Food and Agriculture Organization of the United Nations

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

Report of the 20th Session of the IOTC Working Party on Tropical Tunas

Seychelles, 29 October – 3 November 2018

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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 20th Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Tropical Tunas (WPTT) was held in Seychelles, from 29 October – 3 November 2018. 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 57 participants attended the Session (49 in 2017, 44 in 2016), including the invited expert Dr. Rishi Sharma (NOAA).

The following are a subset of the complete recommendations from the WPTT20 to the Scientific Committee, which are provided at Appendix X.

Review new information on fisheries and associated environmental data

WPTT20.01 (para. 81): The WPTT **ACKNOWLEDGED** the importance of the proposed harmonisation of FOB types and FOB activity definitions and **RECOMMENDED** that the concept of harmonisation be taken up by the WPDCS and Scientific Committee with the aim of harmonising IOTC definitions with those used by other tRFMOs in the context of the joint tRFMO Working Group on FADs.

Review of the statistical data available for skipjack tuna

WPTT20.02 (para. 129): The WPTT **NOTED** that total catches in 2017 (524,282 t) were more than 10% higher than the catch limit generated by the Harvest Control Rule (470,029 t) which applies to the years 2018–2020, and that there has been an increasing trend in catches over the past 3 years. The WPTT **RECOMMENDED** that the Scientific Committee advise the Commission of the urgent need to monitor catches of skipjack in the 2018–2020 period to ensure catches do not exceed the limit.

Review of new information on the status of yellowfin tuna

WPTT20.03 (para. 200): The WPTT **RECOMMENDED** the continuation of CPUE standardization analyses as this is a critical input to the bigeye tuna and yellowfin tuna stock assessments .

Yellowfin tuna: Stock Assessments

WPTT20.04 (para. 222): The WPTT **RECOMMENDED** that the in the future, model diagnostics, including retrospective analyses, jittering and likelihood profiling be conducted to increase confidence that the models are reaching a global minima during fitting and to look for major conflict in data sources.

Future yellowfin assessments: issues for consideration

WPTT20.05 (para. 225): 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.

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

Development of management advice for yellowfin tuna

WPTT20.06 (paras. 228): The WPTT **RECOMMENDED** that final management advice be developed from the SS3 models including the reference grid given a relative weight of 75% to Q1 CPUE scenario compared to 25 % weight to Q2 in the grid results. The estimates from the grid are provided in Table 3 While the biomass and reference point trajectories are included in Figure 1. The Kobe strategy matrix derived from the 24 models in the grid is provided in Figure 2. These results indicate that the stock is currently overfished and subject to overfishing

Revision of the WPTT Program of Work (2019–2023)

WPTT20.07 (paras. 253): The WPTT **RECOMMENDED** that the SC consider and endorse the WPTT Program of Work (2019-2023), as provided at Appendix IX.

Review of the draft, and adoption of the report of the 20th session of the WPTT

WPTT20.08 (para. 263): The WPTT **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPTT20, 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 2018 (Fig.7):

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

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

Stock	Indicators		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Advice to the Commission
Bigeye tuna *Thunnus obesus*	Catch in 2017: Average catch 2013–2017: 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):	90,050 t 95,997 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 2018, thus, the stock status is determined on the basis of the 2016 assessment and other indicators presented in 2018. On the weight-of-evidence available in 2018, 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 2017: Average catch 2013–2017: 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):	524,282 t 454,103 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%** **			No new stock assessment was carried out for bigeye tuna in 2018, thus, stock status is determined on the basis of the 2016 assessment and other indicators presented in 2018.. 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 2018, the skipjack tuna stock is determined to be **not overfished** and is **not subject to overfishing**. However it should be noted that that total catches in 2017 (524,282 t) were more than 10% higher than the catch limit generated by the Harvest Control Rule (470,029 t) which applies to the years 2018–2020 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 2017: Average catch 2013–2017: MSY (1000 t) (plausible range):	409,101,282 t 399,830 t 403 (339–436)							**94%** **	**68%** **		**94%** **	A new stock assessment was carried out for yellowfin tuna in 2018, thus, the stock status is determined on the basis of the 2018 assessment integrated across of grid of 24 model runs. On the

	F_{MSY} (plausible range): SB_{MSY} (1,000 t) (plausible range): F_{2017}/F_{MSY} (plausible range): SB_{2017}/SB_{MSY} (plausible range): SB_{2017}/SB_0 (plausible range):	0.17 (0.13–0.17) 1069 (789–1387) 1.20 (1.00–1.71) 0.83 (0.74–0.97) 0.30 (n.a.–n.a.)											weight-of-evidence available in 2017, 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 20th Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Tropical Tunas (WPTT) was held in Seychelles, from 29 October – 3 November 2018. 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 57 participants attended the Session (49 in 2017, 44 in 2016), 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 WPTT20 are listed in Appendix III.

3. The WPTT **ACKNOWLEDGED** a statement made on behalf of Mauritius. This statement is included in Appendix XI.

3. The IOTC process: Outcomes, updates and progress

3.1 Outcomes of the 20th Session of the Scientific Committee

4. The WPTT **NOTED** paper IOTC–2018–WPTT20–03 which outlined the main outcomes of the 20th Session of the Scientific Committee (SC20), specifically related to the work of the WPTT, and **AGREED** to consider how best to progress these issues at the present meeting.

5. The WPTT **NOTED** that in 2017, the SC made a number of requests in relation to the WPTT19 report (noting that updates on Recommendations of the SC20 are dealt with under Agenda item 3.4 below). Those requests are provided here for reference and the associated responses from the WPTT20 are provided herein.

- ***Review of new information on the status of bigeye tuna: Nominal and standardised CPUE indices***
    - *(Para. 78) The SC acknowledged 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 SC **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.*
- ***Skipjack stock assessment***
    - *(Para. 81) The SC noted the annual 1% increase in fishing effort that was used to represent the effort creep in the purse seine CPUE analysis since 1995, and **REQUESTED** that the WPTT explore alternative methods of incorporating effort creep in future.*

      *The SC noted the Recommendation from TCMP01, which was subsequently **ENDORSED** by the Commission (S21) that:*

      "When establishing a catch limit for skipjack tuna using the Harvest Control Rule (HCR) adopted in Resolution 16/02, the following procedure will be applied: after the review of the assessment of skipjack tuna by the SC, the result of the assessment will be used by the SC in the calculation of a catch limit using the adopted HCR. The Secretariat will then notify CPCs of the new catch limit for skipjack tuna that will apply for 2018" (IOTC-2017-S21-R, Para. 56).

The SC noted that catches of skipjack in recent years are close to the recommended annual catch limit from the HCR, and ***RECOMMENDED*** *that the Commission encourage CPCs to closely monitor catches of skipjack tuna to ensure that the integrity of the catch limit is maintained.*

- ***Parameters for future analyses: Yellowfin tuna CPUE standardisation and stock assessments***
  - *(Para. 89) The SC* ***AGREED*** *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), incorporation of unraised samples in addition to the already provided extrapolated EU purse seiners, thorough review of the other 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.*
- ***Update on the status of the joint CPUE indices (yellowfin tuna, bigeye tuna and albacore)***
  - *(Para. 100) The SC recognised the importance of normalizing these procedures and approaches into the various Working Party stock assessments making use of longline catch rate indices,* ***ENDORSED*** *such joint analyses, and* ***RECOMMENDED*** *these continue into the future as a normal course of business. It was noted that additional time for more detailed analysis is still needed and SC* ***REQUESTED*** *that methods to increase analysis time, such as the use of secure, cloud-based data exchange and increased use of electronic communication between analysts be investigated.*
- ***Resolution 17/01 on an interim plan for rebuilding the Indian Ocean yellowfin tuna stock***
  - *(Para. 109) The SC* ***REQUESTED*** *that collaborative work is carried out by different purse seine fleets active in the Indian Ocean, so as to increase the frequency of production of corrected estimates of yellowfin tuna catches to monitor yellowfin quota consumption and* ***REQUESTED*** *the WPTT and WPM to investigate additional or complementary management measures (e.g., input control measures) for purse seiners and other gears that will facilitate the control and monitoring of the management measures adopted by IOTC.*
- ***Development of management advice***
  - *(Para. 133) The SC* ***REQUESTED*** *that the agreed IOTC* Guidelines for the presentation of CPUE standardisations and stock assessment models *are used in future by all authors presenting CPUE analyses to the WPs.*
  - *(Para. 137) The SC* ***AGREED*** *that analysis should be carried out to evaluate potential retrospective patterns in stock assessments, noting that this can have a great impact on the stock assessment quality and is already part of the advice in the* IOTC Guidelines for the presentation of CPUE standardisations and stock assessment models *which states:*
    - "Alternative scenarios and retrospective analyses should ideally be carried and, if included, a description of the motivation for the selection of base and alternative cases should be added, giving detail of how the alternative case assumptions differ from those of the base case" (Appendix I, IOTC–2014–SC17–06).

  - *(Para. 138) The SC noted the current format of the KOBE II Strategy Matrix can provide information that is of very coarse resolution and* ***AGREED*** *that the projections are based on catches which vary in intervals of 5% instead of the current 10%, especially around the values close to the 50% probability. The SC further* ***REQUESTED*** *that the tables are extended to ensure that an appropriate range is covered to enable management advice to be provided based on a 50% probability. The SC* ***REQUESTED*** *that the performance of catch projection be evaluated retrospectively to ensure the quality of risk analysis in developing management advice.*
  - *(Para. 139) The SC further* ***REQUESTED*** *that IOTC Working Parties ensure that the advice in paras. 137 and 138 is followed for future assessments and* ***REQUESTED*** *that the WPM update the guidelines for stock assessment*[1] *developed by the SC in 2015 to reflect this.*
- ***Biodegradable FAD (BIOFAD) Project***
  - *(Para. 164) Noting that IOTC, along with other tuna RFMOs, recommended and adopted resolutions to promote reduction of the amount of synthetic marine debris by the use of natural or biodegradable materials for drifting FADs, the SC* ***ENDORSED*** *this large-scale project to test the use of biodegradable materials and designs for the construction of drifting FADs in natural environmental conditions. The SC* ***REQUESTED*** *the project to present the outcomes of the at sea trials to the next WPEB, WPTT and SC meetings.*
- ***Program of Work (2018–2022) and assessment schedule***
  - *(Para. 206) The SC* ***AGREED*** *on the consolidated table of priorities across all Working Parties, as developed by each WP Chair, and* ***REQUESTED*** *that the IOTC Secretariat, in consultation with the Chair and vice-Chair of the SC and relevant Working Parties, develop ToRs for the specific projects to be carried out (Table 4).*
- ***Invited experts***
  - *(Para. 211) The SC* ***REQUESTED*** *that at least one 'Invited Expert' be brought to each of the science Working Parties in 2018 and in each subsequent year, so as to further increase the capacity of the Working Parties to undertake the work detailed in the Program of Work.*

3.2 Outcomes of the 22nd Session of the Commission

6. The WPTT **NOTED** paper IOTC–2018–WPTT20–04 which outlined the main outcomes of the 22nd 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.

7. The WPTT **NOTED** the 10 Conservation and Management Measures (CMMs) adopted at the 22nd Session of the Commission (consisting of 10 Resolutions and 0 Recommendations) as listed below:

IOTC Resolutions

- Resolution 18/01 *On an interim plan for rebuilding the Indian Ocean yellowfin tuna stock in the IOTC Area of Competence.*

[1] The SC further **REQUESTED** that IOTC Working Parties ensure that the advice in paras. 137 and 138 is followed for future assessments and **REQUESTED** that the WPM update the guidelines for stock assessment (http://iotc.org/documents/guidelines-presentation-cpue-standardisations-and-stock-assessment-models-1) developed by the SC in 2015 to reflect this.

- Resolution 18/02 *On management measures for the conservation of blue shark caught in association with IOTC fisheries.*
- Resolution 18/03 *On establishing a list of vessels presumed to have carried out illegal, unreported and unregulated fishing in the IOTC Area of Competence.*
- Resolution 18/04 *On bioFAD experimental project.*
- Resolution 18/05 *On management measures for the conservation of billfish, striped marlin, black marlin, blue marlin and Indo-Pacific sailfish.*
- Resolution 18/06 *On establishing a programme for transshipment by large scale fishing vessels.*
- Resolution 18/07 *On measures applicable in case of non-fulfilment of reporting obligations to the IOTC.*
- Resolution 18/08 *Procedures on a fish aggregating devices (FADs) management plan, including a limitation of the number of FADs, more detailed specifications of catch reporting from FAD sets, and the development of improved FAD design to reduce the incidence of entanglement of non-target species.*
- Resolution 18/09 *On a scoping study of socio-economic indicators of IOTC fisheries.*
- Resolution 18/10 *On vessel chartering in the IOTC Area of Competence.*

8. 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 2018–26 (i.e., **7 June 2018**).

9. **NOTING** that the Commission also made a number of general comments and requests on the recommendations made by the Scientific Committee in 2017, which have relevance for the WPTT (details as follows: paragraph numbers refer to the report of the Commission (IOTC–2018–S22–R): the WPTT **AGREED** that any advice to the Commission would be provided in the relevant sections of this report, below.

- ***Report of the 20th Session of the Scientific Committee***
  - *(Para. 26) The Commission **NOTED** the stock status summaries for species of tuna and tuna-like species under the IOTC mandate, as well as other species impacted by IOTC fisheries (Appendix 5 IOTC–2018-S22-RE) and considered the recommendations made by SC20 in its report that related specifically to the Commission. The Commission **ENDORSED** the SC 2017 list of recommendations as its own, noting the additional activities requested by the Commission at this meeting.*
- ***On the status of tropical and temperate tunas***
  - *(Para. 29) 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 revised the interim rebuilding plan for this stock through Resolution 17/01, 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 2018 assessment.*

***Skipjack tuna**: A skipjack assessment was carried out in 2017. The stock is not overfished and not subject to overfishing. A model grid was used to characterize the uncertainty in the assessment related to growth, tag mixing period, tagging programs, natural mortality, steepness and tag-release mortality. The median value of the distribution of spawning biomass relative to the unfished spawning biomass from the stock assessment was used by the Scientific Committee to calculate the overall skipjack catch limit for Indian Ocean, based on the Harvest Control Rule as established through Resolution 16/02. The IOTC Secretariat has informed the CPCs of the catch limit to be implemented for 2018–2020.*

- ***Consideration of management measures relevant to tropical and temperate tunas***
  - *(Para. 30) The Commission **CONSIDERED** working paper IOTC–2018–S22–08 by the European Union and **REQUESTED** the Scientific Committee to review the effect of the revised interim plan for rebuilding yellowfin tuna in the IOTC Area (Resolution 17/01) as amended in the proposal.*
  - *(Para. 31) The Commission **NOTED** that the revised interim rebuilding plan in Resolution 17/01 On an interim plan for rebuilding the Indian Ocean yellowfin tuna stock in the IOTC area of competence, which directs the Working Party on Tropical Tunas of the Scientific Committee to evaluate the effectiveness of the measures contained in the resolution, taking into account all sources of fishing mortality and possible alternatives aimed to restore and maintain biomass levels at the target levels, as stipulated in IOTC Resolution 15/10 On target and limit reference points and a decision framework.*

- ***Consideration of management measures related to all species***
  - *(Para. 52) The Commission **ADOPTED** Resolution 18/08* On 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 Design to Reduce the Incidence of Entanglement of Non-Target Species.
  - *(Para. 53) The Commission **ADOPTED** Resolution 18/01* On an interim plan for rebuilding the Indian Ocean yellowfin tuna stock in the IOTC Area of Competence. *The Commission also **AGREED**, notwithstanding paragraph 3 c) iii of Resolution 18/01, to grant a special approval for Japan to register one support vessel.*
  - *(Para. 54) The Commission **AGREED** to defer IOTC–2018–S22–PropD and PropJ* On a Regional Observer Scheme. *The proponents of these proposals attempted to merge the two proposals; however, they agreed more work needed to be done to reach a consensus and indicated that a revised proposal will be submitted to the next session of the Commission.*

- ***Development of management procedures – report of the Technical Committee on Management Procedures***
  - *(Para. 69) The Commission **NOTED** the report (IOTC–2018–TCMP–02–R) from the 2nd meeting of the Technical Committee on Management Procedures (TCMP) and **ENDORSED** its recommendations.*
  - *(Para. 70) The Commission **NOTED** the success of the TCMP in engaging discussions on Management Procedures through the use of interactive tools.*
  - *(Para. 71) The Commission **NOTED** the importance of the work of the TCMP and in addressing MSE issues. The Commission further **NOTED** the TCMP workplan for 2019–2020 and the proposed budget of approximately US$91,500 and **EXPRESSED** its support for this work to continue, provided there is no increase in overall*

Commission budget. To this end, the Commission ***REQUESTED*** *the IOTC Secretariat to seek sources of extra-budgetary funds to support the proposed work.*

- *(Para. 72) The Commission* ***NOTED*** *that the other tuna RFMOs are also undertaking work on management procedures and encouraged the TCMP to hold a dialogue with the t-RFMOS to ensure an exchange of information and to avoid duplication of work.*
- *(Para. 73) The Commission* ***NOTED*** *the importance of data quality in developing management procedures and* ***RECOMMENDED*** *that the longline CPUE data for swordfish be made available and jointly standardized.*
- *(Para. 74) The Commission* ***NOTED*** *that the Harvest Control Rule was implemented for skipjack tuna through Resolution 16/02 and* ***ENCOURAGED*** *CPCs to begin to develop management proposals for other IOTC species that are based on TCMP outputs and advice once the results of the current MSE analyses are reviewed and endorsed.*
- *(Para. 75) The Commission* ***PROVIDED*** *directions on management objectives and guidance on the specifics of the risks and probabilities the Commission might want to consider to achieve its management objectives.*

3.3 Review of Conservation and Management Measures relating to tropical tunas

10. The WPTT **NOTED** paper IOTC–2018–WPTT20–05 which aimed to encourage participants at the WPTT20 to review the existing Conservation and Management Measures (CMM) relevant to tropical tunas, noting the CMMs contained in document IOTC–2018–WPTT20–04; 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.
11. 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 WPTT19

12. The WPTT **NOTED** paper IOTC–2018–WPTT20–06, which provided an update on the progress made in implementing the recommendations of the WPTT19, and the requests of SC20, taking into consideration the recommendations from the SC and decisions of the Commission, and **AGREED** to consider and revise as necessary, the recommendations, and for these to be combined with any new recommendations arising from the WPTT20, noting that these will be provided to the SC for its endorsement.
13. The WPTT **NOTED** that Japan is considering the possibility of submitting historical size-data for its longline fleet (for 2008 and previous years) as 5x5 instead of 10x20 degrees grids, as these are currently available to the IOTC Secretariat.

3.5 Outcomes of the 2nd Technical Committee on Management Procedures

14. The WPTT **NOTED** paper IOTC–2018–WPTT20–07, which informed WPTT20 of the general recommendations to the Commission arising from the 2nd Session of the IOTC Technical Committee on Management Procedures (TCMP02), specifically relating to the work of the WPTT, and **CONSIDERED** how best to progress these issues at the present meeting. Recommendations relevant to the WPTT are included below:

Discussion of the actions needed for next iteration of management procedure development

- *(Para. 45)* The TCMP **AGREED** that the definition of status is a complex issue and **RECOMMENDED** discussions on potential refinements to the KOBE plots and definitions of "overfished" and "overfishing" in relation to target and limit reference points to be conducted in collaboration with other t-RFMO, ideally through the KOBE process.

- *(Para. 46)* The TCMP **RECOMMENDED** that this issue is also discussed within the SC.
- *(Para. 47)* The TCMP **RECOMMENDED** that the longline CPUE data be available and joint standardization be conducted in the future to support the MP (CPUE-based and model based) for different stocks on which these data are critical (ALB, BET, YFT, SWO).

Yellowfin tuna

- *(Para. 49)* The TCMP **RECOMMENDED** to retain tuning objective TY 5, as well as to examine a number of alternative simulation/projection timeframe (to rebuilding targets at 2024, 2029 and 2034). The TCMP also **AGREED** to also investigate alternative TAC constraints.

Bigeye tuna

- *(Para. 53)* The TCMP **RECOMMENDED** a revised set of tuning objectives based on TB2, TB3, TB4 that is calculated over 2030-2034.

Work Plan

- *(Para. 59)* The TCMP **NOTED** that the budget for progressing the work on MSE agreed by the Commission is not secured. Thus, the TCMP **RECOMMENDED** that Commission considers reviewing the budget for 2019 adopted by SCAF to include the work of MSE provided that total budget approved by SCAF is not increased.
- *(Para. 60)* Moreover, the TCMP **RECOMMENDED** that SC identify the budget related to the progress on MP/MSE work for all species in its report so as SCAF can review to include in Commission regular budget to complete the workplan on MSE agreed by the Commission in 2017.

4. New Information on Fisheries and Associated Environmental Data Relating to Tropical Tunas

4.1 Review of the statistical data available for tropical tunas

15. The WPTT **NOTED** paper IOTC–2018–WPTT20–08 which provided a review of the statistical data and fishery trends for tropical tunas received by the IOTC Secretariat, in accordance with IOTC Resolution 15/02 Mandatory statistical reporting requirements for IOTC Contracting Parties and Cooperating Non-Contracting Parties (CPCs), for the period 1950–2017. 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 supporting information for the WPTT is provided in Appendix IV.

16. 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.

17. The WPTT **NOTED** issues with alternative catch series that were being considered and queried the implications for the Management Strategy Evaluation (MSE) processes, particularly for yellowfin tuna and skipjack tuna. The WPTT **ACKNOWLEDGED** the complexity of this issue and **NOTED** that uncertainties relating to reconstruction of catch histories were not decreasing

over time. The WPTT **NOTED** that these issues would be explored further throughout the meeting.

18. The WPTT **NOTED** efforts by Indonesia and Pakistan to develop tuna markets in the United States and that market data, including import statistics, may be useful for validating catch data.

19. The WPTT **NOTED** that there are ongoing issues with late reporting and non-reporting by CPCs, which leads to issues of data availability and currency in assessments and requires catches to be assumed from previous years, and strongly **ENCOURAGED** CPCs to report their data in accordance with Resolution 15/02.

20. The WPTT **NOTED** the large increase in the Indonesian yellowfin tuna catch and queried whether this may be a result of error in data entry or reporting. Indonesia clarified that data verification was needed and an update on this would be included in their national report to SC21.

21. The WPTT **NOTED** that much of the work on reconstruction of catch histories has been focused on recent years and decades and has often resulted in higher catches than have previously been estimated, and **NOTED** that this has implications for stock assessment outcomes. The WPTT **NOTED** that confidence around the older data remained low and underreporting was likely in earlier years, although the scale of underreporting varies by species and fishery. The WPTT also **NOTED** that differences in reporting rates over the history of the fishery could result in a biases that may influence stock assessment outcomes.

22. The WPTT **NOTED** that it may be beneficial to include a sensitivity run in the yellowfin tuna stock assessment that investigates the potential bias due to the uncertainties in the catch estimates, which would enable comparison of results with the standard approach that uses the reconstructed catch histories estimated by the IOTC Secretariat. The WPTT further **NOTED** that this approach was not undertaken during the 2018 yellowfin tuna assessment. The WPTT **NOTED** that such an approach may require additional calculations.

23. The WPTT **NOTED** the update provided by the IOTC Secretariat on the implementation of Resolution 18/01 *On an interim plan for rebuilding the Indian Ocean yellowfin tuna stock*, and that many of the fisheries subject to catch reductions had achieved either a partial or full decrease in catches in 2017 in accordance with the levels of reductions specified in the Resolution.

24. The WPTT further **NOTED**, however, that total catches of yellowfin tuna in 2017 increased by 3% from 2014/2015 levels, as the decrease in catches by fisheries subject to Resolution 18/01 were offset by increases in the catches from gillnet and other coastal fisheries exempt from limitations on their catches of yellowfin tuna (Table 1) – for example, Pakistan (gillnetters), Mauritius (purse seiners), Oman (gillnetters and handline), and I.R. Iran (coastal longliners).

Table 1: Catches of YFT in relation to the implementation of Resolution 18/01.

