewed:
    - the annual status coding scheme;
    - the historic coding scheme;
    - consideration of the status coding scheme for years when no quantitative stock assessment is available.

239. The WPTT **RECOMMENDED** that the SC consider and endorse the WPTT Program of Work (2018–2022), as provided at Appendix IX.

Data exchange timings

240. The WPTT **RECALLED** that the current time frames for data exchange do not allow enough time to conduct thorough stock assessment analyses, which has a detrimental effect on the quality of advice provided. The WPTT **ENCOURAGED** that exchanges of data (CPUE indices and coefficient of variation) should be made as early as possible, but **no later than** 60 days prior to a working party meeting, so that stock assessment analysis can be provided to the IOTC Secretariat no later than 30 days before a working party meeting.

Consultants

241. **NOTING** the excellent work by IOTC consultants in the past and for the WPTT19, the WPTT **RECALLED** that the Commission has pre-approved a consultant to undertake a yellowfin tuna stock assessment in 2018, by the inclusion of funds in the 2018 budget. The WPTT **CONSIDERED** whether a multi-species assessment would be required for subsequent WPTT meetings, given the likelihood of more regular updates of stock status required to support Resolution 17/02 *On interim plan for rebuilding the Indian Ocean yellowfin tuna stock in the IOTC Area of Competence*, and Resolution 16/02 *On harvest control rules for skipjack tuna in the IOTC Area of Competence*.

242. The WPTT **AGREED** that a number of priority issues (in order of importance) should be examined to support further development of the stock assessments for tropical tunas. The Chairperson and IOTC Secretariat shall develop Terms of Reference and seek funding. Specifically:
    - **Yellowfin tuna / Bigeye tuna**
        - Further development of the collaborative longline CPUE, and European purse seine CPUE.
        - Review of the purse seine and longline size data for tropical tunas in the IOTC database.
        - Review of the assumptions associated with the mixing of tagged fish following release.
        - Determination of the structural uncertainty of the assessment model, incorporating the interactions among key model parameters (e.g., a grid approach).
        - Exploration of alternate assessment areas.
        - Development of a two sex model to account for sex specific differences in the biological parameters (especially growth and natural mortality).
    - **Skipjack tuna**
        - Evaluation of Maldives logbook, CPUE series (e.g., extending the series back to the 1970s).
        - Exploration of gillnet (or other alternative) CPUE.
        - European purse seiner CPUE.
        - External fisheries indicators (e.g., number of FADs).
        - Derive a time series of abundance from assessment outputs of YFT or BET and data on the species composition of PS.

9.2 Development of priorities for an Invited Expert at the next WPTT meeting

243. The WPTT **NOTED** with thanks, the contribution of the invited expert, Dr. Rishi Sharma (NOAA), both during the WPTT and WPM meetings, and which contributed greatly to the group's discussions of tropical tuna data, CPUE standardisation and stock assessment methods.

244. The WPTT **AGREED** to the following core areas of expertise and priority areas for contribution that need to be enhanced for the next meeting of the WPTT in 2018, by an Invited Expert:
   - **Expertise**: Stock assessment; including from regions other than the Indian Ocean; size data analysis; and CPUE standardisation.
   - **Priority areas for contribution**: Providing expert advice on stock assessments; refining the information base, historical data series and indicators for tropical tuna species for stock assessment purposes (species focus: skipjack tuna and yellowfin tuna).

10. OTHER BUSINESS

10.1 Election of a Chair and Vice-Chairperson of the WPTT for the next biennium

245. The WPTT **NOTED** that the second term of the current Chairperson, Dr. M. Shiham Adam (Maldives) and Vice-chairperson, Dr. Gorka Merino (Spain) is due to expire at the closing of the WPTT-20 meeting.

10.2 Date and place of the 20th and 21st Sessions of the WPTT

246. The WPTT **THANKED** the IOTC Secretariat for hosting the 19th Session of the WPTT and commended Seychelles on the warm welcome, the excellent facilities and assistance provided to the IOTC Secretariat in the organisation and running of the Session.

247. **NOTING** the discussion on who would host the 20th and 21st Sessions of the WPTT in 2018 and 2019 respectively, the WPTT **REQUESTED** that the IOTC Secretariat liaise with CPCs to determine if they would be able to host the 20th and 21st sessions of the WPTT respectively (Table 12).

Table 12. Draft meeting schedule for the WPTT (2018 and 2019).

Meeting	2018		2019	
	Date	Location	Date	Location
Working Party on Tropical Tunas	Third week in October (6 days)	TBD	Third week in October (6 days)	TBD

10.3 Review of the draft, and adoption of the Report of the 19th Session of the WPTT

248. The WPTT **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPTT19, provided at Appendix X, as well as the management advice provided in the draft resource stock status summary for each of the three tropical tuna species under the IOTC mandate, and the combined Kobe plot for the three species assigned a stock status in 2017 (**Fig.7**):
   - Bigeye tuna (*Thunnus obesus*) – Appendix VI
   - Skipjack tuna (*Katsuwonus pelamis*) – Appendix VII
   - Yellowfin tuna (*Thunnus albacares*) – Appendix VIII

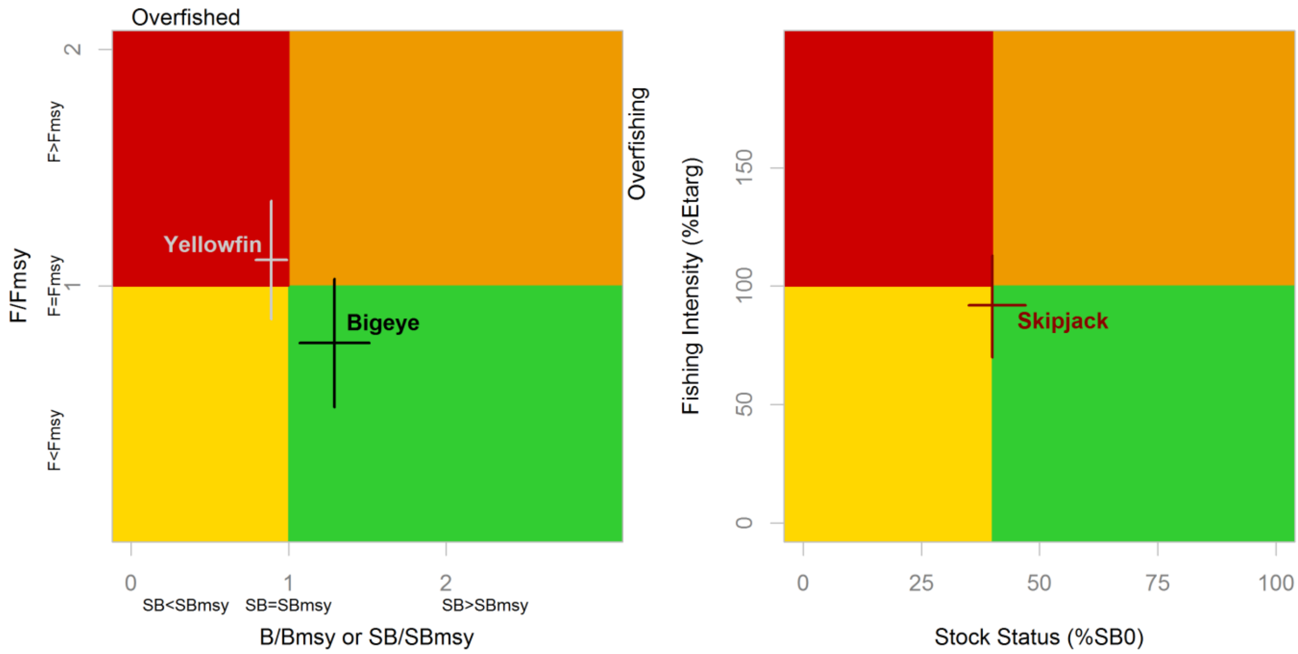


Fig.7. (Left) Combined Kobe plot for bigeye tuna (black: 2016), and yellowfin tuna (grey: 2016) showing the estimates of current stock size (SB) and current fishing mortality (F) in relation to optimal spawning stock size and optimal fishing mortality. (Right) Kobe plot for skipjack tuna showing the estimates of the current stock status. Cross bars illustrate the range of uncertainty from the model runs with a 80% CI.

249. The report of the 19th Session of the Working Party on Tropical Tunas (IOTC–2017–WPTT19–R) was **ADOPTED** on the 22 October 2017.

APPENDIX I
LIST OF PARTICIPANTS

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APPENDIX II
AGENDA FOR THE 19TH WORKING PARTY ON TROPICAL TUNAS

Date: 17 October – 22 October 2017
Location: Seychelles
Venue: (Eden Bleu Hotel Conference Room)
Time: 09:00 – 17:00 daily
Chair: Dr Shiham Adam (Maldives) **Vice-Chair**: Dr Gorka Merino (EU,Spain)

1. **OPENING OF THE MEETING** (Chair)

2. **ADOPTION OF THE AGENDA AND ARRANGEMENTS FOR THE SESSION** (Chair)
   - IOTC–2017–WPTT19–01a Draft: Agenda of the 19th Working Party on Tropical Tunas
   - IOTC–2017–WPTT19–01b Draft: Annotated agenda of the 19th Working Party on Tropical Tunas
   - IOTC–2017–WPTT19–02 Draft: List of documents for the 19th Working Party on Tropical Tunas

3. **THE IOTC PROCESS: OUTCOMES, UPDATES AND PROGRESS**

   3.1 **Outcomes of the 19th Session of the Scientific Committee (IOTC Secretariat)**
   - IOTC–2017–WPTT17–03 Outcomes of the 19th Session of the Scientific Committee (IOTC Secretariat)

   3.2 **Outcomes of the 21st Session of the Commission (IOTC Secretariat)**
   - IOTC–2017–WPTT19–04 Outcomes of the 20th Session of the Commission (IOTC Secretariat)

   3.3 **Review of Conservation and Management Measures relevant to tropical tuna (IOTC Secretariat)**
   - IOTC–2017–WPTT19–05 Review of Conservation and Management Measures relevant to tropical tuna (IOTC Secretariat)

   3.4 **Progress on the recommendations of WPTT18 (IOTC Secretariat)**
   - IOTC–2017–WPTT19–06 Progress made on the recommendations of WPTT18 (IOTC Secretariat)

4. **NEW INFORMATION ON FISHERIES AND ASSOCIATED ENVIRONMENTAL DATA RELATING TO TROPICAL TUNAS**

   4.1 Review of the statistical data available for tropical tunas (IOTC Secretariat)
   - IOTC–2017–WPTT19–07 Review of the statistical data and fishery trends for tropical tunas (IOTC Secretariat)

   4.2 Review new information on fisheries and associated environmental data (general CPC papers)
   - IOTC–2017–WPTT19–09 Outline of climate and oceanographic conditions in the Indian Ocean: an update to August 2017 (Marsac F)
   - IOTC–2017–WPTT19–10 Present status of Tropical tuna fisheries In the Indian Ocean of Iran (Akhondi M)
   - IOTC–2017–WPTT19–11 Six years for improving statistic data collection in Comoros (Toihir, I)
   - IOTC–2017–WPTT19–12 Status of gillnet fisheries and data reconstruction of tropical tunas in Pakistan (Khan M)
   - IOTC–2017–WPTT19–13 The Mauritius purse seine fishery since 2013 (Mamode A and Sooklall T)
   - IOTC–2017–WPTT19–14 Statistics Catch of Tropical Tunas from Longliners Landing at Port of Phuket, Thailand, during 1994-2016 (Panjarat S and Rodpradit S)
   - IOTC–2017–WPTT19–15 Catches of yellowfin tuna and bigeye tuna from longline in Kenya EEZ during the year 2016 (Ndwega S)
   - IOTC–2017–WPTT19–16 Colonization of drifting fish aggregating devices (DFADs) in the Western Indian Ocean, assessed by fishers' echo-sounder buoys (Orúe B, et al)
   - IOTC–2017–WPTT19–17 Main results of the Spanish Best Practices program: evolution of the use of Non-entangling FADs, interaction with entangled animals, and fauna release operations (Lopez J, et al)
   - IOTC–2017–WPTT19–18 Monitoring the number of active FADs used by the Spanish and associated Purse Seine fleet in the IOTC and ICCAT Convention Areas (Santiago J, et al)
   - IOTC-2017-WPTT19-50 Moving away from synthetic materials used at FADs: Evaluating biodegradable ropes degradation (Moreno G, et al)

- IOTC-2017-WPTT19-51 Pilot Project to test biodegradable ropes at FADs in real fishing conditions in Western Indian Ocean (Moreno G, et al)
- IOTC–2017–WPTT19–19 Testing designs of Biodegradable FADs in natural conditions to mitigate impacts of drifting FADs on the Ecosystem (Zudaire I, et al)
- IOTC–2017–WPTT19–20 The Dynamic Simulation of Pelagic Longline Retrieving (Song L, et al)
- IOTC–2017–WPTT19–21 Preliminary findings of AFAD research project in the Maldives **(**Jauharee A, et al)
- IOTC–2017–WPTT19–22 Towards the derivation of abundance indices for tropical tuna: Recent progress in the analysis of echo-sounder buoys data (Baidai Y, et al)
- IOTC–2017–WPTT19–23 Proposals to revisions to the IOTC Tropical Tuna Executive Summaries (Marsac F and Fontenau A)

5. BIGEYE TUNA – REVIEW OF NEW INFORMATION ON STOCK STATUS

5.1 Review of the statistical data available for bigeye tuna (IOTC Secretariat)

5.2 Review new information on bigeye tuna biology, ecology, stock structure, their fisheries and associated environmental data (CPC papers)

- IOTC–2017–WPTT19–25 Movements and behavior of yellowfin and bigeye tuna associated to oceanic structures in the western Indian Ocean (Sabarros P, et al)

5.3 Review of new information on the status of bigeye tuna (all)

- **Nominal and standardised CPUE indices**

- IOTC–2017–WPTT19–26 Standardization of catch-per-unit effort for bigeye tuna for the South African longline fishery operating in the Indian Ocean (Winker H, et al)
- IOTC–2017–WPTT19–27 Consideration on high jump of Japanese longline CPUE for bigeye and yellowfin tuna in the late 1970s in the Indian Ocean (Matsumoto T, et al)
- IOTC–2017–WPTT19–28 Updated Japanese longline CPUE for bigeye tuna in the Indian Ocean standardized by GLM (Matsumoto T, et al)
- IOTC–2017–WPTT19–29 Standardization of bigeye and yellowfin tuna CPUE by Japanese longline in the Indian Ocean, which includes cluster analysis (Matsumoto T, et al)
- IOTC–2017–WPTT19–31 Updated CPUE standardizations for bigeye and yellowfin tuna caught by Taiwanese longline fishery in the Indian Ocean, using Generalized Liner Model (Yeh Y, Hoyle S and Chang L)
- IOTC–2017–WPTT19–32 Collaborative study of tropical tuna CPUE from multiple Indian Ocean longline fleets in 2017 (Hoyle S, et al)
- IOTC–2017–WPTT19–33 Exploring possible causes of historical discontinuities in Japanese longline CPUE (Hoyle S, Satoh K and Matsumoto T)
- IOTC–2017–WPTT19–34 Selectivity changes and spatial size patterns of bigeye and yellowfin tuna in the early years of the Japanese longline fishery (Hoyle S, Satoh K and Matsumoto T)
- IOTC–2017–WPTT19–35 Exploration of Japanese size data and historical changes in data management (Hoyle S, Satoh K and Matsumoto T)
- IOTC–2017–WPTT19–36 Regional scaling factors for Indian Ocean stock assessments (Hoyle S)
- IOTC–2017–WPTT19–37 CPUE standardizations of the Seychelles Indian Ocean longline fleet 2004-2015 (Fu D, Lucas J, Assan C, Govinden R)

- **Stock assessments**

- IOTC–2017–WPTT19–39 An online tool to easily run stock assessment models, using SS3 and YFT and BET as an example (Nieblas A, et al)
- IOTC–2017–WPTT19–40 Stock assessment of Indian Ocean bigeye tuna using integrated model: implication of considering bias in catch data (Li Y, Zhu J and Dai X)

- **Selection of Stock Status indicators for bigeye tuna**

5.4 Development of management advice for bigeye tuna (all)

5.5 Update of bigeye tuna Executive Summary for the consideration of the Scientific Committee (all)

6. SKIPJACK TUNA – REVIEW OF NEW INFORMATION ON STOCK STATUS

6.1 Review of the statistical data available for skipjack tuna (IOTC Secretariat)

6.2 Review new information on skipjack tuna biology, ecology, stock structure, their fisheries and associated environmental data (CPC papers)

- IOTC–2017–WPTT19–41 Reconstruction of Maldives Historic Fleet Size Composition from Partial Register Data 1970-2004 (Medley P, Ahusan and M, Shiham A)
- IOTC–2017–WPTT19–42 Preliminary stock structure study of skipjack tuna from south java using otolith shape analysis (Wujdi A, et al)
- IOTC–2017–WPTT19–43 Data-derived stock status indicators for skipjack tuna of the Indian Ocean (Marsac F, Fonteneau A and Dorizo J)

6.3 Review of new information on the status of skipjack tuna (all)

- Nominal and standardised CPUE indices

- IOTC–2017–WPTT19–44 Maldives pole and line skipjack tuna CPUE standardization 2004-2015 (Medley P, Ahusan M, and Shiham A).
- IOTC–2017–WPTT19–45 Relationship between skipjack tuna CPUE and fishing operation related parameters: A case study for the gillnet fishery of Sri Lanka (Haputhantri S)
- IOTC–2017–WPTT19–38 Standardization of skipjack tuna CPUE for the EU purse seine fleet operating in the Indian Ocean (Isidora K, et al)

- Stock assessments

- IOTC–2017–WPTT19–46 Stock assessment of Indian Ocean skipjack tuna using biomass dynamics model (Li Y, Zhu J and Dai X)
- IOTC–2017–WPTT19–47 Indian Ocean Skipjack tuna stock assessment 1950-2016 (stock synthesis) (Fu D).

- **Selection of Stock Status indicators for skipjack tuna**

6.4 Development of management advice for skipjack tuna (all)

6.5 Update of skipjack tuna Executive Summary for the consideration of the Scientific Committee (all)

7. YELLOWFIN TUNA – REVIEW OF NEW INFORMATION ON STOCK STATUS

7.1 Review of the statistical data available for yellowfin tuna (IOTC Secretariat)

7.2 Review new information on yellowfin tuna biology, ecology, stock structure, their fisheries and associated environmental data (CPC papers)

7.3 Review of new information on the status of yellowfin tuna (all)

- Nominal and standardised CPUE indices

- IOTC–2017–WPTT19–48 Updated Japanese longline CPUE for yellowfin tuna in the Indian Ocean standardized by generalized linear model (Matsumoto T, et al)

- Stock assessments
- Selection of Stock Status indicators for yellowfin tuna

7.4 Development of management advice for yellowfin tuna (all)

- IOTC–2017–WPTT19–49 Update on Yellowfin Tuna Management Procedure Evaluation Oct 2017, (Kolody D & Jumppanen P)

7.5 Update of yellowfin tuna Executive Summary for the consideration of the Scientific Committee (all)

8. DEVELOPMENT OF OPTIONS FOR ALTERNATIVE MANAGEMENT MEASURES FOR TROPICAL TUNAS IN THE IOTC AREA OF COMPETENCE

9. WPTT PROGRAM OF WORK

9.1 Revision of the WPTT Program of Work (2018–2022)

- IOTC–2017–WPTT19–08 Revision of the WPTT Program of Work (2018–2022) (IOTC Secretariat)

9.2 Development of priorities for an Invited Expert at the next WPTT meeting

10. OTHER BUSINESS

10.1 Election of a Chairperson and a Vice-Chairperson for the next biennium (IOTC Secretariat)
10.2 Date and place of the 20th and 21st Sessions of the WPTT (Chair and IOTC Secretariat)
10.3 Review of the draft, and adoption of the Report of the 19th Session of the WPTT (Chair)

APPENDIX III
LIST OF DOCUMENTS

DRAFT: LIST OF DOCUMENTS FOR THE 19TH WORKING PARTY ON TROPICAL TUNAS

LAST UPDATED: 17 OCTOBER 2017

Document	Title	Availability
IOTC–2017–WPTT19–01a	Draft: Agenda of the 19th Working Party on Tropical Tunas	✓(2 October 2017)
IOTC–2017–WPTT19–01b	Draft: Annotated agenda of the 19th Working Party on Tropical Tunas	✓(2 October 2017)
IOTC–2017–WPTT19–02	Draft: List of documents for the 19th Working Party on Tropical Tunas	✓(2 October 2017)
IOTC–2017–WPTT19–03	Outcomes of the 19th Session of the Scientific Committee (IOTC Secretariat)	✓(2 October 2017)
IOTC–2017–WPTT19–04	Outcomes of the 21th Session of the Commission (IOTC Secretariat)	✓(2 October 2017)
IOTC–2017–WPTT19–05	Review of Conservation and Management Measures relevant to tropical tunas (IOTC Secretariat)	✓(2 October 2017)
IOTC–2017–WPTT19–06	Progress made on the recommendations of WPTT18 (IOTC Secretariat)	✓(2 October 2017)
IOTC–2017–WPTT19–07	Review of the statistical data and fishery trends for tropical tunas (IOTC Secretariat)	✓(12 October 2017)
IOTC–2017–WPTT19–08	Revision of the WPTT Program of Work (2018–2022) (IOTC Secretariat)	✓(2 October 2017)
Environmental conditions		
IOTC–2017–WPTT19–09	Outline of climate and oceanographic conditions in the Indian Ocean: an update to August 2017 (Marsac F)	✓(12 October 2017)
Fisheries information		
IOTC–2017–WPTT19–10	Present status of Tropical tuna fisheries In the Indian Ocean of Iran (Akhondi M)	✓(2 October 2017)
IOTC–2017–WPTT19–11	Six years for improving statistic data collection in Comoros (Toihir, I)	Withdrawn
IOTC–2017–WPTT19–12	Status of gillnet fisheries and data reconstruction of tropical tunas in Pakistan (Khan M)	✓(25 September 2017)
IOTC–2017–WPTT19–13	The Mauritius purse seine fishery since 2013 (Mamode A and Sooklall T)	✓(29 September 2017)
IOTC–2017–WPTT19–14	Statistics Catch of Tropical Tunas from Longliners Landing at Port of Phuket, Thailand, during 1994-2016 (Panjarat S and Rodpradit S)	✓(12 October 2017)
IOTC–2017–WPTT19–15	Catches of yellowfin tuna and bigeye tuna from longline in Kenya EEZ during the year 2016 (Ndwega S)	✓(11 October 2017)
IOTC–2017–WPTT19–20	The Dynamic Simulation of Pelagic Longline Retrieving (Song L, et al)	✓(21 September 2017)
IOTC–2017–WPTT19–22	Towards the derivation of abundance indices for tropical tuna: Recent progress in the analysis of echo-sounder buoys data (Baidai Y, et al)	✓(3 October 2017)
IOTC–2017–WPTT19–23_Rev2	Proposals to revisions to the IOTC Tropical Tuna Executive Summaries (Marsac F and Fontenau A)	✓(3 October 2017)
Bigeye tuna		
IOTC–2017–WPTT19–24	How shear currents affect catch rates of Yellowfin tuna and Bigeye tuna in tuna longline fisheries (Nishida T)	*Withdrawn (INFO paper)*

Document	Title	Availability
IOTC–2017–WPTT19–25	Movements and behavior of yellowfin and bigeye tuna associated to oceanic structures in the western Indian Ocean (Sabarros P, et al)	✓(6 October 2017)
IOTC–2017–WPTT19–26	Standardization of catch-per-unit effort for bigeye tuna for the South African longline fishery operating in the Indian Ocean (Winker H, et al)	✓(17 October 2017)
IOTC–2017–WPTT19–27	Consideration on high jump of Japanese longline CPUE for bigeye and yellowfin tuna in the late 1970s in the Indian Ocean (Matsumoto T, et al)	✓(2 October 2017)
IOTC–2017–WPTT19–28	Updated Japanese longline CPUE for bigeye tuna in the Indian Ocean standardized by GLM (Matsumoto T, et al)	✓(2 October 2017)
IOTC–2017–WPTT19–29	Standardization of bigeye and yellowfin tuna CPUE by Japanese longline in the Indian Ocean, which includes cluster analysis (Matsumoto T, et al)	✓(2 October 2017)
IOTC–2017–WPTT19–30	CPUE standardization of bigeye tuna caught by Korean tuna longline fishery in the Indian Ocean (Lee S)	Withdrawn
IOTC–2017–WPTT19–31	Updated CPUE standardizations for bigeye and yellowfin tuna caught by Taiwanese longline fishery in the Indian Ocean, using Generalized Liner Model (Yeh Y, Hoyle S and Chang L)	✓(2 October 2017)
IOTC–2017–WPTT19–32	Collaborative study of tropical tuna CPUE from multiple Indian Ocean longline fleets in 2017 (Hoyle S, et al)	✓(29 September 2017)
IOTC–2017–WPTT19–33	Exploring possible causes of historical discontinuities in Japanese longline CPUE (Hoyle S, Satoh K and Matsumoto T)	✓(29 September 2017)
IOTC–2017–WPTT19–34	Selectivity changes and spatial size patterns of bigeye and yellowfin tuna in the early years of the Japanese longline fishery (Hoyle S, Satoh K and Matsumoto T)	✓(29 September 2017)
IOTC–2017–WPTT19–35	Exploration of Japanese size data and historical changes in data management (Hoyle S, Satoh K and Matsumoto T)	✓(29 September 2017)
IOTC–2017–WPTT19–36	Regional scaling factors for Indian Ocean stock assessments (Hoyle S)	✓(2 October 2017)
IOTC–2017–WPTT19–37	CPUE standardizations of the Seychelles Indian Ocean longline fleet 2004-2015 (Fu D, Lucas J, Assan C, Govinden R)	✓(2 October 2017)
IOTC–2017–WPTT19–38	Standardization of skipjack tuna CPUE for the EU purse seine fleet operating in the Indian Ocean (Isidora K, et al)	✓(5 October 2017)
IOTC–2017–WPTT19–39_Rev1	An online tool to easily run stock assessment models, using SS3 and YFT and BET as an example (Nieblas A, et al)	✓(2 October 2017) & (11 October)
IOTC–2017–WPTT19–40_Rev1	Stock assessment of Indian Ocean bigeye tuna using integrated model: implication of considering bias in catch data (Li Y, Zhu J and Dai X)	✓(13 October 2017) & (17 October 2017)
Skipjack tuna		
IOTC–2017–WPTT19–41	Reconstruction of Maldives Historic Fleet Size Composition from Partial Register Data 1970-2004 (Medley P, Ahusan and M, Shiham A)	✓(2 October 2017)
IOTC–2017–WPTT19–42	Preliminary stock structure study of skipjack tuna from south java using otolith shape analysis (Wujdi A, et al)	✓(22 September 2017)
IOTC–2017–WPTT19–43	Data-derived stock status indicators for skipjack tuna of the Indian Ocean (Marsac F, Fonteneau A and Dorizo J)	✓(5 October 2017)
IOTC–2017–WPTT19–44	Maldives pole and line skipjack tuna CPUE standardization 2004-2015 (Medley P, Ahusan M, and Shiham A).	✓(2 October 2017)
IOTC–2017–WPTT19–45	Relationship between skipjack tuna CPUE and fishing operation related parameters: A case study for the gillnet fishery of Sri Lanka (Haputhantri S)	✓(1 October 2017)
IOTC–2017–WPTT19–46_Rev	Stock assessment of Indian Ocean skipjack tuna using biomass dynamics model (Li Y, Zhu J and Dai X)	✓(13 October 2017) & (17 October 2017)