Purse seine fleets		Target: catch reduction from baseline	2014	2015	2016	2017	% change from 2014
Subject to Resolution 18/01	EU	-15%	91,405	86,149	87,075	86,893	-5%
	Rep. of Korea		8,852	7,509	10,347	6,362	-28%
	Seychelles		*39,072**	39,072	40,014	41,694	7%
	Sub-total		**139,329**	**132,730**	**137,437**	**134,949**	**-3%**
Exempt from Resolution 18/01	I.R. Iran	N/A	4,832	3,842	3,465	1,764	-63%
	Japan		433	338	422	657	52%
	Mauritius		4,844	5,448	7,404	7,681	59%
	Philippines					73	
	Sub-total		**10,109**	**9,628**	**11,292**	**10,175**	**1%**
All PS fleets			**149,438**	**142,358**	**148,728**	**145,124**	**-3%**

Longline fleets (LL & FLL)		Target: catch reduction from baseline	2014	2015	2016	2017	% change from 2014
Subject to Resolution 18/01	Taiwan,China	-10%	12,285	13,921	16,958	9115	-26%
	Sri Lanka		8,625	5,933	3,939	6448	-25%
	Sub-total		**20,910**	**19,855**	**20,896**	**15,563**	**-26%**
Exempt from Resolution 18/01	Belize	N/A	46				
	China		1,078	1,793	1,812	2,962	175%
	India		322	662	97	97	-70%
	Indonesia		4,009	5,077	2,826	2,353	-41%
	Japan		3,639	3,140	2,976	3,305	-9%
	Rep. of Korea		1,557	1,674	1,374	1,802	16%
	Malaysia		77	144	156	370	379%
	Maldives		120	63	286	220	83%
	Mauritius				40	141	
	NEI.Fresh		4,065	3,009	418		
	NEI.Frozen		417	451	693		
	Oman		28	205	135	135	385%
	Philippines		69				
	Seychelles		1,601	2,298	2,671	3,215	101%
	Tanzania		155	108	109		
	Thailand		187	109			
	Sub-total		**17,370**	**18,732**	**13,593**	**14,600**	**-16%**
All longline fleets			**38,281**	**38,587**	**34,489**	**30,163**	**-21%**

Gillnet fleets		Target: catch reduction from baseline	2014	2015	2016	2017	% change from 2014
Subject to Resolution 18/01	India (offshore GN)	-10%	5,153	3,974	4,392	4392	-15%
	I.R. Iran (offshore GN)		24,401	26,780	31,079	**32,347**	**33%**
	Sub-total		**29,554**	**30,754**	**35,471**	**36,739**	**24%**
Exempt from Resolution 18/01	Australia	N/A	0	0	1	1	226%
	Bahrain		1	1	1	0	-55%
	Comoros		16	117	905	547	3295%
	Djibouti		37	31	51	26	-29%
	East Timor		0	1	1	0	-29%
	Egypt			6	5	3	
	Indonesia		341	334	317	317	-7%
	I.R. Iran		16,925	11,632	4,031	13,204	-22%
	Jordan		12	9	8	5	-56%
	Kenya		54	82	82	82	52%
	Oman		2,268	8,145	6,914	9,646	325%
	Pakistan		14,452	16,791	23,392	25,471	76%
	Qatar		110	133	120	77	-30%
	Sri Lanka		11,246	8,559	5,469	3,142	-72%
	Tanzania		3,210	3,814	3,814	3,814	19%
	Yemen		81				
	Sub-total		**48,755**	**49,656**	**45,110**	**56,335**	**16%**
All gillnet fleets			**78,308**	**80,411**	**80,582**	**93,074**	**19%**

CPC's other (coastal) gears		Target: catch reduction from baseline	2014	2015	2016	2017	% change from 2014
Subject to Resolution 18/01	Maldives (BB)	-5%	18,481	15,796	8,550	17500	-5%
	Maldives (HL)		30,246	36,300	44,385	30563	1%
	Sub-total		**48,727**	**52,096**	**52,935**	**48,063**	**-1%**
Exempt from Resolution 18/01	Australia	N/A	19	73	66	66	239%
	Comoros		1,383	1,630	4,679	4259	208%
	East Timor		3	3	3	3	0%
	Egypt			10	10	12	
	EU		1,185	1,094	1,215	814	-31%
	India		27,953	12,523	14,755	14755	-47%
	Indonesia		20,925	20,534	19,492	19492	-7%
	I.R. Iran		57	345	6,535	8806	15252%
	Jordan		14	16	17	20	45%
	Kenya		17	27	27	27	52%
	Madagascar		735	747	736	703	-4%
	Maldives		364	279	485	1078	196%
	Mauritius		65	82	141	194	201%
	Mozambique		5	69	174	168	3022%
	Oman		4,912	6,833	13,935	9693	97%
	Seychelles		16	98	576	747	4626%
	South Africa		83	182	183	247	198%
	Sri Lanka		17,907	18,180	24,327	28388	59%
	Tanzaia		76	90	90	90	19%
	UK Territories		2	2	2	3	63%
	Yemen		29,093	24,576	21,100	21100	-27%
	Sub-total		104813	87394	108547	110665	6%
All CPC's other gears			**105,998**	**88,488**	**109,763**	**111,478**	**5%**

25. The WPTT **NOTED** that the information presented in relation to the progress and effectiveness on implementation of Resolution 18/01 was informative and **ENCOURAGED** the Secretariat to present this information at future WPTT and SC meetings.

4.2 Review new information on fisheries and associated environmental data

Climate and oceanographic conditions

26. The WPTT **NOTED** paper IOTC–2018–WPTT20–10 which provided an outline of climate and oceanic conditions in the Indian Ocean: update to mid-2018, including the following abstract provided by the authors:

> *"The trend and variability of climate and oceanic variables were investigated with emphasis on the conditions for the recent years (2016-2018). The ENSO cycle has been mostly in a neutral phase since September 2016, however a La Niña event developed between October 2017 and March 2018. Normal conditions prevailed since then but there is a high probability (65-70%) that an El Niño develops by the end of 2018. The Indian Ocean Dipole was in negative phase in 2017 and turned into a positive phase in 2017. There is a high probability that it returns to a normal phase by December. These cycles were associated to inter-annual changes in SST, thermocline depth and sea surface chlorophyll. However, in 2017, the thermocline pattern did not exhibit the typical situation observed during a positive dipole as the mixed layer remained shallow throughout 2017 and until March 2018 between latitudes 10°N-10°S. These conditions which occurred in the core of the purse seine fishing grounds, could have promoted the vulnerability of schools to the purse seine gear. The recent trend (since 2014) in chlorophyll concentration is characterized by higher productivity which may promote the aggregation of tuna preys and ultimately, a greater abundance of tuna schools. That link between chlorophyll and CPUE on free schools and floating objects associated schools was further investigated. It leads to the conclusion that the chlorophyll concentration is an important factor to incorporate in CPUE standardization, in addition to other physical-derived factors."*

27. The WPTT **THANKED** the authors for the paper and presentation and **NOTED** the value of such information to inform the work of the WPTT.

28. In relation to a discussion on the influence of dissolved oxygen levels on fish availability and catchability, the WPTT **NOTED** that there was a lack of time series data for dissolved oxygen content and that the maps presented were derived from discrete profiles made during research cruises. The WPTT was informed that the only way of having time series in the high seas would be to use outputs of biogeochemical models such as those produced by the European Copernicus (Marine Environment Services) system, which include dissolved oxygen at depth among other biogeochemical variables.

29. The WPTT **NOTED** that for the western Indian Ocean the simulations of the Intergovernmental Panel for Climate Change (IPCC) based on greenhouse gas emissions scenarios for the 21st century give high confidence that dissolved oxygen content will increase at depth in the West Indian Ocean, implying that habitat preferences for tuna in relation to oxygen and other variables such as depth and temperature were likely to change over time.

30. The WPTT queried whether IPCC predictions predicted similar increases in dissolved oxygen in the Arabian Sea over time, but it was **NOTED** that dissolved oxygen content was predicted to decrease slightly in the extreme North of that region over time.

31. The WPTT **NOTED** the data indicating a shallow thermocline in combination with high chlorophyll levels in 2017 in the western Indian Ocean and that such conditions would likely improve foraging conditions, tuna school aggregation and catchability in the purse seine fisheries and other fleets using surface gears.

32. The WPTT **NOTED** that there may be value in exploring the relationship between environmental and oceanographic data (e.g. chlorophyll levels) and recruitment that may inform alternative recruitment hypotheses, and queried whether environmental data series are available for some of the areas used in the yellowfin stock assessment. The WPTT **NOTED** that although there are some correlations between environmental variables and CPUE, it is difficult to relate these to specific processes such as recruitment. The ability to explore relationships between anomalies in environmental and oceanographic data with assessment results has not been resolved, and this is not specific to the Indian Ocean.

33. The WPTT **NOTED** the value in considering how the information included in the paper relating to the change in environmental characteristics over time could be included in CPUE series and **ENCOURAGED** the continuation of this work.

I.R. Iran tropical tuna fisheries

34. The WPTT **NOTED** paper IOTC–2018–WPTT20–11 which described trends in tropical tuna catch in Iran, including the following abstract provided by the author:

    "Tuna catches covers 7 percent of the world total catch. But in Iran more than 40 percent of the country catch belongs to tuna and tuna-like species. So tuna catch in Iran is very important.

    About 11,200 fishing vessels in 7 coastal provinces are engaged in fishing. Because about 6,300 out of 11,200 fishing vessel with 60,000 fishers are engaged in fishing activities and as the capture fishery in Iran is handled mainly small scale, so there are variety of socio-economic and management issues." – see paper for full abstract.

35. The WPTT **NOTED** that information on the spatial distribution of catch and effort would be useful and queried whether these data were being collected. It was clarified that coverage of data from logbooks, which include these data fields, was generally better for the coastal fisheries whereas there was a much lower coverage for the offshore fisheries. Information based on logbook data are being submitted to the IOTC Secretariat in accordance with Resolution 15/02. The WPTT **NOTED** that logbooks were being deployed on the fleets operating offshore.

36. The WPTT **NOTED** that, as a result of a data compliance mission conducted by the IOTC Secretariat in November 2017, I.R. Iran begun providing catch-and-effort data with a proper time-area breakdown in accordance with Resolution 15/02, and that submission of historical data in the same format for years prior to 2016 is expected soon. Also, the WPTT **NOTED** that this information is in the process of being incorporated in the IOTC database and will be made available for the next working parties. I.R. Iran thanked the IOTC Secretariat for their assistance.

37. The WPTT **NOTED** a sharp increase in catches of yellowfin tuna from 2014 to 2017, much of which is being caught in the offshore gillnet fishery (subject to Resolution 18/01) and also **ACKNOWLEDGED** that better data reporting is crucial for the assessment of compliance with Resolution 18/01. The WPTT also **NOTED** the ongoing efforts from I.R Iran to improve logbook reporting and implementation of VMS systems to help monitor these catches.

Transshipment of tuna at Port Louis and analysis of the catch of foreign tuna longliners licensed in Mauritius

38. The WPTT **NOTED** paper IOTC–2018–WPTT20–12 which provided information on the transhipment of tuna at Port Louis and analysis of the catch of foreign tuna longliners licensed in Mauritius, including the following abstract provided by the authors:

> *"This paper depicts the transshipment activities of vessels involved in the tuna fishery at Port Louis over the last five years and an analysis of the longline tuna fishery carried out by foreign longliners holding a Mauritian fishing licence. The transshipment of tuna at Port Louis in the last five years have more than tripled when compared to the period 2002 to 2007 where only 12 433 to 17667 tons were transshipped. This rise is mainly attributed to the continuous development of the port and the different services offered while its location in the Indian Ocean has always been one of the most advantageous feature Port Louis could offer as a port. The increase in the number of licences (from 13 in 1995 to 169 in 2017) issued to foreign tuna longliners over the years has also played a role in a rise of the quantity of tuna being transshipped at Port Louis. Over the past five years (2013 to 2017), an average of 50 216 tons of tuna and tuna-like species were transshipped at Port Louis yearly." – see paper for full abstract.*

39. The WPTT **NOTED** that foreign vessels licensed to Mauritius are required to report catch and effort data to Mauritius, and that Mauritius reports these data as well as data from its domestic fleet to the IOTC Secretariat.

40. The WPTT **NOTED** a consistent decline in catches of yellowfin tuna and an increase in bigeye tuna catches from 2015 onwards of foreign tuna longliners licensed in Mauritius. It was **NOTED** that the spatial distribution of fishing effort has not changed significantly and potential factors explaining this decline may be related to changes in fishing depths and/or market factors.

41. The WPTT **NOTED** the potential availability of transhipment data and whether these are used to cross check logbook data for foreign licensed vessels. Mauritius noted that these vessels are required to submit logbooks as a condition of the licence as they arrive in port. In case of unlicensed vessels, they must at least submit their catch declarations including their fishing positions to the Mauritian authorities. Compliance with VMS reporting is also required as part of the license conditions.

42. The WPTT **NOTED** the that the foreign licensed longliners were less active in the second quarter of the years 2013 to 2017. The peak licensing period correlating to the main fishing season starts in September, with much lower effort during April to June.

Status of yellowfin and skipjack tuna fisheries in Pakistan

43. The WPTT **NOTED** paper IOTC–2018–WPTT20–13 which provided a description of the work undertaken by WWF-Pakistan and the Government of Pakistan on the data of Tropical Tuna catches in Pakistan for 2016 and 2017 and the status of its gillnet fisheries, including the following abstract provided by the authors:

"Tropical tuna is represented by two species in Pakistan; of these yellowfin tuna (Thunnus abacares) contributes 25,471 m. tons during 2017. Annual landings of skipjack tuna (Katsuwonus pelamis) during 2017 were recorded to be 3,178 m. tons. During 2017, a major part of the fleet mainly operated in the offshore deeper waters; therefore, landings of both yellowfin and skipjack tunas were comparatively much higher than previous years."

44. The WPTT **ACKNOWLEDGED** WWF-Pakistan's support 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. The WPTT **CONGRATULATED** WWF-Pakistan's efforts in facilitating improvements in the quality and reporting of fisheries data by Pakistan to the IOTC.

45. The WPTT **NOTED** the sharp increase of yellowfin tuna catches from the Pakistan tuna gillnet fishery by Pakistan's reconstructed catch series in recent years (i.e., 76% from 14,000 t in 2014 to 25,000 t in 2017), and which are currently exempt from Resolution 18/01 due to uncertainties on the location of fishing grounds. The WPTT **REQUESTED** WWF-Pakistan and the Government of Pakistan provide further clarity on gillnet fishing effort and catches taken in areas beyond national jurisdiction for the next WPTT meeting.

46. 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.

47. The WPTT **NOTED** that WWF-Pakistan has taken several initiatives to improve the quality of fisheries data collection, including: the acquisition and incorporation of AIS data, development of data validation systems and 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.

Catch statistics from tuna longline landings at Port of Phuket, Thailand during 2013–2017

48. The WPTT **NOTED** paper IOTC–2018–WPTT20–14 which provided catch statistics from tuna longline landings at Port of Phuket, Thailand during 2013–2017, including the following abstract provided by the authors:

"Catch statistic from foreign tuna longline fishery unloading at Phuket ports, Thailand during 2013-2017 show that there were 1,097 trips and 29,890 tons of total catch. The highest number of trip and total catch was in 2015 as 295 trips and 10,575 tons. Taiwan, China was a major part which accounted for 69.74% of total trips and 63.15% of total catch (5 years average). In 2017, the number of vessels unloading declined sharply when compared to 2015 and the trend of total catch per trip decreased dramatically since 2015. This caused the total catch in 2017 (2,268 tons) to be lower than ever. In terms of catch composition, tuna species accounted for 67.66% of total catch; the remaining was billfish and other fish as 23.64% and 8.70%, respectively. For tropical tuna, the highest catch occurred in 2015 (8,508 tons). After that, tuna catch reduced continuously due to a reduction in the number of vessels and catch rates,. Unloaded tuna catch was 1,788 tons in 2017. Yellowfin tuna was the main species (85.26%) followed by bigeye (13.57%), skipjack (0.59%) and albacore tuna (0.58%)."

49. The WPTT **NOTED** that the newly instituted vessel monitoring system that is tracking vessels entering and exiting the Port of Phuket may be contributing to a reduction in vessels using this port. It was unclear where vessels that were formerly unloading in Phuket are now unloading catches in other ports in the region.

Assessment of the tuna catch composition of a longline vessel in the Kenyan EEZ and the high seas

50. The WPTT **NOTED** paper IOTC–2018–WPTT20–46 which provided an assessment of the tuna catch composition of a longline vessel in the Kenyan EEZ and the high seas, including the following abstract provided by the authors:

"The fishing period under consideration was July to November in 2016 and the same period in 2017. Yellowfin tuna (Thunnus albacares), and bigeye tuna (Thunnus obesus) were the main target pelagic species caught by a Kenyan longliner in the Kenyan EEZ during the 2016 period, representing 25.6% and 18.4% of the catches respectively. In the high seas, the main catches were albacore and yellowfin tuna representing 27.8% and 17.8% of the total catch. Although the species caught in both areas were similar, blue sharks were caught in Kenyan EEZ while in the high seas the reported catches were of tiger sharks. The average deepest hook depth was 349m, 341m and 313m for the bigeye tuna, yellowfin tuna and albacore respectively in the high seas while the depth of 276m and 203m for bigeye and yellowfin tuna respectively was noted in the Kenyan EEZ. A look at the temporal distribution of the catches showed the albacore were more dominant in August and September while yellowfin and bigeye were more dominant in October and November respectively in the high seas. In the EEZ, bigeye tuna dominated in September while the yellowfin tuna was more dominant in July and November. The average weights of bigeye tuna and yellowfin tuna were 49.2 ± 7.3 kgs and 44.2 ± 13.7 kgs respectively for the EEZ catches while the average weights of albacore, bigeye tuna and yellowfin tuna in the high seas were 17.7 ± 4.5 kgs, 36.1 ± 16.6 kgs and 30.5 ± 10.8 kgs respectively."

51. The WPTT **NOTED** the progress made by Kenya towards the implementation of logbooks and associated improvements in data collection and reporting, and **ACKNOWLEDGED** that efforts are underway to submit existing data to the IOTC Secretariat (both the aggregated statistics in the format required by Resolution 15/02 and the scientific observer data collected according to the ROS requirements) following due validation with existing VMS data.

Spanish purse seiner fishery for tropical tuna in the Indian Ocean

52. The WPTT **NOTED** paper IOTC–2018–WPTT20–15 which provided an update on the statistics of the EU-Spain purse seine fleet in the Indian Ocean (1990–2017), including the following abstract provided by the authors:

"This document provides an update of the statistics of the Spanish purse seine fleet fishing in the Indian Ocean for the period 1990 to 2017. Data include catch and effort statistics, as well as some fishery indicators by species and fishing mode. Information about the scheme and coverage of the sampling, together with maps and diagrams illustrating the spatio-temporal fishing patterns of this fleet are also provided. A total of 14 Spanish purse seiners operated in the IOTC area during 2017. Purse seiners' carrying capacity for most of the vessels is higher than 1,200 t. The total estimated catches for the main target species in 2017 were: 54,513 t of yellowfin (YFT), 84,432 t of skipjack (SKJ), 12,345 t of bigeye (BET) and 100 t of albacore (ALB). The total catch in 2017 was 151,424 t (including other species), 11 % higher than last year and 12% higher than the average previous 5 years, mainly due to the increase in skipjack catch. Although skipjack has been the main component of the catch in the previous five years (2012–2016), skipjack catches increased by 37% during 2017 in relation to this period. During 2017, YFT catches were 5% lower than the previous five years average (2012–2016). Effort, measured in searching days, has changed in relation to the average of the last five years, thus during 2017 there were 2618 fishing days vs. 3274.2 searching days in average for the period 2012–2016. This significant reduction was probably due to the closing of fishing activity on 5th November of 2017 up to the end of the year. During 2017, the length of 73,606 tropical tuna fishes from the Spanish fleet was collected, not only from landing at port but also by scientific observers from discards on board: 8409 bigeye, 20,207 skipjack, and 44,990 yellowfin."

53. The WPTT queried whether there are any efforts to limit the capacity of the Spanish purse seine fleet and it was **NOTED** that another new vessel is expected to enter the fishery in 2019 to replace a vessel that sunk in 2016.

54. The WPTT **NOTED** that FAD sets by the Spanish purse seine fleet have increased compared to free school sets and **NOTED** the importance of considering changes in these ratios.

Assessment of accuracy in processing purse seine tropical tuna catches with T3 methodology

55. The WPTT **NOTED** paper IOTC–2018–WPTT20–16 which provided an assessment of accuracy in processing purse seine tropical tuna catches with T3 methodology, including the following abstract provided by the authors:

"The multi-species nature of tropical tuna surface fisheries gives rise to a series of difficulties when estimating the catch by species and catch by size statistics. The T3 processing was built about 30 years ago in order to correct biases of the logbook on species composition and to provide more accurate estimates of catch by species for the European purse seine fleet. However, the evolution of fishing practices and fishing stock according to climate change have challenged the T3 methodology on some part of its processing. The aim of this paper is to give key elements to understand the potential biases that could occur in the catch assessments of tropical tunas of purse seiners and secondly, to explore some ways to increase accuracy of T3 processing in future. By comparing catch weight obtained from T3 processing output and from sale slips weight produced by cannery factories, we found a potential overestimation of catch of less dominant species, which leads to an underestimation of dominant species. This bias could be a consequence of the evolution of length-weight relationships used in T3 processing, for a minor part, but should mainly be due to the too large spatio-temporal stratification used to predict species catch. We also discussed the limit on the T3 processing in relation to the data quality and the reliability of the sale slips."

56. The WPTT **NOTED** paper IOTC–2018–WPTT20–INF03 paper which describes strengths and uncertainties with the results of the T3 software, and provides a series of recommendations allowing reductions in the past and future uncertainties and errors in the purse seine statistics handled by T3.

57. **NOTING** potential biases associated with spill and grab sampling of fish in Pacific fisheries, the WPTT sought clarification on how random sampling of fish within wells was achieved. It was **NOTED** that two weight categories are considered, a <10kg category and a >10kg category, which are estimated by the skipper and recorded in logbooks and on well maps. Those categories are sampled independently at random. For the >10kg category 100 fish are measured at landings. For the <10kg category, sampling is undertaken twice with the first sample of 300 fish taken at the beginning of landing and another sample of 200 fish taken one hour later, corresponding to a 500 fish total. Wells are selected to ensure suitably stratified coverage and to optimize the sampling effort to avoid further biases on the species composition.

Potential biases of scientific estimates of catches of tropical tunas of purse seiners the EU and other countries report to the ICCAT and IOTC

58. The WPTT **NOTED** paper IOTC–2018–WPTT20–17 which discussed potential biases of scientific estimates of catches of tropical tunas of purse seiners the EU and other countries report to the ICCAT and IOTC, including the following abstract provided by the authors:

"This document represents a first attempt to explore potential differences between the catches of tropical tunas estimated using the European software T3 and those recorded on sale slips completed by the canning factories purchasing fish from 48 vessels registered with OPAGAC in the Atlantic and Indian oceans, over the period 2011–16. The analysis identified potential sources of bias in estimates of catch of tropical tunas that have been reported to the ICCAT and the IOTC during those years, or probably a longer period. The magnitude of the biases identified varied depending on the ocean, fleet, and size category,

with the largest bias recorded in the Indian Ocean, where the catches of yellowfin tuna and bigeye tuna recorded by the IOTC, especially of large size, appear to be well below those obtained from sale slips. To a lesser extent, in the Atlantic Ocean the catches of yellowfin and bigeye tunas seem to be also subject to bias, although in this case underestimation of both large and small fish seem to be responsible. Even though the study is preliminary and the available datasets need to be further explored and cross-verified with actual monitoring of fish in processing plants, the results obtained, if confirmed, could have consequences on the statistics, stock assessments, management advice, and management measures adopted by ICCAT and IOTC."

59. The WPTT **NOTED** the potential biases presented and **ENCOURAGED** EU and Seychelles scientists and the fishing industry to further explore the data and sources in order to assess if the issues identified in the document have an impact on estimates. It was **AGREED** that while the EU system may be appropriate to produce estimates of total catch by species for the purse seine fishery as a whole, its use to monitor catches by species for individual vessels is highly dependent on the sampling coverage at the vessel scale. To date, sampling coverage for Spanish and Seychelles vessels has been below the level which will allow the use of these samples to produce estimates by vessels.

60. The WPTT **NOTED** that EU scientists implemented port sampling in the Atlantic and Indian oceans stratified by size category with separate samples conducted for >10kg and <10kg; the system relies on skipper reports, with sampled weights for each size category raised to the total weight of fish reported by skippers in the fish wells sampled. This is because on unloading of fish from the well stevedores separate the >10kg and <10kg fish which makes it complicate for port samplers to take a random sampling of the whole.

61. The WPTT **NOTED** that sale slips from canning factories do provide valuable information on the total amount of market species by purse seine unloading in terms of both weight and commercial category. The WPTT **NOTED** that sale slips are not always available in near real-time, especially for some of the sampling teams , and that they may not accurately represent the whole of the loaded catches in some cases. However, the WPTT **AGREED** that having this information, whenever possible, may assist in the estimation of catches by size and species for the EU and other purse seine fleets that use the EU sampling and estimation scheme. The WPTT **NOTED** that provision of this information is compulsory in Spain and this information is available.

62. The WPTT **NOTED** that the length-weight relationships of the three principal market tunas updated in 2016 (IOTC–2016–WPCDS12–INF05) have not been used for re-processing the historical (i.e. prior to 2016) EU and Seychelles purse seine catch data, and **ENCOURAGED** the CPCs to conduct this work and submit to the IOTC Secretariat revised catch at size data. In term of catch at size coverage, the WPTT further **NOTED** that since 1990, only a very small fraction of strata did not have associated size frequency samples and that, overall, the sum of catch and effort by large sampling regions (as defined in the T3 process) is in agreement with the catch at size produced in the same large regions. However, the WPTT **NOTED** that size data are missing in some years and **ENCOURAGED** the EU and Seychelles scientists to report a complete record set for the entire time series.

63. The WPTT **NOTED** that the collection of length and weight samples of tropical tunas on a routine basis to facilitate the use of length-weight relationships by time-period and area has been implemented since 2017, and that this collection will assist in the estimation of more precise sampled weights and species composition in the future.

64. **RECALLING** IOTC Resolution 15/02, the WPTT also **REITERATED** that all purse seine fishing CPCs should provide raw (i.e. unraised) length frequency data to the IOTC Secretariat in addition to catch-at-size data.

65. The WPTT **NOTED** that the EU sampling is stratified by fishing mode with fish coming from free-school and associated school sets sampled separately. However, it was **NOTED** that the

species and size composition of free-schools may vary substantially, including free-schools of purely large yellowfin tuna and other free-schools having a species and size composition more similar to that obtained in associated schools. The WPTT showed concern about the consequences on selectivity and catch estimates that having this mix of fish within the same type of school may have and **ENCOURAGED** EU and Seychelles scientists to further investigate this issue.

Incorporation of oceanographic conditions into CPUE standardization using Habitat Suitability Index

66. The WPTT **NOTED** paper IOTC–2018–WPTT20–18 which described an attempt to incorporate oceanographic conditions into CPUE standardization using HSI (Habitat Suitability Index), including the following abstract provided by the authors:

"IOTC CPUE workshop (2013) recommended that when environmental covariates are incorporated in CPUE standardization, it should be conducted in sub-areas where ecological processes produce good habitat areas and the variability in pattern of the environmental signature is well identified. We attempted to implement this recommendation using one case study with Indian Ocean yellowfin tuna incorporating oceanographic variables into CPUE standardization using HSI (Habitat Suitability Index). We used four oceanographic variables affecting YFT habitat: thermocline depth and depth-specific sea temperature, salinity and vertical shear currents. SI (Suitable Index) was then estimated for each oceanographic variable through spatial correlations with YFT CPUE. SI is % frequency distribution representing the most suitable sea temperature range for YFT (for example) as 1.0 then for other ranges, proportional scales (0 to less than 1) are assigned. HSI then integrated four SI using geometric means and was represented as one scale from 0 (worst habitat) to 1 (best habitat). As SI is based on CPUE, we cannot use it in GLM due to violation of assumption of GLM (CPUE will be in both sides in GLM). Thus, we changed to use operation-based SI as the proxy for CPUE-based SI. We then attempted CPUE standardization in sub-area (higher HSI score areas instead of the whole area) as recommended by the CPUE workshop. Effectiveness of HSI was tested by GLM with and without HSI in that sub-area. It resulted that HSI effect was the highest significant term when it was incorporated. As this is very preliminary study with only one case study, we cannot make any general conclusion. We need to explore more case studies using different areas, species and fleets to provide reliable conclusions in the future. In addition, it is the critical point that we need to verify if operation-based SI is the proxy of CPUE-based SI. Otherwise, we cannot use this approach."

67. The WPTT **NOTED** alternative methods to estimate HSI can include geometric means, generalised linear models, generalised additive models, artificial intelligence or quantile regression. These options could be explored in future analyses.

68. The WPTT **SUGGESTED** that it may be more appropriate to consider the HSI as a 'fishing suitability index' as 'habitat suitability' is based on areas that have higher nominal CPUE and not necessarily higher abundance, and which do not evenly cover the distribution range of the species.

69. The WPTT **NOTED** that it would be useful to look at habitat suitability in other regions and other fleets as opposed to being based solely on the Japanese data in region 2. Ideally fishery-independent data should be used to estimate HSI to remove the fisheries effect.

70. The WPTT **NOTED** the length of the time series was quite long and noted that mainline material of longline has likely changed over this time period, which could result in different fishing depths. The WPTT **NOTED** that information on gear modifications over time should be factored into future assessments.

Determining capture rates of tuna caught in different gear settings in gillnet fisheries of Pakistan

71. The WPTT **NOTED** paper IOTC–2018–WPTT20–19 which discussed determination of CPUEs surface vs. sub-surface gear settings in tuna gillnet fisheries of Pakistan, including the following abstract provided by the author:

> *"Tuna and tuna like species are important fish stock. Among tropical tunas, yellowfin and skipjack are the two important species. Different gear settings are used to catch tuna and tuna like species as fishers change fishing grounds moving from coastal to offshore and in the high seas. Different gear settings result in different catch and therefore, has proven to be a mitigation measure for reducing entanglement of incidentally caught species. The impact of different gear setting on target catch species has not been determined. Therefore, assessing and providing capture rates for target tuna species is critical for gear settings to be considered an appropriate conservation and management measure. This paper provides capture rates and makes comparisons of target catch with different gear settings using the data collected by four trained skippers (on 15–20 m vessels) actively engaged from 2013–2017. During this period, a total of 3,874 drift gillnet sets was monitored. Two gear settings using multifilament gillnets were used: surface and subsurface gillnets. Surface gillnets were deployed at the surface, whereas "subsurface" gillnets were deployed at 2 meters below the surface (net height varied from 10 to 14m)." – see paper for full abstract.*

72. The WPTT **NOTED** that sub-surface gillnet settings used in the Pakistani EEZ have the same CPUE as surface gillnet settings used in the same area but lower by catch of turtles, cetaceans and sharks. The WPTT also **NOTED** that the authors expressed the need to expand the adoption of the subsurface gear design and collection of data and its analysis from other CPCs.

73. The WPTT **NOTED** that there are uncertainties regarding the operation of gillnet vessels in areas beyond EEZ, however, anecdotal evidence suggests some gillnets longer than 2.5km may be drifting outside the Pakistan EEZ, which needs further investigation. Moreover, the Deep Sea Fishing Policy notified on 24 April 2018 dictates that all tuna vessels should use less than 2.5km of gillnet irrespective if they fish inside or outside the EEZ.

74. The WPTT **NOTED** the lack of bigeye tuna in the Pakistan data may be result of the warmer temperature of waters in the region (~10^0 N). WWF-Pakistan is examining observer and landings data to analyse any records of bigeye taken using gillnet gears.

75. The WPTT **ENCOURAGED** presentation of results on spatial and temporal trends in surface vs. subsurface gillnet CPUE at future WPTT meetings and **NOTED** that exploration of other variables such as vessel and skipper effects would also be useful for exploring surface vs. subsurface CPUE estimates. WWF-Pakistan noted that the data are currently highly aggregated but efforts are underway to disaggregate the data and explore signals that are currently hidden in the data.

76. The WPTT **NOTED** that fishermen have adopted the subsurface design for gillnet gears as the gear configuration is resulting in better catch quality, less fish losses (due to sag in nets and better entanglement) and fewer losses of efficiency due to reductions in bycatch entanglement. WWF-Pakistan reported that most of the fleet has converted to these gears as a result of these incentives. The WPTT **NOTED** that I.R. Iran gillnet vessels are also moving towards these gillnet gear configurations and **SUGGESTED** that other CPCs using gillnets may further investigate and report to WPTT on the benefits of similar gear modifications.

77. The WPTT queried whether subsurface gears might result in more gear losses and a greater potential for ghost fishing as a result of interactions with other vessels; however WWF-Pakistan noted that cargo ships generally pass over nets relatively easily as the subsurface gillnets are generally much deeper than 2m for most of the length of the net.

***Best standards for data collection and reporting requirements on floating objects (FOBs)* and *The use of instrumented buoys to monitor the activity of the purse seine fleet fishing on FADs* (two papers)**

78. The WPTT **NOTED** paper IOTC–2018–WPTT20–20 which discussed standards for data collection and reporting requirements on floating objects (FOBs): towards a science-based FOB fishery management, including the following abstract provided by the authors:

"A major concern for tropical tunas, on these last years, has been the worldwide increasing use of drifting FOBs by purse seiners, which are equipped with satellite buoys and echo-sounders. The use of these floating objects has contributed to increases in the catch of skipjack tuna, but also of juveniles of yellowfin and bigeye tunas. Moreover, it has increased the amount of by-catch (including some species classified as vulnerable or endangered) and has likely resulted in adverse effects on the ecology of fish and on vulnerable areas (e.g. beaching events on coral reef areas). Despite the increasing FOB use and concerns, little information is available on FOB use worldwide for appropriate monitoring and management. Thus, FOB monitoring has become a priority in all t-RFMOs. However, the data collection and reporting requirements around FOBs are not standardized and there are significant data gaps. The aim of this document is to review current requirements and procedures in place and propose standards for data collection and submission on FOBs to t-RFMOs. The proposals included in this document are the result of a collaborative work between scientists and the fishing industry."

79. The WPTT **NOTED** paper IOTC–2018–WPTT20–23 which describes the use of instrumented buoys to monitor the activity of the purse seine fleet fishing on FADs, including the following abstract provided by the authors:

"In response to the increasing use of FADs in purse seiner tropical tuna fishing, legally binding measures have been implemented by RFMOs to limit the number of FADs used by vessels. Broad terminology referring to buoys and FADs use is included in different management measures which should be standardized among RFMOs and precisely defined to avoid subjectivity on the interpretation and harmonize the verification system. To provide detailed definitions and consistent with the buoy use and dynamics, and to clarify and facilitate the monitoring of the number of FADs used by a vessel or a fleet among RFMOs, the buoy dynamic is described and detailed definition for terms used by RFMOs are proposed."

80. The WPTT **NOTED** that current IOTC definitions of FOB types and FOB activities differ in structure and purpose from the CECOFAD project classification, and that this suggests further studies might be required to identify general classifications that could be also better suited to the practical needs of other RFMOs.

81. The WPTT **ACKNOWLEDGED** the importance of the proposed harmonisation of FOB types and FOB activity definitions and **RECOMMENDED** that the concept of harmonisation be taken up by the WPDCS and Scientific Committee with the aim of harmonising IOTC definitions with those used by other tRFMOs in the context of the joint tRFMO Working Group on FADs.

82. WPTT **NOTED** that depending on the kind of buoy, the magnet needs to be removed to be activated. The WPTT also **NOTED** that although the paper focused only on the buoy use, information on which vessels receive fish biomass estimates is important for effort assessment. The paper will also be presented at the Working Party on Data Collection and Statistics (WPDCS). The WPTT **CONGRATULATED** the authors for initiating the work on terminology consistent with buoy use and dynamics.

Using FADs to develop better abundance indices for tropical tuna

83. The WPTT **NOTED** paper IOTC–2018–WPTT20–21 which discussed the use of FADs to develop better abundance indices for tropical tuna, including the following abstract provided by the authors:

"Through its Fishery Improvement Project (FIP), OPAGAC launched a research project with AZTI to support stock assessments for the Indian Ocean. OPAGAC is contributing to abundance indices development, both fishery dependent and independent, by providing its

FAD data, which is necessary to support and improve the sustainable management of tropical tuna nowadays. For fishery dependent indices this includes catch and effort, sizes, and FAD density; and for fishery independent indices the acoustic records of beacons' echo sounders is provided. Additionally, to contribute to a more comprehensive study, a temporal data series was made available."

84. The WPTT **WELCOMED** the release to national scientists by the fishing industry of data sets on GPS positions and echosounder data which provide information on fish biomass aggregated around floating objects and **NOTED** such data are useful for multiple scientific applications including, in the future, the standardisation of purse seine CPUE as well as fishery independent abundance indices.

85. The WPTT queried the temporal coverage of information and it was **NOTED** that there are currently three service providers, with the longest time series (from 2009 to the present) being available from one provider.

86. The WPTT **SUGGESTED** that this work be presented to the WPDCS for additional consideration and discussion.

Definitions of biodegradable FADs

87. The WPTT **NOTED** paper IOTC–2018–WPTT20–22 which discussed potential definitions of biodegradable FADs, including the following abstract provided by the authors:

"The use of non-entangling and biodegradable components-based FADs (i.e., BIOFAD) by the tropical tuna purse seine industry is promoted by tuna Regional Fisheries Management Organizations through different recommendations and resolutions published during recent years. This implies the development of an accurate definition of what a BIOFAD should be, and specially the conditions to be met by the materials used in their construction when applying biodegradability requirements for permitted materials. This document tries to address specific conditions to be considered when the word biodegradable is applied to define the materials used for BIOFAD construction."

88. The WPTT **NOTED** a lack of harmonization of definitions of BIOFADs in other RFMOs and further **NOTED** the value in formulating clear definitions to underpin robust resolutions.

89. The WPTT **NOTED** the proposed definition for BIOFADs is aimed at providing a baseline and fostering discussions on biodegradable criteria. The WPTT **NOTED** that the definition proposed for BIOFADs builds on industrial standards that may not be adequate for describing FADs that should be biodegradable in natural conditions.

90. The WPTT **NOTED** that potential microplastic contamination of fish as a human food source was a growing issue.

91. The WPTT **NOTED** that the contribution of experts in the domain of plastic degradation would be helpful to advance the discussion.

Fluid dynamics analysis of FADs using particle image velocimetry

92. The WPTT **NOTED** paper IOTC–2018–WPTT20–24 which described fluid dynamics analysis of FADs using particle image velocimetry, including the following abstract provided by the authors:

"In the process of developing a fish aggregating device (FAD) for reducing the entanglement of bycatch, the flows that occur in both existing high-risk net-type entangling FADs and low-risk rope-type FADs equipped with non-entangling cloth attractors were measured using a flow visualization technique. At an inlet velocity of 0.504 m/s, the mean velocity data for net and rope FADs were 0.525 m/s and 0.280 m/s, respectively, and the turbulence intensity data were measured as 10.8% and 46.9%, respectively. The mean velocity data for the rope FAD and spindle-type fish were 0.126 m/s and 0.164 m/s, respectively, and the turbulence intensity data were 37.0% and 17.9% respectively, at an

inlet velocity of 0.2 m/s. For the measurement and analysis of the flow data, the particle image velocimetry method was used. The flow velocity and turbulence intensity data revealed that compared to existing net-type entangling FADs, rope-type FADs equipped with ribbons had a significantly larger or smaller difference in the velocity and turbulence intensity compared to the surrounding flow rate."

93. The WPTT **SUGGESTED** future research could incorporate the influence of waves on FAD movement into the experiment.

94. The WPTT **NOTED** that FADs can be used to provide valuable oceanographic data in the future and could also be used to inform CPUE standardisation.

95. The WPTT **NOTED** that the authors used chub mackerel instead of tuna in the experimental setup and noted that the fluid dynamics may differ from tuna. The authors intend to continue this working using body shapes of other fishes..

Recent advances on the use of supervised learning algorithms for detecting tuna aggregations under FADs from echosounder buoys data

96. The WPTT **NOTED** paper IOTC–2018–WPTT20–25 which described recent advances on the use of supervised learning algorithms for detecting tuna aggregations under FADs from echosounder buoys data, including the following abstract provided by the authors:

"Assessing the accuracy of biomass estimates obtained through echosounder buoys and improving the current algorithms used for estimating the associated biomass is a key step towards the derivation of fisheries-independent abundance indices for tropical tuna. Recent results obtained through supervised learning algorithms on M3I buoys, one of the main buoy models deployed by the French tuna purseseiners, demonstrate a good accuracy for assessing the presence and absence of tuna under FADs, regardless of the ocean. However, these algorithms (and buoy model) are less accurate in determining the size of tuna aggregations. In this paper we investigated possible ways of improving the classification of tuna aggregation sizes by accounting for the species composition constituting the aggregation. Also, we inspected how environmental variables (sea-surface temperature and chlorophyll-a) can affect the accuracy of the biomass estimates. Our results demonstrate that accounting for the species composition of tuna aggregation, sea-surface temperature and chlorophyll-a does not improve significantly the accuracy of biomass estimates with this buoy model."

97. The WPTT **NOTED** that the random forest algorithm used in the analysis assumes that purse seine catches should reflect abundance of tuna under the FADs. Although this is generally true, sometime small or even large fish can escape the purse seine set and thus purse seine catches can be a biased index of abundance of tuna under the FADs. The same applies because of the presence of bycatch species under the FADs. The WPTT **NOTED** that in a relatively small number of sets the school can be captured through multiple successive fishing sets.

98. The WPTT **NOTED** that the discrimination between tuna and other associated fish species remains a challenge and that this could affect the indication of tuna presence under a floating object from positive acoustic signal. The WPTT **NOTED** that associated species represent a small proportion of catches (5–10% in weight with a large inter-set variability) and generally occur in shallow waters. The WPTT **NOTED** that the study aims to account for differences in vertical behaviour by providing more weight to deeper layers where mostly tunas occur.

99. The WPTT **NOTED** that the study relies on single frequency buoys available from one predominating brand model in the French purse seine fleet while other buoy brands are used in other fleet components (EU-Spain, Korea) and two-frequency buoys have recently been emerging on the market. The WPTT **NOTED** that single frequency buoy models remain the most widely used across fleets.

100. The WPTT **NOTED** the substantial progress of the work since 2017 and its major interest for deriving fishery-independent abundance indices for tropical tuna stocks.

101. The WPTT **NOTED** that International Seafood Sustainability Foundation (ISSF) is supporting research into buoy technology.

Progress on a project to develop a spatial operating model of the tropical tuna population, incorporating tagging data for evaluating assessment bias

102. The WPTT **NOTED** that paper IOTC–2018–WPTT20–27 on a project to develop a spatial operating model of the tropical tuna population, incorporating tagging data for evaluating assessment bias, was not presented by the authors due to time constraints, but the document was made available and included the following abstract:

> *"We present planning for and progress towards the development of a spatially explicit population model of yellowfin tuna in the Indian Ocean. SPM (Spatial Population Model) is software that captures the dynamics of spatial heterogeneity of a population along with age structure, movement and reproductive stage transition in a holistic framework. Using this software, spatially explicit age-structured models will be developed for the yellowfin tuna (Thunnus albacares) population in the Indian Ocean and used as operating models to evaluate the performance of stock assessments. The models will be generalised Bayesian population models, optimised by fitting to fishery observations. Movement is parameterised using preference functions based on spatially discrete environmental layers. The shapes of the preference functions will be established through iterative model testing with the parameters defining the preference functions estimated within each model. The spatial structure of the models divides the Indian Ocean region into five-degree cells. The underlying spatial distribution of the population was either restricted to the western tropical area, or to the entire Indian Ocean. Estimates of movement rates will be compared with the results of tagging studies, and fits to the other observations explored (size, CPUE, reproductive development). These operating models will then be used to investigate potential biases of the current Stock Synthesis assessment."*

5. Bigeye tuna – Review of New Information on Stock Status

5.1 Review of the statistical data available for bigeye tuna

103. The WPTT **NOTED** paper IOTC–2018–WPTT20–08 which provided a review of the statistical data and fishery trends 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 (CPCs)*, for the period 1950–2017. 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 supporting information for the WPTT is provided in Appendix IVb.

104. The WPTT **NOTED** that, prior to the introduction of logbooks in 2013, catches of bigeye tuna by baitboats in the Maldives were often reported as aggregated with possible misidentification with yellowfin tuna and that historical bigeye catches are likely to be underestimated compared to recent years.

105. The WPTT also **NOTED** that the general longstanding concerns with longline size data (including inconsistencies between average weights in the periods before and after 2000) also affect bigeye tuna size-frequency data as these are currently available to the IOTC Secretariat, and that future work is planned for 2019 to improve the relevance of this information that is currently given low weighting in the assessment of the species.

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

106. The WPTT **NOTED** paper IOTC–2018–WPTT20–45, which described pelagic longline fishing operation parameters optimization—a case study on targeting bigeye tuna (*Thunnus obesus*) in the Indian Ocean, including the following abstract provided by the authors:

"In longline fisheries, the habitat and the preferred water layer of the target species should be understood to improve the efficiency of fishing, and the hook depth need to be accurately controlled to set the hooks at the preferred depths of the target species as far as possible. In this paper, the theoretical depths of hooks (D_δ) were calculated by catenary formula. The environmental data, e.g. wind speed (V_w), gear drift velocity (V_g), angle of attack (Q_w) (the angle between the prevailing course in deploying the gear and direction that the fishing gear was drifting), and the wind angle (γ) (the angle between the direction of the wind and the prevailing course in deploying the gear), and operation parameters, e.g. line shooting speed (V_1), vessel speed (V_2), the number of hooks between two floats (N_b), and time interval (t) between two hooks, were collected and the actual hook depth (D_f) were measured on the longliners Huayuanyu No.18 and Huayuanyu No.19 in 2005 and the longliner Yueyuanyu No.168 in 2006." – see paper for full abstract.

107. The WPTT **NOTED** that the results suggesting that the optimisation of hook depth may reduce bycatch have not yet been tested in practice.

108. The WPTT **NOTED** that removing the hooks closest to the float line, which are the shallowest of the set, is a method for reducing bycatch. However, if 27 hooks between floats are used, as the results of this study suggest is optimal for targeting bigeye tuna, then the hook depth is deeper than 65m anyway and so the bycatch rate will be reduced.

5.3 Review of new information on the status of bigeye tuna

5.3.1 Nominal and standardised CPUE indices

109. The WPTT **NOTED** paper IOTC–2018–WPTT20–28 which provided updated information on catch and effort of bigeye tuna (*Thunnus obesus*) from the Indonesian tuna longline fishery, including the following summary provided by the authors:

"Bigeye tuna (Thunnus obesus) is one of the main targets for the Indonesian tuna longline fishery in the Eastern Indian Ocean. The fishery has begun in the early 1980s, when deep longline was introduced. There were two types of data used in this study; the first was the skipper's "logbook" data from the state-owned commercial tuna longline vessels based in Benoa Port (1978–1995), and the latter was the scientific observer data conducted by Research Institute for Tuna Fisheries (RITF) from 2005–2017. Both datasets were then combined to produce nominal catch per unit of effort (CPUE) (no. fish/100 hooks). The result showed that the catch rates of bigeye tuna is declining over the years. The highest CPUE recorded was in 1992 (0.62), while the lowest was in 2016 (0.11). Efforts distributed mainly within 0 – 35°S and 75 – 130°E, while high CPUE areas mainly occurred between 5 – 20°S and 30 – 35°S. We are still in progress of completing the skipper's "logbook" data entry in a hope of presenting the appropriate standardized CPUE in the future."

110. The WPTT **NOTED** that Indonesia is developing a system for validating logbook data and **ENCOURAGED** reporting of data for the Indonesian longline fishery in accordance with Resolution 15/02.

111. The WPTT **NOTED** that the data used in this analysis was likely from vessels targeting bigeye tuna due to the range of the number of hooks between floats (~11–18) which indicated deeper sets.

112. The WPTT **NOTED** that live milkfish used by fresh Indonesian longliners has been reported to increase much higher catch rates, so any future standardization should incorporate bait type..

5.3.2 Stock assessments

113. The WPTT **NOTED** that paper IOTC–2018–WPTT20–30, titled *Stock assessment and management advice for bigeye tuna (Thunnus obesus) in the Indian Ocean: implication of considering bias in catch data*, was withdrawn by the authors.

5.3.3 Selection of Stock Status indicators for bigeye tuna

114. The WPTT **AGREED** that as no new stock assessment was carried out for bigeye tuna in 2018, 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 Update on Management Strategy Evaluation Progress

115. The WPTT **NOTED** paper IOTC–2018–WPTT20–31 which described consultation with the purse seine industry regarding the process of adoption of harvest strategies and harvest control rules for IOTC's tropical tunas, including the following summary provided by the authors:

    "The Sustainable Indian Ocean Tuna Initiative (SIOTI) is a large-scale purse seine Fisheries Improvement Project (FIP) in the Indian Ocean. Pre-assessments for the purse seine fishery MSC certification have identified a series of critical improvement goals. Two of them refer to the adoption of harvest strategies (HS) and harvest control rules (HCR) for the three tropical tuna species in the Indian Ocean. This work is a contribution from SIOTI to the ongoing discussions on the IOTC Management Strategy Evaluation (MSE) process for the implementation of harvest strategies in the IOTC. This analysis aims at presenting the contribution and recommendations of SIOTI partners and purse seine owners in relation to the process of MSE and HS. The results are collated from two type of questionnaires and indicate that in general the industry prefers stock status and safety indicators to evaluate harvest strategies. There is not a clear indicator on the preferred type of harvest control rule (based vs. empirical). These results need to be taken with caution because the few questionnaires received from the industry. Also note that the current paper does not reflect the views of all SIOTI members since questionnaires are not yet completed for 15 of the 42 vessels in SIOTI. An updated paper will be available in 2019 once the questionnaires are completed by all SIOTI partners."