Document	Title	Availability
IOTC–2017–WPTT19–47	Indian Ocean Skipjack tuna stock assessment 1950-2016 (stock synthesis) (Fu D).	✓(2 October 2017)
Fish Aggregating Devices		
IOTC–2017–WPTT19–16	Colonization of drifting fish aggregating devices (DFADs) in the Western Indian Ocean, assessed by fishers' echo-sounder buoys (Orúe B, et al)	✓(3 October 2017)
IOTC–2017–WPTT19–17	Main results of the Spanish Best Practices program: evolution of the use of Non-entangling FADs, interaction with entangled animals, and fauna release operations (Lopez J, et al)	✓(3 October 2017)
IOTC–2017–WPTT19–18	Monitoring the number of active FADs used by the Spanish and associated Purse Seine fleet in the IOTC and ICCAT Convention Areas (Santiago J, et al)	✓(3 October 2017)
IOTC–2017–WPTT19–19	Testing designs of Biodegradable FADs in natural conditions to mitigate impacts of drifting FADs on the Ecosystem (Zudaire I, et al)	✓(12 October 2017)
IOTC–2017–WPTT19–21	Preliminary findings of AFAD research project in the Maldives **(**Jauharee A, et al)	✓(2 October 2017)
IOTC–2017–WPTT19–50	Moving away from synthetic materials used at FADs: Evaluating biodegradable ropes degradation (Moreno G, et al)	✓(2 October 2017)
IOTC–2017–WPTT19–51	Pilot Project to test biodegradable ropes at FADs in real fishing conditions in Western Indian Ocean (Moreno G, et al)	✓(2 October 2017)
Yellowfin tuna		
IOTC–2017–WPTT19–48	Updated Japanese longline CPUE for yellowfin tuna in the Indian Ocean standardized by generalized linear model (Matsumoto T, et al)	✓(2 October 2017)
MSE updates		
IOTC–2017–WPTT19–49	Update on Yellowfin Tuna Management Procedure Evaluation Oct 2017, (Kolody D & Jumppanen P)	✓(2 October 2017)
Other papers		
IOTC–2017–WPTT19–23	Proposals to revisions to the IOTC Tropical Tuna Executive Summaries (Marsac F and Fontenau A)	✓(22 September 2017)
Information papers		
IOTC–2017–WPTT19–INFO1	Bayesian CPUE Standardization for Maldives Pole and Line Skipjack Tuna 1970-2015 (Medley P, Ahusan M and Shiham A).	✓(2 October 2017)
IOTC–2017–WPTT19–INFO2	Report of the 4th IOTC CPUE workshop on longline fisheries (IOTC Secretariat, et al)	✓(28 September 2017)
IOTC–2017–WPTT19–INFO3	Workshop for the development of Skipjack indices of abundance for the EU tropical tuna purse seine fishery operating in the Indian Ocean	✓(5 October 2017)
IOTC–2017–WPTT19–INFO4	Does vertical shear current affect catch rates of tuna longline fisheries and do we need in CPUE standardization?	✓(16 October 2017)

APPENDIX IVA
STATISTICS FOR TROPICAL TUNAS

(Extracts from IOTC–2017–WPTT19–07)

Fisheries and catch trends for tropical tuna species

- Main species: Skipjack tuna accounts for 46% of total catches of tropical tunas, followed closely by yellowfin tuna (≈44%), while catches of bigeye tuna account for the remaining 11% of catches (**Fig. 1d**).

- Main fishing gear (2013-16): purse seiners account for 39% of total catches of tropical tunas, with important catches also reported by gillnets (18%), handlines and trolling (19%), longlines (11%), and pole-and-line (11%), in both coastal waters and the high seas.

  Tropical tunas are the target species of many industrial and artisanal fisheries throughout the Indian Ocean, although they are also a bycatch of fisheries targeting other tunas, small pelagic species, or other non-tuna species.

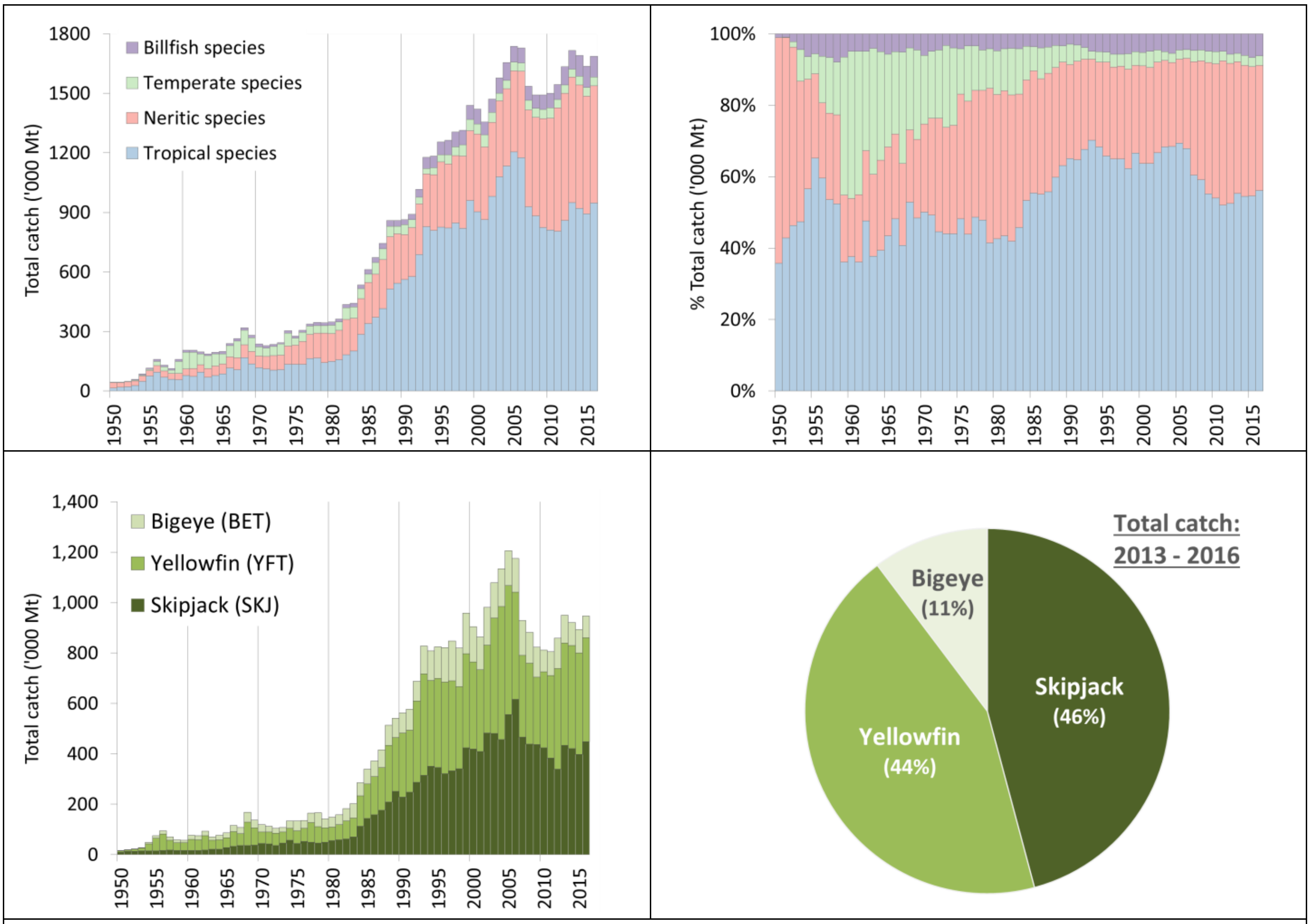
- Main fleets (i.e., highest catches in recent years): Tropical tunas are caught by both coastal countries in the Indian Ocean and distant water fishing nations (**Fig. 2**).

  In recent years the coastal fisheries of five countries (Indonesia, Maldives, Sri Lanka, I.R. Iran, and India) have accounted for ≈53% of the total catches of tropical tuna species in the Indian Ocean, while the industrial purse seiners and longliners flagged as EU-Spain, Seychelles and EU-France reported a further 30% of total catches of these species.

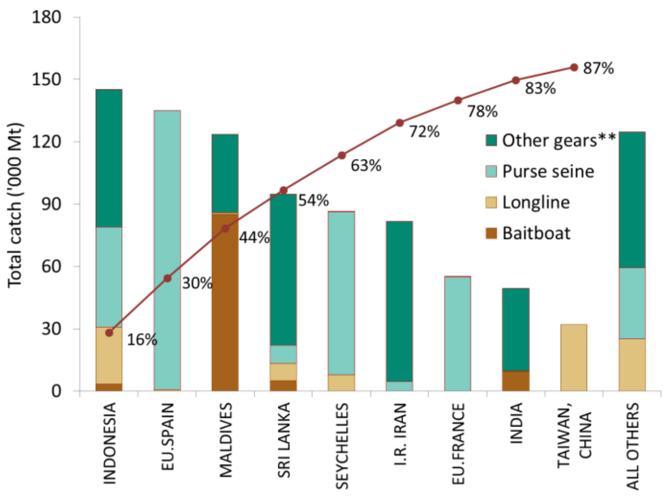
- Retained catch trends: The importance of tropical tunas to the total catches of IOTC species in the Indian Ocean has changed over the years (**Figs. 1a-b.**), in particular following the arrival of industrial purse seine fleets to the Indian Ocean in the early-1980s targeting tropical tunas. With the onset of piracy in the late-2000s, the activities of fleets operating in the north-west Indian Ocean have been displaced or reduced – particularly the Asian distant-water longline fleet – leading to a relative decline in the proportion of catches from tropical tunas (i.e., currently around 55% of total catches of all IOTC species, compared to ≈60% over the (pre-piracy) period 1950-2008).

  Since 2012 catches of tropical tunas appear to show signs of recovery – in particular catches from the distant water longline fleets (e.g., Taiwan,China) – as a result of the reduction of the threat of piracy and return of fleets and to the north-west Indian Ocean. Total catches of tropical tunas have increased from < 820,000 t during the years of piracy in the late 2000s, to over 950,000 t in 2013.

- Economic markets: The majority of catches of tropical tuna species are sold to international markets, including the *sashimi* market in Japan (large specimens of yellowfin tuna and bigeye tuna in fresh or deep-frozen condition), and processing plants in the Indian Ocean region or abroad (small specimens of skipjack tuna and, to a lesser extent, yellowfin tuna and bigeye tuna). A component of the catches of tropical tunas, in particular skipjack tuna caught by some coastal countries in the region, is sold in local markets or retain by the fishermen for direct consumption.



Figs. 1a-d. Top: Contribution of the three tropical tuna species under the IOTC mandate to the total catches of IOTC species in the Indian Ocean, over the period 1950-2016 (a. Top left: total catch; b. Top right percentage, same colour key as Fig. 1a).; **Bottom:** Contribution of each tropical tuna species to the total combined catches of tropical tunas (c. Bottom left: nominal catch of each species, 1950-2016; d. Bottom right: share of tropical tuna catch by species, 2013-16)



*** Other gears includes handline, gillnet, gillnet-longline, trawling.*

Fig. 2. All tropical tunas: average catches in the Indian Ocean over the period 2013–16, by country. Countries are ordered from left to right, according to the importance of catches of tropical tunas reported. The red line indicates the (cumulative) proportion of catches of tropical tunas for the countries concerned, over the total combined catches of species reported from all countries and fisheries.

APPENDIX IVB
MAIN STATISTICS OF BIGEYE TUNA

(Extracts from IOTC–2017–WPTT19–07)

Fisheries and main catch trends

- Main fishing gear (2013–16): industrial fisheries account for the majority of catches of bigeye tuna, i.e., deep-freezing and fresh longline (≈51%) and purse seine (≈31%) (**Table 2; Fig. 3**).

  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 (2013–16):
  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. 5**).

- 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.4**).

  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. 5**).

  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. 3**) 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. 5**) – 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 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. 6**).

- 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 2016.

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 (2007–2016), in tonnes. Catches by decade represent the average annual catch, noting that some gears were not in operation since the beginning of the fishery. Data as of September 2017.

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 (2006–2016), in tonnes. Catches by decade represent the average annual catch. Data as of October 2017.

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.

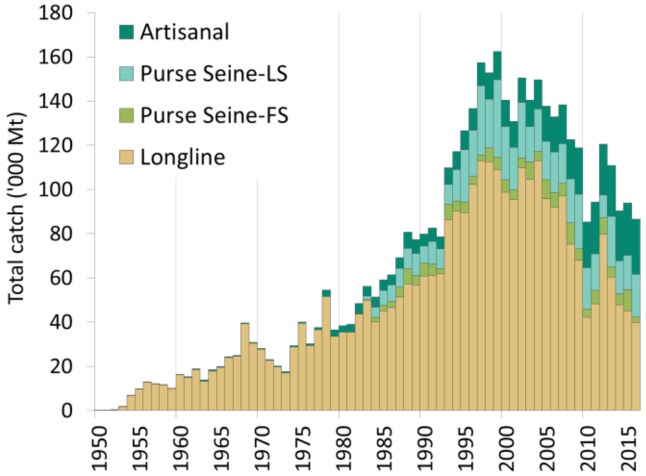
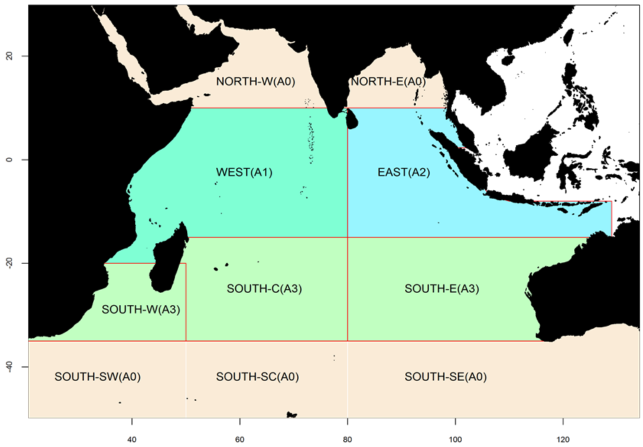


Fig. 3. Annual catches of bigeye tuna by gear (1950–2016). Data as of September 2017.

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**).



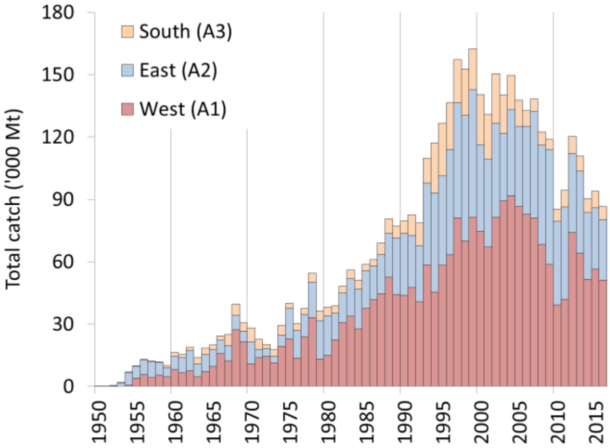


Fig. 4(a-b). Bigeye tuna: Catches of bigeye tuna by (SS3) stock assessment area by year (1950–2016). Catches outside the areas presented in the map were assigned to the closest neighbouring area for the assessment. Data as of September 2017.

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.

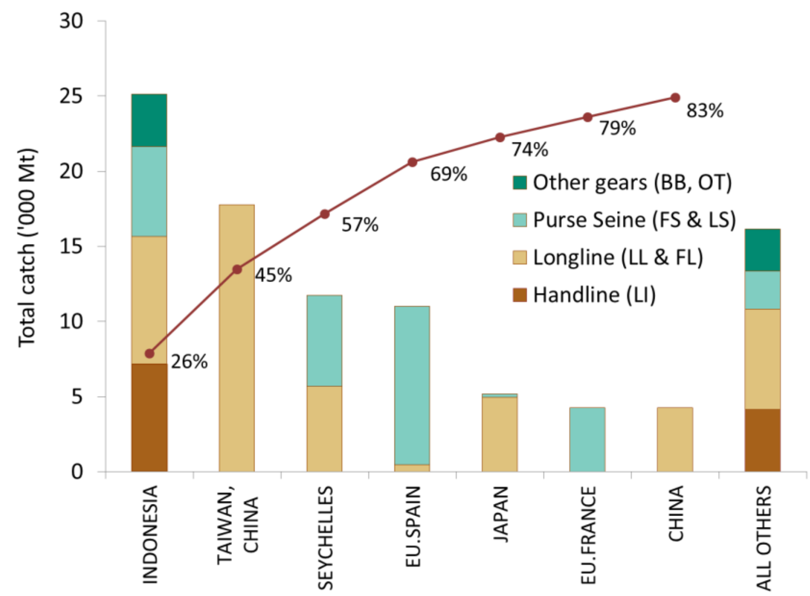


Fig. 5. Bigeye tuna: average catches in the Indian Ocean over the period 2013–16, by country. Countries are ordered from left to right, according to the importance of catches of bigeye reported. The red line indicates the (cumulative) proportion of catches of bigeye for the countries concerned, over the total combined catches of this species reported from all countries and fisheries. Data as of September 2017.

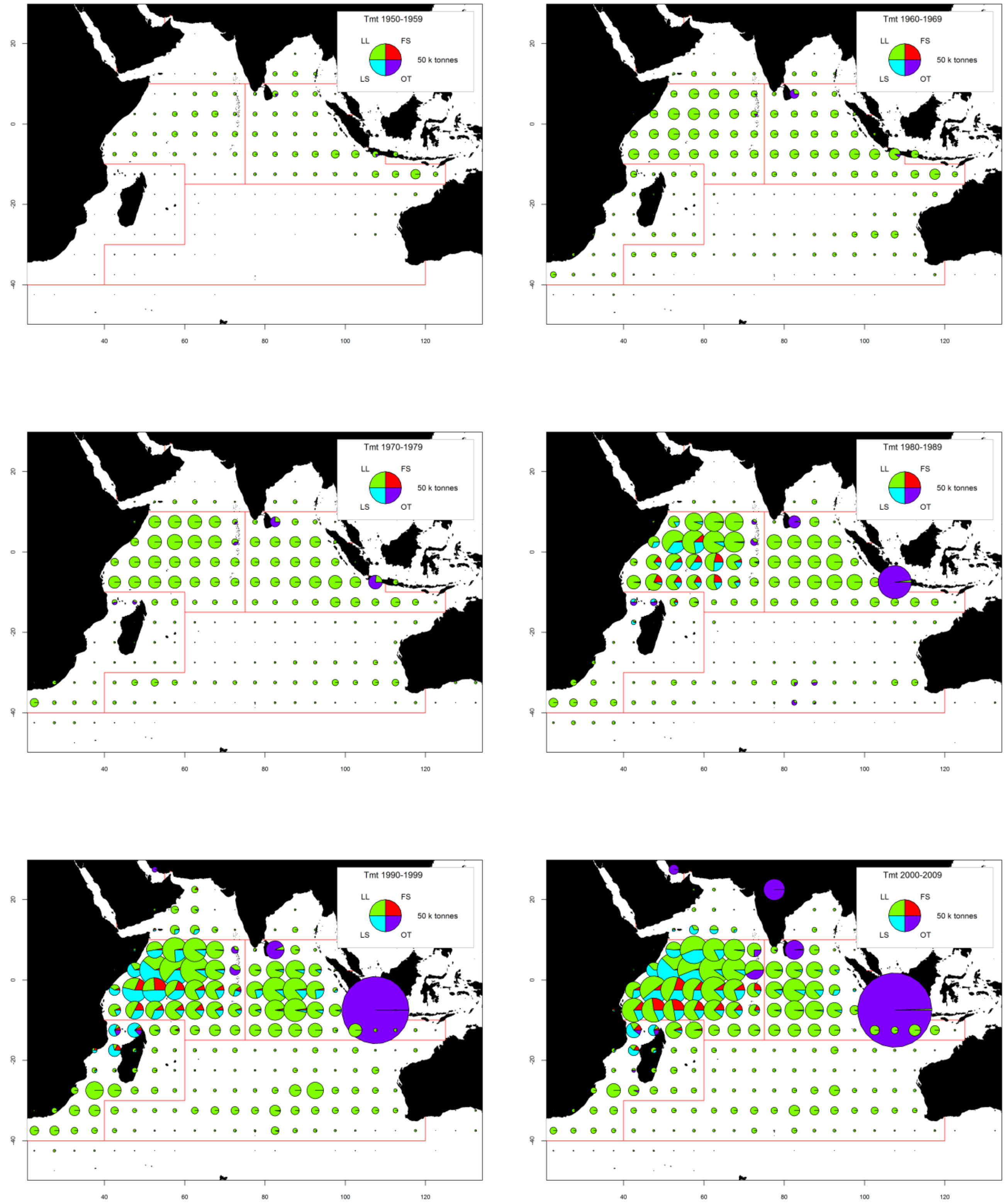


Fig. 6(a-f). Time-area catches (total combined in tonnes) of bigeye tuna estimated for the period 2007–2011 by type of gear and for 2012–16, by year and type of gear. Longline (**LL**), Purse seine free-schools (**FS**), Purse seine associated-schools (**LS**), and other fleets (**OT**), including pole-and-line, 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.

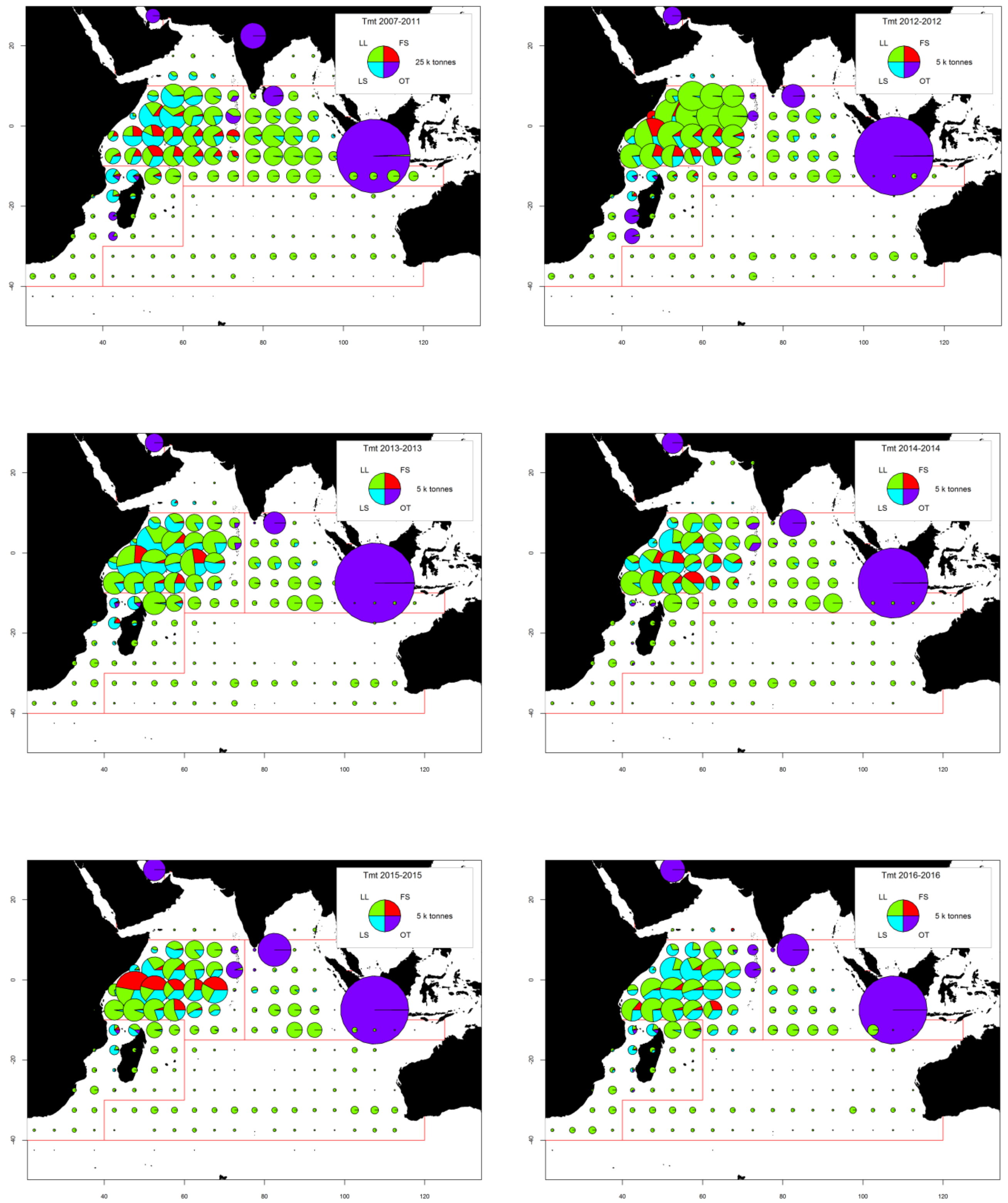


Fig. 7(a-f). Time-area catches (total combined in tonnes) of bigeye tuna estimated for the period 2007–2011 by type of gear and for 2012–16, by year and type of gear. Longline (**LL**), Purse seine free-schools (**FS**), Purse seine associated-schools (**LS**), and other fleets (**OT**), including pole-and-line, 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. 8a**).
- 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).