116. The WPTT **NOTED** that the purse seine owners and associations surveyed participating in the Sustainable Indian Ocean Tuna Initiative (SIOTI) indicated a preference for management of Indian Ocean tropical tuna stocks in a manner that provided for low probability of stocks breaching biomass limits and a high probability of rebuilding to or maintaining stocks at levels that could produce MSY, which is consistent with agreed IOTC Management Framework guidelines (Resolution 15/10).

117. However, the WPTT also **CONSIDERED** that the outcomes of the SIOTI survey documented should be considered preliminary and provisional owing to the relatively low number of responses received. Additionally, although the indicated preference for management of the stocks was the use of output (catch) control, the WPTT further **NOTED** that the questionnaire used for the survey was not fully inclusive regarding input control options that might be preferred by the SIOTI fleets included in the survey.

118. The WPTT **SUGGESTED** that some capacity building regarding input and output control options and the respective costs and benefits for managing stocks through these forms of control should be provided to the SIOTI participants.

119. The WPTT also **NOTED** that there is likely a range of opinions within the SIOTI fleets surveyed regarding appropriate control mechanisms for either rebuilding to or maintaining stocks at levels

that could produce MSY and that opinions regarding the most appropriate form of fishery management might not match the views held by all SIOTI members exploiting the tropical tuna stocks of the Indian Ocean.

120. The WPTT **NOTED** paper IOTC–2018–WPM09–09 which provided an update on IOTC bigeye tuna operating model development, October 2018, including the following summary provided by the authors:

> *"This paper summarizes progress on the development of Operating Models (OMs) for IOTC bigeye (BET) tuna. Additional background detail on recent software developments is provided in the yellowfin (YFT) companion paper (Kolody and Jumppanen 2018f). MP evaluation updates for BET and YFT are described in Kolody and Jumppanen (2018a). This paper builds on the work presented and reviewed at the IOTC informal MSE Working Group in March 2018 (Kolody and Jumppanen 2018d,e), and represents the first time that the formal IOTC WPTT and WPM have the opportunity to review the substantial BET OM developments since the phase 1 work was completed in 2016."*

121. The WPTT reviewed and **ENDORSED** the progress to date on MSE for bigeye tuna while recognizing the discussions held at TCMP and the advice of WPM, but **INDICATED** the need to consider some additional uncertainty dimensions in the bigeye tuna MSE workplan agreed by WPM.

122. In particular, WPTT **ENCOURAGED** that the MSE work consider the importance of an alternative growth curve for bigeye tuna. The WPTT **SUGGESTED** the growth curve estimated by Farley et. al. (2016) is based on a broader size range (up to 160cm+) and may have a more plausible Linf value (~178 cm) than the Eveson (2015) model currently used in the OM. Furthermore, the Farley et. al. (2016) growth curve is derived from samples from the eastern Indian Ocean so may provide additional information on growth from a different region. However, the WPTT acknowledged that the Farley et. al. (2016) growth function may not describe well the length-at-age for fish smaller than 70cm LJFL which is the size range of most of the tagged fish for which the model estimates age.

123. Therefore, the WPTT **SUGGESTED** either anchoring the growth curve to a plausible age at zero length, or using Eveson et al (2015) for the lower age classes, or preferably combining the data from the Farley et al. (2006) growth curve with the Eveson et al. (2015) and fitting both Von-Bertalanffy Growth Function (VBGF) and multi-stanza growth models to determine the best model fit.

124. The WPTT expressed some concern in combining size at age data from different time periods to estimate a single growth curve due to the potential for temporal shifts in growth, but also **NOTED** that the inclusion of an additional growth curve was to capture a plausible range of uncertainty in growth.

125. The WPTT NOTED that the proposed new uncertainty dimensions would be evaluated with respect to plausibility and impact before deciding whether to assign them to the OM reference set or robustness trials. The informal MSE working group will review these decisions in March 2019.

126. The WPTT **NOTED** that there may be a need to revise the number of age classes used in the models when using a different growth curve due to shift in the distribution of size at age.

5.5 Development of management advice for bigeye tuna

127. 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 2017 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

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

6.1 Review of the statistical data available for skipjack tuna

128. The WPTT **NOTED** paper IOTC–2018–WPTT20–08 which provided a review of the statistical data and fishery trends 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 (CPCs)*, for the period 1950–2017. 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 supporting information for the WPTT is provided in Appendix IVc.

129. The WPTT **NOTED** that total catches in 2017 (524,282 t) were more than 10% higher than the catch limit generated by the Harvest Control Rule (470,029 t) which applies to the years 2018–2020, and that there has been an increasing trend in catches over the past 3 years. The WPTT **RECOMMENDED** that the Scientific Committee advise the Commission of the urgent need to monitor catches of skipjack in the 2018–2020 period to ensure catches do not exceed the limit.

130. The WPTT **NOTED** that the catch limits adopted for the yellowfin tuna stock have led to changes in targeting by purse seiners, which since 2017 have avoided setting on free schools of large yellowfin tuna. The increase of targeting of tuna schools associated with FADs has led to changes in the species and size composition of the catch, with more catches of juvenile YFT and BET and increased catches of SKJ, which is the main species on FADs. The WPTT **EXPRESSED CONCERN** that the change in fishing strategy may not be exclusive to purse seine fisheries and could be detrimental to the status of the stocks of tropical tunas and **REQUESTED** further evaluation of this issue and, where necessary, which alternative options could be implemented to avoid such adverse impacts on the stock.

131. The WPTT **NOTED** that the reconstructed Pakistan catches would not have a large influence the overall time series for the species.

132. The WPTT **NOTED** the particularly large average size of skipjack tuna recorded by the gillnet fishery of I.R. Iran in the years between 1992 and 1997, and that the coarseness of the reported size bins (3cm) prevent this information from being effectively used for the assessment of the species. For this reason, the WPTT **REQUESTED** the IOTC Secretariat to liaise with scientists from I.R. Iran to confirm the peculiarity of these findings and eventually re-submit the data at the expected level of resolution (1cm size bins).

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

Indian Ocean skipjack purse seine catchability trends estimated from bigeye and yellowfin assessments

133. The WPTT **NOTED** paper IOTC–2018–WPTT–20–32 which described Indian Ocean purse seine catchability trends estimated from bigeye and yellowfin assessments, including the following summary provided by the authors:

"Relative abundance indices derived from commercial catch per unit effort (CPUE) are the most important data inputs to most tuna stock assessments (along with total catch removals), but their use is critically dependent on the assumption that one can establish a time series that is related to abundance in a manner that is understood (usually proportional) and consistent over time. The 2017 IOTC skipjack (SKJ) assessment included purse seine log set (PSLS) CPUE, even though the standardization analysis did not identify any evidence that catchability had changed over time (i.e. nominal and standardized CPUE series were essentially the same). Recognizing that this was not consistent with the

efficiency improvements expected through technological development, alternative catchability trends of 0 and 1% per year were imposed in the assessment with equal plausibility weighting. These were fairly arbitrary values, not supported by any quantitative analysis. This paper follows up on one of the 2017 WPTT suggestions - to estimate PS catchability trends from assessments for other species which have more reliable data." – see paper for full abstract.

134. The WPTT **NOTED** that the estimates obtained from the bigeye assessment suggest a substantial PSLS catchability increase (4.1% per year compounded annually) while the yellowfin estimates suggest a fairly continuous catchability increase of 1.25% per year.

135. The WPTT **NOTED** that, in the absence of other information, catchability trends of at least 1.25% per year should be used as the minimum in the next assessment of skipjack tuna.

136. **NOTING** that the second phase of the CECOFAD project has been initiated and that this will involve the collation of more information from FADs in order to better capture the effort changes in the fishery, the WPTT **AGREED** that it will be important to compare the results of this work with the current analysis to further improve the index of abundance.

137. The WPTT **NOTED** that while the bigeye and yellowfin trends over the past two decades are similar, there was a rapid increase in the catchability of bigeye tuna around 1995 and **AGREED** to investigate possible causes of this.

138. The WPTT **NOTED** that the main technological advances that have been identified within the FAD fishery have been observed to take place as block changes rather than through a continuous increase in catchability and that this could also be considered for the next assessment.

139. The WPTT **NOTED** that estimates of effort creep are also available for tropical tuna species from other oceans, such as the Pacific, and that a comparison with these values would be a similarly useful exercise.

140. The WPTT **NOTED** that while this paper explored the results from one of the suggestions of the WPTT19, there may also be other methods to capture changes in SKJ abundance such as the alternative method also suggested by WPTT19 which involves modelling species composition of catches instead. In this approach, the species composition of purse seine sets might be used to estimate SKJ abundance using the ratio of the SKJ/YFT multiplied by the (fishery selected) YFT assessment abundance.

6.3 Review of new information on the status of skipjack tuna

6.3.1 Nominal and standardised CPUE indices

141. The WPTT **NOTED** paper IOTC–2018–WPTT20–44, which described the application of generalized linear models for the analysis of catch rates of skipjack tuna (*Katsuwonus pelamis*) in the gillnet fishery of Sri Lanka, including the following summary provided by the authors:
"Thirteen years of port sampling data (2005–2017) in the gillnet fishery of Sri Lanka was used to analyze the catch rates of skipjack tuna. Skipjack tuna is the main target species in the gillnet fishery. All gillnet catches including the catches made by popular gear combinations operate in gillnet fishery (gillnet–longline, gillnet-handline and gillnet-ringnet) were considered for this study. Five vessel types which were operated during this period in the tuna fishery of Sri Lanka have caught skipjack tuna. Fish landing data and biological data of key species in gillnet fishery are collected during the port sampling. Accordingly, the unloaded skipjack tuna catches made by the vessels are recorded and these data with other data relating to fishing operations are also recorded and entered into the national database (PELAGOS). Year, month, boat type, gear/ type, trip duration (in days) and number of net panels used for fishing operation were considered for this analysis. A monthly series of skipjack tuna Catch Per Unit Effort (CPUE) in terms of catch in kg per boat per trip was derived from the catch data. A Gamma based Generalized

Linear Model (GLM) was fitted to determine the relationship between the explanatory variables and monthly average CPUE. All zero-catch rates of skipjack tuna were excluded for the analysis. All main effects and their first order interactions were taken into consideration. The fitted GLM model explains 83.8% of the deviance and the vessel type was found to be the most significant factor for determining the catch rates of skipjack tuna. Among the first order interactions, year : month was found to be the key explanatory variable. The fitted GLM model comprised of main effects only explains 65.5% of the deviance."

142. The WPTT **NOTED** the value of this work and **ENCOURAGED** the continuation of additional work required to estimate standardised CPUE. The WPTT also **ENCOURAGED** the inclusion of spatial data which includes variation in gear effects, as there is currently confounding factors between different boats with differing catch rates in different locations.

143. The WPTT **NOTED** that analysing and plotting the data on a log scale would provide a clearer description of the CPUE series.

144. In response to a query about whether Sri Lankan fishers would be willing to test subsurface gear configurations in order to reduce bycatch, it was **NOTED** that surface gillnets are most often used.

6.3.2 Stock assessments

145. The WPTT **NOTED** that as skipjack tuna was not the priority species at WPTT20, no papers were submitted for this agenda item in 2018.

6.3.3 Selection of Stock Status indicators for skipjack tuna

146. The WPTT **AGREED** that as no new stock assessment was carried out for skipjack tuna in 2018, management advice should be based on the range of results from the 2017 assessment.

6.4 Update on Management Strategy Evaluation Progress

147. The WPTT **RECALLED** 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.

6.5 Development of management advice for skipjack tuna

148. 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 2017 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.

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

7.1 Review of the statistical data available for yellowfin tuna

149. The WPTT **NOTED** paper IOTC–2018–WPTT20–08 which provided a review of the statistical data and fishery trends 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 (CPCs)*, for the period 1950–2017. 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 supporting information for the WPTT is provided in Appendix IVd.

150. The WPTT **NOTED** ongoing issues with the Taiwanese length frequency data, particularly from early 2000s onwards. A key concern is that the data may not be representative of the fishery, particularly given the absence of smaller fish despite a large volume of samples. Historical time series data for Japan were also queried. It was suggested that these issues could be partly overcome by downweighting these size data. Alternatively, these data could be removed or other data e.g. tagging data could replace it.

151. The WPTT **NOTED** that Electronic Monitoring Systems (EMS), including for example stereoscopic cameras, could potentially be used to collect better size frequency data. Self-sampling programs are also being implemented (e.g. in the Seychelles) which may improve these data.

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

152. The WPTT **NOTED** paper IOTC–2018–WPTT20–34 which provided a review of yellowfin tuna fisheries in the Maldives, including the following summary provided by the authors:

"Yellowfin tuna (Thunnus albacares), in the Maldives, is exploited by the four gears that target tunas; pole and line, handline, longline and trolling. It is the second most important species after skipjack tuna (Katsuwonus pelamis). Average catch for the recent 5 years, from all gears were around 50,000 t and contributed between 35 and 43 percent of all tunas landed (SKJ, YFT, BET, FRI, KAW). Pole and line, which used to be the most important gear for yellowfin tunas, exploit surface swimming juveniles, below ~70 cm FL, with 80% of catch between 38 and 63 cm FL. Handline yellowfin tuna fishery lands surface swimming sub adults and adults above ~80 cm FL, with 80% of the catch between 99 and 155 cm FL. The longline fishery also lands similar sized fish (80–168 cm). The historically predominant troll fishery catches tunas from the atoll lagoons and outer atoll reefs. A seasonal troll fishery targeting yellowfin tuna existed in the 1990s. Nominal catch for PL shows the catches to be fluctuating around a mean of 14,500 t, with a declining contribution to total YFT catch. Handline fishery shows clear increasing trend in catch from 189 t to 30,500 t. In terms of catch, handline gear has become the most important for yellowfin tuna in the Maldives. Cessation of licensing foreign or joint venture longliners in 2010 to allow for a fully local fleet, clearly disrupted the catch trend. Landings from the longline fleet remained between 1,100 and 3,100 t prior to cessation of foreign licensing, while the latter period showed catches below 1,200 t. As for marine species of special interest, Maldives implements a number of measures to protect such species." – see paper for full abstract.

153. The WPTT **NOTED** that handline catches had decreased by ~30% from 2016 (44,000 t) to 2017 (30,000 t) with the likely reason for this decrease being a reduction in effort and catchability. The WPTT also **NOTED** that introductions of logbooks appear to have resulted in increases in reported catches for the handline fishery but not for other gears. A possible reason for this is that there may not have been appropriate accommodation of the new gears in older reporting mechanisms until the logbooks were introduced.

154. The IOTC Secretariat noted that it was aware of some Maldivian observer data that had not been submitted. Maldives clarified that this was a result of confusion around requirements for observer certification but that this had been resolved, and data would be submitted in the relevant template.

155. The WPTT **NOTED** ongoing issues with identification of juvenile bigeye tuna and yellowfin tuna in catch data. It was **NOTED** that identification has improved as a result of efforts by fishers to record bigeye tuna separately in logbooks over the last three years. Efforts are underway to train fishers to better identify bigeye tuna and yellowfin tuna and to raise awareness of the requirement for fishers to record and report catches of these smaller fish at a species level.

156. The WPTT **NOTED** the paper IOTC–2014–WPTT16–26 presented in WPTT16 that analysed tag release data on proportions of bigeye tuna and yellowfin tuna, which included data for northern and southern regions. The WPTT **NOTED** that the species proportion data from this analysis could potentially be used to validate estimates of bigeye tuna species composition from pole and line gear in the earlier years.

157. The WPTT queried whether selection of larger fish due to market demand was occurring (i.e. size grading) and **NOTED** that this may cause bias in the size frequency data. It was **NOTED** that data collected from landing sites are likely to be more biased than sampling by fishers on board, the latter of which is thought to be more representative of size frequency.

158. The WPTT **NOTED** that the characteristics of the Maldivian pole and line, longline and handline fisheries are related to cultural and economic factors. Longline generally results in better product for export but fishers prefer to fish closer to shore and for shorter periods, hence the preference for using the gears other than longline. Longline licences also require much larger investment, which has created more incentives for handline fishing.

7.3 Review of new information on the status of yellowfin tuna

7.3.1 Nominal and standardised CPUE indices

Updated CPUE standardizations for bigeye and yellowfin tuna caught by Taiwanese longline fishery in the Indian Ocean using generalized linear model

159. The WPTT **NOTED** paper IOTC–2018–WPTT20–35, which provided updated CPUE standardizations for bigeye and yellowfin tuna caught by Taiwanese longline fishery in the Indian Ocean using generalized linear model, including the following abstract provided by the authors:

> *"Bigeye and Yellowfin tuna CPUE standardization were presented. Updated Taiwanese longline fishery data to 2017 was used in this analysis. Cluster analysis was used to classify longline sets in relation to species composition of the catches to obtain target species proxy which can be used in CPUE standardization. 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 June 2018 in Keelung. Comparing to Joint CPUE indices for yellowfin tuna, Taiwanese CPUE indices showed a decreasing trend with smaller scale in tropical region. In 2017, yellowfin catch decreased to around 4,600 tons by Taiwanese longline fishery. Taiwan Tuna Association commented that the reduction of yellowfin catch in 2017 was due to quota management."*

160. The WPTT **NOTED** that the Taiwanese logbook data analysed in this report only includes large vessels (>100 t), which contribute around 40–60% of the total yellowfin tuna catch in the last decade.

161. The WPTT **NOTED** that Taiwanese size data which are submitted to IOTC were the collection of length measurements of specimens sampled for length on-board. Several issues concerning the size data have been identified. As for lack of small fish length data during some periods, the WPTT **NOTED** that one possible reason is improper sampling or other improper reporting behaviours by fishermen.

162. The WPTT **NOTED** that spatial effects were estimated to have a much larger effect on Taiwanese clustering than gear effects, and suggested that the use of species-specific core areas might be used instead of clustering, to remove the effect of confounding between clustering and abundance.

163. The WPTT **NOTED** that effort has reduced dramatically in the eastern Indian Ocean and **NOTED** this may have implications for the representativeness of data in recent years.

164. The WPTT **NOTED** that no analysis is shown for the Arabian Sea region R1a. The east region R5 has lower catches and does not include data from small vessels.

165. The WPTT **NOTED** the potential for cluster analysis that combines species composition with other types of variables to get an integrated set for targeting and **SUGGESTED** that this is worth investigating.

166. The WPTT **NOTED** the value of aggregating data to some degree so as to avoid undue influence of randomness in catch composition.

167. The WPTT **NOTED** that the introduction of Resolution 18/01 may have influenced a decrease in catch rates reported in logbooks in 2017. The WPTT **NOTED** that in this context, CPCs need to make efforts to collect information on the fate of catches, i.e. whether they are retained or discarded.

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

168. The WPTT **NOTED** paper IOTC–2018–WPTT20–36, which described standardization of yellowfin tuna CPUE for the EU purse seine fleet operating in the Indian Ocean, including the following abstract provided by the authors:

> *"The EU purse seine fleet catches of yellowfin tuna (Thunnus albacares) from the Indian Ocean were standardized using the framework described in Katara et al. (2016, 2017) with a Delta-lognormal generalised linear mixed model developed specifically for the standardisation of tropical tuna catch per unit effort (CPUE) time series. The CPUE time series were treated by fishing mode: free school (FSC) sets and sets associated with floating objects (FOBs). CPUE for FSC was defined as the catch per hour of large yellowfin tuna (> 10 kg) since FSC sets are mainly dominated by adult fishes. For FOBs sets, CPUE was defined as the catch per positive set of small yellowfin tuna (< 10 kg) – a positive set defined as a set with small yellowfin catches > 0 - since mainly juveniles are caught under FOBs. The time series considered were 1986-2017 and 2010-2017 for FSC and FOB, respectively. The two time-series are of different length due to the availability of covariates that likely affect them. In both cases, the least absolute shrinkage and selection operator method was applied for model selection. The resulting time series of standardised CPUE for FSC and FOBs do not show significant trends. Environmental variables were shown to affect catchability."*

169. The WPTT **NOTED** that the standardized PS CPUE confidence intervals for free school purse seine indices were very wide and not easy to interpret (i.e. included negative values). It was clarified that catch per hour had been plotted on a log scale.

170. The WPTT **NOTED** that the standardized floating object set purse seine indices were essentially identical to the nominal CPUE series, which is not consistent with the continuous technological evolution that the purse seine fishery has experienced. However, the WPTT **NOTED** that while the nominal CPUE for the free school purse seine fishery has a positive trend, the standardised indices produce a relatively flatter CPUE trend, thereby better reflecting the increase in fishing power.

171. The WPTT **NOTED** that the effort definition used for defining relative abundance index where the fishing time for free school sets and the positive set for the floating object, which are straightforward effort units recorded for purse seine fleets. However, quantifying the effort creep is a complex issues which is being investigated by the scientists of the concerned CPCs. The WPTT **NOTED** that the standardised free school series presented suggests that biomass is higher now than 20–30 years ago, which raises concerns about the standardisation.

172. The WPTT **NOTED** that gear parameters relating to total net length, maximum height, sinking speed and depth of net are available from the logbook data but these variables were assumed to be constant in the current analysis. The WPTT **NOTED** that gear configuration had not changed much over time. Information on sinking rates is sometimes observed by skippers but this information is not captured in logbooks on a regular basis. It was suggested that this information could be collected by observers if necessary.

173. The WPTT **NOTED** that there had been technological improvements, including the use of echosounder buoys, that assist searching and queried how this might influence the FOB standardisations. The author responded that they included this information but it was uninformative at the scale of the standardization. The WPTT **NOTED** that only partial information informing FOB density distribution was available for this study, and that the complete coverage will be gathered to update the present analysis for WPTT21.

Japanese longline BET and YFT CPUE standardization (three papers and combined presentation)

174. The WPTT **NOTED** paper IOTC–2018–WPTT20–29 which discussed Japanese longline CPUE for bigeye tuna in the Indian Ocean standardized using a generalized linear model (GLM), including the following summary provided by the authors:

   "Standardization of Japanese longline CPUE for bigeye tuna was conducted up to 2017 by using GLM (generalized linear model, log normal error structured). 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 there was a high jump in 1977 and 1978, slight decrease after that, and increasing trend in the recent few years were observed. Vessel effect was also used in a part of analyses, and it has some influence on CPUE trend."

175. The WPTT **NOTED** paper IOTC–2018–WPTT20–37 which described standardization of bigeye and yellowfin CPUE by Japanese longline in the Indian Ocean which includes cluster analysis, including the following abstract 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."

176. The WPTT **NOTED** paper IOTC–2018–WPTT20–38 which describes Japanese longline CPUE for yellowfin tuna in the Indian Ocean standardized by generalized linear model, including the following abstract provided by the authors:

   "Japanese longline CPUE for yellowfin tuna in the Indian Ocean (area aggregated and area-specific) was standardized up to 2017 by GLM mainly based on similar methods used in the previous studies. Basically, standardized CPUEs showed similar trends among areas. CPUE continuously decreased from 1950s to around 1974, and kept in the same level until 1990. Thereafter, it declined to a historically low level and then slightly increased in recent years. A vessel effect was also used in a part of analyses, and it has some extent of influence on CPUE trend. Decline in CPUE got less steep by using the vessel effect. There was somewhat difference between the trend of CPUEs in this study and those created in the collaborative analysis (with cluster analysis and vessel ID)."

177. The WPTT **NOTED** that the recent Japanese CPUE series were less useful for stock assessment because of the restricted spatial coverage, but that it was useful to compare similar analyses among Japan, Korea and Taiwan, China to examine if there were problems with pooling all fleets in the joint standardization analysis.

178. The WPTT **NOTED** the value of continuity analysis to be able to observe the effects of changing methods.

179. The WPTT queried the effect of the number of hooks per set on CPUE trend and whether this was tested as an effect and it was **NOTED** that this was included in the updated collaborative analysis.

180. The WPTT sought clarification on which method would be recommended out of the four different approaches that had been applied. The authors noted that the new method was preferred as it included vessel effect and cluster analysis which are not included in the traditional method. The WPTT **NOTED** a preference for quantitative criteria for the selection of a preferred method. Time constraints prevented full exploration of the analyses undertaken that could provide a more quantitative justification for the preference of methods.

CPUE standardization of yellowfin tuna caught by Korean longline fishery in the Indian Ocean

181. The WPTT **NOTED** paper IOTC–2018–WPTT20–39 which described CPUE standardization of yellowfin tuna caught by Korean longline fishery in the Indian Ocean, including the following abstract provided by the authors:

 "In this study we standardized CPUE of yellowfin tuna caught by Korean tuna longline fisheries in the Indian Ocean using Generalized Linear Models (GLM) with operational data. The data used for the GLMs were catch (number), effort (number of hooks), number of hooks between floats (HBF), fishing location (5° cell), and vessel identifier by year, quarter, and region. We applied cluster analysis to address concerns about target change through time which can affect CPUE indices. The CPUE was standardized using lognormal constant and delta lognormal approaches, considering with vessel effects and without vessel effects, and the main indices was estimates from delta lognormal approach."

182. The WPTT **NOTED** that there has been a relatively low number of vessels operating in the Korean fishery and that yellowfin tuna effort has increased compared to previous years.

Bayesian skipjack and yellowfin tuna CPUE standardization model for Maldives pole and line 1970–2016

183. The WPTT **NOTED** paper IOTC–2018–WPTT20–40 which described Bayesian skipjack and yellowfin tuna CPUE standardization model for Maldives pole and line fishery from 1970–2016, including the following abstract provided by the authors:

 "An abundance index for skipjack and juvenile yellowfin tuna from 1970 to 2016 has been developed from Maldives pole and line catch and effort data. Solutions for missing data were a random effects component used to account for missing mechanization information on the fleet 1974–1979 (Medley et al. 2017a) and the reconstruction of vessel length information using a vessel survival regression (described in Medley et al. 2017c). Fishing power effects related to vessel length are explained using a segmented regression that accounts for different classes of vessel. Both skipjack and yellowfin are combined into a single multivariate model, with skipjack catch rates standardized through a log-normal regression and yellowfin through a delta-lognormal regression. Additional fishing power effects which have not been recorded in the data have been estimated using subjective priors based on an expert meeting, and these could be included in the model. The model was fitted obtaining a MCMC approximation to the Bayes posterior for the abundance indices using Stan software. Remaining issues include poor estimation of catch rates for the smallest vessels and unaccounted for differences among landing atolls, as the reasons for these differences are not understood. Also, recent declines in logbook reporting rates are a cause for concern."

184. The WPTT **NOTED** that there was a discontinuity associated with the introduction of logbooks which affected the reliability of recent indices.

185. The WPTT **NOTED** the decline in skipjack and yellowfin CPUE series and that in absolute terms there may be a >80% reduction in the skipjack CPUE and a ~80% decrease for yellowfin between 1970 and 2017, and queried whether declines of these magnitudes were plausible. The results suggest that skipjack tuna may be more depleted in the Maldives area than previously thought.

186. The WPTT **NOTED** that the historical CPUE time series was a composite derived from different data in different periods. The resulting time series was very sensitive to expert opinions about how different factors were expected to affect catchability (with a combined effect of a factor of 4 change), and the time series estimated much higher depletion than recent assessments. This may be partly an effect of localized depletion, with consequences for the assessment structure.

187. The WPTT **NOTED** that the analysis might be further improved by recovering the vessel register prior to 1995, and examining the time available for fishing following changes in the bait fishery.

188. **ACKNOWLEDING** that this work represented significant progress, the WPTT **ENCOURAGED** the continuation of this work in the lead up to the skipjack tuna assessment planned for 2020 and **NOTED** the importance of exploring mechanisms to refine these results.

189. The WPTT **NOTED** the PL yellowfin CPUE series could be used as a sensitivity run in future assessments, but cautioned its limited representativeness of the PL CPUE for Region 1.

190. The WPTT **NOTED** that the International Pole and Line Foundation is supportive of this work.

Collaborative study of yellowfin tuna CPUE from multiple Indian Ocean fleets in 2018

191. The WPTT **NOTED** paper IOTC–2018–WPM09–12 which described a collaborative study of yellowfin tuna CPUE from multiple Indian Ocean fleets in 2018, including the following abstract provided by the authors:

> *"In May and June 2018 a collaborative study was conducted between national scientists with expertise in Japanese, Korean, Seychelles, and Taiwanese longline fleets, an independent scientist, and an IOTC scientist. The meetings addressed Terms of Reference covering several important issues related to yellowfin and albacore tuna CPUE indices in the Indian Ocean. The study was funded by the Indian Ocean Tuna Commission (IOTC)."*
> *– see paper for full abstract.*

192. The WPTT **NOTED** that the analyses had limited ability to account for some important factors including that hooks between floats (HBF) is a poor proxy for set depth, because it does not account for gear configuration, line material or setting rate, and current shear will affect the sag depth.

193. The WPTT **NOTED** that it would be preferable to subset the data on the basis of known fishing depth, but this information is not generally available.

194. The WPTT **NOTED** that vessel ID could be modelled as either a fixed or random effect **-** random effects are probably more appropriate when generalizing about a whole population from samples, whereas fixed effects are appropriate in this case, because the vessels represent the whole population of interest, and do not require additional assumptions about error distributions. The author indicated that the choice did not make much difference in this case.

195. The WPTT **NOTED** that the length composition of the catches of the longline fleets is estimated considering the longline catches from Korea, Japan, Seychelles and Taiwan, China in the 4 regions. The length composition between these fleets are different, some of them (e.g. Taiwan, China) showing changes over time. Thus, the WPTT **REQUESTED** that this issues are investigated in the future analysis of the joint-LL CPUE index.

196. The WPTT **NOTED** that when species composition groups are not clearly differentiated, cluster definitions can be confounded with changing abundance of the target species, which leads to a flattening of the abundance trend. This is a concern in tropical regions for bigeye and yellowfin tuna, since both species are targeted together. It was argued that the cluster analysis is important for separating out temperate sets that are clearly targeting oilfish, albacore or southern bluefin tuna.

197. The WPTT **NOTED** that the standardization approach does not estimate time-area interactions within regions. This was expected to be most important in relation to the gradual reduction of the

Japanese and Korean operations over time, and the dramatic effort reduction caused by Somalian piracy.

198. The WPTT **NOTED** two concerns about the CPUE series prior to 1979: i) Hyper-depletion is clearly evident in the early years of the fishery, such that the CPUE series has been truncated in 1972 (a subjective decision), and ii) vessel IDs are important, but are not available for the analysis prior to 1979 (which means that vessel IDs either have to be omitted from the whole time series or heterogeneous series must be combined).

199. The WPTT **NOTED** that the CPUE regional scaling factors calculated over 1979–94, using method 8 were recommended for assessments, because this approach includes the most important factors and the fewest data gaps.

200. The WPTT **RECOMMENDED** the continuation of CPUE standardization analyses as this is a critical input to the bigeye tuna and yellowfin tuna stock assessments.

7.3.2 Stock assessments

201. The WPTT **NOTED** that two (2) modelling methods (SCAA and SS3) were applied to the assessment of yellowfin tuna in 2017. The different assessments were presented to the WPTT in documents IOTC–2018–WPTT20–21 and IOTC–2018–WPTT20–33. Each model is summarized in the sections below.

Yellowfin tuna: Summary of stock assessment models in 2018

202. 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).

Preliminary stock assessment of Indian Ocean yellowfin tuna using Statistical-Catch-At-Age (SCAA)

203. The WPTT **NOTED** paper IOTC–2018–WPTT20–41 which described a preliminary stock assessment of Indian Ocean yellowfin tuna using SCAA, including the following summary provided by the authors:

> *"We attempted a preliminary stock assessment for yellowfin tuna (YFT) in the Indian Ocean using SCAA (Statistical-Catch-At-Age) with available data for 68 years (1950–2017). The preliminary results suggested that YFT stock status (2017) is lightly overfished, i.e., the red zone in the Kobe plot but very close to both MSY levels (F and SSB) with F (2017)/Fmsy=1.08 and SSB (2017)/SSBmsy=0.88."*

204. The WPTT **NOTED** the results of the SCAA assessment, as included in Table 3.

Table 3. Results of 4 converged SCAA runs with 0.0010 [C]

Scenario no	h (steepness)	Sigma (SR)	SSB0 (1,000 t)	Total likelihood	r2	SSB (1,000 t)	MSY (1,000 t)	SSB/SSBmsy	F/Fmsy
(2)	0.7	0.5	4446	-70.6	0.9	1321	404	0.87	1.07
(4)	0.7	0.7	5517	-70.6	0.9	1504	480	0.81	0.98
(5)	0.7	0.8	6176	-70.6	0.9	1549	533	0.74	0.96
(10)	0.8	0.8	5646	-70.6	0.9	1472	536	0.88	0.84

205. The WPTT **NOTED** the similarity of the results from the final SCAA model configuration with the previous SS3 assessment results (2015). The authors clarified that the similarity of assessment results was unintentional and that expert judgement had been used in selecting the final model and its associated plausible assumption, that is no drastic change of stock status in three years under constant catch levels (400,000 t) in the last 6 years (2012–2017). The WPTT **NOTED** that

quantitative methods for model parameter selection were preferred. They authors suggested that the results were highly preliminary, thus results should not be used for management advice.

206. The WPTT **NOTED** a number of caveats with the analysis relating to catch at age, selectivity and limited sensitivity runs. The authors noted, if appropriate, there is potential to refine the fleet definition in future assessment iterations.

Diagnostics for stock synthesis model on yellowfin tuna in the Indian Ocean

207. The WPTT **NOTED** paper IOTC–2018–WPTT20–42 which described diagnostics for stock synthesis model on yellowfin tuna in the Indian Ocean, including the following summary provided by the authors:

> *"Diagnoses of stock synthesis model SS3 were conducted using that for Indian Ocean yellowfin tuna stock assessment in 2016, based on the methods used in this year's ICCAT bigeye tuna assessment. Jitter analysis, residual analysis, retrospective analysis, R0 likelihood profile and age structured production model (ASPM) analysis were conducted. According to the results of these diagnoses, the model seems to be comparatively good and robust. The diagnoses are useful, and so hopefully will be applied to other stocks as well."*

208. The WPTT **NOTED** that the diagnostics for the 2016 model showed similar convergence issues to the 2018 model.

209. The WPTT **NOTED** that the jitter analysis indicated that the 2016 base model might encounter a local minima of the maximum likelihood, which was also observed in the 2009 MULTIFAN assessment.

210. The WPTT **NOTED** the value in exploring model diagnostics and **ENCOURAGED** this work be repeated in future. It was **NOTED** that stock assessment diagnostics are difficult to run each year and a more efficient approach is required if such diagnostics are to be used in the selection of the best model to be used for formulating management advice from the most recent stock assessments.

211. The WPTT **NOTED** that the longline CPUE is driving most of the assessment outcomes and expressed concerns that even with good statistical diagnostics the model may still be misleading in terms of conveying the most accurate representation of the stock. The WPTT **NOTED** that the MSE and management procedure evaluation seeks to address these issues by exploring broad ranges of uncertainties. Such an approach accepts that the optimum will never be reached but will provide a reasonable and balanced management outcome.

212. The WPTT **NOTED** that the structure and complexity of stock assessments limits the time that can be spent exploring model diagnostics, and **SUGGESTED** that the WPM consider formulating an approach that allows this to occur before the meetings. The WPTT **NOTED** a possible structure that includes adequate time to 1) explore the quality of data input streams, 2) explore diagnostics on provisional model structure and 3) investigate the full grid used to formulate management advice. The WPTT **SUGGESTED** that the IOTC Stock Assessment Protocol could be updated to include such processes.

Preliminary Indian Ocean yellowfin tuna stock assessment 1950–2017 (Stock Synthesis)

213. The WPTT **NOTED** paper IOTC–2018–WPTT20–33 which described a preliminary Indian Ocean yellowfin tuna stock assessment 1950–2017 using Stock Synthesis III, including the following summary provided by the authors:

> *"This paper presents a preliminary stock assessment of yellowfin tuna (Thunnus albacares) in the Indian Ocean (IO) including fishery data up to 2017. The assessment implements an age- and spatially-structured population model using the Stock Synthesis software (Methot 2013, Methot & Wetzel 2013)."*

214. The WPTT **RECALLED** the request from the Commission to understand how the stock is responding to management measures and **NOTED** the value in maintaining, as much as possible,

previous stock assessment assumptions that have been used. It was **NOTED** that further evaluations are appropriate and healthy but there was high level of value in retaining the base level of structure that has been used in previous assessments. The WPTT **NOTED** that such an approach has pitfalls in that models and outputs need to be interactive as information and understanding of stock dynamics improve.

215. The WPTT **NOTED** the key assessment results for the SS3 model and thanked the author for his extremely thorough work. Based on the results of the preliminary model outlined in the paper, The WPTT **NOTED** the following key issues relating to model structure and core assumptions in the SS3 assessment model, summarised below:

- Movement dynamics: It was **NOTED** that the northern boundary of R2 has changed between assessments. The WPTT **NOTED** that it may be more useful to estimate in which region fish should be at certain ages, freeing up where the model estimates recruitment rather than confining to set preconceived regions in the model. The WPTT further **NOTED** that there is no way to estimate recruitment between region 3 and region 4 as there was little tagging data to estimate this movement.

- Gillnet distribution of size frequencies: The WPTT **NOTED** that there are unreported data on bimodal size distribution of the catches due to entanglement and gilling processes that should result in a binormal selectivity curve. The WPTT **NOTED** that it would be useful to present these data to the next WPTT meeting. Additional evidence is required to inform assumptions around a bimodal distribution and this evidence is not currently available to the IOTC Secretariat. The WPTT **SUGGESTED** that additional work exploring an assumed bimodal selectivity for gillnet would be useful.

- Longline size data: The WPTT queried sampling coverage rates for the LL fisheries in South Africa, Seychelles and Australia and the potential implications of these size data composed of mostly larger fish on assessment outcomes. The WPTT **NOTED** that there could be variability in LF data within regions and **NOTED** that coverage is not representative across each region. The WPTT **NOTED** that the size data are required to estimate selectivity but because of trend and lack of representativeness urged caution that this does not necessarily represent biomass trends in model outputs. The WPTT **NOTED** that the minimum sampling coverage of one fish measured per metric tonne from LL fleets was not reached for yellowfin tuna for 12 years during the last 16 years of data. The WPTT **NOTED** that smaller fish are not present in LF distributions and that perhaps the LL fleets are not sampling these smaller fish or fishermen are not reporting them. The WPTT **NOTED** concerns that this might result in fish missing from the record and influence CPUE. The WPTT **NOTED** that the absence of small fish in the Taiwanese fleet does not change the CPUE trend because this occurred since 2000s and the Taiwanese data is included since 2005 in the CPUE, which is the most relevant consideration from the standardisation. The WPTT **NOTED** that length composition data for Japan, Taiwan, China and Korea should be considered in future joint CPUE standardisation updates to assist future assessment. The WPTT **SUGGESTED** a thorough review of LL size data during 2019.

- Selectivity: the WPTT **NOTED** the assumption that selectivity is the same for the four regions and for the LL fleets, when differences are observed in the size frequencies by region/fleet. The WPTT **NOTED** that hook size and depth of hooks may differ by fleet, which could influence differences in mean LFs by fleet. The WPTT **NOTED** that it was likely different fleets have different selectivity, but that some simplification in the assessment is required to reduce complexity. If there is clear evidence of differences then this should be considered.

- Tag biases: The WPTT **NOTED** that assessment models with very large regions cannot reliable estimate movement rates from tagging data and that such inferences should not be over interpreted. The WPTT **NOTED** that no or very few tag recovery rate estimates in region 3 and region 4 make it very difficult to extrapolate from the very small number of available tags.

- Tag mixing assumptions: The WPTT **NOTED** that the 3 quarter tag mixing assumption may be inappropriate. Previous studies (Langley and Million, 2012) indicated that tagged fish were not mixed after 2 quarters but 3 quarters may also be too little.

216. The WPTT **NOTED** the results of the preliminary set of runs with SS3 produced for the assessment of this stock. With regards to this first set of results the WPTT **NOTED** the following:

- The WPTT **NOTED** the conflicting CPUE series in R1 and R2 and that this could represent 2 alternate scenarios. This should be investigated by downweighting the CPUEs for each region alternately and exploring the model fits.
- The WPTT **NOTED** evidence of greater depletion in core area of the purse seine fishery. This would appear counter intuitive if the movement rate was indeed very high between regions.
- The WPTT **NOTED** that the decline in PSFSC CPUE in R1b has some correlation with LL declines, which coincide with a drop in catches due to piracy (2007–2011). The WPTT **NOTED** that the decrease in CPUE during these years was probably caused by the changes in catchability from the spatial contraction of the fleet rather than changes in abundance. The WPTT further **NOTED** that a deeper thermocline around 2007 may have reduced catchability for the purse seine fleet. The piracy would have affected the PS fleets less than the LL fleets as they changed the fishing strategy fishing on pairs and brought security onboards. The WPTT **ACKNOWLEGED** however, that the patterns in CPUE would not match up exactly between the PS and LL fleets as they target different sizes of fish and so there would expect to be a time lag in the LL CPUE from the PS signal.
- The WPTT **STRESSED** the influence of piracy on the CPUE in area 1b. This resulted in a marked contraction of the operation of the LL fleet and a severe reduction (ca 60%) in the number of vessels in the Indian Ocean. This would result in lower coverage for that period, which may lead to biases in the CPUE estimates for this time period. As such the WPTT considered a scenario in which the CPUE data for this time period be dropped from the model. The WPTT **ACKNOWLEDGED** that this was not ideal as the parameters in the CPUE standardisation were estimated using this data and therefore should these years be dropped, ideally the CPUE should be re-estimated. The WPTT further **NOTED** that the catchability for the LL fleets before and after the piracy period may have changed and that this should be explored.
- The WPTT also **DISCUSSED** the initial tag mortality value of 10% that was used in the reference case model. A study conducted by Hoyle et al. (2015) using the tagging data from the RTMP database suggested that this rate should be closer to 27.5%. The WPTT **NOTED** that this was the only study that addressed this issue for the Indian Ocean. Other published literature that was discussed had considered tag loss but not tagging mortality. There was a lack of consensus regarding this issue and so it was **AGREED** that both estimates should be included and explored further.
- The WPTT **NOTED** the large residuals when fitting to the LL size frequency data at the end of the time series. The WPTT **EXPRESSED CONCERN** over the sampling coverage or representativeness of the size data over the last few years. It was therefore **REQUESTED** that size data should be dropped or downweighted at the end of the series.
- The WPTT **NOTED** the analysis of R0 profiles to inform the effect of different data components (CPUE, size data and tagging data) in the fit of the stock assessment models

and to inform about different model configurations to capture the sources of uncertainty in relation to data. Thus, the WPTT **AGREED** to use different series/weight for CPUE, size data and tag data for formulation the uncertainty grid.

217. The WPTT **NOTED** that the complexity of these assessments and the desire to explore many possibilities was pushing up against computational bounds and time constraints. The WPTT **SUGGESTED** exploring alternatives such as cloud computing in the future (e.g. as used in other tuna RFMOs).

Final reference case and reference grid model specification

218. Based on the above discussions the WPTT **SUGGESTED** several sensitivity runs to the reference case model presented in the document to build the uncertainty grid:
    - A four quarter tag mixing period
    - Increasing the initial tag mortality to 27.5%
    - Tag data weighting lambda = 0.1
    - Removing the size frequency data for the final years of the model (2015 – 2017)
    - Down-weighting the LL CPUE during the piracy period (2007 – 2011 and constant q.)

219. The WPTT **NOTED** that the revised reference case resulted in improvement to the fits of several key parameters as well as less patterns in the retrospective analysis. The WPTT **NOTED** that this reference case does not represent a single "Best Model" and it was not given any more weight in the subsequent modelling approaches listed below.

220. Using the reference case as a starting point, the WPTT **AGREED** to build a reference grid as a practical way forward to assist with the inclusion of the major sources of uncertainty and the formulation of management advice.

    Thus, the WPTT **NOTED** the following scenarios for inclusion in the grid (n=24):
    - Alternative levels of steepness (0.7, 0.8 and 0.9)
    - Initial tag mortality (10% and 27.5%)
    - Tag lambda (0.1 and 1)
    - CPUE LL
        i. Downweighting piracy period (2007–2011) and constant q (Q1)
        ii. Removing piracy period with separate q estimates before and after piracy (Q2)

    It was agreed that Q1 would be given a relative weight of 75% compared to Q2 (25%) in the grid result

221. The WPTT **NOTED** that the grid demonstrated a relatively tight range for F/FMSY and B/BMSY but large variation in the biomass estimates.

222. The WPTT **RECOMMENDED** that the in the future, model diagnostics, including retrospective analyses, jittering and likelihood profiling be conducted to increase confidence that the models are reaching a global minima during fitting and to look for major conflict in data sources.

223. The WPTT **REQUESTED** a sensitivity run exploring the effect of the growth function, by incorporating the Dortel et al. (2014) growth model. The WPTT **NOTED** that the outputs using the Dortel et al. growth differ from the reference grid growth which suggest that this assumption has an important influence on the model results. However, the group also **NOTED** that the use of

a new growth curve would need further adjustments in other model parameters such as the natural mortality. The WPTT **AGREED** that this requires further exploration, and this will be incorporated into the future plan of work.

224. The WPTT **NOTED** that the PS CPUE represents a large proportion of the yellowfin tuna caught in the Indian Ocean (25%) as opposed to the LL CPUE which since 2008 represents only around 5% of the total catch. In addition, the large uncertainty around the LL CPUE indices, particularly in the light of the contraction of the fishing activity during the piracy years were cause for concern and may result in the LL CPUE indices not adequately representing the abundance of the stock. As a result, the WPTT **PROPOSED** a sensitivity run including the European Free School Purse Seine index. Future runs would consider alternative configurations when incorporating PS CPUE; for example, scenarios exploring catchability changes over time such as including an increasing delta q per year of 1.25% or other estimates from future studies

Future yellowfin assessments: issues for consideration

225. 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.

226. The WPTT **REQUESTED** that estimates of natural mortality are updated using the tagging data, outside the assessment model, given that new information (e.g. tag recaptures and revised catch estimates) are now available.

227. The WPTT **NOTED** the lack of agreement regarding the initial tag mortality estimates. The WPTT therefore **AGREED** that an expert working group should review the current available literature and provide future guidance on best estimates for use in assessment models.

7.4 Development of management advice for yellowfin tuna

228. The WPTT **RECOMMENDED** that final management advice be developed from the SS3 models including the reference grid given a relative weight of 75% to Q1 CPUE scenario compared to 25% weight to Q2 in the grid results. The estimates from the grid are provided in Table 4 While the biomass and reference point trajectories are included in Figure 1. The Kobe strategy matrix derived from the 24 models in the grid is provided in Figure 2. These results indicate that the stock is currently overfished and subject to overfishing.