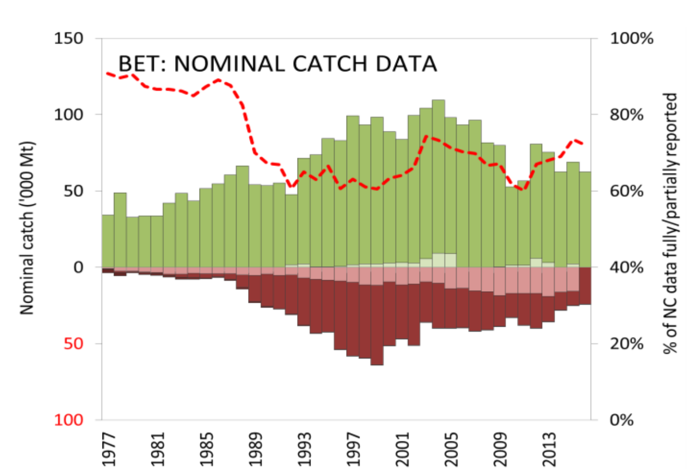
  For most other fisheries, catch-and-effort are either not available (**Fig. 8b**), or are considered to be of poor quality – especially since the early-1990s and for the following fisheries/fleets:
  - NEI purse seine and longliners: no data available.
  - Fresh-tuna longline fisheries: no data are available 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.

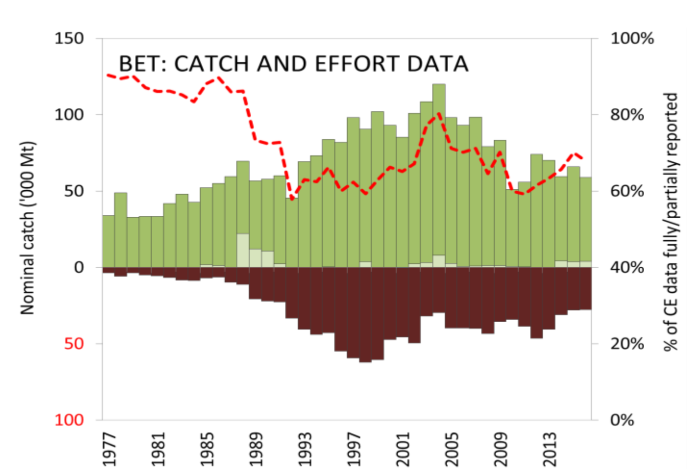
Fish size or age trends (e.g., by length, weight, sex and/or maturity)

- Average fish weight: can be assessed for several industrial fisheries although they are incomplete (**Fig. 8c**) 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).





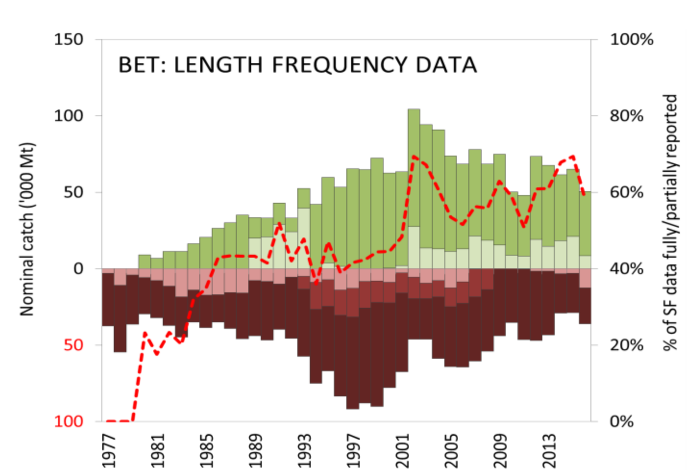


Fig. 8a-c. Bigeye tuna: data reporting coverage (1977–2016). *Each IOTC dataset (nominal catch, catch-and-effort, and length frequency) are assessed against IOTC reporting standards, where: a score of 0 indicates the amount of nominal catch associated with each dataset that is fully reported according 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.*

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)

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, 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[3]. 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.

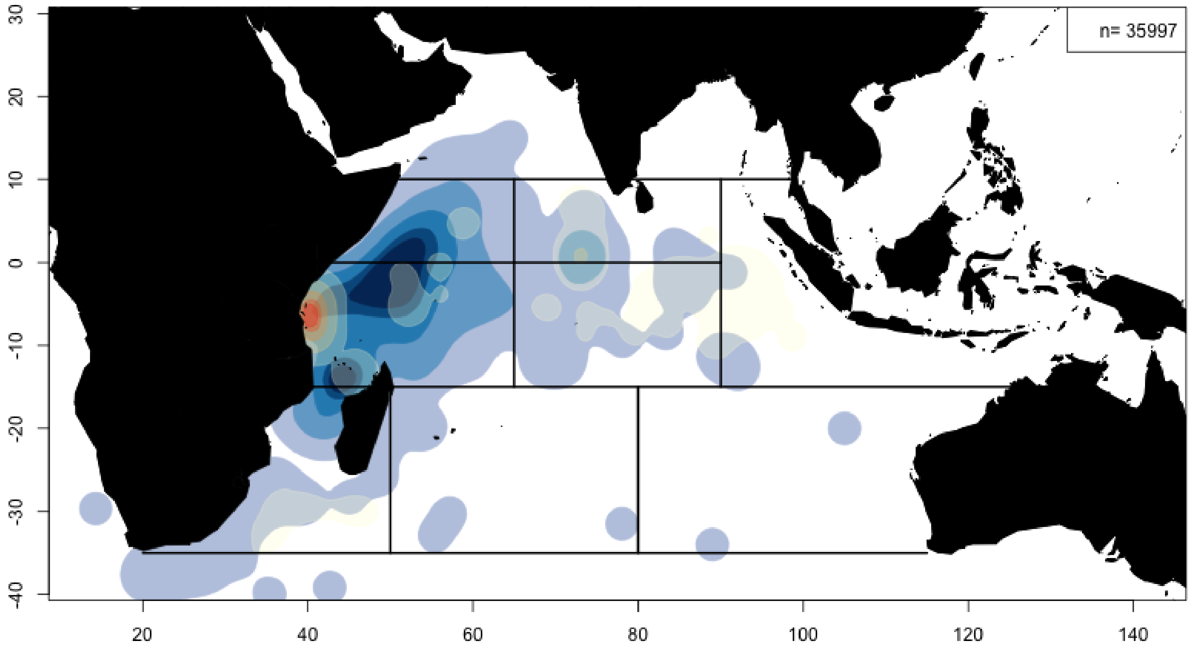


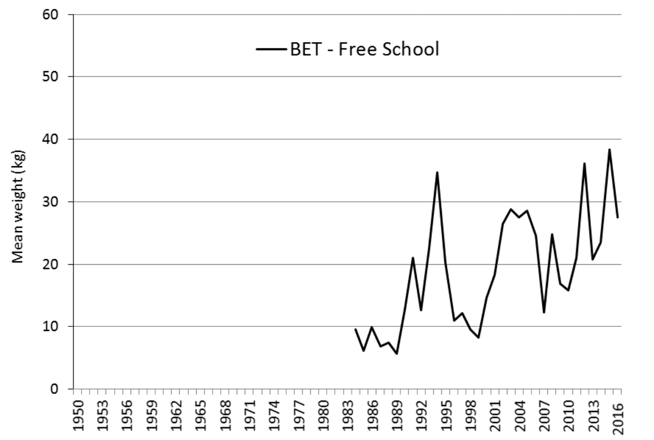
Fig. 9. Bigeye tuna: densities of releases (in red) and recoveries (in blue). The black line represents the stock assessment areas. Includes specimens tagged during the IOTTP and also Indian Ocean (Maldivian) tagging programmes during the 1990s.

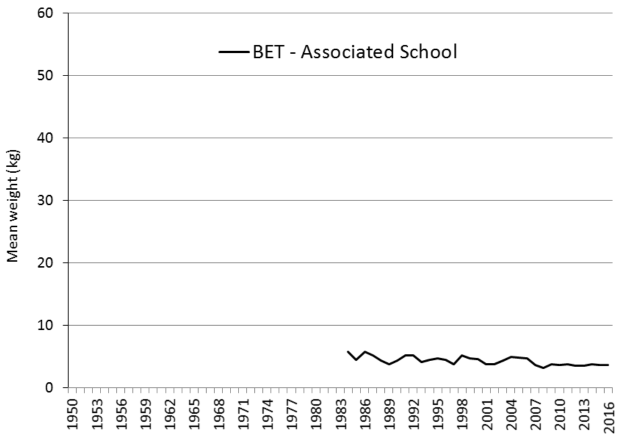
[3] Recoveries by species based on species ID recorded during tagging, prior to release.

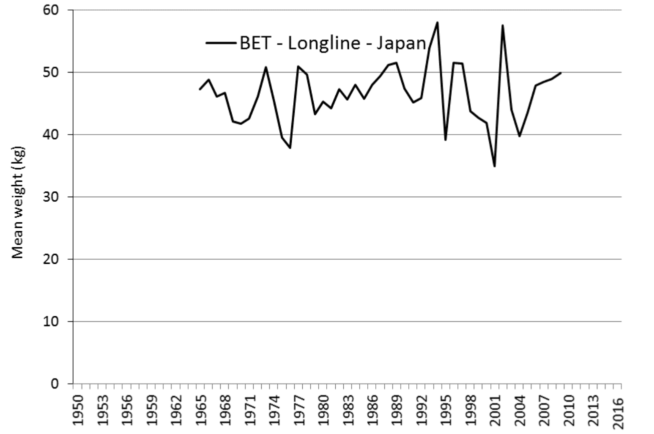
Bigeye tuna (BET)

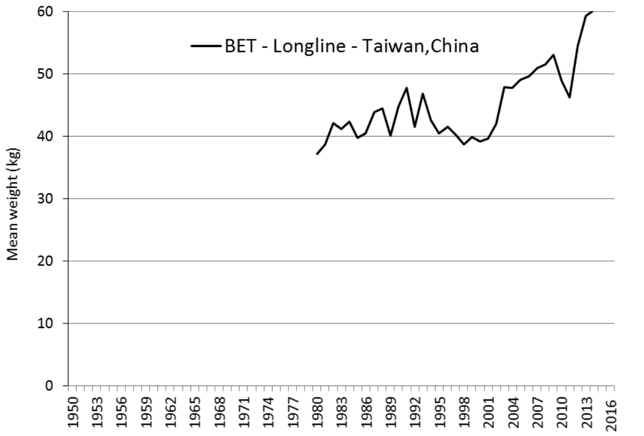
Average weight of bigeye tuna (BET) taken by:

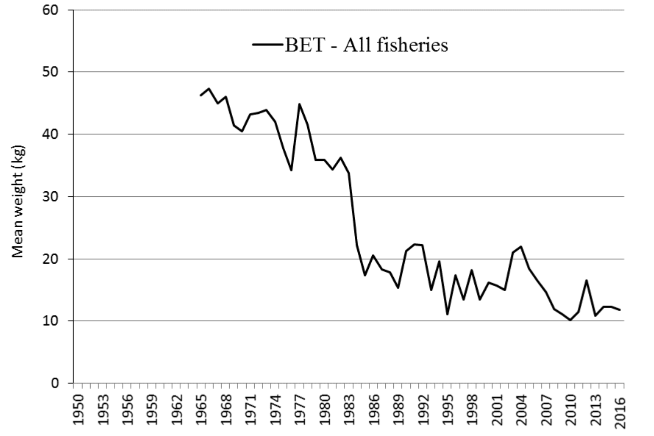
- Purse seine on free (top left) and associated (top right) schools,
- Longlines from Japan (second row left) and Taiwan,China (second row right)
- All fisheries (bottom row left), and all fisheries and main gears (bottom row left)

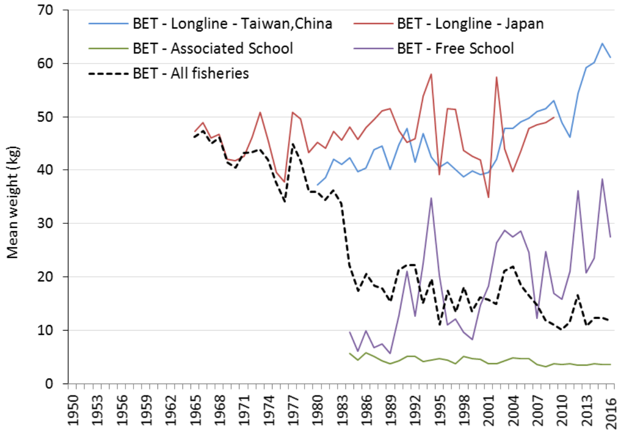


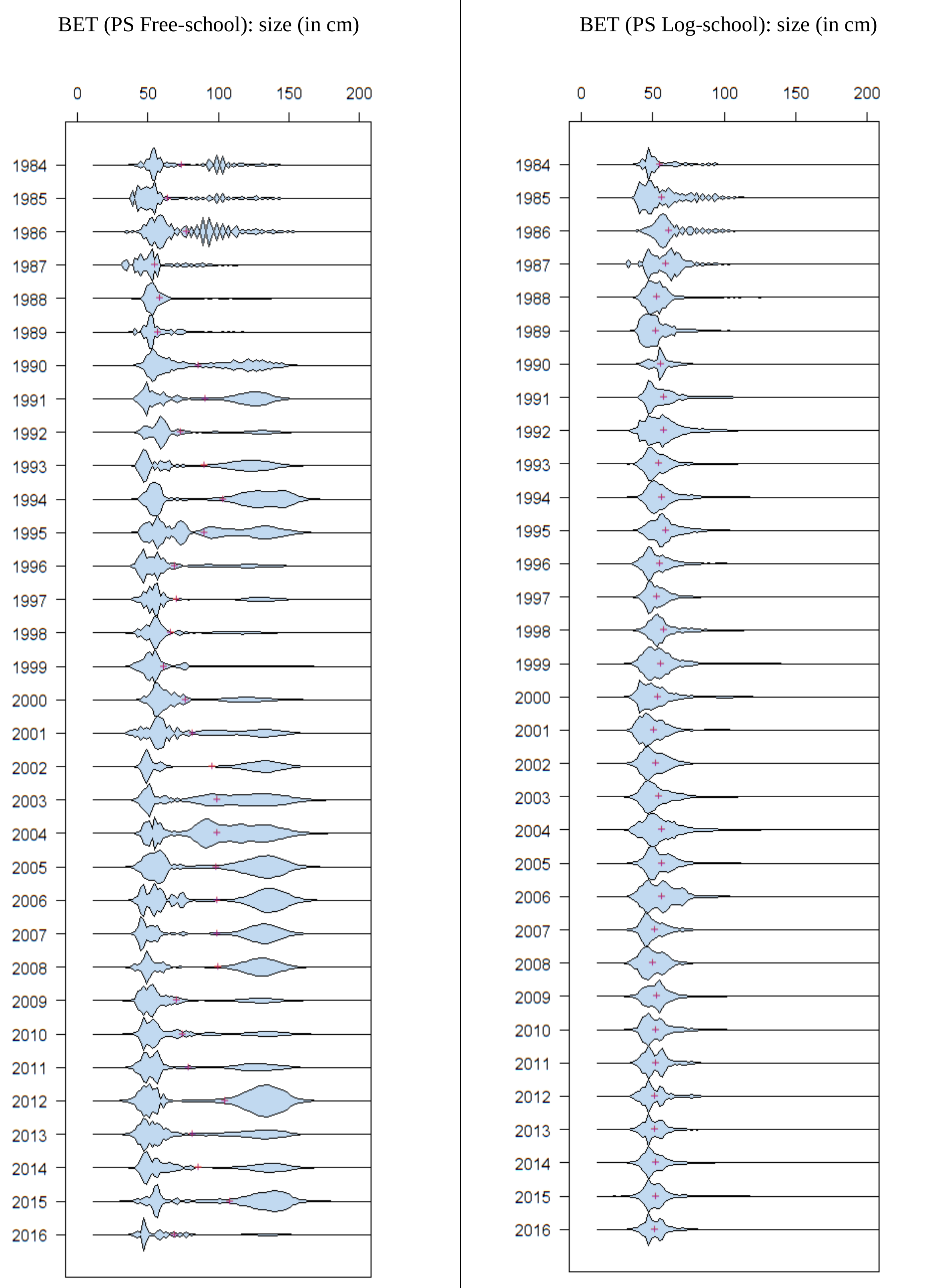




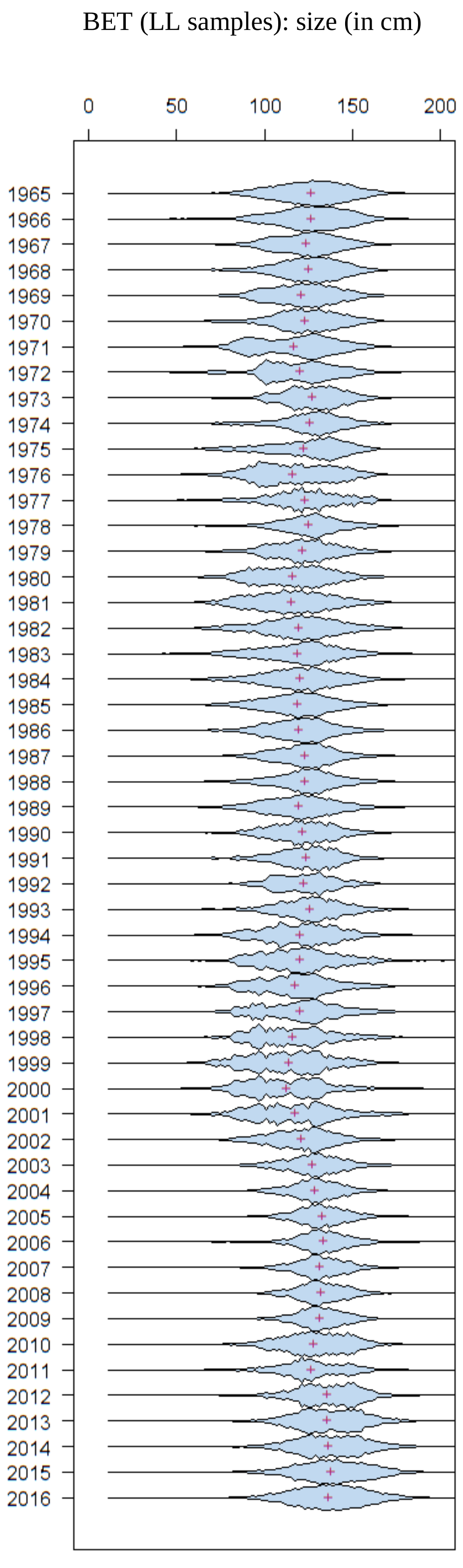








Bigeye tuna (purse seine): **Left:** length frequency distributions for BET PS Free school fisheries (by 2 cm length class). **Right**: Length frequency distributions for BET PS Associated (log) school fisheries (by 2 cm length class). Source: IOTC database.



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). Source: IOTC database.

APPENDIX IVC
MAIN STATISTICS OF SKIPJACK TUNA

(Extracts from IOTC–2017–WPTT19–07)

Fisheries and main catch trends

- Main fishing gear (2013–16): skipjack tuna are mostly caught by industrial purse seiners (≈44%), gillnet (≈23%) and pole-and-line (≈20%) (**Table 4; Fig. 10**).

- Main fleets (and primary gear associated with catches): percentage of total catches (2013–16):
  Almost 70% of catches are accounted for by four fleets (**Fig. 12**):
  - Indonesia (coastal purse seine, troll line, gillnet): 19%; Maldives (pole-and-line): 17%; Sri Lanka (gillnet-longline): 16%; EU-Spain (purse seine): 13%.

- Main fishing areas:

  Primary: Western Indian Ocean (West R2), in waters off Somalia (**Table 5; Fig.11**)
  - In recent years catches of skipjack in this area have dropped considerably as fishing effort has been displaced or reduced due to piracy – particularly catches from industrial purse seiners and fleets using driftnets flagged under I.R. Iran and Pakistan.

  Secondary: Maldives (Area R2b)
  - Since the mid-2000s decreases in skipjack catches have also been reported by the Maldivian pole-and-line fishery – although the reasons remain unclear, but may possibly be related to a change in targeting to yellowfin tuna.

- Retained catch trends:
  Purse seine fisheries:
  The increase in catches of skipjack tuna in the last 30 years have largely been driven by the arrival of purse seiners in the early 1980s, and the development of the fishery in association with Fish Aggregating Devices (FADs) since the 1980s. In recent years, well over 90% of the skipjack tuna caught by purse seine vessels are taken from around FADs.
  Annual catches peaked at over 600,000 t in 2006. The constant increase in catches and catch rates of purse seiners until 2006 are believed to be associated with increases in fishing power and also an increase in the number of FADs (and technology associated with them) used in the fishery.
  Since 2006 catches have declined to around 340,000 t in 2012 – the lowest catches recorded since 1998 – although catches since 2013 have ranged between 390,000 t to 425,000 t.
  Pole-and-line fisheries:

  The Maldivian pole-and-line fishery effectively increased its fishing effort with the mechanisation of its fleet since 1974, including an increase in boat size and power, as well as the use of anchored FADs since 1981. Skipjack tuna represents around 80% of the total catch of Maldives, where catches of skipjack tuna increased regularly between 1980 and 2006 – from around 20,000 t to over 130,000 t.

  Catches of skipjack tuna reported by Maldives pole-and-line have since declined in recent years to as low as 55,000t - less than half the catches taken in 2006 - although the reasons for the decline remain unclear. One explanation may be improvements in the data collection with the introduction of logbooks and more accurate, albeit lower, estimates of skipjack landed; while the introduction of handlines and a shift in targeting from skipjack tuna to yellowfin tuna may also be a contributing factor.

  Gillnet fisheries:
  Several fisheries using gillnets have reported large catches of skipjack tuna in the Indian Ocean, including the gillnet/longline fishery of Sri Lanka, driftnet fisheries of I.R. Iran and Pakistan, and gillnet fisheries of Indonesia. In recent years gillnet catches have represented as much as 20% to 30% of the total catches of skipjack tuna in the Indian Ocean. Although it is known that vessels from I.R. Iran and Sri Lanka have been using gillnets on the high seas in recent years, reaching as far as the Mozambique Channel, the activities of these fleets are poorly understood, as no time-area catch-and-effort series have been made available for those fleets to date.

- 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 2016.

Table 4. Skipjack tuna: Best scientific estimates of the catches of skipjack tuna (*Katsuwonus pelamis*) by gear and main fleets [or type of fishery] by decade (1950–2009) and year (2007–2016), in tonnes. Catches by decade represent the average annual catch, noting that some gears were not used since the beginning of the fishery. Data as of September 2017.

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	9,000	12,800	19,275	35,459	67,760	100,496	95,807	85,584	65,018	71,585	52,489	51,134	72,583	67,301	68,965	68,712
FS	0	0	0	13,658	25,197	24,342	23,567	14,863	9,498	8,708	8,930	2,924	5,625	6,467	7,535	6,511
LS	0	0	0	30,673	107,845	153,298	108,252	117,835	135,797	139,770	120,115	77,992	117,046	118,856	118,785	174,046
OT	6,015	14,067	27,597	49,997	118,867	198,114	237,993	220,143	227,486	203,928	201,557	206,667	239,038	228,379	201,238	197,453
Total	**15,015**	**26,867**	**46,872**	**129,788**	**319,670**	**476,251**	**465,620**	**438,425**	**437,799**	**423,991**	**383,091**	**338,718**	**434,292**	**421,002**	**396,523**	**446,721**

Gears: Pole-and-Line (**BB**); Purse seine free-school (**FS**); Purse seine associated school (**LS**); Other gears nei (**OT**) (e.g., troll line, handline, beach seine, Danish seine, liftnet).

Table 5. Skipjack tuna: Best scientific estimates of the catches of skipjack tuna (*Katsuwonus pelamis*) by area [as used for the assessment] by decade (1950–2009) and year (2006–2016), in tonnes. Catches by decade represent the average annual catch. Data as of September 2017.

	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
R1	4,524	9,951	19,284	34,584	80,744	118,318	137,692	139,937	151,486	154,434	153,882	149,769	167,639	141,656	123,037	111,563
R2	1,492	4,116	8,313	59,744	171,166	257,437	232,121	212,903	221,295	197,972	176,720	137,814	194,070	212,046	204,520	266,446
R2b	9,000	12,800	19,275	35,459	67,760	100,496	95,807	85,584	65,018	71,585	52,489	51,134	72,583	67,301	68,965	68,712
Total	**15,015**	**26,867**	**46,872**	**129,788**	**319,670**	**476,251**	**465,620**	**438,425**	**437,799**	**423,991**	**383,091**	**338,718**	**434,292**	**421,002**	**396,523**	**446,721**

Areas: East Indian Ocean (**R1**); West Indian Ocean, (**R2**); Maldives baitboat (R2b).

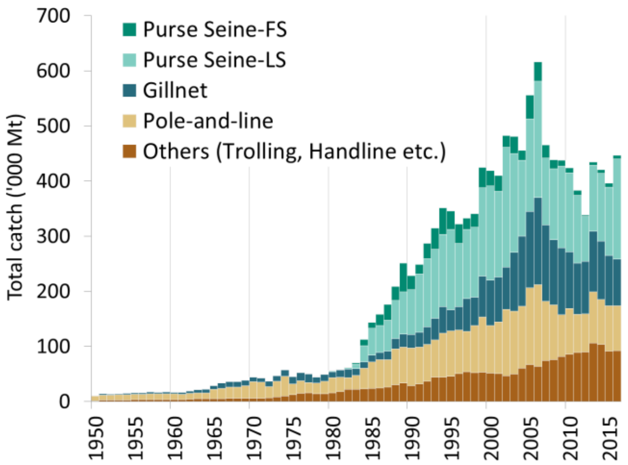


Fig. 10. Annual catches of skipjack tuna by gear (1950–2016). Data as of September 2017.

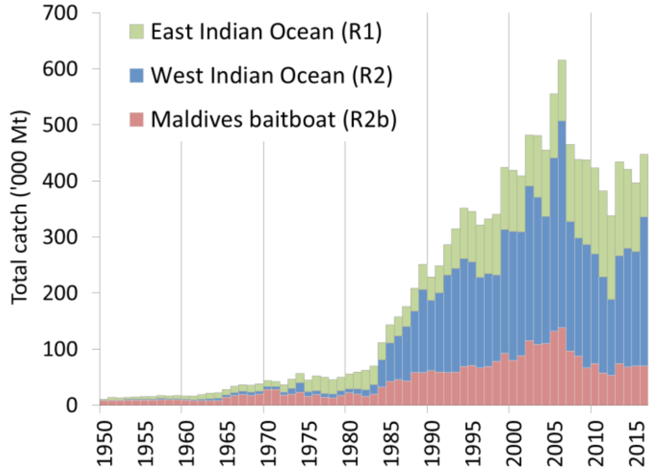


Fig. 11. Skipjack tuna: Catches of skipjack tuna by area by year estimated for the WPTT (1950–2016). **Areas**: East Indian Ocean (**R1**); West Indian Ocean (**R2**); Maldives baitboat (**R2b**). Data as of September 2017.