Table 4. Yellowfin tuna: Estimates from the reference grid and sensitivity runs

Option	SB_0	SB_{MSY}	SB_{MSY}/SB_0	SB_{2017}	SB_{2017}/SB_0	SB_{2017}/SB_{MSY}	F_{2017}/F_{MSY}	FMSY	MSY
Grid									
io_h70_q1_tm10_dw1	3,003,510	1,120,700	0.37	843,270	0.28	0.75	1.48	0.13	371,436
io_h70_q1_tm10_dw2	3,675,820	1,387,230	0.38	1,112,548	0.30	0.80	1.16	0.13	429,048
io_h70_q1_tm30_dw1	2,589,010	937,520	0.36	694,956	0.27	0.74	1.71	0.13	339,148
io_h70_q1_tm30_dw2	3,338,450	1,237,790	0.37	967,355	0.29	0.78	1.33	0.13	406,652
io_h70_q2_tm10_dw1	2,973,180	1,112,310	0.37	875,641	0.29	0.79	1.44	0.13	364,839

io_h70_q2_tm10_dw2	3,520,970	1,307,100	0.37	1,147,210	0.33	0.88	1.14	0.14	417,336
io_h70_q2_tm30_dw1	2,595,200	939,918	0.36	777,725	0.30	0.83	1.60	0.13	327,912
io_h70_q2_tm30_dw2	3,475,750	1,234,200	0.36	1,092,650	0.31	0.89	1.12	0.14	402,632
io_h80_q1_tm10_dw1	2,824,950	1,022,630	0.36	818,672	0.29	0.80	1.31	0.14	386,378
io_h80_q1_tm10_dw2	3,306,620	1,199,830	0.36	1,005,244	0.30	0.84	1.09	0.15	431,148
io_h80_q1_tm30_dw1 (reference)	2,529,310	868,874	0.34	697,122	0.28	0.80	1.39	0.15	351,806
io_h80_q1_tm30_dw2	3,150,990	1,122,560	0.36	936,027	0.30	0.83	1.14	0.15	415,948
io_h80_q2_tm10_dw1	2,800,350	1,006,200	0.36	854,379	0.31	0.85	1.25	0.15	381,028
io_h80_q2_tm10_dw2	3,316,480	1,187,310	0.36	1,089,720	0.33	0.92	1.01	0.15	426,428
io_h80_q2_tm30_dw1	2,528,510	848,657	0.34	865,381	0.34	1.02	1.16	0.16	335,177
io_h80_q2_tm30_dw2	3,227,900	1,112,920	0.34	1,052,565	0.33	0.95	1.00	0.16	416,256
io_h90_q1_tm10_dw1	2,690,880	924,276	0.34	799,077	0.30	0.86	1.18	0.16	400,052
io_h90_q1_tm10_dw2	2,911,370	1,069,000	0.37	849,429	0.29	0.79	1.22	0.15	433,108
io_h90_q1_tm30_dw1	2,428,380	788,933	0.32	686,737	0.28	0.87	1.20	0.17	367,180
io_h90_q1_tm30_dw2	3,015,130	1,013,810	0.34	912,487	0.30	0.90	1.03	0.16	436,184
io_h90_q2_tm10_dw1	2,674,940	919,234	0.34	839,751	0.31	0.91	1.13	0.16	393,053
io_h90_q2_tm10_dw2	3,185,460	1,095,860	0.34	1,090,063	0.34	0.99	0.91	0.16	448,172
io_h90_q2_tm30_dw1	2,377,880	772,269	0.32	752,123	0.32	0.97	1.21	0.17	360,262
io_h90_q2_tm30_dw2	2,948,540	980,149	0.33	938,349	0.32	0.96	1.00	0.17	424,964
sensitivity									
gDortel	2,334,030	806,337	0.35	527,898	0.23	0.65	1.95	0.56	318,036
*PSCPUE**	2,223,340	773,852	0.35	757,563	0.34	0.98	1.31	0.56	317,850

* Note: In the sensitivity run for PSCPUE, the model included both the FOB and Free school indices. It was noted that the future sensitivity should only include the Free school index

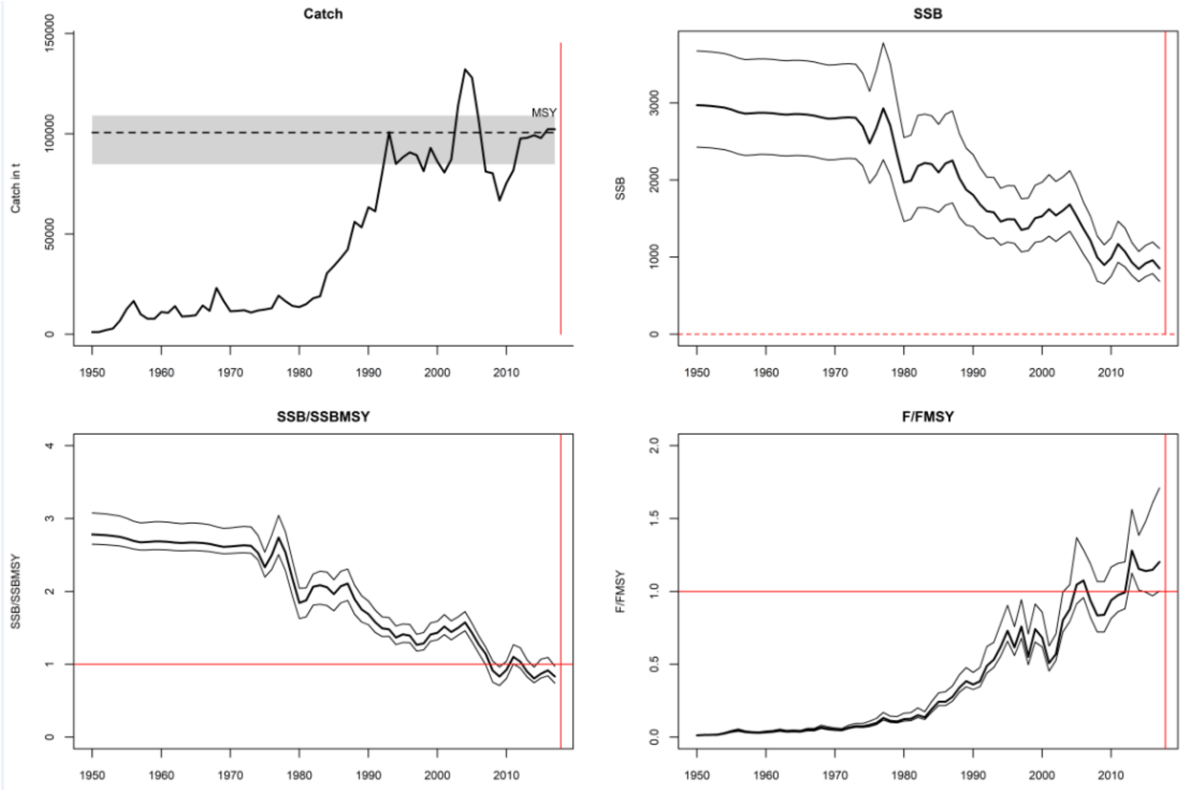

Figure 1. Stock status summary for the Indian Ocean yellowfin for the grid of 24 models. Thick black lines represent the median values from the grid, while pale grey lines represent 5th and 95th percentiles. In the catch plot, catches correspond to quarterly catches, dotted lines represent the estimate of MSY, the shaded area represents 5th and 95th percentiles. The red lines represent

the terminal year of the model (i.e.2017). The median and the percentiles are weighted across the grid of 24 models (see Para 220).

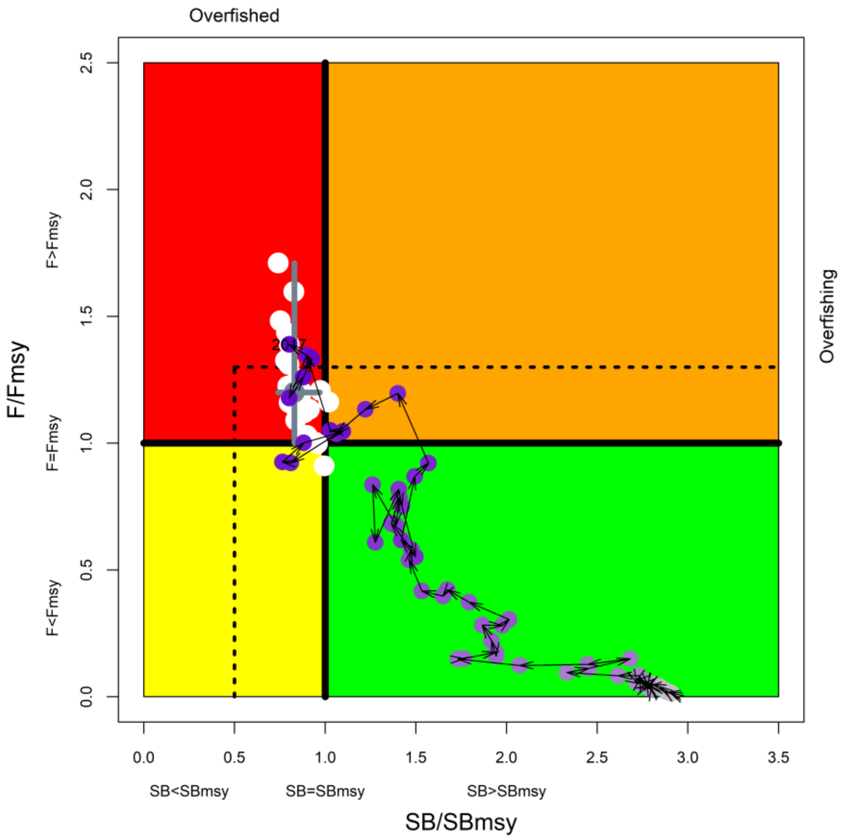

Figure 2. Yellowfin tuna: SS3 Indian Ocean assessment Kobe plot. Pink dots indicate the trajectory of the point estimates for the B/BMSY and F/FMSY ratios for each year from the reference case model (1950–2017) and white dots indicate the terminal estimates from each of the 24 grid models. The grey point represents the weighted median of the 24 model options with associated 80% confidence interval.

Projections and K2SM

229. SS3 projections will be conducted intersessionally, and the results to be presented in a separate working document to the Scientific Committee, including Kobe strategy matrices The Kobe2 Strategy Matrix probabilities will be calculated using deterministic constant catch projections from the 24 reference grid scenarios given a relative weight of 75% to Q1 CPUE scenario compared to 25 % weight to Q2 in the grid results. This describes the range of uncertainty among models encompassed by the Maximum Posterior Density estimates, but does not describe uncertainty due to parameter estimation error, or stochastic future recruitment variability. The executive summary, including the management advice, will then be developed during the SC.

230. The WPTT **ADOPTED** 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 2017 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 Update of yellowfin tuna Executive Summary for the consideration of the Scientific Committee

231. The WPTT **NOTED** that Executive Summary would be updated during Scientific Committee after examining the K2SM which would be done intersessionally.

Prospects for an effort-based management of Indian Ocean yellowfin stock

232. The WPTT **NOTED** paper IOTC–2018–WPTT20–43 which described prospects for an effort-based management of Indian Ocean yellowfin stock, including the following summary provided by the authors:

"During the 2017 Scientific Committee (SC) meeting it was noted that Alternative Management Measures should be explored to improve the management of yellowfin tuna. This document discusses the potential of one alternative to the management measures currently in force for the purse seine fleets operating in the IOTC area of competence. In brief, we would like the Working Party on Tropical Tunas (WPTT) and SC to discuss the pros and cons of inputs controls (i.e. limiting the duration of the fishing season) in comparison to the output controls (i.e. current catch limits). The main reason for this is that the implementation of the catch limits for yellowfin in 2017 has been problematic. In the case of purse seiners, several problems have been identified. We list these and discuss their effects throughout this document. Some are general consequences of the application of catch based measures to multi-specific fisheries such as the Indian Ocean tropical tunas and some are derived from the dynamics of this fishery and the purse seine gear operations."

233. The WPTT **NOTED** that there may be examples where effort controls have worked effectively in other RFMOs and **SUGGESTED** that these should be explored to inform potential options in IOTC.

234. The WPTT **NOTED** potential difficulties with mixed fisheries where there may be a need to have prior agreement about allocation across different gear types in order to establish total allowable effort levels. The IOTC's Technical Committee on Allocation Criteria has made limited progress towards an allocation model, although this is being addressed in 2019.

235. The WPTT **NOTED** that depending on the management strategy catches may need to be monitored in near real-time, which has implications in terms of the required levels of sampling effort and associated costs.

236. The WPTT **NOTED** that fishers are efficient at increasing catches in response to effort controls, which can make it difficult to derive effort limits from agreed catch limits.

237. The WPTT **NOTED** that total seasonal closures have been used in some fisheries to limit effort. The WPTT **NOTED** the potential impact that such closures could have on the constant supply of fish to the market, on which many businesses such as canneries are heavily reliant.

7.5.1 Selection of Stock Status indicators for yellowfin tuna

238. The WPTT **AGREED** that the final grid of 24 model runs from the SS3 stock assessment would be used for development of management advice for the Scientific Committee's consideration.

7.6 Update on Management Strategy Evaluation Progress

239. The WPTT **NOTED** paper IOTC–2018–WPM09–10, which provided an update on the development of the operating model for IOTC yellowfin tuna (October 2018) including the following summary provided by the authors:

"*This paper summarizes progress on the development of Operating Models (OMs) for IOTC yellowfin (YFT) tuna. MP evaluation updates for yellowfin and bigeye tunas are* *described in Kolody and Jumppanen (2018a). This paper builds on the work presented and reviewed at the IOTC informal MSE Working Group in March 2018 (Kolody and Jumppanen 2018d,e).* [See paper for full abstract]"

240. The WPTT reviewed and **ENDORSED** the progress to date on MSE for yellowfin tuna while recognizing the discussions held at TCMP and the advice of WPM, but **INDICATED** the need to alter some of the assumptions used in the operating model grid and consider some additional uncertainty dimensions in the yellowfin tuna MSE workplan agreed by WPM.

241. The WPTT **NOTED** the need to modify the assumed time required to achieve mixing of tagged YFT with the untagged population to 4 quarters (from 3 quarters) based on decisions taken for the 2018 YFT stock assessment. Further, the WPTT **ENCOURAGED** that the MSE work consider the importance of also assuming the time needed for mixing of the tagged and untagged populations of 8 quarters for use in examining robustness of MPs to this assumption.

242. The WPTT **ENCOURAGED** that the MSE work consider the importance of alternative growth for yellowfin tuna based on the growth model estimated by Dortel et al. (2014) for use in examining robustness of yellowfin MPs to alternative growth models.

243. The WPTT further **ENCOURAGED** that the MSE work also consider the importance of adding the Purse Seine Free School CPUE as documented in IOTC–2018–WPTT20–36_Rev1, assuming a 1% per year cumulative increase in catchability (q) for the time period, for use in examining robustness of yellowfin MPs.

244. The WPTT also **NOTED** that the decisions taken for the 2018 YFT assessment regarding short-term and chronic tag loss differed from the YFT Operating Model grid and **REQUESTED** that the 2018 YFT assessment assumptions be mimicked in the Operating Model grid.

245. The WPTT **NOTED** that the proposed new uncertainty dimensions would be evaluated with respect to plausibility and impact before deciding whether to assign them to the OM reference set or robustness trials. The informal MSE working group will review these decisions in March 2019.

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

246. The WPTT **NOTED** paper IOTC–2018–WPM09–11, which provided an update on IOTC bigeye and yellowfin management procedure evaluation progress (October 2018), including the following abstract provided by the authors:

" This document presents MP evaluation results for bigeye and yellowfin tunas, using the new operating models (OMs) proposed in Kolody and Jumppanen (2018a, b) and the new tuning levels requested by TCMP (2018). The results of various robustness scenarios are included, at this point largely to help facilitate the discussion of their role in the MP development and selection process and how they should be presented to the TCMP.".

247. A summary of this document and related discussions are presented under Agenda item 5.4 and 7.4 respectively.

9. WPTT PROGRAM OF WORK

9.1 Revision of the WPTT Program of Work (2019–2023)

248. The WPTT **NOTED** paper IOTC–2018–WPTT20–09, which provided the WPTT20 with an opportunity to consider and revise the WPTT Program of Work (2019–2023), by taking into account the specific requests of the Commission, Scientific Committee, and the resources available to the IOTC Secretariat and CPCs.

249. 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)

250. 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.

251. **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.

252. The WPTT **RECOMMENDED** that the SC consider and endorse the WPTT Program of Work (2019–2023), as provided at Appendix IX.

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

253. 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.

254. 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 2019, 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: bigeye tuna).

10. OTHER BUSINESS

255. On behalf of the WPTT, the Chairperson **THANKED** all attendees for their constructive and valuable contributions during the intersessional period and throughout the WPTT20 meeting.

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

256. The WPTT **NOTED** that the terms of the current Chairperson, Dr. M. Shiham Adam (Maldives), and current vice-Chairperson, Dr. Gorka Merino (Spain) expired at the close of the WPTT20 meeting. On behalf of the WPTT, the IOTC Secretariat **THANKED** Drs. Adam and Merino for their excellent contributions made to the work and objectives of the WPTT and the IOTC more broadly.

257. The WPTT **NOTED** that Dr. Gorka Merino (Spain) was nominated as Chairperson of the WPTT for the next biennium (2019–2020), and this nomination was **ENDORSED** by the WPTT. The WPTT **CONGRATULATED** Dr. Merino on his election as Chairperson and expressed gratitude for the acceptance of his nomination.

258. The current chairperson, Dr M Shiham Adam was nominated as vice-Chairperson of the WPTT for the next biennium, and this nomination was **ENDORSED** by the WPTT. The WPTT **CONGRATULATED** Dr. Adam on his election as vice-Chairperson.

10.2 Date and place of the 21st and 22nd Sessions of the WPTT

259. The WPTT **THANKED** the IOTC Secretariat for hosting the 20th 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.

260. **NOTING** the discussion on who would host the 21st and 22nd Sessions of the WPTT in 2019 and 2020 respectively, the WPTT **REQUESTED** that the IOTC Secretariat liaise with CPCs to determine if they would be able to host the 21st and 22nd sessions of the WPTT respectively (Table 12).

261. The EU offered to host the 21st session of the WPTT in 2019 in San Sebastian, Spain.

262. The Maldives offered to host the 22nd session of the WPTT in 2020 in Malé, Maldives.

Table 5. Draft meeting schedule for the WPTT (2019 and 2020).

Meeting	2019		2020	
	Date	**Location**	**Date**	**Location**
Working Party on Tropical Tunas	Third week in October (6 days)	San Sebastian, Spain	Third week in October (6 days)	Maldives

10.3 Review of the draft, and adoption of the Report of the 20th Session of the WPTT

263. The WPTT **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPTT20, 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 2018 (**Fig.3**):
   - Bigeye tuna (*Thunnus obesus*) – Appendix VI
   - Skipjack tuna (*Katsuwonus pelamis*) – Appendix VII
   - Yellowfin tuna (*Thunnus albacares*) – Appendix VIII

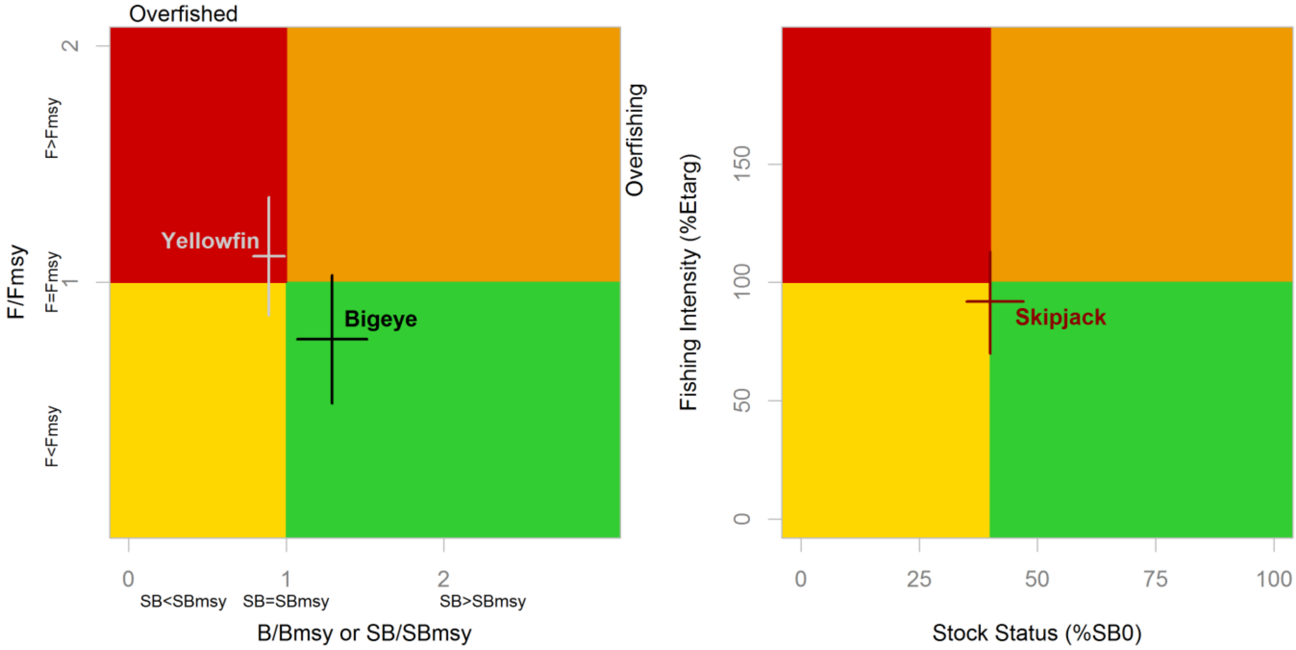

Fig.3. (Left) Combined Kobe plot for bigeye tuna (black: 2016), and yellowfin tuna (grey: 2016) showing the estimates of current stock size (SB) and current fishing mortality (F) in relation to optimal spawning stock size and optimal fishing mortality. (Right) Kobe plot for skipjack tuna showing the estimates of the current stock status. Cross bars illustrate the range of uncertainty from the model runs with a 80% CI.

264. The report of the 20th Session of the Working Party on Tropical Tunas (IOTC–2018–WPTT20–R) was **ADOPTED** on 3 November 2018.

APPENDIX I
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APPENDIX II

AGENDA FOR THE 20TH WORKING PARTY ON TROPICAL TUNAS

Date: 29 October – 03 November 2018
Location: Seychelles
Venue: (TBC)
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)
3. **THE IOTC PROCESS: OUTCOMES, UPDATES AND PROGRESS**
   - 3.1 Outcomes of the 20th Session of the Scientific Committee (IOTC Secretariat)
   - 3.2 Outcomes of the 22nd Session of the Commission (IOTC Secretariat)
   - 3.3 Review of Conservation and Management Measures relevant to tropical tunas (IOTC Secretariat)
   - 3.4 Progress on the recommendations of WPTT19 (IOTC Secretariat)
   - 3.5 Outcomes of the 2nd Technical Committee on Management Procedures (TCMP02)
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)
   - 4.2 Review new information on fisheries and associated environmental data (general CPC papers)
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)
   - 5.3 Review of new information on the status of bigeye tuna (all)
     - Nominal and standardised CPUE indices
     - Stock assessments
     - Selection of Stock Status indicators for bigeye tuna
   - 5.4 Update on Management Strategy Evaluation Progress (OM formulation)
   - 5.5 Development of Management advice for bigeye tuna
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)
   - 6.3 Review of new information on the status of skipjack tuna (all)
     - Nominal and standardised CPUE indices
     - Stock assessments
     - Selection of Stock Status indicators for skipjack tuna
   - 6.4 Update on Management Strategy Evaluation Progress (OM formulation)
   - 6.5 Development of management advice for skipjack tuna (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
     - Stock assessments
   - 7.4 Development of management advice for yellowfin tuna (all)
   - 7.5 Update of yellowfin tuna Executive Summary for the consideration of the Scientific Committee (all)

- Selection of Stock Status indicators for yellowfin tuna

7.6 Update on Management Strategy Evaluation Progress (OM formulation)

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 (2019–2023)

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 21st and 22nd Sessions of the WPTT (Chair and IOTC Secretariat)

10.3 Review of the draft, and adoption of the Report of the 20th Session of the WPTT (Chair)

APPENDIX III

LIST OF DOCUMENTS FOR THE 20TH WORKING PARTY ON TROPICAL TUNAS

Document	Title	Availability
IOTC–2018–WPTT20–01a	Draft: Agenda of the 20th Working Party on Tropical Tunas	✓(25 September 2018)
IOTC–2018–WPTT20–01b	Draft: Annotated agenda of the 20th Working Party on Tropical Tunas	✓(16 October 2017)
IOTC–2018–WPTT20–02	Draft: List of documents for the 20th Working Party on Tropical Tunas	✓(17 October 2017)
IOTC–2018–WPTT20–03	Outcomes of the 20th Session of the Scientific Committee (IOTC Secretariat)	✓(4 October 2018)
IOTC–2018–WPTT20–04	Outcomes of the 22nd Session of the Commission (IOTC Secretariat)	✓(4 October 2018)
IOTC–2018–WPTT20–05	Review of Conservation and Management Measures relevant to tropical tunas (IOTC Secretariat)	✓(4 October 2018)
IOTC–2018–WPTT20–06	Progress made on the recommendations of WPTT19 (IOTC Secretariat)	✓(5 October 2018)
IOTC–2018–WPTT20–07	Outcomes of the 2nd Session of the Technical Committee on management Procedures (IOTC Secretariat)	✓(5 October 2018)
IOTC–2018–WPTT20–08	Review of the statistical data and fishery trends for tropical tunas (IOTC Secretariat)	✓(16 October 2018)
IOTC–2018–WPTT20–09	Revision of the WPTT Program of Work (2019–2023) (IOTC Secretariat)	✓(11 October 2017)
IOTC–2018–WPTT20–10	Outline of climate and oceanic conditions in the Indian Ocean: update to mid-2018 (Marsac F and Demarcq H.)	✓(15 October 2018)
IOTC–2018–WPTT20–11	Trends of Tropical Tuna catch in Iran (Akhondi M.)	✓(15 October 2018)
IOTC–2018–WPTT20–12	Transshipment of tuna at Port Louis and analysis of the catch of foreign tuna longliners licensed in Mauritius (Shung C L and Sheikmamode A)	✓(15 October 2018)
IOTC–2018–WPTT20–13	Status of fisheries of yellowfin and skipjack in Pakistan (Khan M.)	✓(15 October 2018)
IOTC–2018–WPTT20–14	Catch statistic form Tuna Longline Landing at Port of Phuket, Thailand, during 2013-2017 (Hoimuk S, Maeroh K and Rodpradit S)	✓ (19 October 2018)
IOTC–2018–WPTT20–15	Updating the statistics of the EU-Spain purse seine fleet in the Indian Ocean (1990-2017) (Báez J C, Fernández F, Pascual-Alayón P J,Ramos M L, Déniz S and Abascal F.)	✓(15 October 2018)
IOTC–2018–WPTT20–16	Assessment of accuracy in processing purse seine tropical tuna catches with T3 methodology (Duparc A., Cauquil P., Depetris M., Floch L., Gaertner D., Lebranchu J., Marsac F., Bach P.)	✓(15 October 2018)
IOTC–2018–WPTT20–17	On the Potential Biases of Scientific Estimates of Catches of Tropical Tunas of Purse Seiners the EU and Other Countries Report to the ICCAT and IOTC (Herrera M and Baez J C.)	✓(15 October 2018)
IOTC–2018–WPTT20–18	Attempt incorporating oceanographic conditions into CPUE standardization using HSI (Habitat Suitability Index) (Nishida T. et al.)	✓(24 October 2018)
IOTC–2018–WPTT20–19	Determining CPUEs of surface vs sub-surface gear settings in Tuna gillnet fisheries of Pakistan (Shahid U.)	✓(15 October 2018)
IOTC–2018–WPTT20–20	Best standards for data collection and reporting requirements on FOBs: towards a science-based FOB fishery management (Grande M, Baez J.C., Ramos M.L., Ruiz J., Krug I., Zudaire I., Santiago J., Pascual P., Abascal F., Gaertner D., Cauquil P., Floch L., Maufroy A., Muniategi A., Herrera M., Murua H.)	✓(16 October 2018)