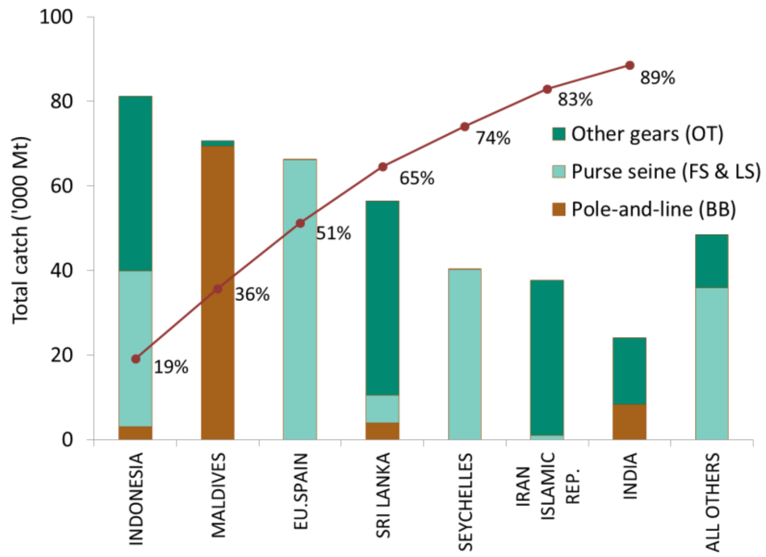


Fig. 12. Skipjack tuna: average catches in the Indian Ocean over the period 2013–16, by country. Countries are ordered from left to right, according to the importance of catches of skipjack reported. The red line indicates the (cumulative) proportion of catches of skipjack for the countries concerned, over the total combined catches of this species reported from all countries and fisheries. Data as of October 2016.

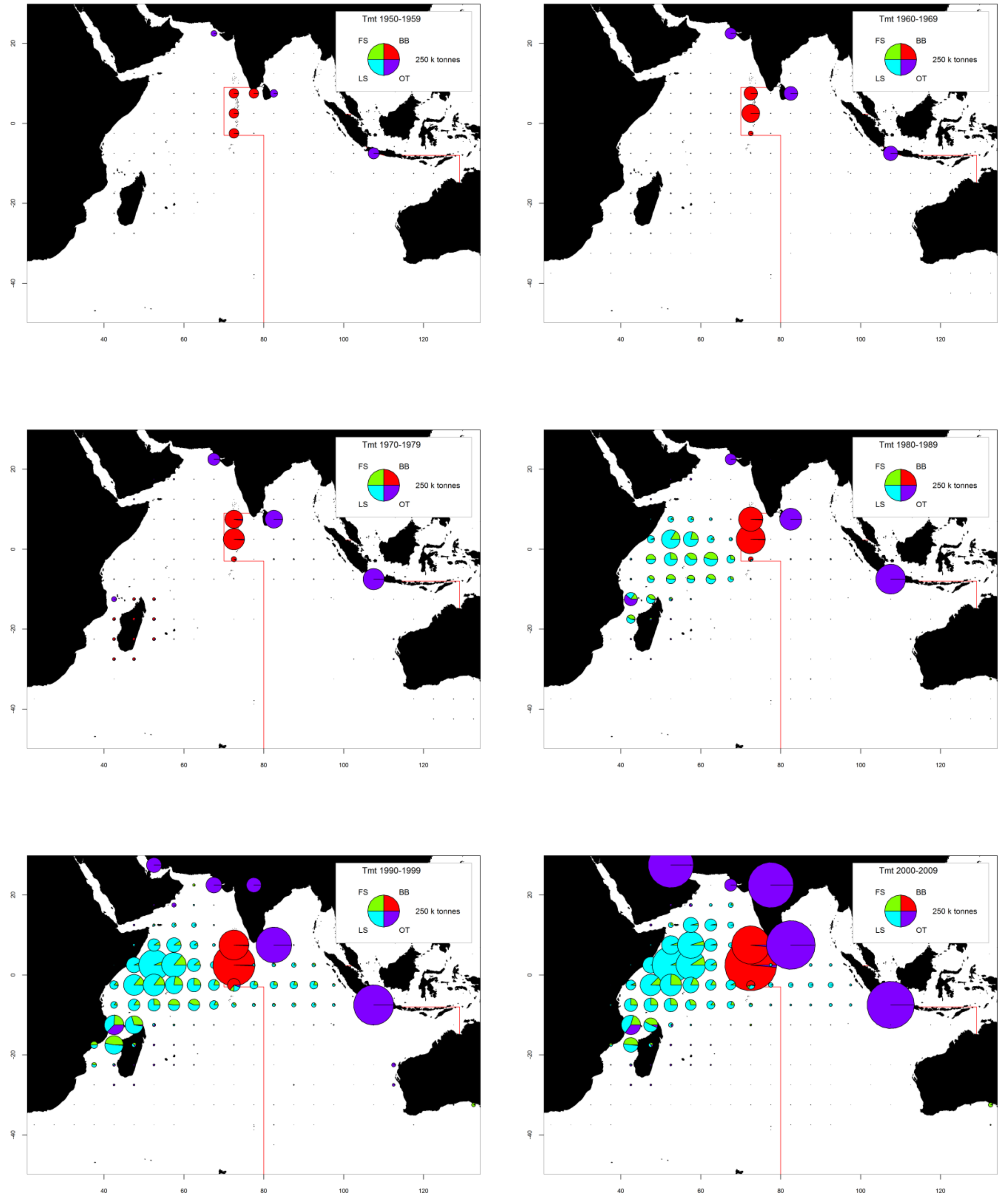


Fig. 13(a-f). Skipjack tuna: Time-area catches (total combined in tonnes) of skipjack tuna estimated for the period 1950–2009, by decade and type of gear. Purse seine free-schools (**FS**), Purse seine associated-schools (**LS**), pole-and-line (**BB**), and other fleets (**OT**), including longline, 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 and Pakistan, gillnet and longline fishery of Sri Lanka, and coastal fisheries of Comoros, Indonesia and India.

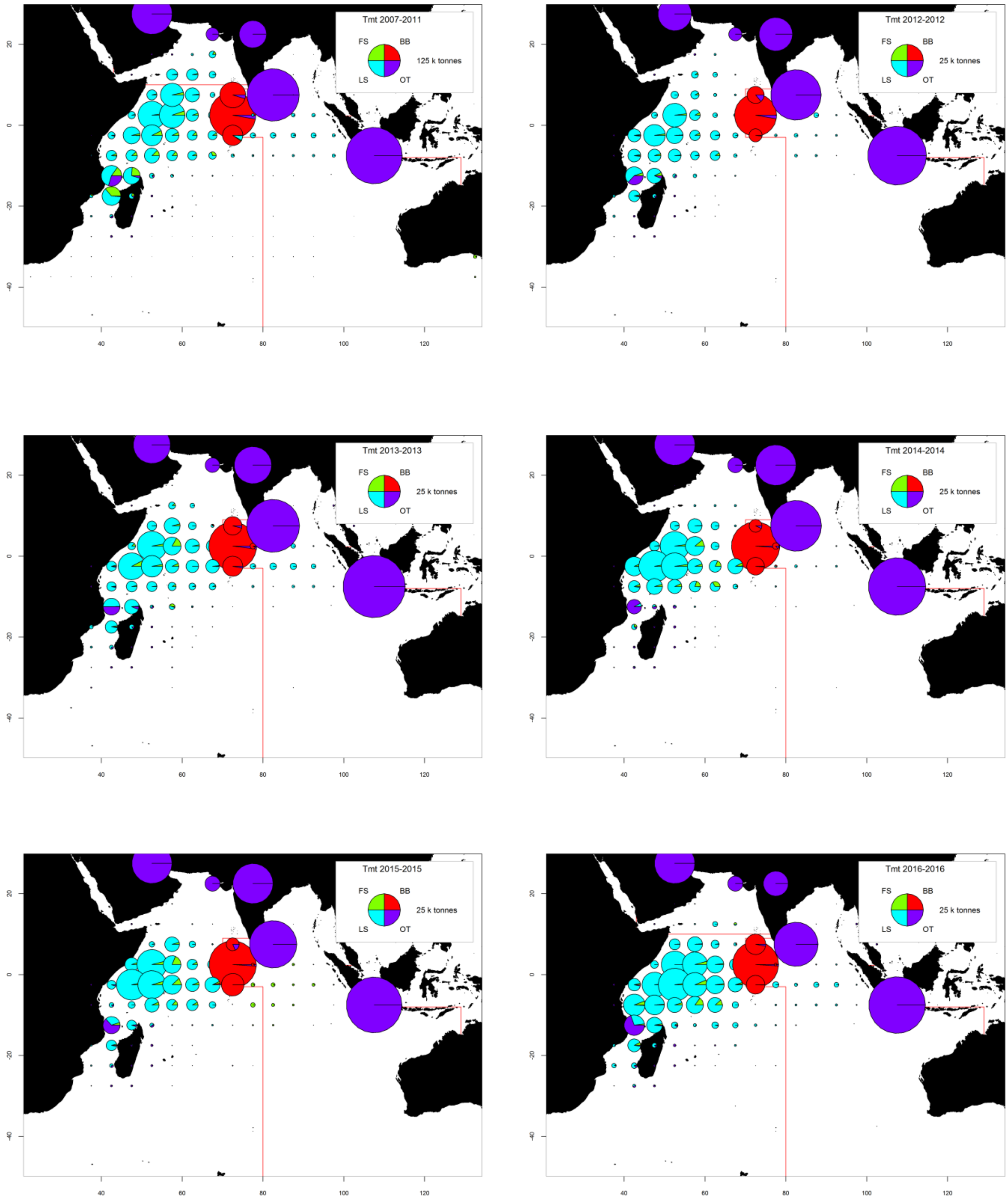


Fig. 14(a-f). Skipjack tuna: Time-area catches (total combined in tonnes) of skipjack tuna estimated for the period 2007–11 by type of gear and for 2012–16, by year and type of gear. Purse seine free-schools (**FS**), Purse seine associated-schools (**LS**), pole-and-line (BB), and other fleets (**OT**), including longline, drifting gillnets, and various coastal fisheries.

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 and Pakistan, gillnet and longline fishery of Sri Lanka, and coastal fisheries of Comoros, Indonesia and India.

Skipjack tuna: data availability and related data quality issues

Retained catches

- Retained catches are considered to be generally well known for the major industrial fleets, with the proportion of catches estimated, or adjusted, by the IOTC Secretariat relatively low (**Fig. 15a**). Catches are less certain for many artisanal fisheries for a number of reasons, including:
    - catches not fully reported by species;
    - uncertainty in the catches from some significant fleets including the Sri Lankan coastal fisheries, and coastal fisheries of Comoros and Madagascar.

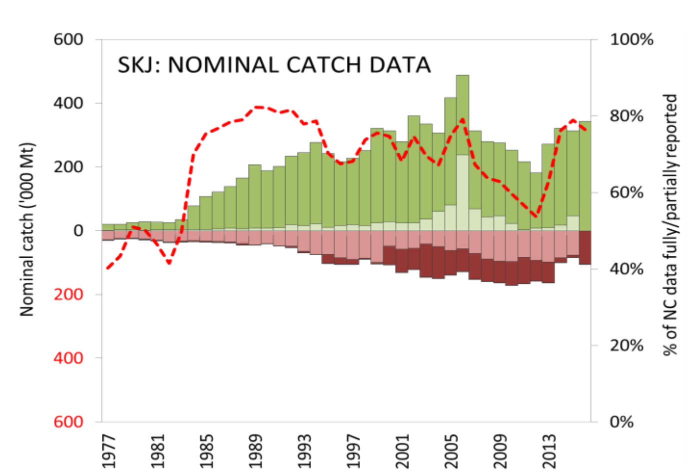
Catch-per-unit-effort (CPUE) trends

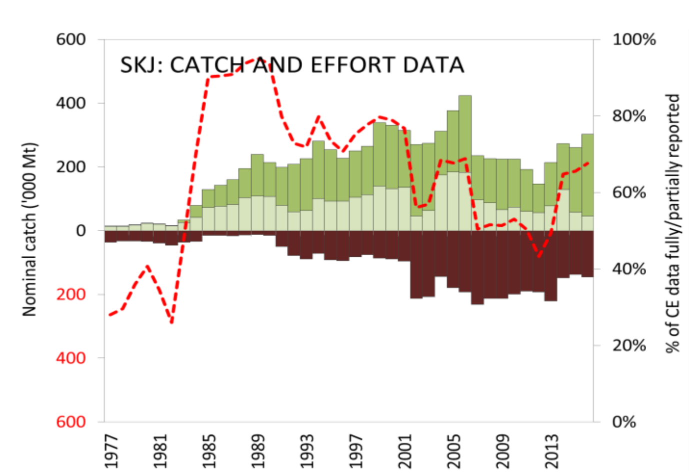
- Catch-and-effort series are available for the various industrial and artisanal fisheries (e.g., Maldives pole-and-line fishery, EU-France purse seine).

  However for a number of other important fisheries catch-and-effort are either not available (**Fig. 15b**), or are considered to be of poor quality, notably:
    - insufficient data available for the gillnet fisheries of I.R. Iran and Pakistan;
    - poor quality effort data for the gillnet-longline fishery of Sri Lanka. In previous years catch-and-effort has not been reported fully by area, or disaggregated by gear (i.e., gillnet-longline) according to the IOTC reporting standards – however in 2014 detailed information by EEZ area (for coastal fisheries) and grid area (for offshore fisheries) and gear was submitted to the IOTC Secretariat for the first time;
    - no catch-and-effort data are available for important coastal fisheries using hand and/or troll lines, in particular Indonesia, India and Madagascar.

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

- Average fish weight: trends in average weights cannot be assessed before the mid-1980s and are also incomplete for most artisanal fisheries, namely hand lines, troll lines and many gillnet fisheries (e.g., Indonesia) (**Fig. 15c**).
- Catch-at-Size (Age) table: are available but the estimates are uncertain for some years and fisheries due to:
    - a general lack of size data before the mid-1980s, for all fleets/fisheries;
    - lack of size data available for some artisanal fisheries, notably most hand lines and troll line fisheries (e.g., Madagascar, Comoros) and many gillnet fisheries (e.g., Indonesia, Sri Lanka) – although in 2014 Sri Lanka reported size information for gillnets for the first time since the early-1990s.





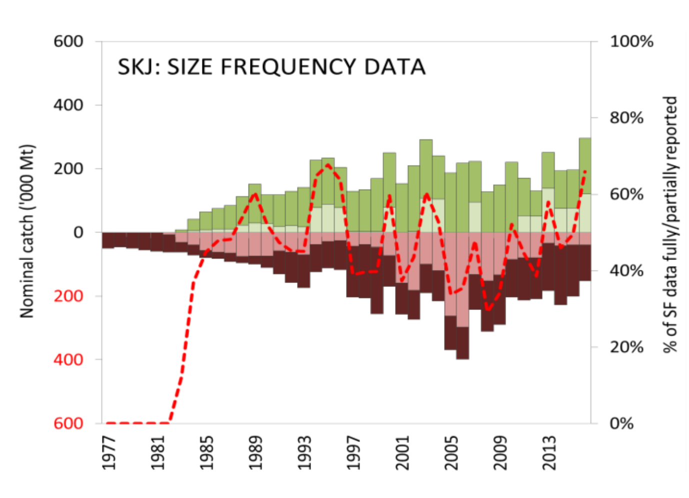


Fig. 15a-c. Skipjack tuna: data reporting coverage (1977–2016).
Each IOTC dataset (nominal catch, catch-and-effort, and length frequency) are assessed against IOTC reporting standards, where: a score of 0 indicates the amount of nominal catch associated with each dataset that is fully reported according 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.

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)

Skipjack tuna: Tagging data

- A total of 101,212 skipjack (representing 50.2% of the total number of fish tagged) were tagged during the Indian Ocean Tuna Tagging Programme (IOTTP). Most of them, 77.4%, were released during the main Regional Tuna Tagging Project-Indian Ocean (RTTP-IO) and were released around Seychelles, in the Mozambique Channel and off the coast of Tanzania, between May 2005 and September 2007 (**Fig. 16**). The remaining were tagged during small-scale tagging projects, and by other institutions with the support of IOTC, around the Maldives, India, and in the south west and the eastern Indian Ocean.
- To date, 17,667 specimens (17.5% of releases for this species), have been recovered and reported to the IOTC Secretariat. Around 69.6% of the recoveries were from the purse seine fleets operating from the Seychelles, and around 28.8% by the pole-and-line vessels mainly operating from the Maldives. The addition of the data from the past projects in the Maldives (in 1990s) added 14,506 tagged skipjack tuna to the databases, or which 1,960 were recovered mainly in the Maldives.

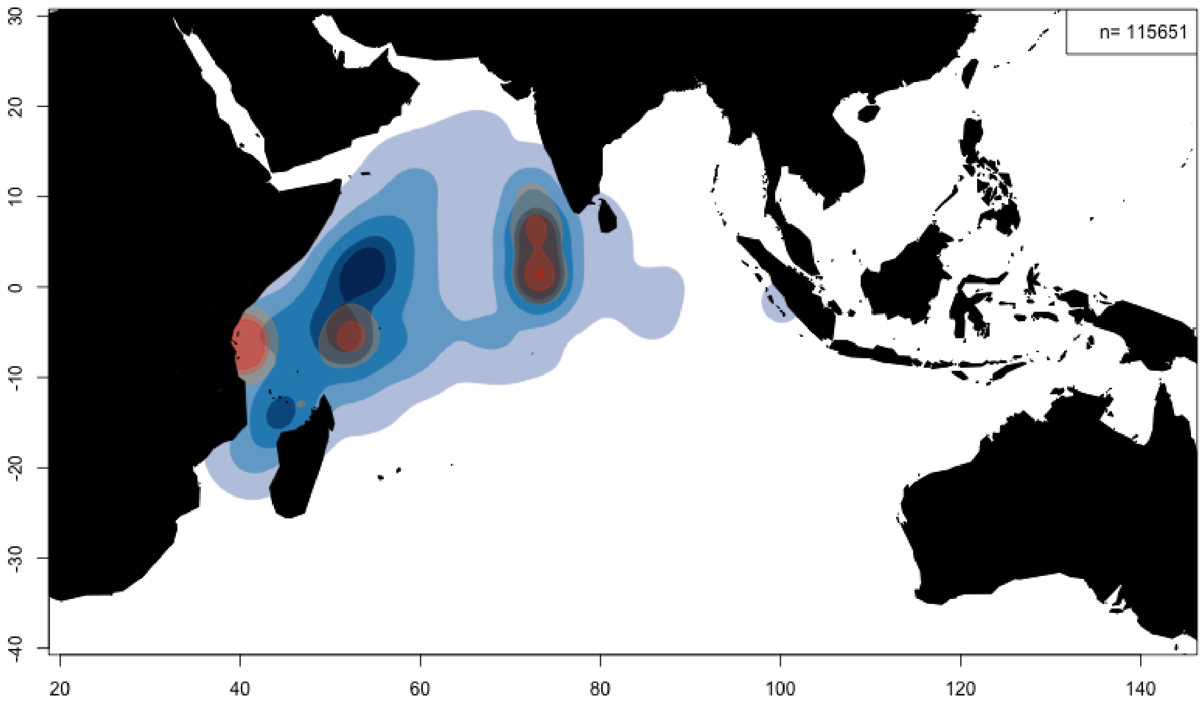
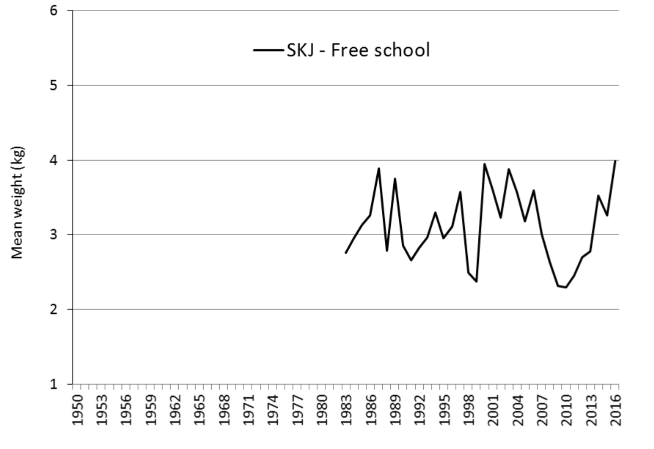


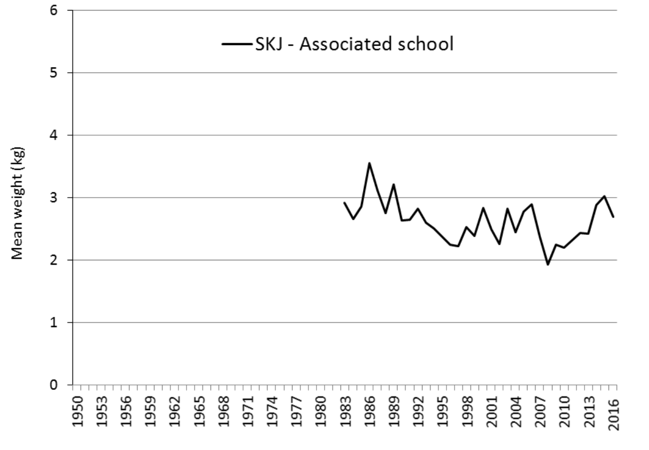
Fig. 16. Skipjack tuna: Densities of releases (in red) and recoveries (in blue). Includes specimens tagged during the IOTTP and also Indian Ocean (Maldivian) tagging programmes during the 1990s.

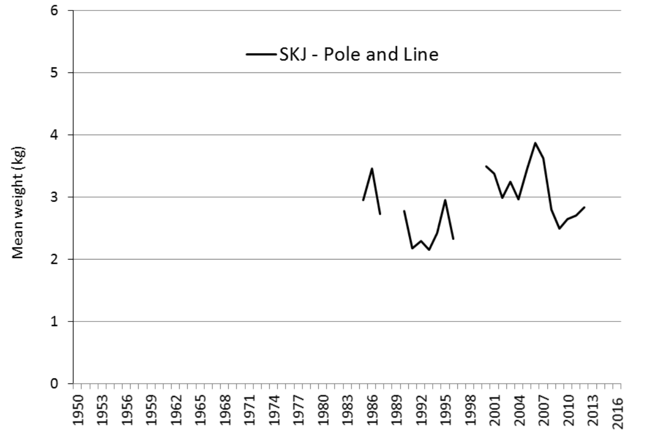
Skipjack tuna (SKJ)

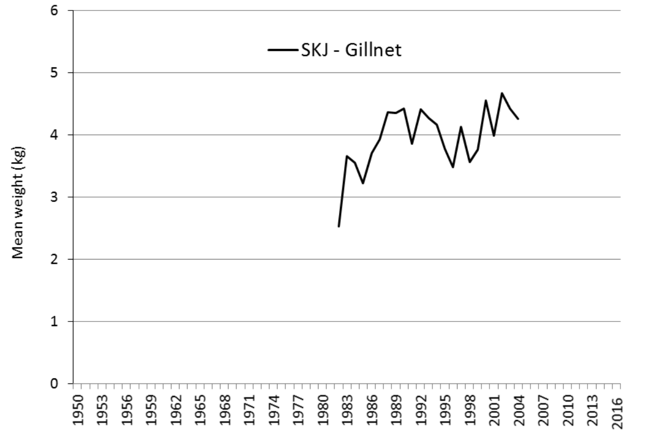
Average weight of skipjack tuna (SKJ) taken by:

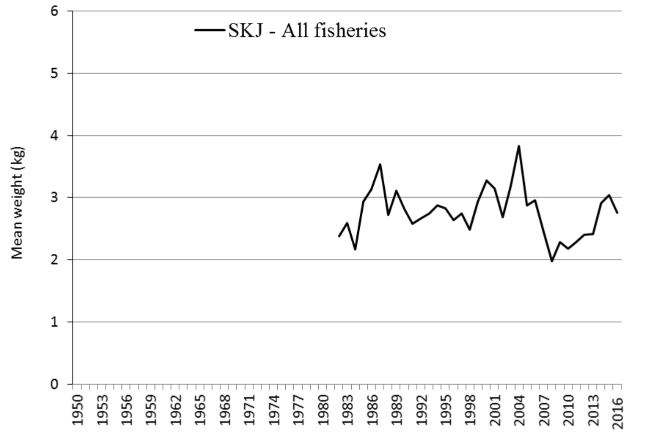
- Purse seine on free (top left) and associated (top right) schools,
- Pole-and-line from Maldives and India (second row left), and gillnets from Sri Lanka, Iran, and other countries (second row right)
- All fisheries (bottom row left), and all fisheries and main gears (bottom row left)

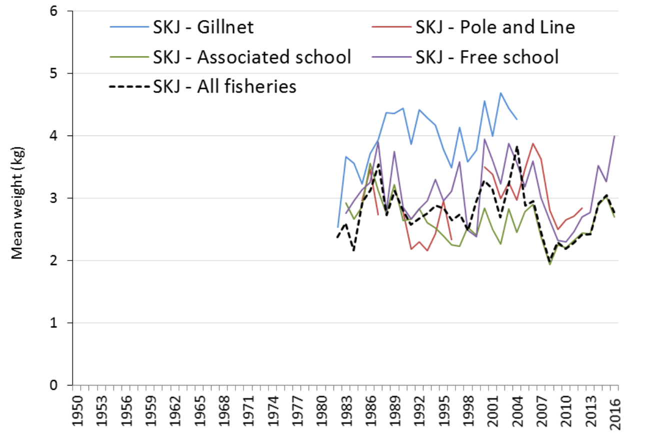


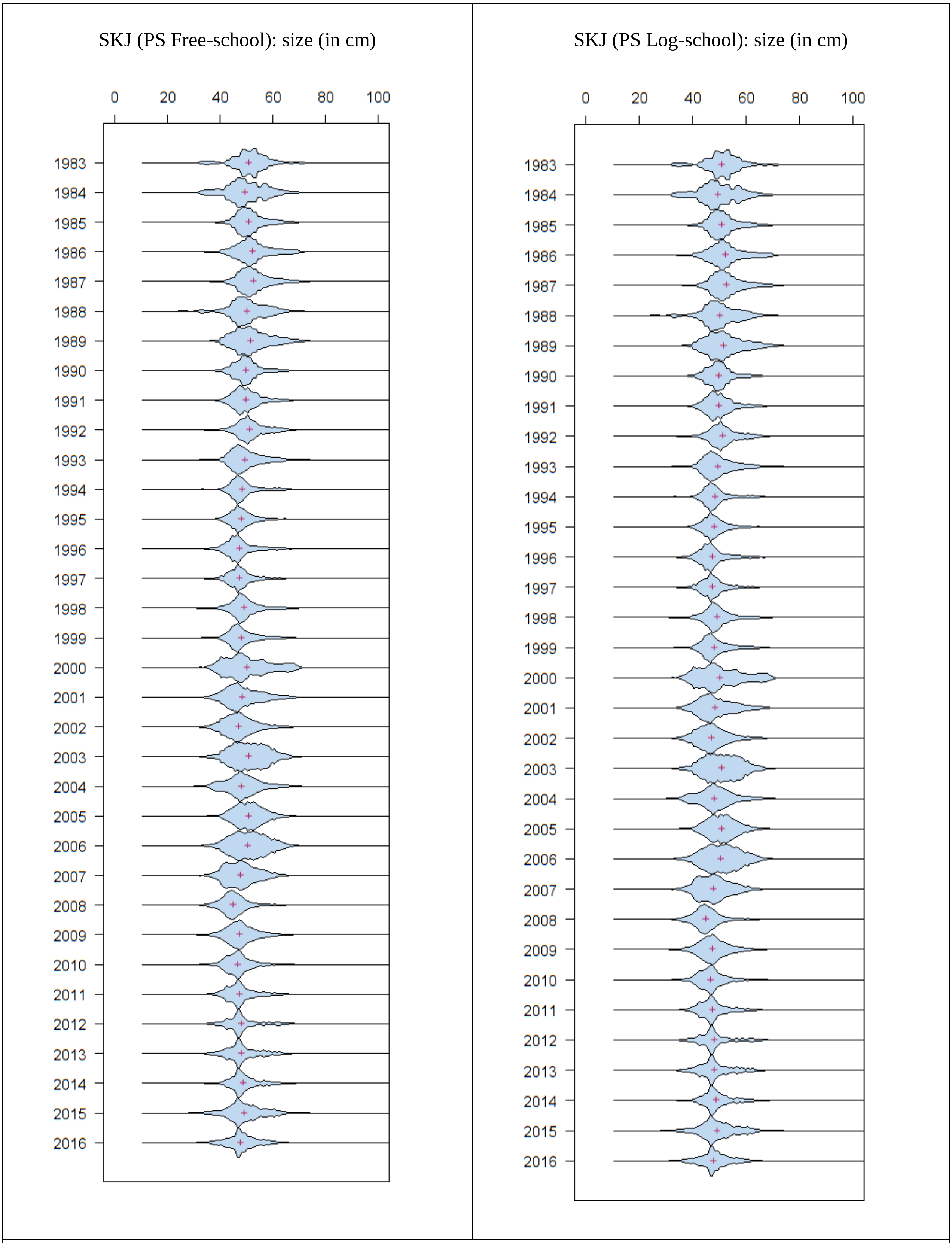












Skipjack tuna (purse seine): **Left:** length frequency distributions for SKJ PS Free school fisheries (by 2 cm length class). **Right**: Length frequency distributions for SKJ PS Associated (log) school fisheries (by 2 cm length class). Source: IOTC database.

APPENDIX IVD
MAIN STATISTICS OF YELLOWFIN TUNA

(Extracts from IOTC–2017–WPTT19–07)

Fisheries and main catch trends

- Main fishing gear (2013–16): In recent years catches have been evenly split between industrial and artisanal fisheries. Purse seiners (free and associated schools) and longline fisheries still account for around 50% of total catches, while catches from artisanal gears – namely handline, gillnet, and pole-and-line – have steadily increased since the 1980s (**Table 6**; **Fig. 17**).

  Contrary to other oceans, the artisanal fishery component of yellowfin catches in the Indian Ocean are substantial, accounting for catches of over 200,000 t per annum since 2012. Moreover, the proportion of yellowfin catches from artisanal fisheries has increased from around 30% in 2000 to nearly 50% in recent years.
- Main fleets (and primary gear associated with catches): percentage of total catches (2012–15):
  EU-Spain (purse seine): 14%; Maldives (handline, pole-andline): 12%; I.R. Iran (gillnet): 10%; Indonesia (fresh longline, handline): 10% (**Fig. 19**).
- Main fishing areas: Primary: Western Indian Ocean, around Seychelles and waters off Somalia (Area R2), and Mozambique Channel (Area R3) (**Fig.18**).
- Retained catch trends:
  Catches of yellowfin tuna remained stable between the mid-1950s and the early-1980s, ranging between 30,000 t and 70,000 t, with longliners and gillnetters the main fisheries. Catches increased rapidly in the early-1980s with the arrival of the purse seiners and increased activity of longliners and other fleets, reaching over 400,000 t by 1993.

  Exceptionally high catches were recorded between 2003 and 2006 – with the highest catches ever recorded in 2004 at over 525,000 t – while catches of bigeye tuna which are generally associated with the same fishing grounds as yellowfin tuna remained at average levels.

  Between 2007 and 2011 catches dropped considerably (around ≈40% compared to 2004) as longline fishing effort in the western Indian Ocean have been displaced eastwards or reduced due to the threat of piracy. Catches by purse seiners also declined over the same period – albeit not to the same extent as longliners – due to the presence of security personnel onboard purse seine vessels of the EU and Seychelles which has enabled fishing operations to continue.

  Since 2012 catches have once again been increasing, with catches over 400,000 t recorded.

  Purse seine fishery:

  Although some Japanese purse seiners have fished in the Indian Ocean since 1977, the purse seine fishery developed rapidly with the arrival of European vessels between 1982 and 1984. Since then, there has been an increasing number of yellowfin tuna caught, with a larger proportion of the catches consisting of adult fish, as opposed to catches of bigeye tuna, which are mostly composed of juvenile fish.

  The purse seine fishery is characterized by the use of two different fishing modes. The fishery on floating objects (FADs) catches large numbers of small yellowfin tuna in association with skipjack tuna and juvenile bigeye tuna, compared to the fishery on free swimming schools, which catches larger yellowfin tuna on multi-specific or mono-specific sets.

  Longline fishery:

  The longline fishery started in the early 1950's and expanded rapidly over throughout the Indian Ocean. The longline fishery targets several tuna species in different parts of the Indian Ocean, with yellowfin tuna and bigeye tuna being the main target species in tropical waters. The longline fishery can be subdivided into a deep-freezing longline component (i.e., large scale deep-freezing longliners operating on the high seas from Japan, Korea and Taiwan,China) and a fresh-tuna longline component (i.e., small to medium scale fresh tuna longliners from Indonesia and Taiwan,China).
- 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 2016.

Table 6. Yellowfin tuna: Best scientific estimates of the catches of yellowfin tuna (*Thunnus albacares*) by gear and main fleets [or type of fishery] by decade (1950–2009) and year (2007–2016), in tonnes. Catches by decade represent the average annual catch, noting that some gears were not used since the beginning of the fishery. Data as of September 2017.

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
FS	-	-	18	31,552	64,938	89,204	53,526	74,985	36,049	32,135	36,453	64,593	34,494	47,426	63,944	48,202
LS	-	-	17	17,597	56,278	61,890	43,778	41,540	51,351	73,383	76,659	66,166	101,868	86,370	78,382	98,659
LL	21,990	41,352	29,589	33,968	66,318	56,878	51,426	26,039	20,002	18,744	20,667	19,670	16,010	15,595	17,847	19,530
LF	164	1,255	2,369	7,946	58,965	55,605	55,619	58,102	49,884	50,485	43,455	54,643	60,679	63,004	52,767	61,646
BB	2,111	2,318	5,810	8,295	12,803	16,072	16,326	18,279	16,827	14,105	14,009	15,511	24,046	20,502	17,599	10,342
GI	1,566	4,109	7,928	11,995	39,539	49,392	43,511	47,871	41,907	51,118	49,279	63,459	56,159	71,361	71,117	64,762
HD	552	537	2,916	7,274	18,849	34,169	33,796	30,316	28,296	34,081	59,348	79,408	70,176	71,078	73,207	81,808
TR	1,079	1,934	4,243	7,462	12,456	16,679	19,894	17,568	15,259	19,982	19,618	28,836	32,753	22,105	16,597	18,244
OT	80	193	453	1,870	3,379	5,402	6,704	6,557	7,359	7,704	7,871	8,215	8,861	10,624	10,923	9,486
Total	**27,542**	**51,698**	**53,344**	**127,959**	**333,524**	**385,291**	**324,580**	**321,259**	**266,933**	**301,737**	**327,359**	**400,502**	**405,048**	**408,065**	**402,384**	**412,679**

Gears: Purse seine free-school (**FS**); Purse seine associated school (**LS**); Deep-freezing longline (**LL**); Fresh-tuna longline (**FL**); Pole-and-Line (**BB**); Gillnet (**GI**); Hand line (**HD**); Trolling (**TR**); Other gears nei (**OT**).

Table 7. Yellowfin tuna: Best scientific estimates of the catches of yellowfin tuna (*Thunnus albacares*) by area by decade (1950–2009) and year (2007–2016), in tonnes. Catches by decade represent the average annual catch. The areas are presented in Fig. 18(a). Data as of September 2017.

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
R1	2,079	4,611	6,685	16,063	61,992	71,877	72,864	63,492	46,088	54,888	73,410	102,775	100,381	92,968	87,062	85,019
R2	11,483	23,134	21,280	71,721	138,292	180,936	127,720	137,696	104,650	124,450	147,025	178,977	180,642	195,177	206,460	209,695
R3	847	7,555	5,889	9,620	24,018	25,203	25,194	21,541	20,061	19,839	21,177	18,375	22,497	10,719	16,910	20,769
R4	918	1,799	1,411	1,284	8,455	6,464	2,026	1,646	1,467	2,480	2,052	2,415	12,023	2,220	11,198	8,786
R5	11,766	13,737	17,523	27,961	87,187	85,506	85,916	83,224	77,957	85,548	75,594	89,848	80,331	87,792	66,900	69,249
OT	448	862	557	1,310	13,581	15,305	10,861	13,660	16,710	14,533	8,101	8,111	9,174	19,190	13,853	19,161
Total	**27,542**	**51,698**	**53,344**	**127,959**	**333,524**	**385,291**	**324,580**	**321,259**	**266,933**	**301,737**	**327,359**	**400,502**	**405,048**	**408,065**	**402,384**	**412,679**

Areas: Arabian Sea (**R1**); Off Somalia (**R2**); Mozambique Channel including southern (**R3**); South Indian Ocean including southern (**R4**); East Indian Ocean including Bay of Bengal(**R5**), Other fishing areas (OT) corresponds to Area R0 in Fig.18 below.

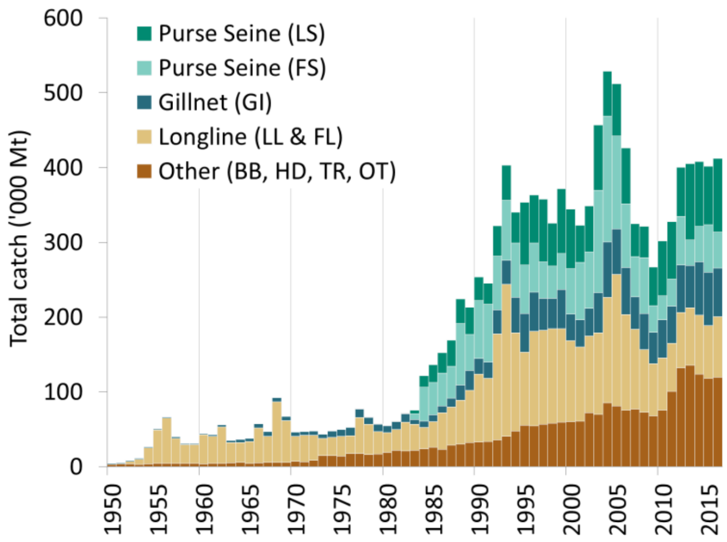


Fig. 17. Annual catches of yellowfin tuna by gear (1950–2016). Data as of September 2017.

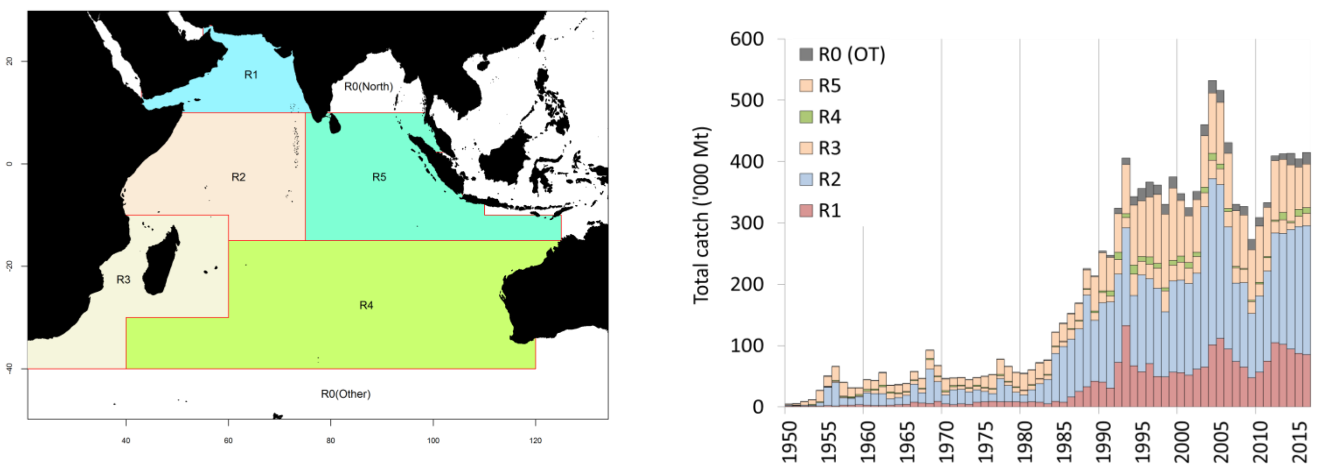


Fig. 18(a-b). Yellowfin tuna: Catches of yellowfin tuna by area by year estimated for the WPTT (1950–2016). Catches in areas R0 were assigned to the closest neighbouring area for the assessment. Data as of September 2017.

Areas: Arabian Sea (**R1**); Off Somalia (**R2**); Mozambique Channel, including southern (**R3**); South Indian Ocean including southern (**R4**); East Indian Ocean, including Bay of Bengal(**R5**); All other areas (**R0**(OT).

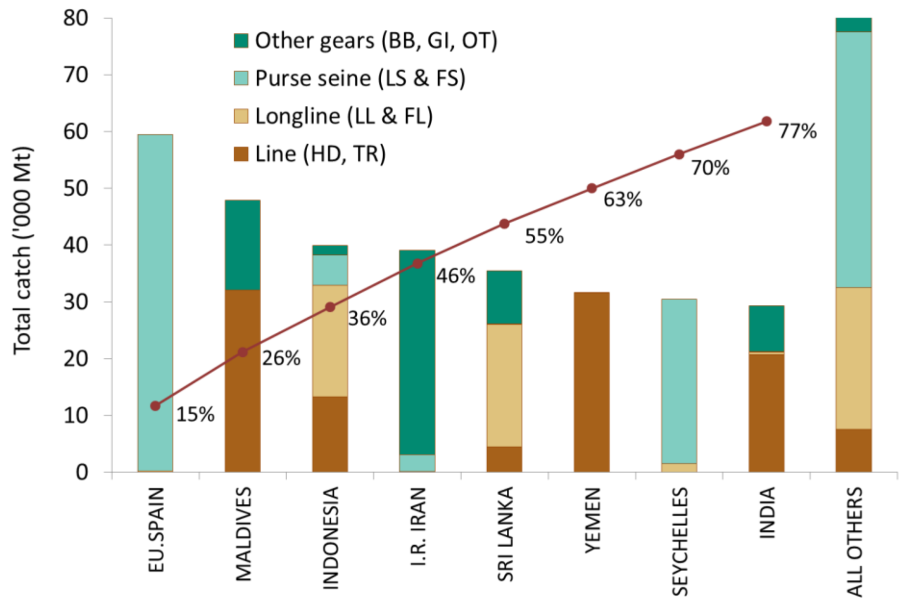


Fig. 19. Yellowfin tuna: average catches in the Indian Ocean over the period 2013–16, by country. Countries are ordered from left to right, according to the importance of catches of yellowfin reported. The red line indicates the (cumulative) proportion of catches of yellowfin for the countries concerned, over the total combined catches of this species reported from all countries and fisheries. Data as of September 2017.

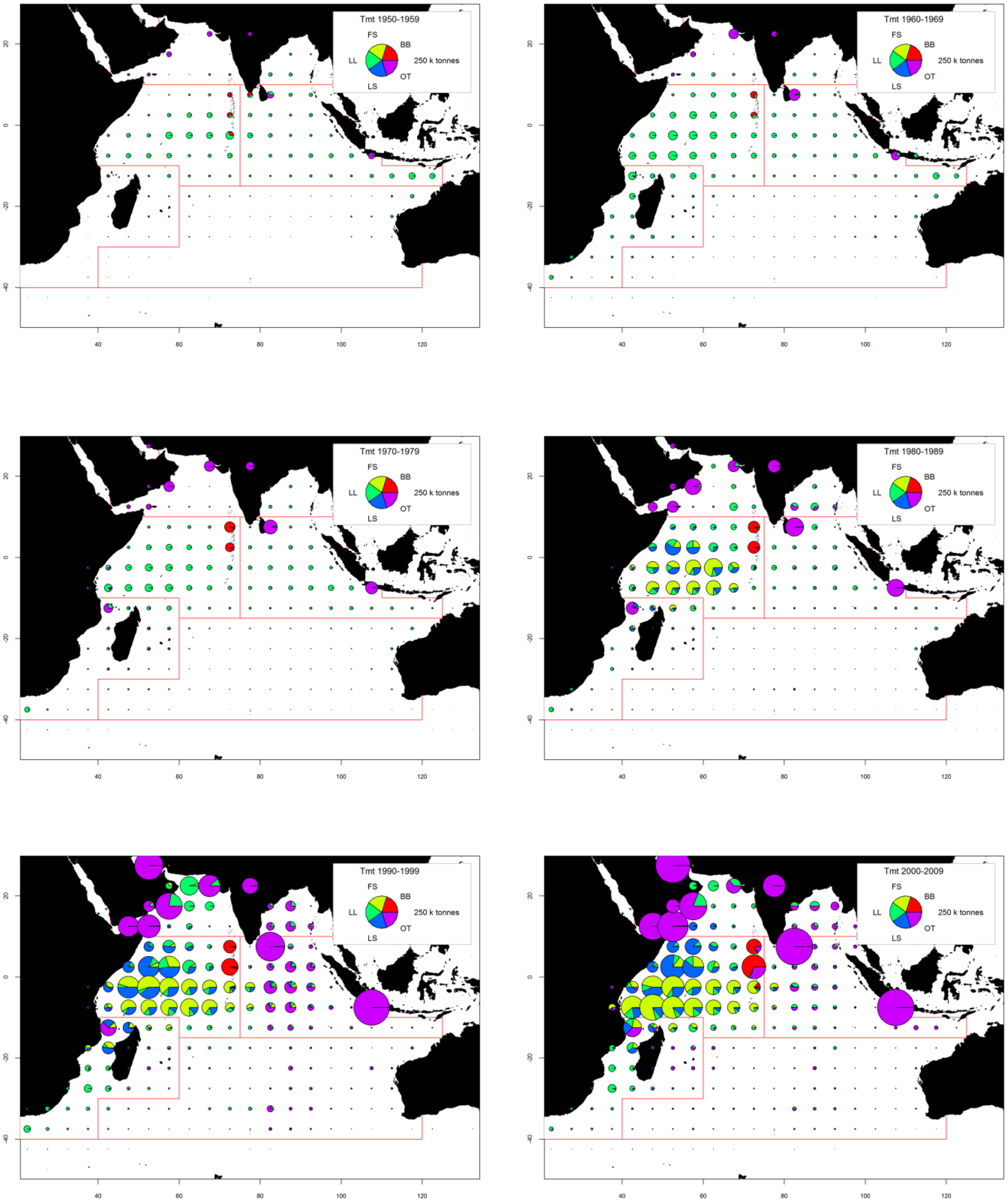


Fig. 20(a-f). Yellowfin tuna: Time-area catches (total combined in tonnes) of yellowfin tuna estimated for the period 1950–2009, by decade and type of gear. Longline (**LL**), Purse seine free-schools (**FS**), Purse seine associated-schools (**LS**), pole-and-line (**BB**), and other fleets (**OT**), including drifting gillnets, and various coastal fisheries.

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 and Pakistan, gillnet and longline fishery of Sri Lanka, and coastal fisheries of Yemen, Oman, Comoros, Indonesia and India.

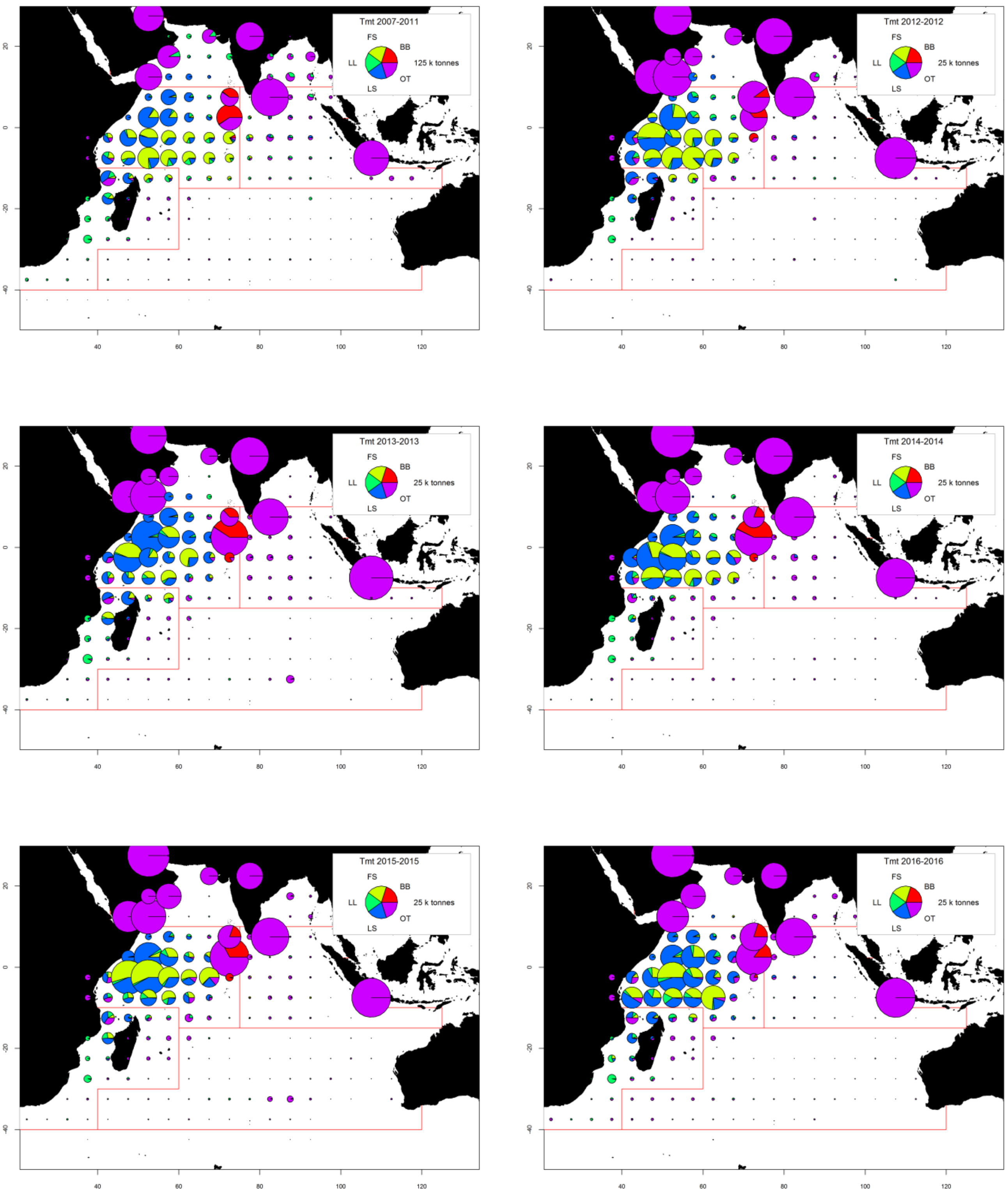


Fig. 21(a-f). Time-area catches (total combined in tonnes) of yellowfin tuna estimated for the period 2007–2011 by type of gear and for 2012–2016, by year and type of gear. Longline (**LL**), Purse seine free-schools (**FS**), Purse seine associated-schools (**LS**), pole-and-line (**BB**), and other fleets (**OT**), including drifting gillnets, and various coastal fisheries.

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 and Pakistan, gillnet and longline fishery of Sri Lanka, and coastal fisheries of Yemen, Oman, Comoros, Indonesia and India.

Yellowfin tuna: data availability and related data quality issues

Retained catches

- Data are considered to be generally well known for the major industrial fisheries, with the proportion of catches estimated, or adjusted, by the IOTC Secretariat relatively low (**Fig. 22a**). Catches are less certain for the following fisheries/fleets:
  - many coastal fisheries, notably those from Indonesia, Sri Lanka, Yemen, and Madagascar;
  - gillnet fishery of Pakistan;
  - Non-reporting industrial purse seiners and longliners (NEI), and longliners of India.