Document	Title	Availability
IOTC–2018–WPTT20–21	Using FADs to Develop Better Abundance Indices for Tropical Tuna (Moniz, Morón J and Herrera M.)	✓(16 October 2018)
IOTC–2018–WPTT20–22	Which is the best definition for the biodegradable FADs? (Zudaire I, Grande M, Suarez M.J., Retolaza J, Santiago J, Murua J, Tolloti M.T., Dagorn L, Ramos M.L., Baez J.C., Moreno G, Murua H.)	✓(26 October 2018)
IOTC–2018–WPTT20–23	The use of instrumented buoys to monitor the activity of the purse seine fleet fishing on FADs (Grande M., Santiago J., Ruiz J., Zudaire I. , Murua J., Krug I., Guery L., Gaertner D., Justel A., Maufroy, A., Moniz I., Baéz J.C, Ramos M.L., Murua H.)	✓(16 October 2018)
IOTC–2018–WPTT20–24	Fluid dynamics analysis of Fish Aggregation Device using particle image velocimetry (Lee K, Kim D-N, Lee S-I)	✓(16 October 2018)
IOTC–2018–WPTT20–25	Recent Advances on the Use of Supervised Learning Algorithms for Detecting Tuna Aggregations Under FADS from Echosounder Buoys Data (Baidai Y, Amande J, Gaertner D , Dagorn L, Capello M)	✓(16 October 2018)
IOTC–2018–WPTT20–26	The code of good practices as a mitigation measure: a quantitative assessment (Grande M., Ruiz J., Krug I., Arregi I., Goñi N., Murua J., Santiago J., Murua H.)	WITHDRAWN
IOTC–2018–WPTT20–27	Progress on project to develop a spatial operating model of the tropical tuna population, incorporating tagging data for evaluating assessment bias (Hoyle S D and Mormede S.)	✓(29 October 2018)
IOTC–2018–WPTT20–28	Updated information on catch and effort of bigeye tuna (Thunnus obesus) from Indonesian tuna longline fishery (Hartaty H, Setyadji B and Fahmi Z.)	✓(16 October 2018)
IOTC–2018–WPTT20–29	Japanese longline CPUE for bigeye tuna in the Indian Ocean standardized by GLM (Matsumoto T et al.)	✓(16 October 2018)
IOTC–2018–WPTT20–30	Stock assessment and management advice of bigeye tuna (Thunnnus obesus) in Indian Ocean: implication of considering bias in catch data (Li Y.)	WITHDRAWN
IOTC–2018–WPTT20–31	Consultation with the purse seine industry regarding the process of adoption of Harvest Strategies and Harvest Control Rules for IOTC's tropical tunas (de Andrés M, Iriondo A, Merino G, and Santiago J.)	✓(16 October 2018)
IOTC–2018–WPTT20–32	Indian Ocean Skipjack Purse Seine Catchability Trends Estimated from Bigeye and Yellowfin Assessments (Kolody D and Jumppanen P)	✓(16 October 2018)
IOTC–2018–WPTT20–33	Preliminary Indian Ocean Yellowfin Tuna Stock Assessment 1950-2017 (Stock Synthesis) (Fu D, Langley A, Merino G and Urtizberea A)	✓ (19 October 2018)
IOTC–2018–WPTT20–34	Review of Yellowfin Tuna Fisheries in the Maldives (Ahusan M and Adam M.S)	✓(16 October 2018)
IOTC–2018–WPTT20–35	Updated CPUE standardizations for bigeye and yellowfin tuna caught by Taiwanese longline fishery in the Indian Ocean using generalized linear model (Yeh Y-M, Hoyle S.D and Chang S-T.)	✓(16 October 2018)
IOTC–2018–WPTT20–36	Standardisation of yellowfin tuna CPUE for the EU purse seine fleet operating in the Indian Ocean (Katara I, Gaertner D, Marsac F, Grande M, Kaplan D, Urtizberea A, Guery L, Depetris M, Duparc A, Floch L, Lopez J and Abascal F.)	✓(16 October 2018)
IOTC–2018–WPTT20–37	Standardization of bigeye and yellowfin tuna CPUE by Japanese longline in the Indian Ocean which includes cluster analysis (Matsumoto T et al.)	✓(16 October 2018)
IOTC–2018–WPTT20–38	Japanese longline CPUE for yellowfin tuna in the Indian Ocean standardized by generalized linear model (Matsumoto T et al.)	✓(16 October 2018)

Document	Title	Availability
IOTC–2018–WPTT20–39	CPUE standardization of yellowfin tuna caught by Korean tuna longline fishery in the Indian Ocean (Lee S-I, Kim D-N, Hoyle S D.)	✓(22 October 2018)
IOTC–2018–WPTT20–40	Bayesian Skipjack and Yellowfin Tuna CPUE Standardisation Model for Maldives Pole and Line 1970-2016 (Medley P, Ahusan M and Adam M.S.)	✓(16 October 2018)
IOTC–2018–WPTT20–41	Preliminary stock assessment of Indian Ocean yellowfin tuna using SCAA (Statistical-Catch-At-Age) (Nishida T. et al.)	✓(22 October 2018)
IOTC–2018–WPTT20–42	Diagnoses for stock synthesis model on yellowfin tuna in the Indian Ocean (Matsumoto T et al.)	✓(16 October 2018)
IOTC–2018–WPTT20–43	Prospects for an effort-based management of Indian Ocean yellowfin stock (Merino G, Urtizberea A, Santiago J, Prellezo R, Abascal F.)	✓(16 October 2018)
IOTC–2018–WPTT20–44	Applying Generalized Linear Models (GLM) for the analysis of catch rates of Skipjack Tuna (*Katsuwonus pelamis*) in gillnet fishery of Sri Lanka (Haputhantri, S.S.K. and Weerasekera S.J.W.W.W.M.M.P)	✓(16 October 2018)
IOTC–2018–WPTT20–45	Pelagic longline fishing operation parameters optimization - A case study on targeting bigeye tuna (*Thunnus obesus*) in the Indian Ocean. (Qi, Y and Song L)	✓(16 October 2018)
IOTC–2018–WPTT20–46	Assessment of the tuna catch composition of a longline vessel in the Kenyan EEZ and the high seas (Ndegwa S, Benedict K and Ndoro C)	✓(16 October 2018)
IOTC–2018–WPTT20–47	Statistics of the French Purse Seine Fishing Fleet Targeting Tropical Tunas in the Indian Ocean (1981-2017) (Floch L, Dewals P , Médieu A, Depetris M, Duparc A, Lebranchu J and Bach P	✓(29 October 2018)
Other Documents		
IOTC–2018–WPM09–09	Update on IOTC Bigeye Tuna Operating Model Development October 2018 (Kolody D and Jumppanen P)	✓(11 October 2018)
IOTC–2018–WPM09–10	Update on IOTC Yellowfin Tuna Operating Model Development October 2018 (Kolody D and Jumppanen P)	✓(11 October 2018)
IOTC–2018–WPM09–11	IOTC Bigeye and Yellowfin Management Procedure Evaluation Progress October 2018 (Kolody D and Jumppanen P)	✓(11 October 2018)
IOTC–2018–WPM09–12	Collaborative study of yellowfin tuna CPUE from multiple Indian Ocean longline fleets in 2018 (Hoyle S D, Chassot E, Fu D, Kim D N, Lee S I, Matsumoto T, Satoh K, Wang S-P, Yeh Y-M, and Kitakado T)	✓(11 October 2018)
Information papers		
IOTC–2018–WPM09–INF01	Update on IOTC Bigeye Tuna Management Procedure Evaluation March 2018 (Kolody D)	✓(12 October 2018)
IOTC–2018–WPM09–INF02	Update on IOTC Yellowfin Tuna Management Procedure Evaluation March 2018 (Kolody D)	✓(12 October 2018)
IOTC–2018–WPTT20–INF01	Using Effort Control Measures to Implement Catch Capacity Limits in ICCAT PS Fisheries (Sharma, R. and M. Herrera)	✓(16 October 2018)
IOTC–2018–WPTT20–INF02	Genomic analysis reveals multiple mismatches between biological and management units in yellowfin tuna (Thunnus albacares) (Mullins R, McKeown N, Sauer W and Shaw P.)	✓(22 October 2018)
IOTC–2018–WPTT20–INF03	Strength and uncertainties in the results of the TTT software, used to estimate statistics of purse seiners (catch and catch at size) and on the ways to improve these results (A. Fonteneau)	✓(29 October 2018)

Document	Title	Availability
IOTC–2018–WPTT20–INF04	Iran small-scale tuna longline fishery targeting yellowfin tuna (Thunnus albacares) in Oman Sea: A preliminary study (Hosseini S, Mirzaei M, Azhang B, Daryanabard, R)	✓(02 November 2018)

APPENDIX IV
APPENDIX IVA
STATISTICS FOR TROPICAL TUNAS
(Extracts from IOTC–2018–WPTT20–08)

Fisheries and catch trends for tropical tuna species

- Main species: Skipjack tuna accounts for 48% of total catches of tropical tunas, followed closely by yellowfin tuna (42%), while catches of bigeye tuna account for the remaining 10% of catches (**Fig. 1d**).

- Main fishing gear (2013-17): purse seiners account for 40% of total catches of tropical tunas, with important catches also reported by handlines and trolling (19%), gillnets (18%), pole-and-line (11%), and longliners (9%), with catches occurring 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.

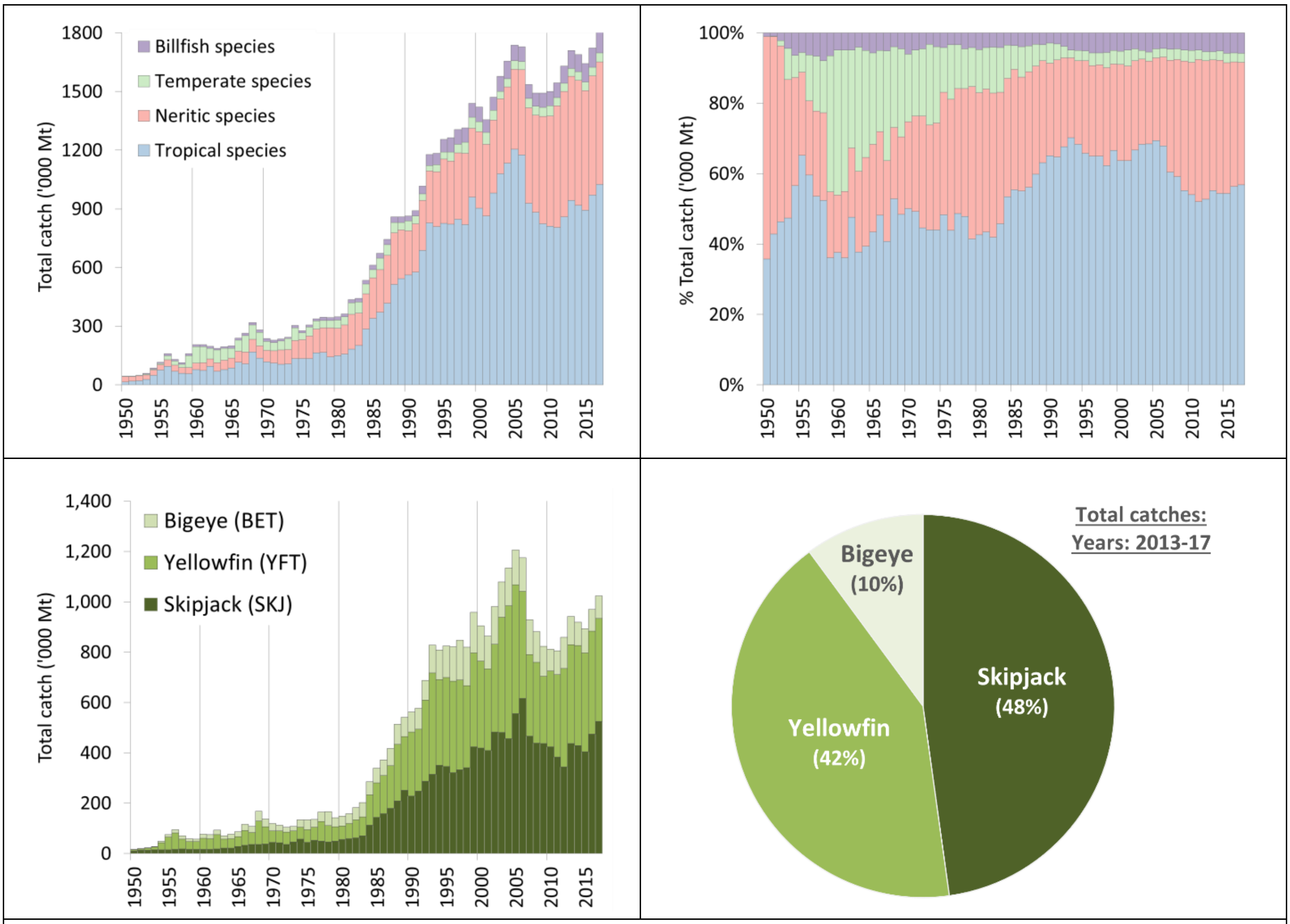
- Main fleets (i.e., highest catches in recent years): Tropical tunas are caught by both coastal countries in the Indian Ocean and distant water fishing nations (**Fig. 2**).

  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 31% of total catches of these species.

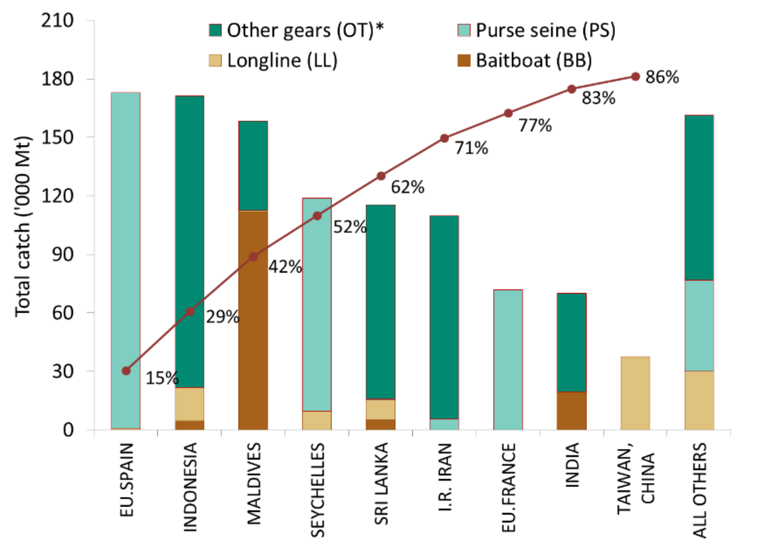
- Retained catch trends: The importance of tropical tunas to the total catches of IOTC species in the Indian Ocean has changed over the years (**Figs. 1a-b.**), in particular following the arrival of industrial purse seine fleets to the Indian Ocean in the early-1980s targeting tropical tunas. With the 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 57% of total catches of all IOTC species, compared to ≈68% 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 >940,000 t in 2013 and >1,000,000 t in 2017.

- 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 1950-2017 (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, 2013-17)



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

Fig. 2. All tropical tunas: average catches in the Indian Ocean over the period 2013–17, 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 (2013–17): industrial fisheries account for the majority of catches of bigeye tuna, i.e., deep-freezing and fresh longline (≈48%) and purse seine (≈26%) (**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): 27%; Taiwan,China (longline): 18%; Seychelles (longline and purse seine): 13%; 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 (at around 90,000 t) 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**).

- <u>Discard levels</u>: 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: There have been no major changes to the catch series since the WPTT meeting in 2017.

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 (2008–2017), 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 2018

Fisher	By decade (average)						By year (last ten years)									
	1950s	1960	1970	1980	1990	2000	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
BB	21	50	266	153	2968	5069	6,10	6,87	6,78	6,88	6,88	7,38	6,71	6,47	6,85	6,30
FS	0	0	0	234	4824	6196	9,64	5,30	3,79	6,22	7,18	4,66	5,00	9,63	2,48	10,24
LS	0	0	0	485	1831	2027	19,87	24,70	18,48	16,38	10,43	22,80	14,86	15,54	19,33	19,42
LL	6488	2186	3041	4307	6223	7134	51,70	51,83	32,04	35,25	66,26	45,61	35,21	33,68	30,81	25,87
FL	0	0	218	306	2628	2349	23,32	15,81	9,78	12,03	16,81	16,72	13,65	12,40	7,65	8,89
LI	43	295	658	238	4325	6478	7,85	9,57	9,54	11,78	11,38	10,65	12,68	13,90	13,61	13,73
OT	38	64	164	860	1475	3339	4,00	4,69	4,93	5,81	5,78	5,33	4,91	4,75	6,08	6,02
Tota		2	3	5	12	13	12	11	8	9	12	11	9	9	8	9

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, smal 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 (2008–2017), in tonnes. Catches by decade represent the average annual catch. Data as of September 2018.

Fishery	By decade (average)						By year (last ten years)									
	1950	1960	1970	1980s	1990s	2000	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
A1	2,49	12,07	17,71	35,05	59,011	78,19	68,38	58,71	39,30	42,00	74,09	64,09	51,58	56,70	52,36	54,44
A2	3,88	7,171	10,16	18,44	43,964	43,80	47,67	55,33	40,18	44,37	42,08	41,54	34,44	31,66	28,62	27,79
A3	204	3,021	3,83	4,617	17,443	14,19	6,462	4,74	5,87	7,99	8,57	7,54	7,01	8,02	5,84	8,26
Total	6,58	22,26	31,71	58,11	120,41	136,1	122,51	118,8	85,36	94,37	124,7	113,1	93,04	96,39	86,84	90,50

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.

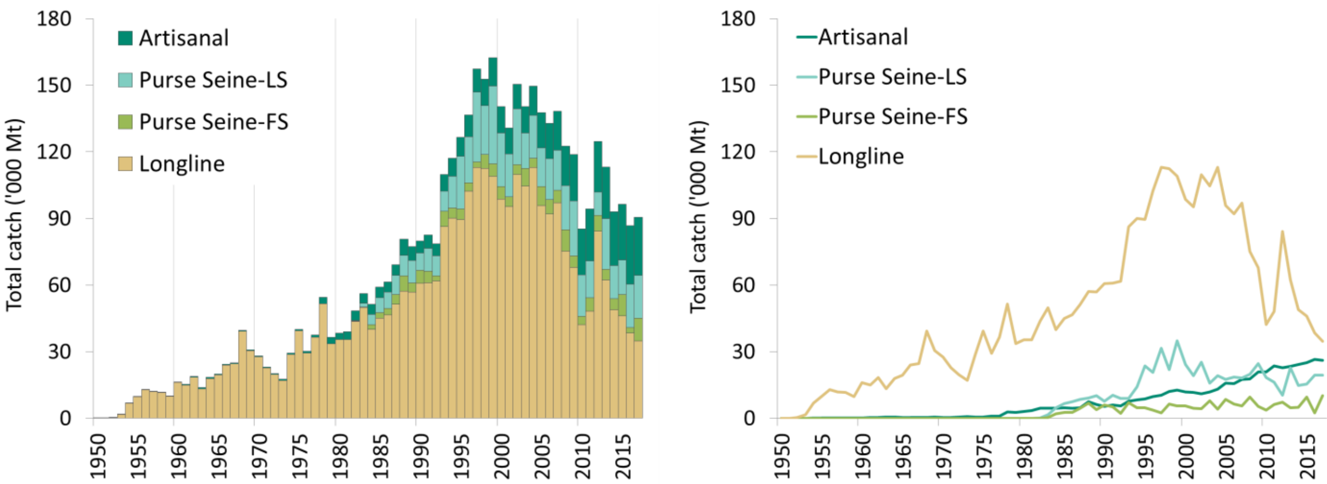


Fig. 3a & b. Annual catches of bigeye tuna by gear (1950–2017). Data as of September 2018.

Gear definitions: Longline (fresh and deep-freezing); Purse seine free-school (FS); Purse seine associated school (LS); Artisa (pole-and-Line, handline, small longlines, gillnet, trolling & other minor artisanal gears).

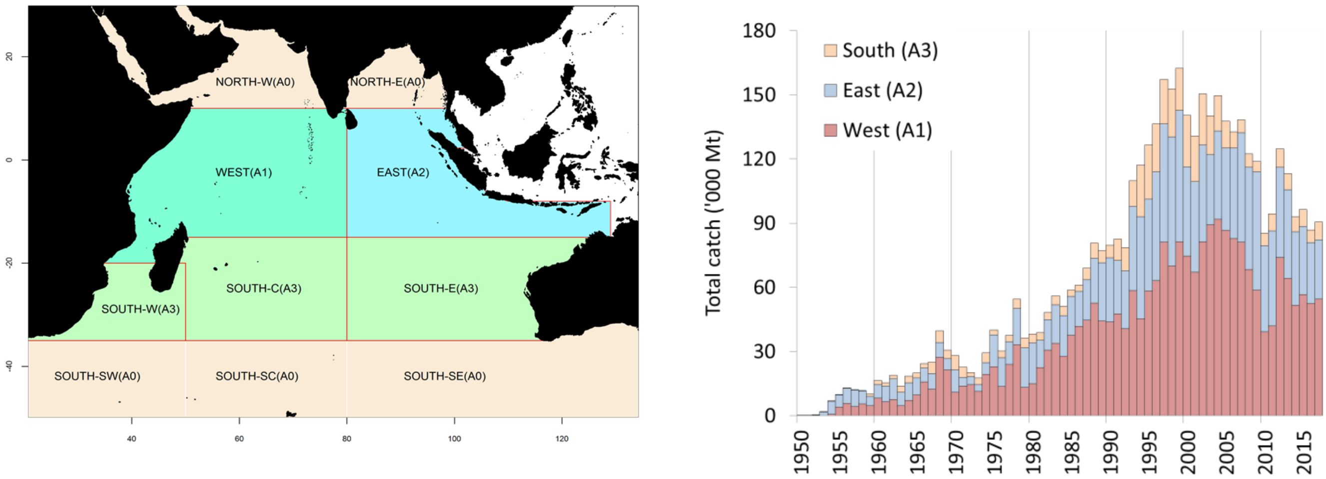


Fig. 4(a-b). Bigeye tuna: Catches of bigeye tuna by (SS3) stock assessment area by year (1950–2017). Catches outside the areas presented in the map were assigned to the closest neighbouring area for the assessment. Data as of September 2017.

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

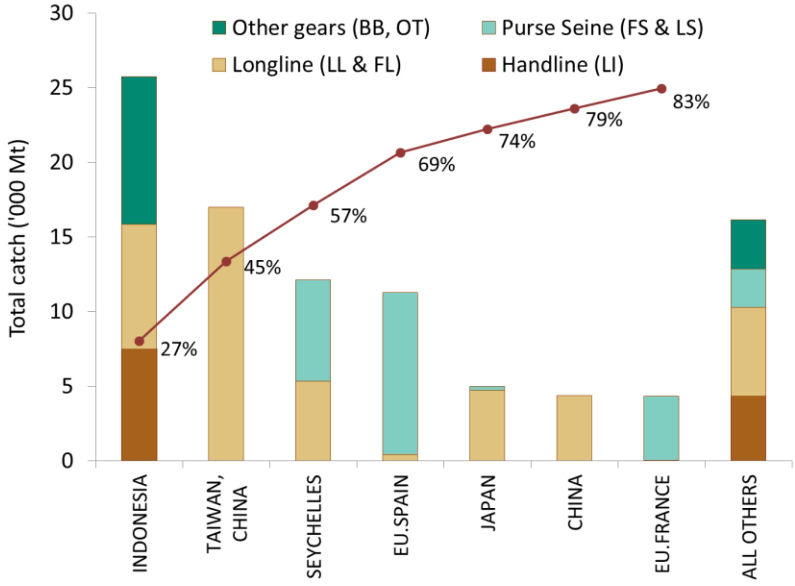


Fig. 5. Bigeye tuna: average catches in the Indian Ocean over the period 2013–17, by country. Countries ordered from left to right, according to the importance of catches of bigeye reported. The red line indic the (cumulative) proportion of catches of bigeye for the countries concerned, over the total combined cat of this species reported from all countries and fisheries. Data as of September 2018.