Catch-per-unit-effort (CPUE) trends

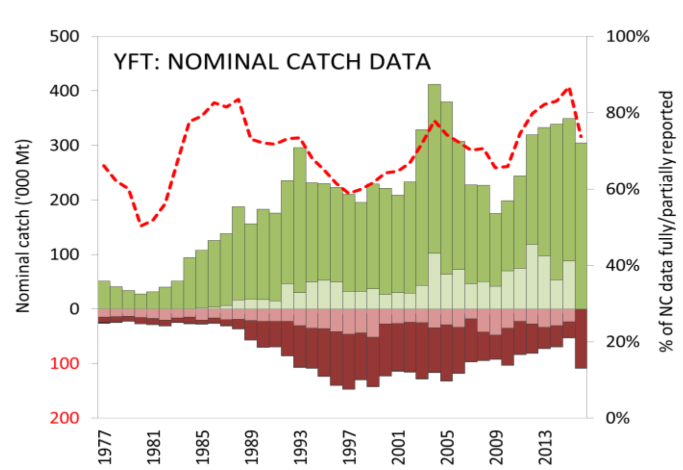
- <u>Availability</u>: Catch-and-effort series are available for the major industrial and artisanal fisheries (e.g., Japan longline, Taiwan,China) (**Fig. 22b**).

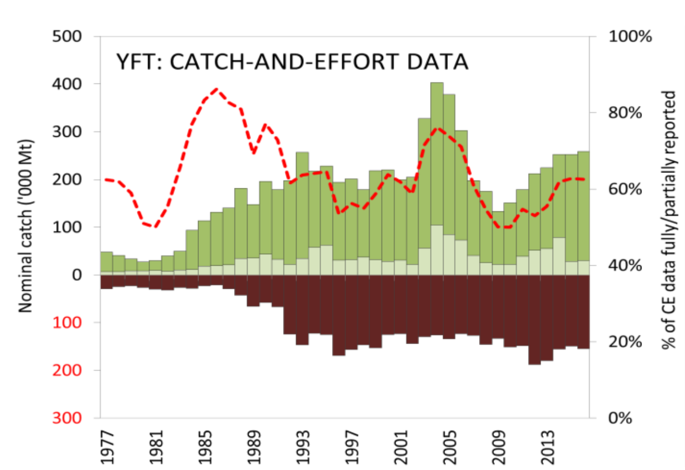
  However, for other important fisheries catch-and-effort are either not available, or are considered to be of poor quality for the following reasons:
  - no data are available for the fresh-tuna longline fishery of Indonesia, over the entire time series, and data for the fresh-tuna longline fishery of Taiwan,China are only available since 2006;
  - insufficient data for the gillnet fisheries of I.R., Iran and Pakistan;
  - poor quality effort data for the significant gillnet-longline fishery of Sri Lanka;
  - no data are available from important coastal fisheries using hand and/or troll lines, in particular Yemen, Indonesia, and Madagascar.

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

- <u>Average fish weight</u>: trends in average weight can be assessed for several industrial fisheries but they are very incomplete or of poor quality for some fisheries, namely hand lines (Yemen, Comoros, Madagascar), troll lines (Indonesia) and many gillnet fisheries (**Fig. 22c**).
  - ➢ Purse seine vessels typically take fish ranging from 40 to 140 cm fork length (FL), while smaller fish are more common in catches taken north of the equator.
  - ➢ Longline gear mainly catches large fish, from 80 to 160 cm FL, although smaller fish in the size range 60 cm – 100 cm (FL) have been taken by longliners from Taiwan,China since 1989 in the Arabian Sea.

- <u>Catch-at-Size (Age) table</u>: data are available, although the estimates are more uncertain in some years and some fisheries due to:
  - size data not being available from important fisheries, notably Yemen, Pakistan, Sri Lanka and Indonesia (lines and gillnets) and Comoros and Madagascar (lines)
  - the paucity of size data available from industrial longliners from the late-1960s up to the mid-1980s, and in recent years (Japan and Taiwan,China)
  - the paucity of catch by area data available for some industrial fleets (NEI fleets, I.R. Iran, India, Indonesia, Malaysia).





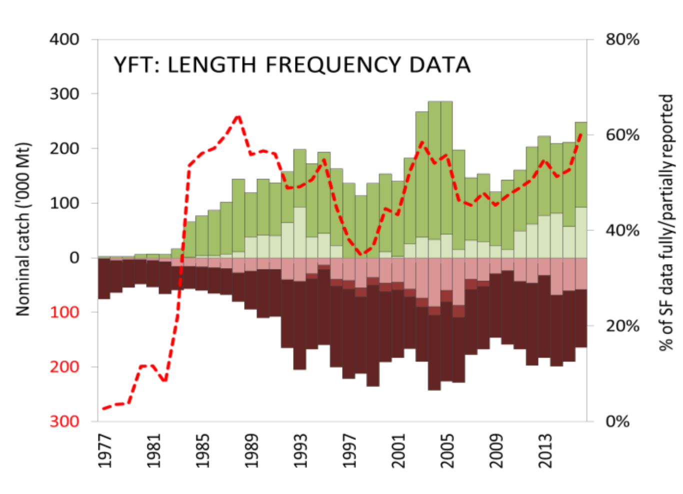


Fig. 22a-c. Yellowfin tuna: data reporting coverage (1977–2016).

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.

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)

Yellowfin tuna: tagging data

- A total of 63,328 yellowfin tuna (representing 31.4% of the total number of specimens tagged) were tagged during the Indian Ocean Tuna Tagging Programme (IOTTP). Most of the tagged specimens (86.4%) were released during the main Regional Tuna Tagging Project-Indian Ocean (RTTP-IO) and were released around Seychelles, in the Mozambique Channel, along the coast of Oman and off the coast of Tanzania, between May 2005 and September 2007 (**Fig. 23**). The remaining specimen were tagged during small-scale tagging projects, and by other institutions with the support of IOTC Secretariat, in Maldives, India, and in the south west and the eastern Indian Ocean.
- To date, around 10,840 specimens (17.1%), have been recovered and reported to the IOTC Secretariat. More than 85.9% of these recoveries we made by the purse seine fleets operating in the Indian Ocean, while around 9.1% were made by pole-and-line and less than 1% by longline vessels. The addition of the data from the past projects in the Maldives (in 1990s) added 3,211 tagged yellowfin tuna to the databases, or which 151 were recovered, mainly from the Maldives.

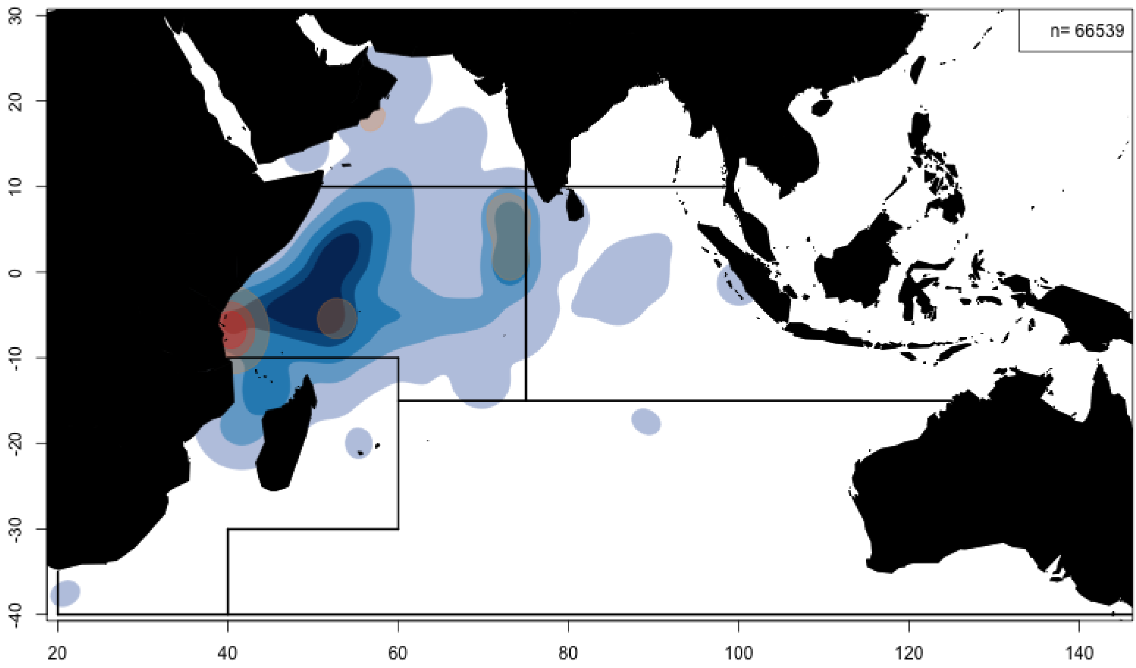
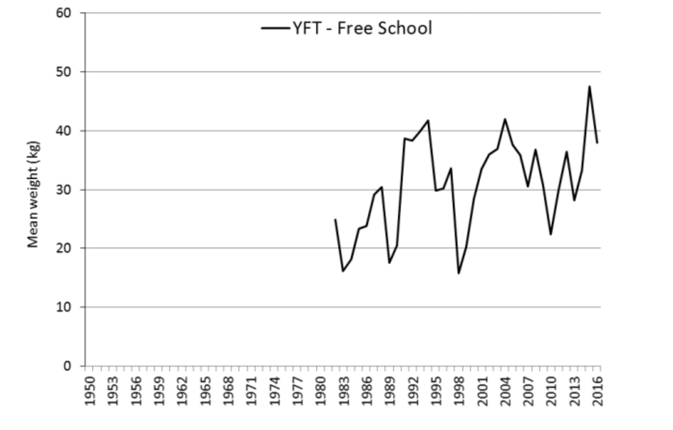


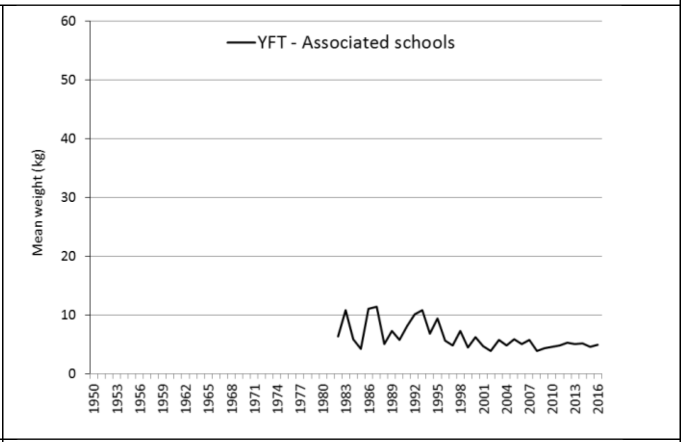
Fig. 23. Yellowfin tuna: Densities of releases (in red) and recoveries (in blue). The black line represents the stock assessment areas. Includes specimens tagged during the IOTTP and also Indian Ocean (Maldivian) tagging programmes during the 1990s.

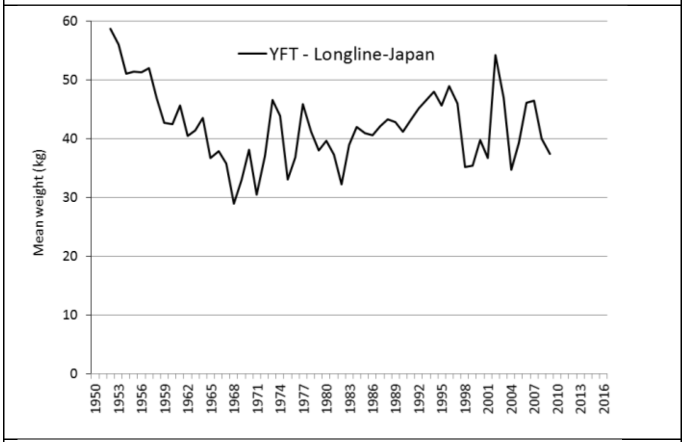
Yellowfin tuna (YFT)

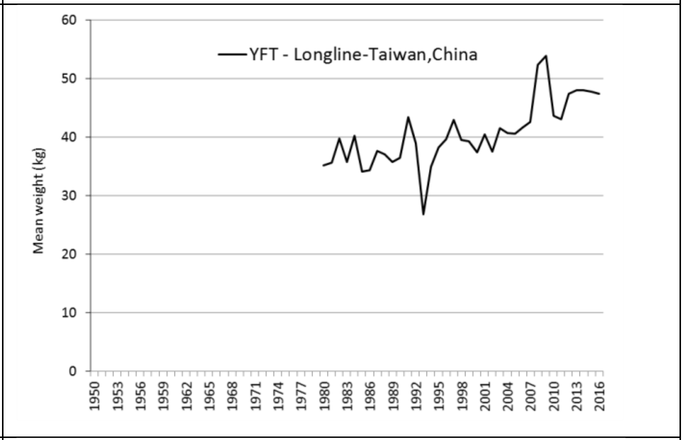
Average weight of yellowfin tuna (YFT) taken by:

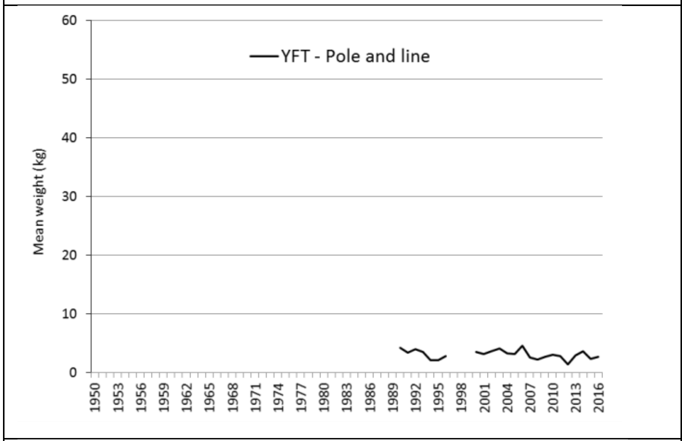
- Purse seine on free (top left) and associated (top right) schools,
- Longlines from Japan (second row left) and Taiwan,China (second row right)
- Pole-and-line from Maldives and India (third row left), and gillnets from Sri Lanka, Iran, and other countries (third row right)
- All fisheries (bottom row left), and all fisheries and main gears (bottom row left)

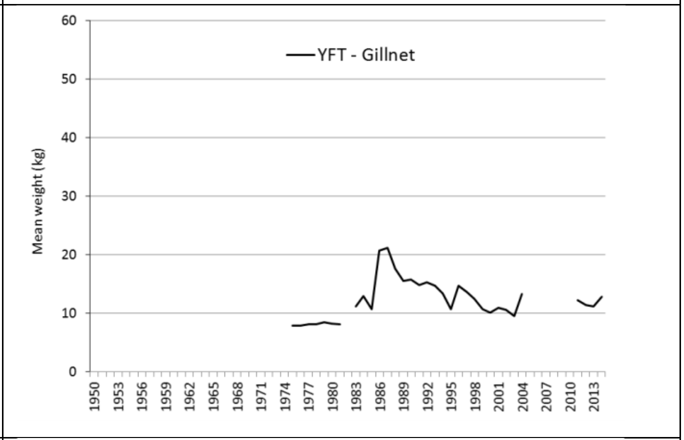


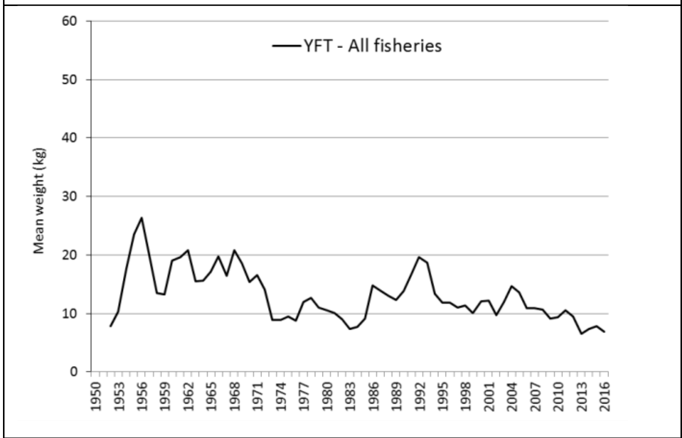


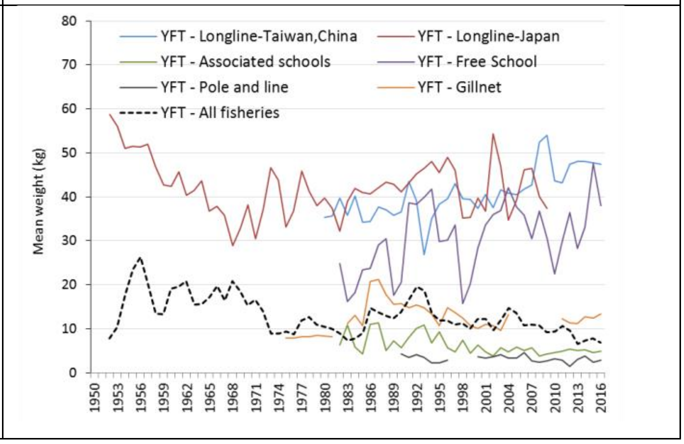


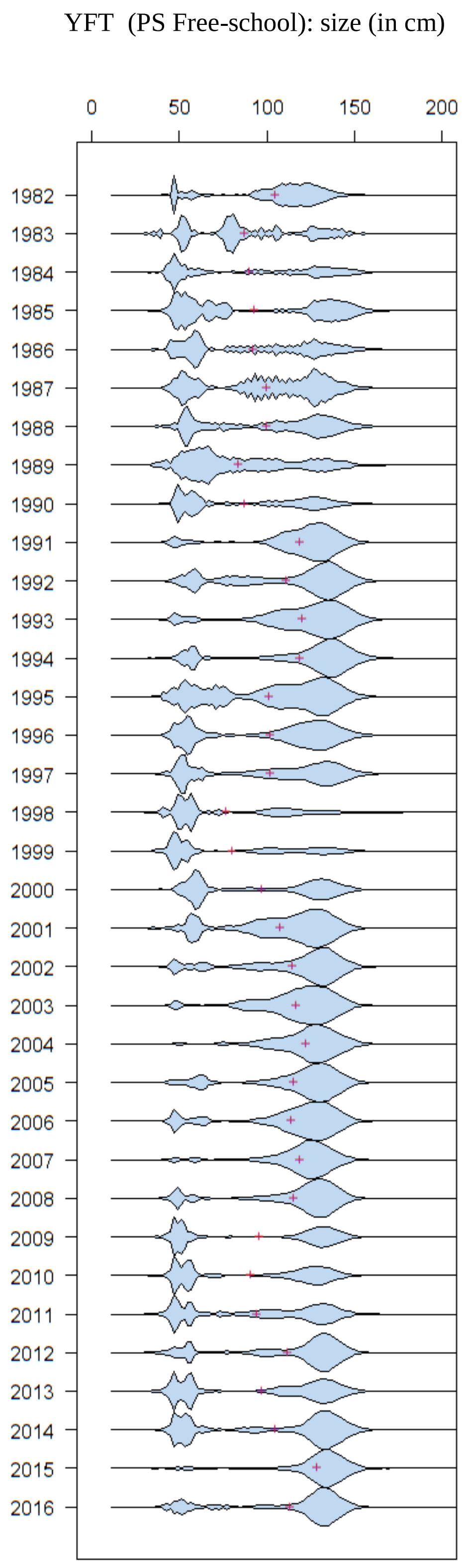


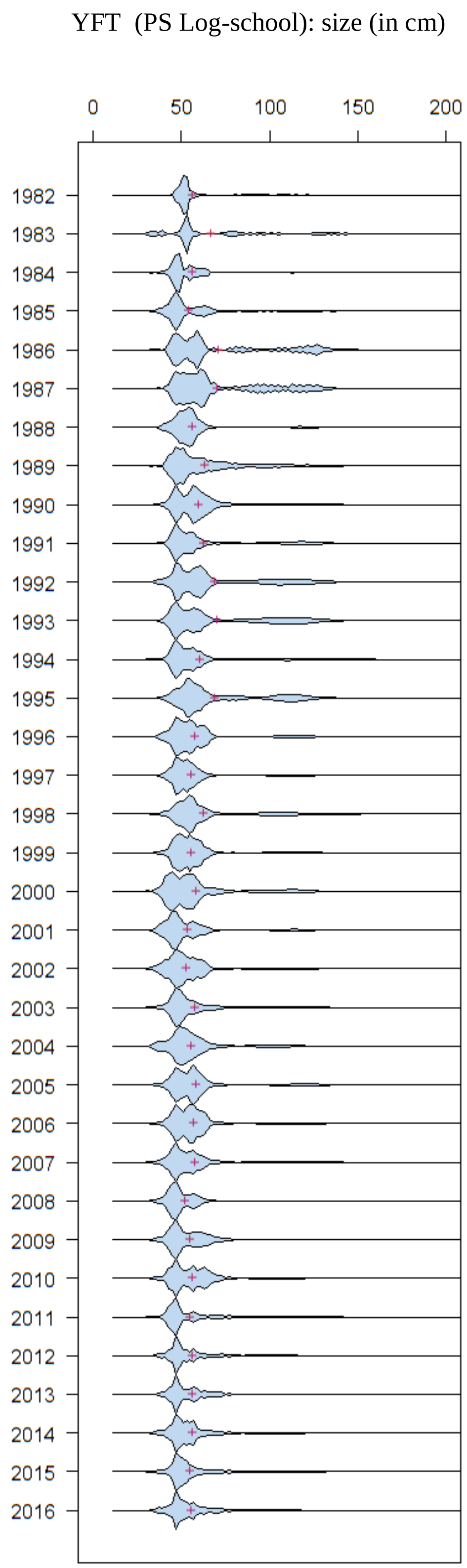




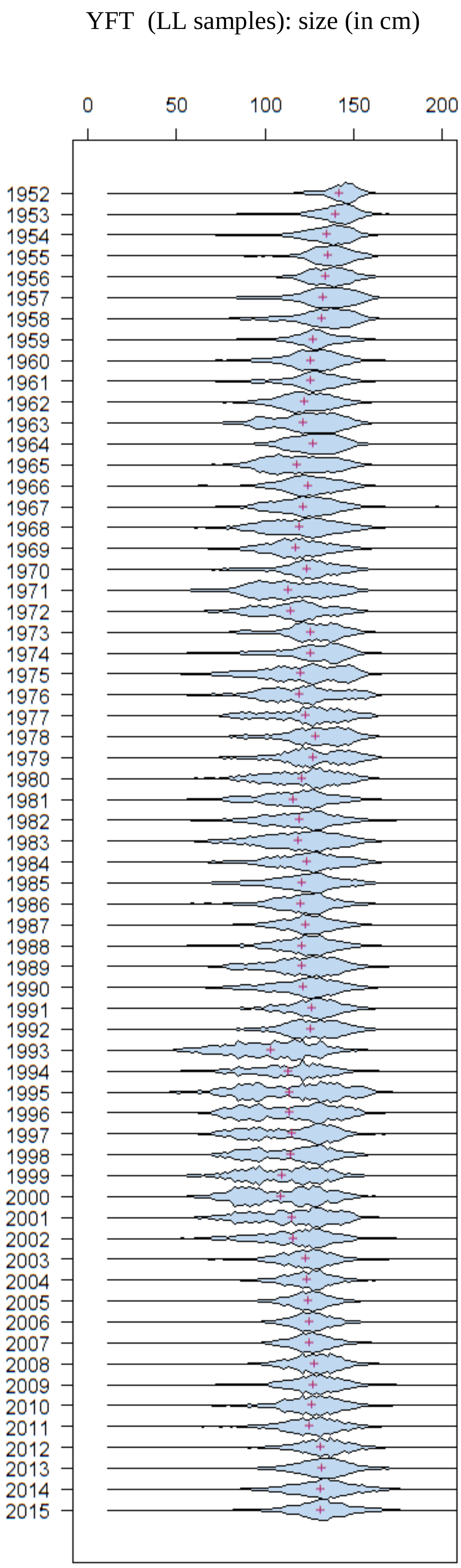








Yellowfin tuna (purse seine): **Left:** length frequency distributions for YFT PS Free school fisheries (by 2 cm length class). **Right**: Length frequency distributions for YFT PS Associated (log) school fisheries (by 2 cm length class). Source: IOTC database.



Yellowfin tuna (longline): Length frequency distributions for longline fisheries (total amount of fish measured by 2 cm length class) derived from data available at the IOTC Secretariat. Source: IOTC database.

APPENDIX V
MAIN ISSUES IDENTIFIED RELATING TO THE STATISTICS OF TROPICAL TUNAS

(Extract from IOTC–2017–WPTT19–07)

The following section provides a summary of the main issues that the IOTC Secretariat considers to negatively affect the quality of tropical tuna statistics available at the IOTC, by type of dataset and fishery, for the consideration of the WPTT.

1. Nominal (retained) catches

- Taiwan,China (longline): inconsistencies have been noted between catches of bigeye tuna originating from the Indian Ocean by the Taiwanese longline fleet – as reported by the nominal catches compared to the Bigeye Statistical Document – as a result of possible of misreporting of catches between the Atlantic and Indian Oceans. Between 2001-2004 the Bigeye Statistical Document has recorded higher catches of Indian Ocean bigeye tuna compared to nominal catches – even after the official nominal catches were been revised upwards by around 3,000 t – 6,000 t per annum. While current bigeye nominal catches in the IOTC database are closer to those reported to the Bigeye Statistical Document, discrepancies still remain and the issue has still not been fully resolved.
- Sri Lanka (gillnet-longline fishery): Although Sri Lanka has reported catches of bigeye tuna for it's gillnet/longline fishery, catches are considered to be too low, possibly due to the mislabelling of catches of bigeye tuna as yellowfin tuna.
- I.R. Iran (drifting gillnet): In 2013 I.R. Iran reported catches of bigeye tuna for its drifting gillnet fishery for the first time, (i.e., data for year 2012). The IOTC Secretariat has estimated caches of bigeye tuna for Iran for years before 2012, assuming various levels of activity of vessels using driftnets on the high seas, depending on the year, and catch ratios between bigeye tuna and yellowfin tuna recorded for industrial purse seiners on free-swimming tuna schools in the northwest Indian Ocean. Catches of bigeye tuna have been estimated for the period 2005–2011 (at around 700 t per year), however estimates remain uncertain.
- Pakistan (drifting gillnet): Up to 2016, Pakistan has not reported catches of bigeye tuna for it's gillnet fishery, although a component of the fleet is known to operate on the high seas, where catches of bigeye tuna are reported by other fleets operating the same area.

  Since 2016-2017 Pakistan has begun to report official catches on a more regular basis, however the IOTC Secretariat has noted large revisions to some of the catches for individual species. The IOTC Secretariat is currently liaising with Pakistan Ministry of Fisheries and WWF to understand, and resolve, the recent inconsistencies in catches reported to the IOTC.
- Coastal fisheries of Indonesia, Madagascar, Sri Lanka[4] (other than gillnet/longline) and Yemen: The catches of tropical tunas for these fisheries have been estimated by the IOTC Secretariat in recent years – although the quality of the estimates is thought to be very poor due to the lack of information available about the fisheries operating in these countries. Currently IOTC estimates are based on FAO data – however the quality of catches remains highly uncertain. A more substantial review of catches is still required.
- Indonesia (longline): has not reported catches for longliners under their flag that are not based in their ports.
- Comoros (coastal fisheries): In 2011-12 the IOTC and the OFCF provided support to the strengthening of data collection for the fisheries of Comoros, including a Census of fishing boats and the implementation of sampling to monitor the catches unloaded by the fisheries in selected locations over the coast. The IOTC Secretariat and the *Centre National de resources Halieutiques* of Comoros derived estimates of catch using the data collected and the new catches estimated are at around half the values reported in the past by Comoros (around 5,000 t per year instead of 9,000 t). The IOTC Secretariat revised estimates of catch for the period 1995-2010 using the new estimates.
  - *Update*: Comoros to provide an update on the status of their data collection and reporting systems during WPTT-19 meeting.

[4] In 2012-13 the Ministry of Fisheries and Aquatic Resources Development of Sri Lanka received support from IOTC, the OFCF and BOBLME to strengthen its data collection and processing system, which should lead to improvements in the estimate of catch for the coastal fisheries of Sri Lanka for 2012 and subsequent years.

2. *Discards – all fisheries*

- The total amount of tropical tunas discarded at sea remains unknown for most fisheries and time periods. Discards of tropical tunas are thought to be significant during some periods of industrial purse seine fisheries using fish aggregating devices (FADs) and may also be high due to depredation of catches of longline fisheries, by sharks or marine mammals, in tropical areas.
  - ➢ *Update*: No change from WPTT-18. The IOTC Secretariat is actively working with CPCs to develop the Regional Observer Scheme, which will lead to improvements in the estimates of discards of tropical tunas. However, for the moment, estimates of discards remain highly uncertain.

3. *Catch-and-effort*

For a number of fisheries important for catches of tropical tuna, catch-and-effort remains either unavailable, incomplete (e.g., missing catches by species or gear), or only partially reported according to the standards of IOTC Resolution 15/02 and of limited value in deriving indices of abundance:

- I.R. Iran (coastal and offshore fisheries): I.R. Iran ranks sixth largest in terms of total catches of tropical tunas (accounted for mostly by drifting gillnets), however catch-and-effort have not been reported according to IOTC standards, in particular for vessels operating outside of its EEZ. No information is reported on effort, while catches are provided by province rather than 5° grid area.
  - ➢ *Update*: The IOTC Secretariat is planning a Data Compliance and Support mission to I.R. Iran in November 2017 to assist with the reporting of catch-and-effort and compliance with IOTC mandatory data reporting requirements.
- Sri Lanka (gillnet-longline): In previous years Sri Lanka has not reported catch-and-effort data as per the IOTC standards, including separate catch-and-effort data for gillnet-longline and catch-and-effort data for those vessels that operate outside its EEZ.
  - ➢ *Update*: In 2014 Sri Lanka provided more detailed catch-and-effort for the first time, which the IOTC Secretariat is currently reviewing.
- Indonesia (longline): To date, Indonesia has not reported catch-and-effort data for its longline fishery. An IOTC-OFCF mission was conducted in November 2015 to assist Indonesia with reporting of catch-and-effort, size frequency data and Regional Observer data collected on-board longline vessels. However catch-and-effort has still not been reported for longliners to date.
- Pakistan (drifting gillnet): no catch-and-effort reported for the gillnet fishery, in particular for vessels that operate outside the EEZ of Pakistan.
  - ➢ *Update*: Pakistan has not implemented a logbook data collection to date. The IOTC Secretariat visited Pakistan in May 2017 to review the ROS data, which includes information on catches and fishing effort by area, which could be used to estimate time-area catches for Pakistan's gillnet fleets.
- India (longline): catches and catch-and-effort data have been reported for its commercial longline fishery for activities inside of the EEZ of India. However, India has not reported catches of tropical tunas or other species for longline vessels under its flag, operating offshore.

4. *Size data (all fisheries)*

- Japan and Taiwan,China (longline fisheries): In 2010, the IOTC Scientific Committee identified several issues concerning the size frequency statistics available for Japan and Taiwan,China, which remain unresolved. In 2013 the IOTC Secretariat presented a paper to WPTT-15 documenting the current data quality issues and inconsistences between the length frequency data and catch-and-effort reported in particular by Taiwan,China since the mid-2000s[5].

  The WPTT recommended an inter-sessional meeting attached to the WPDCS and WPM on *data collection and processing systems for size data from the main longline fleets in the Indian Ocean*, be carried out in early 2014.

[5] See IOTC Secretariat, IOTC-2013-WPTT15-41 Rev_1, for more details.

Unfortunately arrangements for the inter-sessional meeting were never taken forward, however a consultancy is planned for 2018 to work directly the individual national fisheries organizations concerned to resolve the current issues with longline issues.

- In addition, the number of specimens sampled for length on-board longliners flagged in Japan in recent years remains below the minimum recommended by the IOTC (i.e., 1 fish per metric ton of catch measured for length) – although size data is now being reported as part of Japan's Regional Observer Scheme data submission.
- I.R. Iran and Pakistan (gillnet): although both countries have reported size frequency data gillnet fisheries in recent years, data have not been reported by area and the number of samples are below the minimum sample size recommended by the IOTC.
- Sri Lanka (gillnet-longline): Although Sri Lanka has reported length frequency data for tropical tunas in recent years, sampling coverage is below recommended levels and lengths are not available by gear type or fishing area[6]. In 2014 Sri Lanka provided more detailed catch-and-effort for the first time, which the IOTC Secretariat is currently reviewing.
- Indonesia (longline): size frequency data have been reported for its fresh-tuna longline fishery in previous years (e.g., 2002-2003), however samples cannot be fully broken fishing area (i.e., 5° degree grid) and they refer exclusively to longliners based in ports in those countries. An IOTC-OFCF mission was conducted in November 2015 to assist Indonesia with reporting of catch-and-effort, size frequency data and Regional Observer data collected on-board longline vessels. Size data collected by the observers was submitted for the first time in 2016.
- To date, these countries have not reported size frequency data for their fisheries:
  - Longline: India, Oman and the Philippines (longline);
  - Coastal fisheries: India, Indonesia and Yemen (coastal fisheries).

5. *Biological data for all tropical tuna species*

- Surface and longline fisheries, in particular Taiwan,China, Indonesia, Japan, and China:

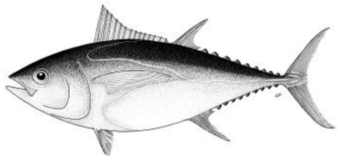
  The IOTC database does not contain enough data to allow for the estimation of statistically robust length-weight keys or non-standard size to standard length keys for tropical tuna species, due to the general lack of biological data available from the Indian Ocean.

  A summary of the current biological length-weight equations and availability of alternative sources are documented in Appendix II for the consideration of the WPTT, following the recommendation of the WPDCS.

[6] In 2012-13 the Ministry of Fisheries and Aquatic Resources Development of Sri Lanka received support from IOTC, the OFCF and BOBLME to strengthen its data collection and processing system, including collection of more length frequency data from the fisheries.

APPENDIX VI
DRAFT RESOURCE STOCK STATUS 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**		**2017 stock status**[3] **determination**
Indian Ocean	Catch in 2016[2]: Average catch 2012–2016:	86,586 t 100,455 t	**83.7%***
	MSY (1,000 t) (80% CI): F_{MSY} (80% CI): SB_{MSY} (1,000 t) (80% CI): F_{2015}/F_{MSY} (80% CI): SB_{2015}/SB_{MSY} (80% CI): SB_{2015}/SB_0 (80% CI):	104 (87-121) 0.17 (0.14-0.20) 525 (364-718) 0.76 (0.49-1.03) 1.29 (1.07-1.51) 0.38 (n.a. – n.a.)	

[1] Boundaries for the Indian Ocean stock assessment are defined as the IOTC area of competence.
[2] Proportion of catch estimated or partially estimated by IOTC Secretariat in 2016: 27%
[3] The stock status refers to the most recent years' data used in the last assessment conducted in 2016.
* Estimated probability that the stock is in the respective quadrant of the Kobe plot (shown below), derived from the confidence intervals associated with the current stock status. The confidence intervals for SB_{2015}/SB_0 were not estimated for the models used.

Colour key	Stock overfished ($SB_{year}/SB_{MSY} < 1$)	Stock not overfished ($SB_{year}/SB_{MSY} \geq 1$)
Stock subject to overfishing ($F_{year}/F_{MSY} > 1$)	**2.1%**	13.8%
Stock not subject to overfishing ($F_{year}/F_{MSY} \leq 1$)	0.4%	83.7%
Not assessed/Uncertain		

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. No new stock assessment was carried out for bigeye tuna in 2017, thus, stock status is determined on the basis of the 2016 assessment and other indicators presented in 2017. In 2016, six models were applied to the bigeye tuna stock in the IOTC area of competence (ASAP, BDM, ASPIC, SCAA, BSPM and SS3). The reported stock status is based on the SS3 model formulation using a grid designed to capture the uncertainty on stock recruitment relationship and the influence of tagging information. Spawning stock biomass in 2015 was estimated to be 38% of the unfished levels (Table 1) and 129% (107–151%) of the level that can support MSY. The assessment is qualitatively similar to the stock assessment conducted in 2013 but with a lower relative biomass (from 144 to 129% SB/SB_{MSY}) and higher relative fishing mortality (from 42 to 76% F/F_{MSY}). Considering the quantified uncertainty, which is conservative, the assessment indicates that, with high likelihood, SB_{2015} is above SB_{MSY} and F_{2015} is below F_{MSY}. The median value of MSY from the model runs presented with SS3 was 104,000 t with a range between 87,000 and 121,000 t (a median level 22% lower than the estimate in 2013). Catches in 2016 (≈86,586 t) remain lower than the estimated MSY values from the stock assessment conducted in 2016 (Table 1). The average catch over the previous five years (2012–16; ≈100,455 t) also remains below the estimated MSY. Thus, on the weight-of-evidence available in 2017, 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 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 the plausible model runs from SS3 in 2016 illustrates the levels of quantified risk associated with varying catch levels over time and could be used to inform future management actions (Table 2). The SS3 projections from the 2016 assessment show that there is a low risk of exceeding MSY-based reference points by 2018, and 2025 if catches are maintained at current catch levels of 86,586 t (Table 2).

Management advice. The stock status determination did not qualitatively change in 2017. If catches remains below the estimated MSY levels estimated for the current mix of fisheries, then immediate management measures are not required. However, increased catch or increases in the mortality on immature fish will likely increase the probabilities of breaching reference levels in the future. Continued monitoring and improvement in data collection, reporting and analysis is required to reduce the uncertainty in assessments (Table 2).

The following key points should also be noted:

- **Maximum Sustainable Yield (MSY):** estimate for the whole Indian Ocean is 104,101 t with a range between 87,000–121,000 t for SS3 (Table 1). The average 2012-2016 catches of ≈100,455 t, and catches for each year since 2009 were below the MSY level.
- **Interim reference points**: Noting that the Commission in 2015 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 at 76% of the interim target reference point of F_{MSY}, and 54% of the interim limit reference point of 1.3*F_{MSY} (Fig. 1).
    - **Biomass**: Current spawning biomass is considered to at 129% of the interim target reference point of SB_{MSY} and well above the interim limit reference point of 0.5*SB_{MSY} (Fig. 1).
- **Main fishing gear** (Average catch 2012–16): Longline ≈54.0%; Purse seine ≈22% (FAD associated school ≈17%; free swimming school ≈6%); All other (artisanal) gears ≈23%.
- **Main fleets** (Average catch 2012–16): Indonesia ≈26%; Taiwan,China ≈21%; European Union ≈14% (EU-Spain: ≈10%; EU-France: ≈4%); Seychelles ≈12%; Japan ≈5%; All other fleets ≈22%.

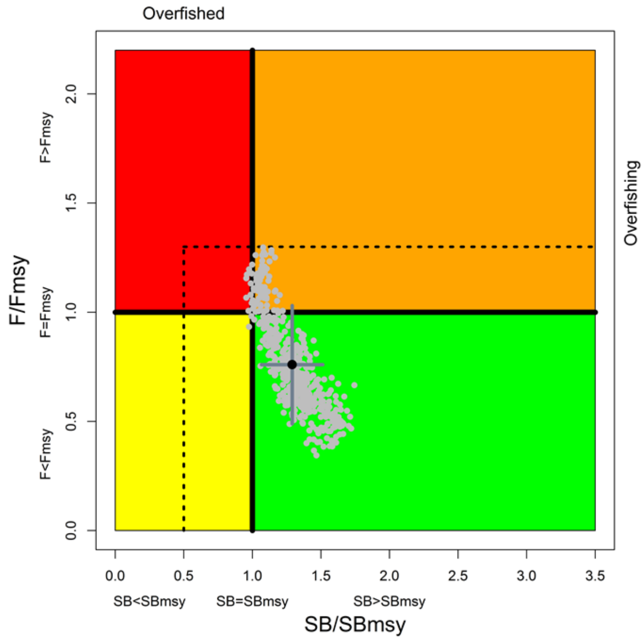


Figure. 1. Bigeye tuna: SS3 Aggregated Indian Ocean assessment Kobe plot. Dotted black lines are the interim limit reference points adopted by the Commission via Resolution 15/10. The grey points represent 500 estimates of 2015 stock status from the six model options. The black point represents the average of the six model options with associated 80% confidence interval.

TABLE 2. Bigeye tuna: Stock Synthesis base case Indian Ocean assessment Kobe II Strategy Matrix. Probability (percentage) of violating the MSY-based target (top) and limit (bottom) reference points for constant catch projections (relative to catches from 2015* (93,040t), ± 20%, + 40%) projected for 3 and 10 years.

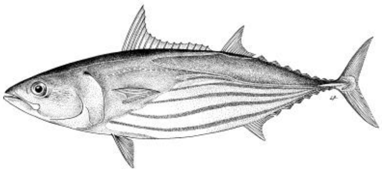
Reference point and projection timeframe	Alternative catch projections (relative to the catch level from 2015*) and weighted probability (%) scenarios that violate reference point			
	80% (74,432t)	**100%** (93,040t)	**120%** (111,648t)	**140%** (130,256t)
$B_{2018} < B_{MSY}$	11	20	30	40
$F_{2018} > F_{MSY}$	2	19	40	61
$B_{2025} < B_{MSY}$	6	25	49	60
$F_{2025} > F_{MSY}$	1	19	42	53

Reference point and projection timeframe	Alternative catch projections (relative to the catch level from 2015*) and probability (%) of violating MSY-based limit reference points ($B_{lim} = 0.5\ B_{MSY}$; $F_{Lim} = 1.3\ F_{MSY}$)			
	80% (74,432t)	**100%** (93,040t)	**120%** (111,648t)	**140%** (130,256t)
$B_{2018} < B_{LIM}$	0	0	0	0
$F_{2018} > F_{LIM}$	0	4	18	37
$B_{2025} < B_{LIM}$	0	1	12	33
$F_{2025} > F_{LIM}$	0	9	30	48

** Catches for 2015, at the time of the last bigeye tuna assessment conducted in 2016.*

APPENDIX VII
DRAFT RESOURCE STOCK STATUS SUMMARY – SKIPJACK TUNA

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



Status of the Indian Ocean skipjack tuna (SKJ: *Katsuwonus pelamis*) resource

TABLE 1. Skipjack tuna: Status of skipjack tuna (*Katsuwonus pelamis*) in the Indian Ocean.

Area[1]	Indicators		2017 stock status determination
Indian Ocean	Catch 2016[2]:	446,723 t	(green)
	Average catch 2012–2016:	407,456 t	
	$Yield_{40\%SSB}$ (1000 t) (80% CI):	510.1 (455.9–618.8)	
	$E_{40\%SSB}$ (80% CI):	0.59 (0.53–0.65)	
	$C_{2016}/C_{40\%SSB}$ (80% CI):	0.88 (0.72-0.98)	
	SB_{2016} (1000 t) (80% CI):	796.66 (582.65-1,059.29)	
	Total biomass B_{2016} (1000 t) (80% CI):	910.4 (873.6-1195)	
	$SB_{2016}/SB_{40\%SSB}$ (80% CI):	1.00 (0.88–1.17)	
	SB_{2016}/SB_0 (80% CI):	0.40 (0.35–0.47)	
	$E_{40\%SSB}$ (80% CI):	0.59 (0.53-0.65)	
	SB_0 (80% CI):	2,015,220 (1,651,230–2,296,135)	

[1] Boundaries for the Indian Ocean stock assessment are defined as the IOTC area of competence.
[2] Proportion of catch estimated or partially estimated by IOTC Secretariat in 2016: 22%

Colour key	Stock overfished ($SB_{year}/SB_{40\%}$< 1)	Stock not overfished ($SB_{year}/SB_{40\%}$≥ 1)
Stock subject to overfishing($F_{year}/F_{40\%}$> 1)	**38%**	2%
Stock not subject to overfishing ($F_{year}/F_{40\%}$≤ 1)	13%	47%
Not assessed/Uncertain		

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. A new assessment was carried out for skipjack tuna in 2017. The 2017 stock assessment model results differ substantively from the previous (2014 and 2011) assessments. The main reasons for this are: (i) the correction of an error in specifying selectivity for small fish in the previous assessments, (ii) the addition of tag-release mortality in the model and (iii) assuming effort creep of 1% per year since 1995 for the standardized European purse seine CPUE. The final overall estimate of stock status indicates that the stock is at the target biomass reference point and that the current and historical fishing mortality rates are estimated to be below the target. Over the history of the fishery, biomass has been well above and the fishing mortality has been well below the established limit reference points. The median value of Catch at the target fishing mortality ($C_{SB40\%}$)from the model runs investigated is 510,090 t with a range between 455,920 and 618,760t. Current spawning stock biomass relative to unexploited levels is estimated at 40% (Table 1). Catch in 2016 (≈446,723 t) remain lower than the estimated range of $C_{SB40\%}$ (Table 1). The average catch over the previous five years (2012–16; ≈ 407,450 t) also remains below the estimated range of $C_{SB40\%}$. Thus, on the weight-of-evidence available in 2017, the skipjack tuna stock is determined to be **not overfished** and is **not subject to overfishing** (Table 1).

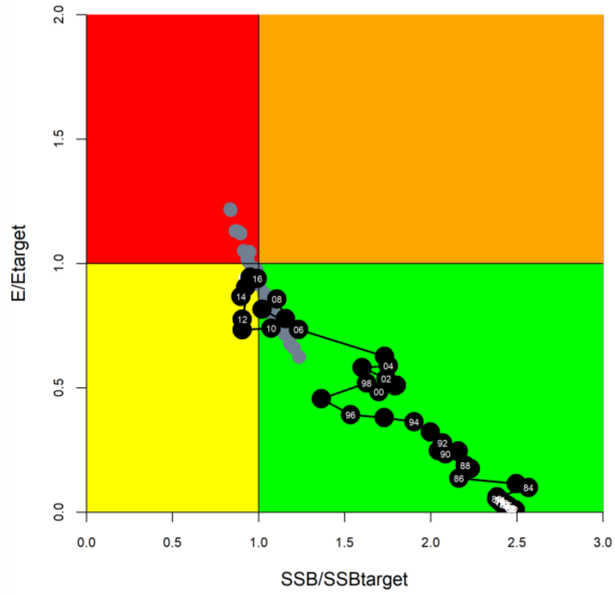
Outlook. Given the current status of the fishery and assuming that catch does not exceed prescription from Resolution 16-02, it would be expected that the stock would fluctuate around the target level. CPUE fluctuations, mainly for the purse seine, coincide with environmental signals at inter-annual timescale (e.g. Indian Ocean Dipole). Due to its specific life traits, skipjack can respond quickly to ambient foraging conditions driven by ocean productivity. Environmental indicators should be closely monitored to inform on the potential increase/decrease of stock productivity. There remains considerable uncertainty in the assessment, and the range of runs analysed illustrate a range of stock status to be between 0.35 and 0.47 of SB_{2016}/SB_0 based on all runs examined.

Management advice. The catch limit will be calculated applying the Harvest Control Rule specified in Resolution 16-02.

The following key points should also be noted:

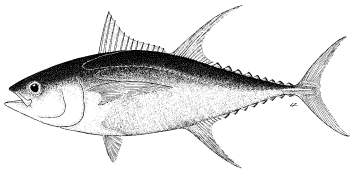
- Yield at the target fishing mortality The median ($C_{SB40\%}$) value from the model runs investigated is 510,090 t with a range between 455,920 and 618,760 t (Table 1) In spite of the fact that the average catch between 2012–2016 (407,456) has been lower than the estimated $C_{SB40\%}$, the stock has declined due to lower than expected recruitment in the recent period. It is unclear if recruitment will return to the expected levels in the near future. The stock appears to be in no immediate threat of breaching the limit reference point.
- **Reference points:** Noting that the Commission in 2016 agreed to Resolution 16/02 on *harvest control rules for skipjack tuna in the IOTC area of competence*, the following should be noted:
- **Fishing mortality**: Current fishing mortality is considered to be below the target reference point of $F_{SB40\%}$, and also below the limit reference point of $F_{SB20\%}$ (Fig. 1). T
- **Biomass**: Current spawning biomass is considered to be at the target reference point of 40% of SB_0, and above the limit reference point of $0.2*SB_0$ (Fig. 1).
- **Main fishing gear** (average catches 2012–16): Purse seine ≈33% (FAD associated school ≈31% and free swimming school ≈2%); Gillnet ≈24%; Pole-and-line ≈20%; Other ≈24%.
- **Main fleets** (average catches 2012–16): Indonesia ≈20%; European Union ≈20% (EU-Spain: ≈15%; EU-France: ≈5%); ≈Maldives 16%; Sri Lanka ≈14%; ≈I.R. Iran 9%; Seychelles ≈9%; India ≈6%; All other fleets ≈6%).

Fig. 1. Skipjack tuna: SS3 Aggregated Indian Ocean assessment Kobe plot of the 2017 uncertainty grid. Black circles indicate the trajectory of the median estimates for the SB/SB_{target} ratio and E/E_{target} ratio across all models of the 2017 uncertainty grid for each year 1950–2016; grey dots are the estimates for year 2016 from individual models.



APPENDIX VIII
DRAFT RESOURCE STOCK STATUS SUMMARY – YELLOWFIN TUNA

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



Status of the Indian Ocean yellowfin tuna (YFT: *Thunnus albacares*) resource

TABLE 1. Yellowfin tuna: Status of yellowfin tuna (*Thunnus albacares*) in the Indian Ocean.

Area[1]	Indicators		2017 stock status[3] determination
Indian Ocean	Catch 2016[2]:	412,679 t	67.6%*
	Average catch 2012–2016:	407,985 t	
	MSY (1000 t) (80% CI):	422 (406-444)	
	F_{MSY} (80% CI):	0.151 (0.148-0.154)	
	SB_{MSY} (1,000 t) (80% CI):	947 (900-983)	
	F_{2015}/F_{MSY} (80% CI):	1.11 (0.86-1.36)	
	SB_{2015}/SB_{MSY} (80% CI):	0.89 (0.79-0.99)	
	SB_{2015}/SB_0 (80% CI):	0.29 (n.a.-n.a.)	

[1]Boundaries for the Indian Ocean stock assessment are defined as the IOTC area of competence.
[2] Proportion of catch estimated or partially estimated by IOTC Secretariat in 2016: 22%
[3] The stock status refers to the most recent years' data used in the last assessment conducted in 2016.
* Estimated probability that the stock is in the respective quadrant of the Kobe plot (shown below), derived from the confidence intervals associated with the current stock status. The confidence intervals for SB_{2015}/SB_0 were not estimated for the models used.

Colour key	Stock overfished ($SB_{year}/SB_{MSY}< 1$)	Stock not overfished ($SB_{year}/SB_{MSY}\geq 1$)
Stock subject to overfishing($F_{year}/F_{MSY}> 1$)	67.6%	3.7%
Stock not subject to overfishing ($F_{year}/F_{MSY}\leq 1$)	27.3%	1.4%
Not assessed/Uncertain		

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. No new stock assessment was carried out for skipjack tuna in 2017, thus, stock status is determined on the basis of the 2016 assessment and other indicators presented in 2017. In 2016, two models were applied to the yellowfin tuna stock in the IOTC area of competence to update the stock status undertaken in 2015: a Biomass Dynamic Model (BDM) and Stock Synthesis III (SS3) model, which gave qualitatively similar results. Stock status and management advice was based on the SS3 model formulation. Spawning stock biomass in 2015 was estimated to be 28.9% of the unfished levels (Table 1) and 89% (79–99%) of the level which can support MSY. The assessment is somewhat more optimistic than the stock assessment undertaken in 2015 mainly due to the use of a new composite LL CPUE series, which results in a lower estimate of fishing mortality in the NE Indian Ocean. In addition, the catch series revised in 2016 reduced the catch data for 2014 by 5.1% (from 430,327 to 408,497, although the impact of this revision on status determination was minor. According to the information available for the stock assessment, the total catch has remained relatively stable at levels somewhat lower than the estimated MSY since 2012 (412,659 t in 2016, 402,384 t in 2015, 408,097 in 2014, 405,048 in 2013 and 400,502 in 2012). The inclusion of revised and new data into the updated assessment using the model structure applied in the 2015 assessment resulted in a higher estimated biomass in 2014 and lower estimated F/F_{MSY} than the corresponding estimates from the 2015 stock assessment. Nonetheless, the updated assessment estimates SB_{2015}/SB_{MSY} at 0.89 (0.79-0.99) and F_{2015}/F_{MSY} at 1.11 (0.86-1.36). The quantified uncertainty in these estimates is an underestimate of the underlying uncertainty of the assessment. On the weight-of-evidence available in 2017, the yellowfin tuna stock is determined to remain **overfished** and subject to **overfishing** (Table 1 and Fig. 1).

Outlook. The increase in longline, gillnet, handline and purse seine effort and associated catches in recent years has substantially increased the pressure on the Indian Ocean stock as a whole, with recent fishing mortality exceeding the

MSY-related levels. There is a risk of continuing to exceed the MSY-based biomass reference point if catches increase or remain at current levels (2016) until 2018 (88% risk that SB < SB_{MSY}) (Table 2). The modelled probabilities of the stock attaining levels consistent with the Commission's current management objective (e.g. SB > SB_{MSY}) are shown in the K2MSM, which provides a range of options for reducing catches and the probabilities of the yellowfin tuna stock recovering to the MSY target levels (Table 2).

Management advice. As no stock assessment was conducted in 2017, the stock status determination has not changed since 2016, and gives a somewhat more optimistic estimate of stock status than the 2015 assessment as a result of the use of more reliable information on catch rates of longline fisheries and catches updated to 2016. The stock status is driven by unsustainable catches of yellowfin tuna taken over the last five (5) years, and the relatively low recruitment levels estimated by the model in recent years. The Commission has an interim plan for the rebuilding of this stock (Resolution 17/01, which is yet to be evaluated and superseded Resolution 16/01) to achieve the recovery of yellowfin stock, with catch limitations based on 2014/2015 levels. The projections produced to advise on future catches are, in the short term, driven by the below average recruitment estimated for in recent years since these year classes have yet to reach maturity and contribute to the spawning biomass (see Table 2).

The following key points should also be noted:

- **Maximum Sustainable Yield (MSY):** estimate for the whole Indian Ocean is estimated at 422,000 t with a range between 406,000-444,000 t (Table 1). The 2012-2016 average catches (407,985 t) were below the estimated MSY level.
- **Interim reference points**: Noting that the Commission in 2015 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 11% above the interim target reference point of F_{MSY}, and below the interim limit reference point of 1.4*F_{MSY} (Fig. 1).
- **Biomass**: Current spawning biomass is considered to be 11% below the interim target reference point of SB_{MSY}, however above the interim limit reference point of 0.4*SB_{MSY} (Fig. 1).
- **Main fishing gear** (average catches 2012–16): Purse seine ≈34% (FAD associated school ≈21%; free swimming school ≈13%); Longline ≈19%; Gillnet ≈16%; All other gears ≈31%.
- **Main fleets** (average catches 2012–16): European Union ≈21% (EU-Spain ≈15%; EU-France ≈7%); Maldives ≈12%; Indonesia ≈10%; I.R. Iran ≈10%; Sri Lanka ≈9%; Yemen ≈7%; India ≈7%; All other fleets ≈23%.

Fig. 1. Yellowfin tuna: Stock synthesis Kobe plot. Blue dots indicate the trajectory of the point estimates for the B/B_{MSY} ratio and F_{MSY} proxy ratio for each year 1950–2015. The grey line represents the 80% confidence interval associated with the 2015 stock

status. Dotted black lines are the interim limit reference points adopted by the Commission via Resolution 15/10.

TABLE 2. Yellowfin tuna: Stock synthesis assessment Kobe II Strategy Matrix. Probability (percentage) of violating the MSY-based target (top) and limit (bottom) reference points for constant catch projections (relative to the catch level from 2015* levels (407,575t), -30%, - 25%, ± 20%, -15%,± 10%, -5%), projected for 3 and 10 years), projected for 3 and 10 years.

Reference point and projection timeframe	**Alternative catch projections (relative to the catch level from 2015*) and probability (%) of violating MSY-based target reference points ($B_{targ} = B_{MSY}$; $F_{targ} = F_{MSY}$)**								
	70% (285,302t)	75% (305,680t)	80% (326,059t)	85% (346,438t)	90% (366,816t)	95% (387,195t)	100% (407,574t)	110% (448,331t)	120% (489,089t)
$B_{2018} < B_{MSY}$	53	61	67	77	80	88	88	97	99
$F_{2018} > F_{MSY}$	2	7	23	47	65	73	100	100	100
$B_{2025} < B_{MSY}$	6	n.a.	20	37	60	100	100	100	100
$F_{2025} > F_{MSY}$	0	n.a.	10	40	57	100	100	100	100

Reference point and projection timeframe	**Alternative catch projections (relative to the catch level from 2015*) and probability (%) of violating MSY-based limit reference points ($B_{lim} = 0.4\ B_{MSY}$; $F_{Lim} = 1.4\ F_{MSY}$)**								
	70% (285,302t)	75% (305,680t)	80% (326,059t)	85% (346,438t)	90% (366,816t)	95% (387,195t)	100% (407,574t)	110% (448,331t)	120% (489,089t)
$B_{2018} < B_{Lim}$	2	1	2	4	6	6	12	21	38
$F_{2018} > F_{Lim}$	0	0	1	10	32	52	100	100	100
$B_{2025} < B_{Lim}$	0	n.a.	1	7	30	>30**	>30**	>30**	>30**
$F_{2025} > F_{Lim}$	0	n.a.	0	11	53	>30**	>30**	>30**	>30**

** Catches for 2015, at the time of the last yellowfin tuna assessment conducted in 2016.*

*** At least one fishery not able to take the catch due to absence of vulnerable fish in the projection period. The probability levels are not well determined, but likely progressively exceed 30% as the catch level increases beyond 90%.*

APPENDIX IX
WORKING PARTY ON TROPICAL TUNAS PROGRAM OF WORK (2018–2022)

The following is the Draft WPTT Program of Work (2018–2022) and is based on the specific requests of the Commission and Scientific Committee. The program of work was revised for 2018-2022 based on the topics discussed and identified during the WPTT19. The Program of Work consists of the following, noting that a timeline for implementation would be developed by the SC once it has agreed to the priority projects across all of its Working Parties:

- **Table 1**: Priority topics for obtaining the information necessary to develop stock status indicators for tropical tunas in the Indian Ocean;
- **Table 2**: Stock assessment schedule.

Table 1. Priority topics for obtaining the information necessary to develop stock status indicators for bycatch species in the Indian Ocean.

Topic	Sub-topic and project	Priority ranking	Lead	Est. budget (potential source)	TIMING				
					2018	2019	2020	2021	2022
1. Stock structure (connectivity and diversity)	1.1 Genetic research to determine the connectivity of tropical tuna species throughout their distribution (including in adjacent Pacific Ocean waters as appropriate) and the effective population size.	High (on-going)	CSIRO/AZTI/IRD/RITF	1.3 m Euro: (European Union; 20% additional co-financing)					
	1.1.1 Next Generation Sequencing (NGS) to determine the degree of shared stocks for tropical tuna species in the Indian Ocean. Population genetic analyses to decipher inter- and intraspecific evolutionary relationships, levels of gene flow (genetic exchange rate), genetic divergence, and effective population sizes.								
	1.1.2 Nuclear markers (i.e. microsatellite) to determine the degree of shared stocks for tropical tuna species in the Indian Ocean with the Pacific Ocean, as appropriate.								
	1.2 Connectivity, movements and habitat use								
	1.2.1 Connectivity, movements, and habitat use, including identification of hotspots and investigate associated environmental conditions affecting the tropical tuna species	Medium		US$?? (TBD)					

Topic	Sub-topic and project	Priority ranking	Lead	Est. budget (potential source)	TIMING				
					2018	2019	2020	2021	2022
	distribution, making use of conventional and electronic tagging (P-SAT). 1.2.2 Investigation into the degree of local or open population in main fishing areas (e.g,, the Maldives and Indonesia – archipelagic and open ocean) by using techniques such flux in FAD arrays or used of morphological features such as shape of otoliths.	Medium		Some work ongoing – MDV, IDN					
2. Biological and ecological information (incl. parameters for stock assessment)	2.1 Age and growth								
	2.1.1 Design and develop a plan for a biological sampling program to support research on tropical tuna biology. The plan would consider the need for the sampling program to provide representative coverage of the distribution of the different tropical tuna species within the Indian Ocean and make use of samples and data collected through observer programs, port sampling and/or other research programs. The plan would also consider the types of biological samples that could be collected (e.g. otoliths, spines, gonads, stomachs, muscle and liver tissue, fin clips etc), the sample sizes required for estimating biological parameters, and the logistics involved in collecting, transporting and processing biological samples. The specific biological parameters that could be estimated include, but are not limited to, estimates of growth, age at maturity, fecundity, sex ratio, spawning season, spawning fraction and stock structure.	High	CPCs directly	US$?? (TBD)					
	2.2 Age-at-Maturity								
	2.2.1 CPCs to provide further research reports on tropical tuna biology, namely age and growth studies including gonad maturity studies, or through use of fish otoliths, either from data collected through observer programs or other research programs.	High	CPCs directly	US$?? (TBD)					
3. Ecological information	3.1 Spawning periods and locations								

Topic	Sub-topic and project	Priority ranking	Lead	Est. budget (potential source)	TIMING				
					2018	2019	2020	2021	2022
	3.1.1 Collect gonad samples from tropical tunas to confirm the spawning periods and location of the spawning area that are presently hypothesised for each tropical tuna species.	Medium		US$?? (TBD)					
4. Historical data review	4.1 Changes in fleet dynamics need to be documented by fleet								
	4.1.1 Provide an evaluation of fleet-specific fishery impacts on the stock of bigeye tuna, skipjack tuna and yellowfin tuna. Project potential impact of realizing fleet development plans on the status of tropical tunas based upon most recent stock assessments.	Medium	Consultant	US$30K					
5. CPUE standardisation	5.1 Develop standardised CPUE series for each tropical tuna fleet/fishery for the Indian Ocean								
	5.1.1 Further development and validation of the collaborative longline CPUE indices using the data from multiple fleets and to provide joint CPUE series for longline fleets where possible	High (on-going)	SC and consultants	US$40K (IOTC)					
	5.1.2 That standardised CPUE index for juvenile yellowfin tuna and bigeye tuna caught by the EU purse seiner fleets, be estimated and submitted to the WPTT before the next round of stock assessments of tropical tunas.		CPCs directly	US$?? (TBD)					
	5.1.3 Development of minimum criteria (e.g. 10% using a simple random stratified sample) for logbook coverage to use data in standardisation processes; and 2) identifying vessels through exploratory analysis that were misreporting, and excluding them from the dataset in the standardisation analysis.		CPCs directly	US$?? (TBD)					
	5.1.4 Vessel identity information for the Japanese fleets for the period prior to 1979 should be obtained either from the original logbooks or from some other source, to the greatest extent		Japan	US$?? (TBD)					

Topic	Sub-topic and project	Priority ranking	Lead	Est. budget (potential source)	TIMING				
					2018	2019	2020	2021	2022
	possible to allow estimation of catchability change during this period and to permit cluster analysis using vessel level data.				X	X	X	X	X
	Bigeye tuna: High priority fleets	High	CPCs directly	US$?? (TBD)		X			
	Skipjack tuna: High priority fleets	High	CPCs directly	US$?? (TBD)			X	X	
	Yellowfin tuna: High priority fleets	High	CPCs directly	US$?? (TBD)	X				
	5.2 That methods be developed for standardising purse seine catch species composition using operational data, so as to provide alternative indices of relative abundance (see Terms of Reference, Appendix IXb below).	High	Consultant and CPCs directly	US$?? (TBD)	X				
	5.3 Investigate the potential to use the Indian longline survey as a fishery-independent index of abundance for tropical tunas.	High	Consultant And CPCs directly	US$30K (TBD)	X	X			
	5.4 Further investigate and use of gillnet CPUE series from Sri Lankan gillnet fishery	High	Consultant And CPCs directly	US$ (TBD)	X	X			
6. Stock assessment / stock indicators	6.1 Develop and compare multiple assessment approaches to determine stock status for tropical tunas 6.2 Scoping of ageing studies of tropical tunas to provide information on population age structure (based on species and age composition of sampled catches) 6.3 Develop a high resolution age structured operating model that can be used to test the spatial assumptions including potential effects of limited tags mixing on stock assessment outcomes (see Terms of Reference, Appendix IXa below). 6.4 Stock assessment priorities – detailed review of the existing data sources, including:	Medium Medium	Consultant and CPCs directly Consultant and CPCs directly		X	X	X	X	X

Topic	Sub-topic and project		Priority ranking	Lead	Est. budget (potential source)	TIMING				
						2018	2019	2020	2021	2022
		i. *Size frequency data: Evaluation of the reliability of length composition from the longline fisheries (including recent and historical data), review of anomalies in the (EU) PS length composition data, and the need for a thorough review of the size frequency data held by IOTC, in collaboration with the fleets involved, to improve the utilization of these data in tropical tuna stock assessments.* ii. *Tagging data: Further analysis of the tag release/recovery data set.* iii. *Alternative CPUE series: a review of the available data from the Indian tuna longline survey data.*								
7. Fishery independent monitoring	7.1	Develop fishery independent estimates of stock abundance to validate the abundance estimates of CPUE series. All of the tropical tuna stock assessments are highly dependent on relative abundance estimates derived from commercial fishery catch rates, and these could be substantially biased despite efforts to standardise for operational variability (e.g. spatio-temporal variability in operations, improved efficiency from new technology, changes in species targeting). Accordingly, the IOTC should continue to explore fisheries independent monitoring options which may be viable through new technologies. There are various options, among which some are already under test. Not all of these options are rated with the same priority, and those being currently under development need to be promoted, as proposed below: i. Acoustic FAD monitoring, with the objective of deriving abundance indices based on the biomass estimates provided by echo-sounder buoys attached to FADs ii. Longline-based surveys (expanding on the Indian model) or “sentinel surveys” in which a small number of commercial sets follow a standardised scientific protocol	 High High	Consultant and CPCs directly	US$?? (TBD) US$60K US$?? (TBD)					

Topic		Sub-topic and project		Priority ranking	Lead	Est. budget (potential source)	TIMING 2018	2019	2020	2021	2022
		iii.	Aerial surveys, potentially using remotely operated or autonomous drones	Medium							
		iv.	Studies (research) on flux of tuna around anchored FAD arrays to understand standing stock and independent estimates of the stock abundance.	Medium							
		v.	Genetics-based tagging techniques using recaptured individuals or identification of close-related pairs. Use of Close Kin Mark Recapture (CKMR) methods to study fishery independent methods of generating spawner abundance estimates based on genotyping individuals to a level that can identify close relatives (e.g. parent-offspring or half-siblings). The method avoids many of the problems of conventional tagging, e.g. live handling is not required (only catch needs to be sampled), tag shedding, tag-induced mortality and recovery reporting rates are irrelevant. It has been cost-effective in a successful application to southern bluefin tuna, but it remains unknown how the cost scales with population size. It would be valuable to conduct a scoping exercise to evaluate the applicability to the tropical tuna species	Medium							
8	Target and Limit reference points	8.1	To advise the Commission, on Target Reference Points (TRPs) and Limit Reference Points (LRPs). 8.1.1 Used when assessing tropical tuna stock status and when establishing the Kobe plot and Kobe matrices	High	CPC's directly	US$?? (TBD)					

Table 2. Assessment schedule for the IOTC Working Party on Tropical Tunas (WPTT)

Species	**2018**	**2019**	**2020**	**2021**	**2022**
Bigeye tuna	Indicators	**Full assessment**	Indicators	Indicators	**Full assessment**
Skipjack tuna	Indicators	Indicators	**Full assessment**	Indicators	Indicators
Yellowfin tuna	**Full assessment**	Indicators	Indicators	**Full assessment**	Indicators

APPENDIX IXa. TERMS OF REFERENCE FOR THE PROVISION OF SCIENTIFIC SERVICES TO THE IOTC: TAG MODELLING PROJECT

Aim: To develop a preliminary spatially explicit operating model of the tropical tuna population for potential use in evaluating assessment bias

Objectives:

1. **To develop a spatially explicit operating model of the tropical tuna population.**
2. **To use the model to simulate data sets for evaluating assessment bias.**

Scientific Methods:

The extent and nature of bias resulting from mixing and movement assumptions in tag data remains a key uncertainty in stock assessment. In particular, it has been recommended that plausible spatial movement models be developed in order to address concerns about the level and nature of the bias that could result from non-homogeneous mixing assumptions of tagged fish.

Dunn & Rasmussen developed a generalised spatially explicit Bayesian statistical catch-at-age population dynamics model for developing and investigating plausible spatial movement models (SPM Manual). Mormede et al. (2014) applied this model to Antarctic toothfish in the Ross Sea as an age and maturity state spatial movement model.

The Project is proposing a similar approach, applied to tropical tunas, dependent on the availability of biological parameters for the tuna species of interest as well as the following data layers:

- Environmental predictor layers (e.g., surface temp, depth of mixed layer, currents, chlorophyll, etc.) by cell for developing preference functions.
- Historical catch history by cell
- Historical CPUE by cell
- Historical tag releases and recaptures by cell
- Age (length?) composition by cell??

Indicative costs and timing

~400 hours (approx. US$70-80k, excluding travel costs) to design a preliminary model up and testing – dependent on on the environmental layers and other data layers being readily available.

Timescale

July – November 2018

APPENDIX IXb. TERMS OF REFERENCE: PROTOCOLS FOR DEVELOPING AN INDEX OF ABUNDANCE BASED ON PURSE SEINE SPECIES COMPOSITION

The following ToR proposes the development of an alternative approach to deriving an index of abundance for skipjack tuna. This method avoids the problem of increasing fishing power that afflicts purse seine CPUE. Work should be carried out to assess and develop the potential of this new method to provide an index or indicator of relative abundance for skipjack tuna.

Background

Stock assessments rely heavily upon indices of abundance, and assessing the Indian Ocean skipjack tuna stock is made difficult by the lack of a reliable long-term index. An index based on the purse seine fishery is desirable, but purse seine CPUE is problematic because the unit of effort is difficult to define. This is because 1) fishing is divided between drifting logs/FADs and free school sets, in proportions that change with various other factors, and it is difficult to allocate a vessel's search effort among set types; 2) search is conducted by purse seiners, support vessels, and FADs (including information provided by echo-sounders), making it more difficult to identify an appropriate unit of search effort; 3) technological change in many aspects of the fishery has dramatically increased fishing power through time; and 4) fish aggregate around FADs, and vessels share information and follow the aggregations, so that the relationship between purse seine catch rates and abundance may be hyperstable.

A CPUE index for the Maldivian pole and line fishery has been developed, but is affected by the small spatial extent of the fishery, variable data quality, and unknown levels of technology change.

An alternative index of abundance for skipjack has been proposed based on purse seine species composition (Maunder and Hoyle 2007), which would avoid the problem of defining a unit of effort. The method was considered by the 16th WPTT, which urged that it be further evaluated.

The WPTT NOTED additional information presented on standardisation of species composition from purse seine catches which included a novel approach to addressing some of the difficulties with using purse seine CPUE.
The WPTT URGED that the methodology be further evaluated and presented at future WPTT meetings.
The WPTT NOTED that the approach showed a reduction in the proportion of skipjack tuna in recent years. However, this proportion will be affected with changes in the abundance of other species, in particular yellowfin tuna. To obtain an index of skipjack tuna abundance it is necessary to incorporate independent estimates of yellowfin tuna abundance of the appropriate size.

To develop this approach, a work plan with some protocols is defined below. These are meant to be guidelines and analysts could use these or some other measures to examine these effects.

Data availability

The European and associated flags purse seine fishing activities have been monitored by the Institut de Recherche pour le Développement (IRD), the Instituto Espanol de Oceanografia (IEO) and the Seychelles Fishing Authority (SFA) in the Indian Ocean during 1981-2014 through the collection of logbook, well maps, and records of unloading and transhipment. Multispecies sampling has been implemented since the early 1980s and is considered to be consistent since 1991. It consists of simultaneous sampling to estimate both size and species composition of the catch. The sampling is carried out during the unloading of purse seiners at fishing ports and involves a 2-step approach: (i) the wells are selected from among those containing homogeneous strata (i.e. large spatial areas, quarter and fishing mode) and (ii) fish are randomly selected, within size category, from the wells and counted and/or measured following a specific protocol. Samples combined with species-specific length-weight relationships are then used to estimate the size and species composition of the catch in each stratum.

Operational fisheries data and size-frequency samples would be made available for the modelling approach under a confidentiality agreement between the Institutes and the IOTC.

Protocols

1) Obtain data inputs, which include set by set purse seine effort and catch data, from both the commercial logbooks and the multispecies catch sampling; with detailed information describing the operational characteristics of each set and the vessel characteristics; and the stock assessment output files for bigeye and yellowfin tuna assessments using Stock Synthesis or MULTIFAN-CL.
2) Explore the operational data including relationships between species composition and covariates at multiple spatial and temporal scales, using appropriate statistical techniques. Develop methods to provide a standardized temporal index of the proportion of skipjack in the catch, for both FAD sets and free school sets. Extract the temporal components.
3) Estimate the trend of skipjack relative abundance by adjusting the skipjack species composition time series according to the estimated vulnerable biomass trends of yellowfin and bigeye tuna.
4) Validate the performance of the method by developing indices for yellowfin and bigeye tuna in purse seine catches for historical periods with well-estimated vulnerable biomass trends.

Budget

An indicative budget of USD 55,000 is estimated for delivery of the project outputs.

To conduct analyses towards addressing the issues identified above, an estimated budget is provided in Table 1. The consultant will work for 15 weeks on purse seine data from the European Union, and the latest stock assessments for Indian Ocean bigeye and yellowfin tunas, and present the results at the subsequent Working Party on Tropical Tunas.

References

Maunder, Mark N., and Simon D. Hoyle. "A novel method to estimate relative abundance from purse-seine catch- per-set data using known abundance of another species." *Inter-Amer. Trop. Tuna Comm., Stock Assessment Report* 7 (2007): 283-297.

APPENDIX X
CONSOLIDATED RECOMMENDATIONS OF THE 19TH SESSION OF THE WORKING PARTY ON TROPICAL TUNAS

Note: Appendix references refer to the Report of the 19th Session of the Working Party on Tropical Tunas (IOTC–2016–WPTT19–R)

Review of the statistical data available for tropical tunas

WPTT19.01 (para. 20): **ACKNOWLEDGING** the substantial gaps in reporting of mandatory IOTC datasets by many CPCs to the IOTC Secretariat, which increases the uncertainty of stock assessments and management advice based on these data, the WPTT strongly **RECOMMENDED** the Commission strengthen the penalty mechanisms adopted in *Resolution 16/06 On measures applicable in case of non-fulfilment of reporting obligations in the IOTC* to improve compliance by CPCs in terms of the submission of basic fishery data in accordance with Resolution 15/01 and 15/02.

Testing designs of Biodegradable FADs in natural conditions to mitigate the impacts of drifting FADs on the Ecosystem

WPTT19.02 (para. 73): The WPTT **NOTED** that WPEB (2017) discussed some of the challenges in conducting biodegradable FAD studies (for example the limit on the number of active FADs per purse seine vessel in the Indian Ocean that may hinder the deployment of BIOFADs following experimental sampling designs, and also engagement with the fleet to deploy BIOFADs that may not be successful for fishing), and the WPTT **RECOMMENDED** the Commission consider special allocations for experimental FADs deployed for the collection of scientific data for vessels willing to participate in biodegradable FAD testing under protocols reviewed and endorsed by the Scientific Committee.

Review of new information on the status of bigeye tuna: Nominal and standardised CPUE indices

WPTT19.03 (para. 107): The WPTT **ACKNOWLEGED** the efficiency value of making the operational logbook data available to appropriate analysts outside of the responsible CPCs, and **RECOMMENDED** that high level arrangements for sharing and confidentiality should be pursued. **NOTING** the confidentiality issues with some of the datasets, the WPTT **REQUESTED** that the IOTC Secretariat and main stakeholders explore options to facilitate future data sharing agreements which, once in place, may not necessitate face-to-face meetings and could instead include remote processes.

WPTT19.04 (para. 108): The WPTT **RECOMMENDED** that the joint longline CPUE standardization for tropical tunas should continue, and that further development work should be assigned a high priority. **ACKNOWLEDGING** that the law of diminishing returns will affect similar future analyses, the WPTT **SUGGESTED** that immediate priorities should focus on the following areas:

- develop joint CPUE indices for other IOTC species (i.e., billfish and sharks);
- explore possibilities for including CPUE data provided by other IOTC CPCs (particularly coastal fisheries);
- identify a unified approach for species targeting using simulation testing (for example, the value of cluster analysis is clear in the temperate regions, but less so in tropical regions);
- recover vessel identification details from historical data;
- further develop the work on time-area interactions. Include a detailed examination of catch rates and related data in the piracy area, comparing pre-piracy and post-piracy effects. Potentially also consider the effects of localised depletion and renewal processes on catch rates.
- conduct further size analyses to explore 1977 discontinuity (other oceans);
- develop an Indian Ocean CPUE reference manual for practitioners to use
- explore other distributions to improve model fit.

Development of management advice for skipjack tuna & update of skipjack tuna Executive Summary for the consideration of the Scientific Committee

WPTT19.05 (paras. 212-214): The WPTT **NOTED** that when providing advice on stock status, IOTC stocks are considered to be overfished and subject to overfishing when the target reference points are breached, and there is no change to stock status when limit reference points are breached.

The WPTT **NOTED** that this may not always be consistent with the intended application of target and limit reference points. For example, when managing stocks to a specific target reference point, the stock can breach the target in some years due to natural fluctuations in stock abundance or other sources of variability. In these years, the stock would be assessed as being overfished and/or subject to overfishing.

The WPTT therefore **RECOMMENDED** that the Scientific Committee review the approach used to provide management advice, particularly in relation to how the outcomes from stock assessments are reported against target and limit reference points.

Parameters for future analyses: Yellowfin tuna CPUE standardisation and stock assessments

WPTT19.06 (paras. 227): The WPTT reiterated its previous **RECOMMENDATION** that development of the next stock assessment of yellowfin tuna should include, or be associated with, a detailed review of the existing data sources, including:

i. Size frequency data: Evaluation of the reliability of length composition from the longline fisheries (including recent and historical data), review of anomalies in the (EU) PS length composition data, and the need for a thorough review of the size frequency data held by IOTC, in collaboration with the fleets involved, to improve the utilization of these data in tropical tuna stock assessments.

ii. Tagging data: Further analysis of the tag release/recovery data set.

iii. Alternative CPUE series: a review of the available data from the Indian tuna longline survey data.

Revision of the WPTT Program of Work (2018–2022)

WPTT19.07 (paras. 239): The WPTT **RECOMMENDED** that the SC consider and endorse the WPTT Program of Work (2018-2022), as provided at Appendix IX.

Review of the draft, and adoption of the Report of the 19th Session of the WPTT

WPTT19.08 (para. 248) The WPTT **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPTT19, provided at Appendix X, as well as the management advice provided in the draft resource stock status summary for each of the three tropical tuna species under the IOTC mandate, and the combined Kobe plot for the three species assigned a stock status in 2017 (**Fig.7**):

- Bigeye tuna (*Thunnus obesus*) – Appendix VI
- Skipjack tuna (*Katsuwonus pelamis*) – Appendix VII
- Yellowfin tuna (*Thunnus albacares*) – Appendix VIII