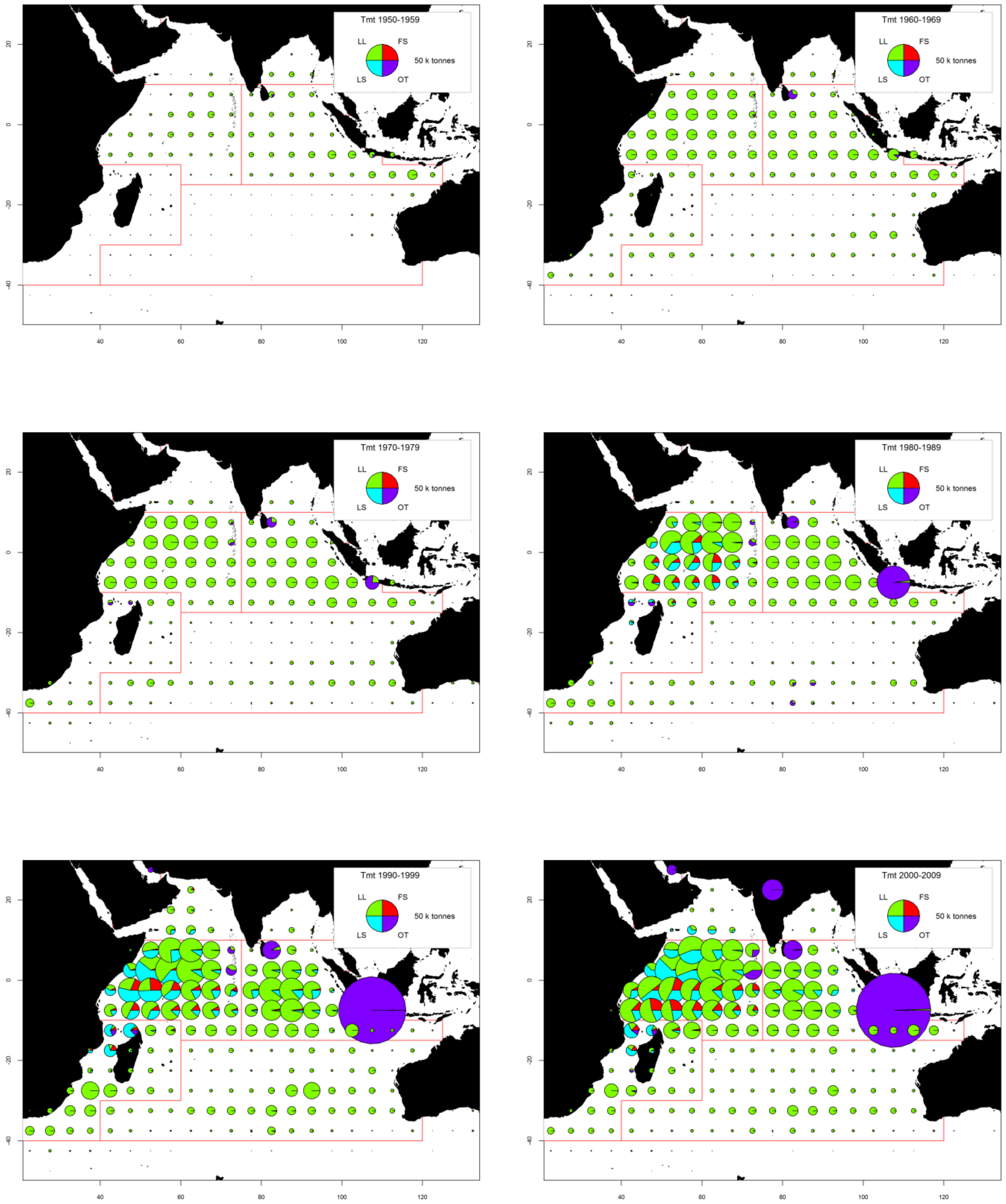


Fig. 6(a-f). Time-area catches (total combined in tonnes) of bigeye tuna estimated for the period 2008–2012 by type of gear and 2013–2017, by year and type of gear. Longline (**LL**), Purse seine free-schools (**FS**), Purse seine associated-schools (**LS**), and oth fleets (**OT**), including pole-and-line, drifting gillnets, and various coastal fisheries.

Note that the catches of fleets for which the flag countries do not report detailed time and area data to the IOTC are recorded wi the area of the countries concerned (as OT), in particular driftnets of I.R. Iran, gillnet and longline fishery of Sri Lanka, and long and coastal fisheries of Indonesia.

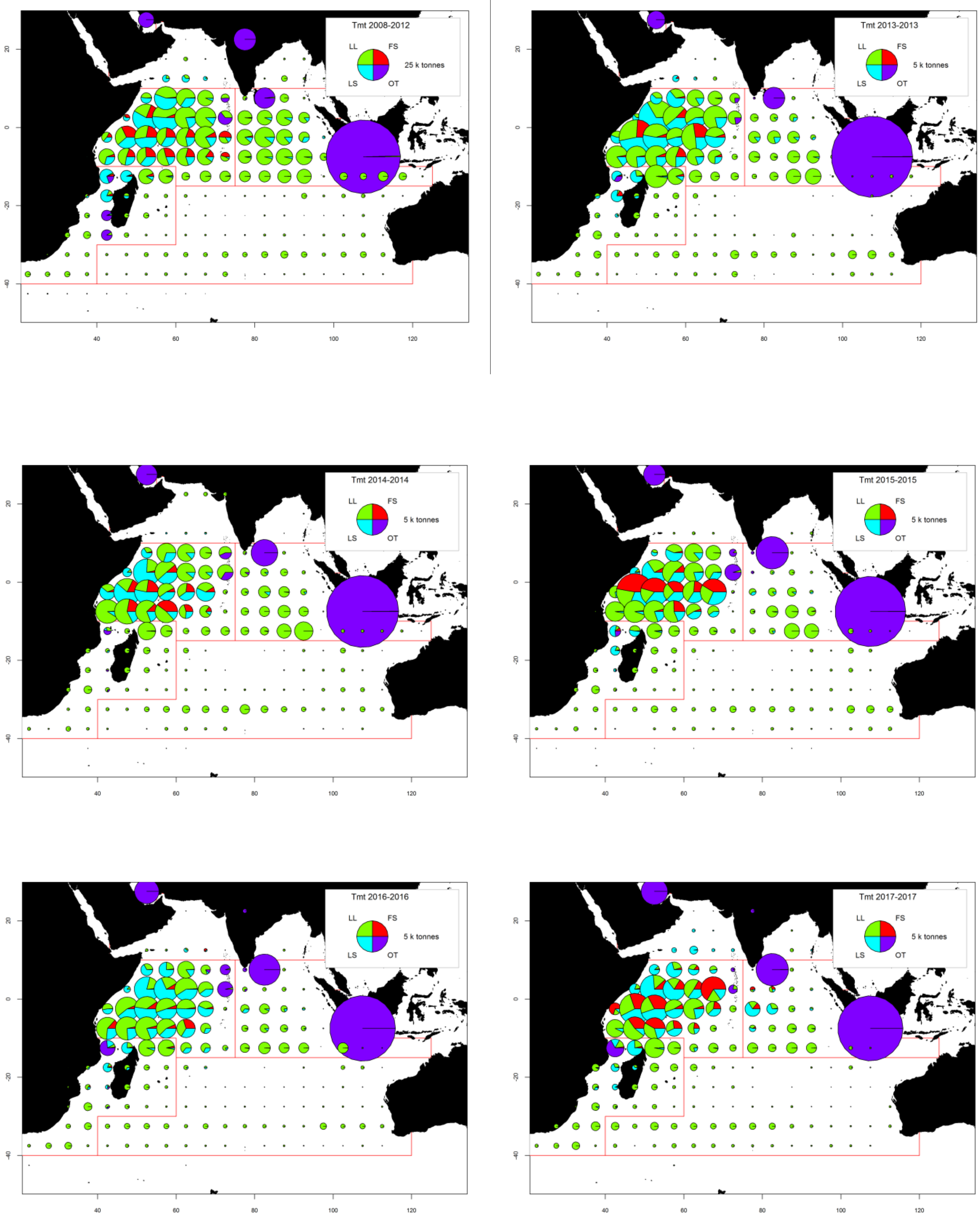


Fig. 7(a-f). Time-area catches (total combined in tonnes) of bigeye tuna estimated for the period 2008–2012 by type of gear and 2013–17, by year and type of gear. Longline (**LL**), Purse seine free-schools (**FS**), Purse seine associated-schools (**LS**), and other fleets (**OT**), including pole-and-line, drifting gillnets, and various coastal fisheries.

Note that the catches of fleets for which the flag countries do not report detailed time and area data to the IOTC are recorded wi the area of the countries concerned (as OT), in particular driftnets of I.R. Iran, gillnet and longline fishery of Sri Lanka, and long 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) (before 2014), 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).

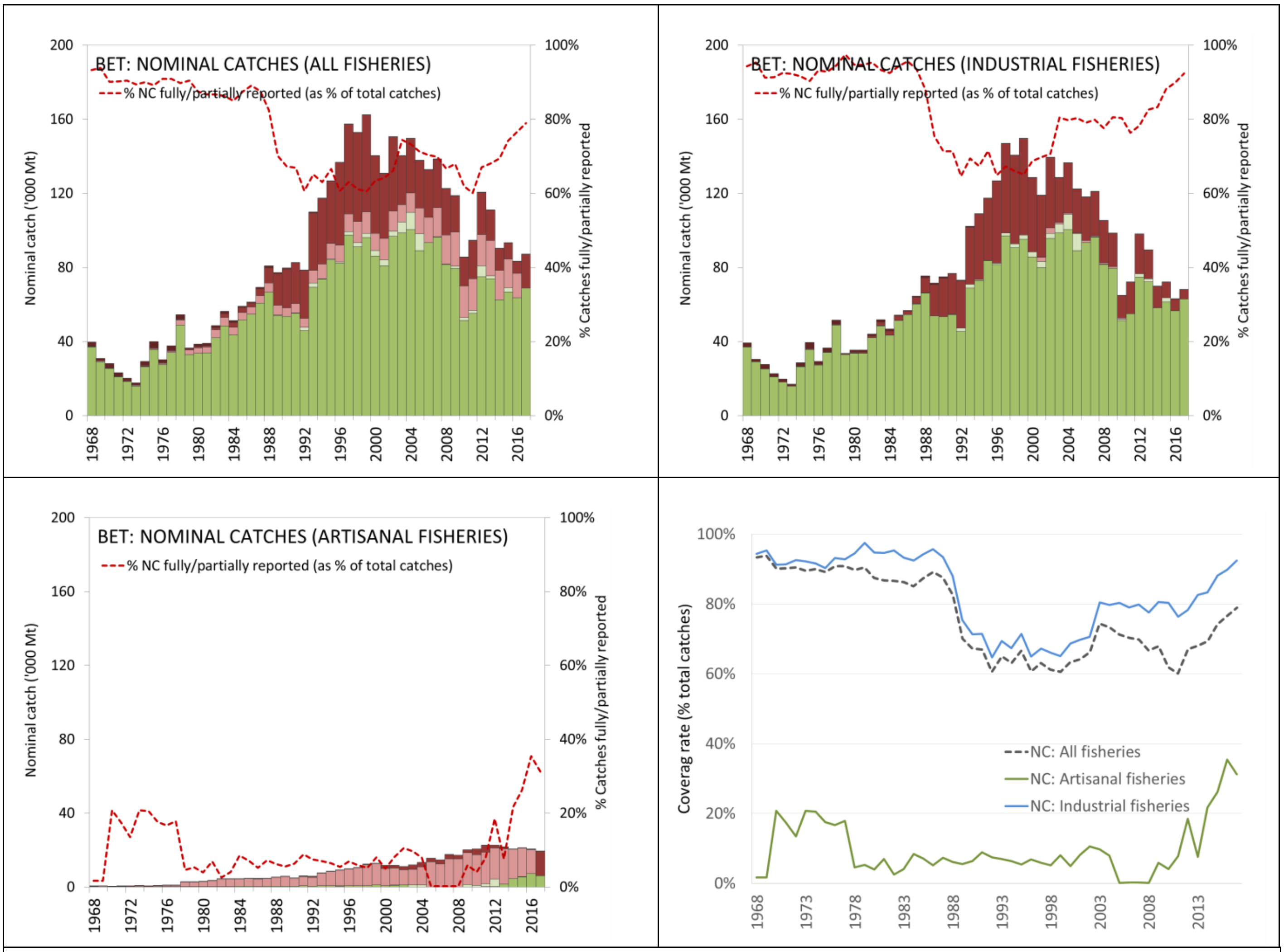


Fig. 8a-d. Bigeye tuna: nominal catches data reporting coverage (1968–2017). The red dotted lines indicate the proportion of catches fully/partially reported according to the IOTC data reporting standards for nominal catches. Data as of September 2018.

Data reporting scores:

	0
	2
	4
	6
	8

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

- **Score: 0** indicates the amount of nominal catch associated with each dataset fully reported according to IOTC standards.
- **Score: 2 – 6** indicates the amount of nominal catches associated with each dataset partially reported by gear and/or species (i.e., adjusted by gear and species by the IOTC Secretariat or for any of the other reasons provided in the document).
- **Score: 8** indicates the amount of nominal catches associated that is fully estimated by the IOTC Secretariat (i.e., nominal catches) or data that is not available (i.e., catch-and-effort or size data).

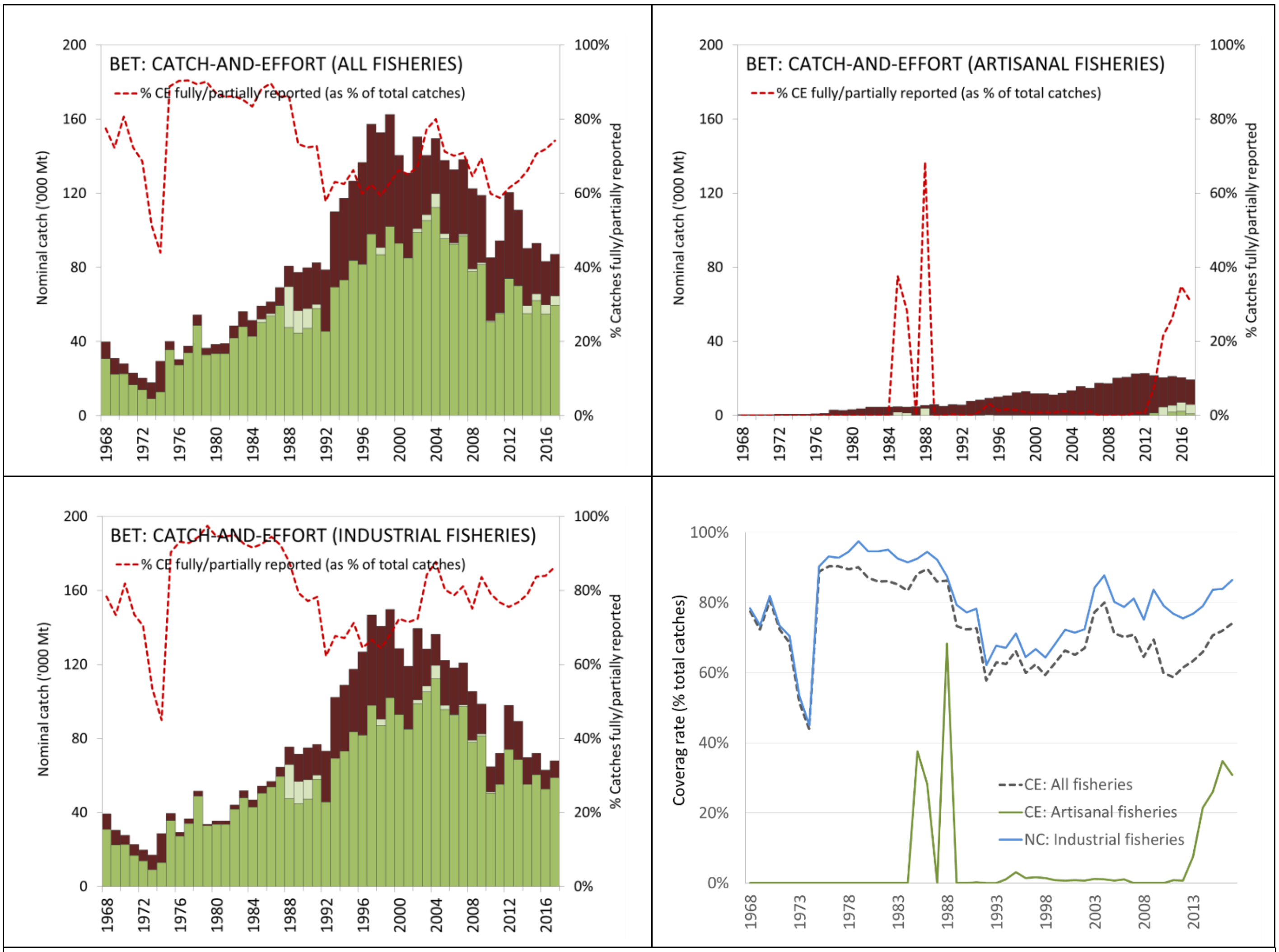


Fig. 8e-h. Bigeye tuna: catch-and-effort data reporting coverage (1968–2017). The red dotted lines indicate the proportion of catches fully/partially reported according to the IOTC data reporting standards for catch-and-effort. Data as of September 2018.

Data reporting scores:

	0
	2
	4
	6
	8

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

- **Score: 0** indicates the amount of nominal catch associated with each dataset fully reported according to IOTC standards.
- **Score: 2 – 6** indicates the amount of nominal catches associated with each dataset partially reported by gear and/or species (i.e., adjusted by gear and species by the IOTC Secretariat or for any of the other reasons provided in the document).
- **Score: 8** indicates the amount of nominal catches associated that is fully estimated by the IOTC Secretariat (i.e., nominal catches) or data that is not available (i.e., catch-and-effort or size data).

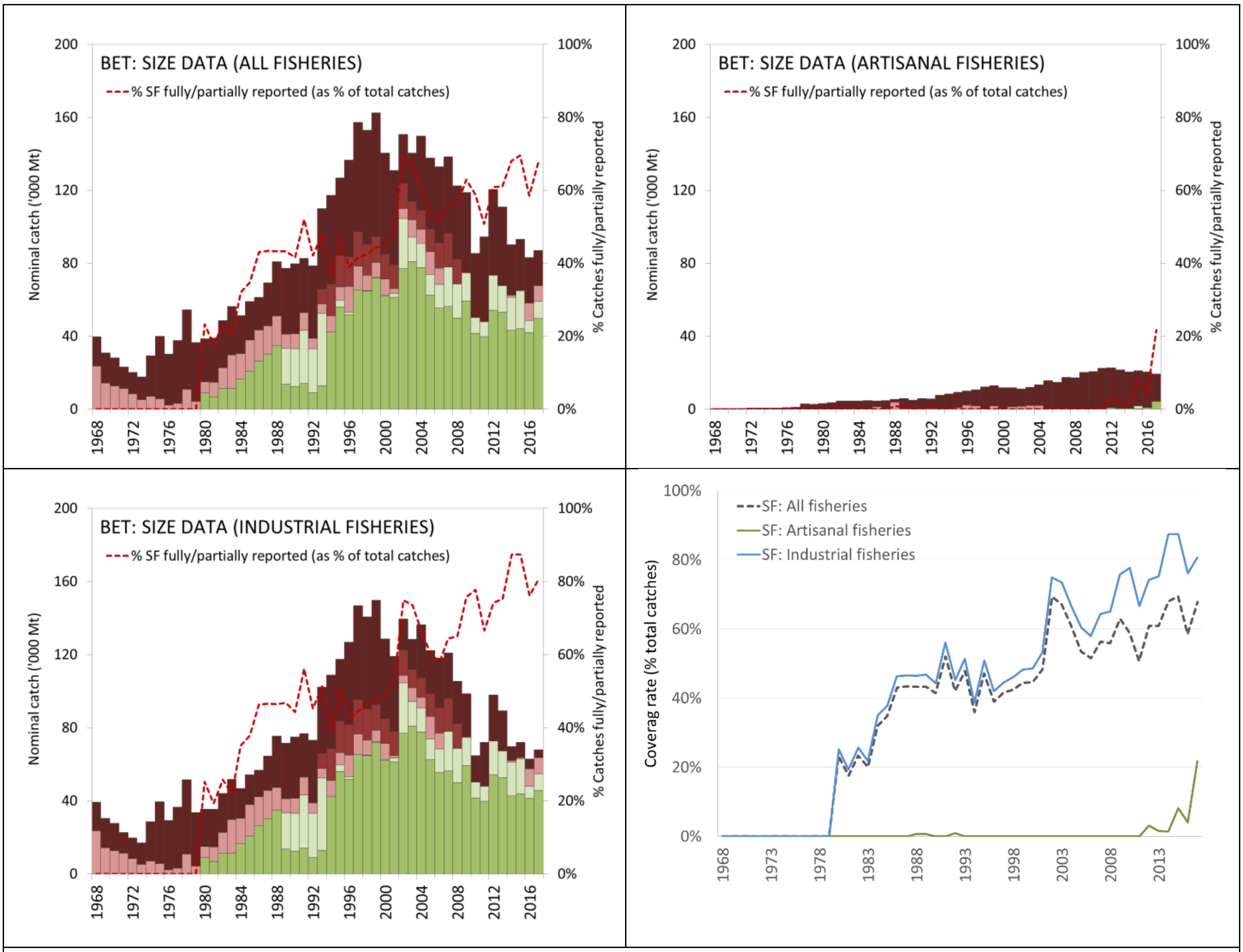


Fig. 8i-l. Bigeye tuna: size frequency data reporting coverage (1968–2017). The red dotted lines indicate the proportion of catches fully/partially reported according to the IOTC data reporting standards for size data. Data as of September 2018.

Data reporting scores:

	0
	2
	4
	6
	8

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

- **Score: 0** indicates the amount of nominal catch associated with each dataset fully reported according to IOTC standards.
- **Score: 2 – 6** indicates the amount of nominal catches associated with each dataset partially reported by gear and/or species (i.e., adjusted by gear and species by the IOTC Secretariat or for any of the other reasons provided in the document).
- **Score: 8** indicates the amount of nominal catches associated that is fully estimated by the IOTC Secretariat (i.e., nominal catches) or data that is not available (i.e., catch-and-effort or size data).

Bigeye tuna: Tagging data

- A total of 36,001 bigeye tuna (representing 16% of the total number of fish tagged) were tagged during the Indian Ocean Tuna Tagging Programme (IOTTP), of which ≈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, 5,833 specimens (16% of releases for this species) have been recovered and reported to the IOTC Secretariat[2]. These tags were mainly reported from the purse seine fleets operating in the Indian Ocean (91%), while 5% were recovered from longline vessels.

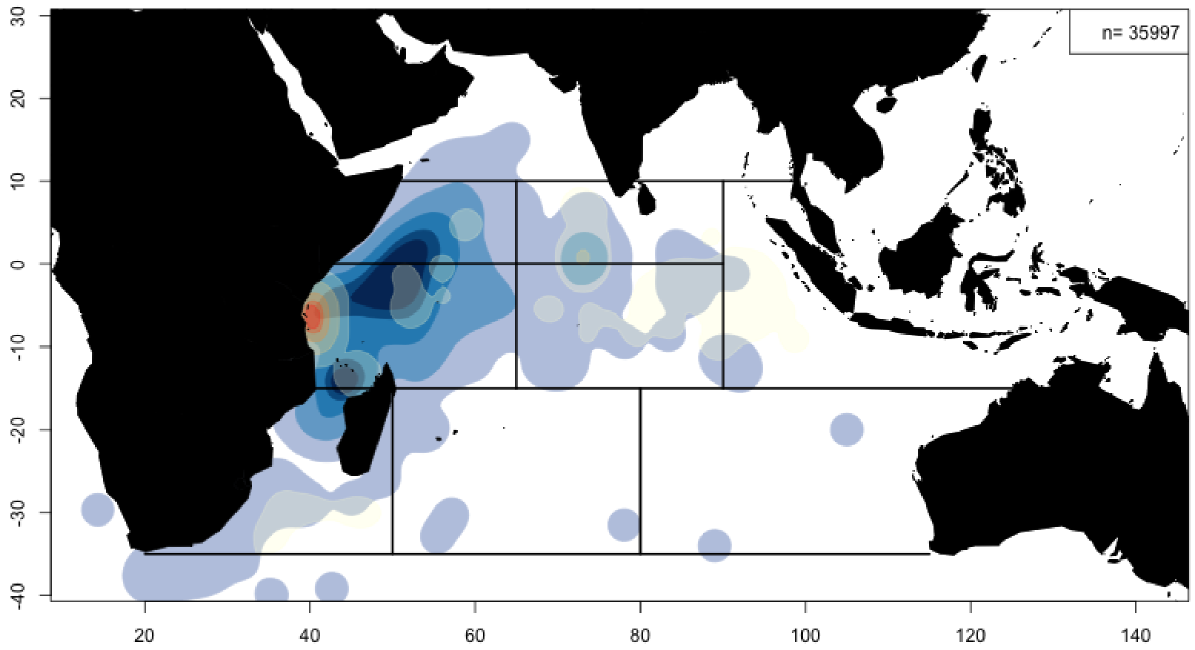


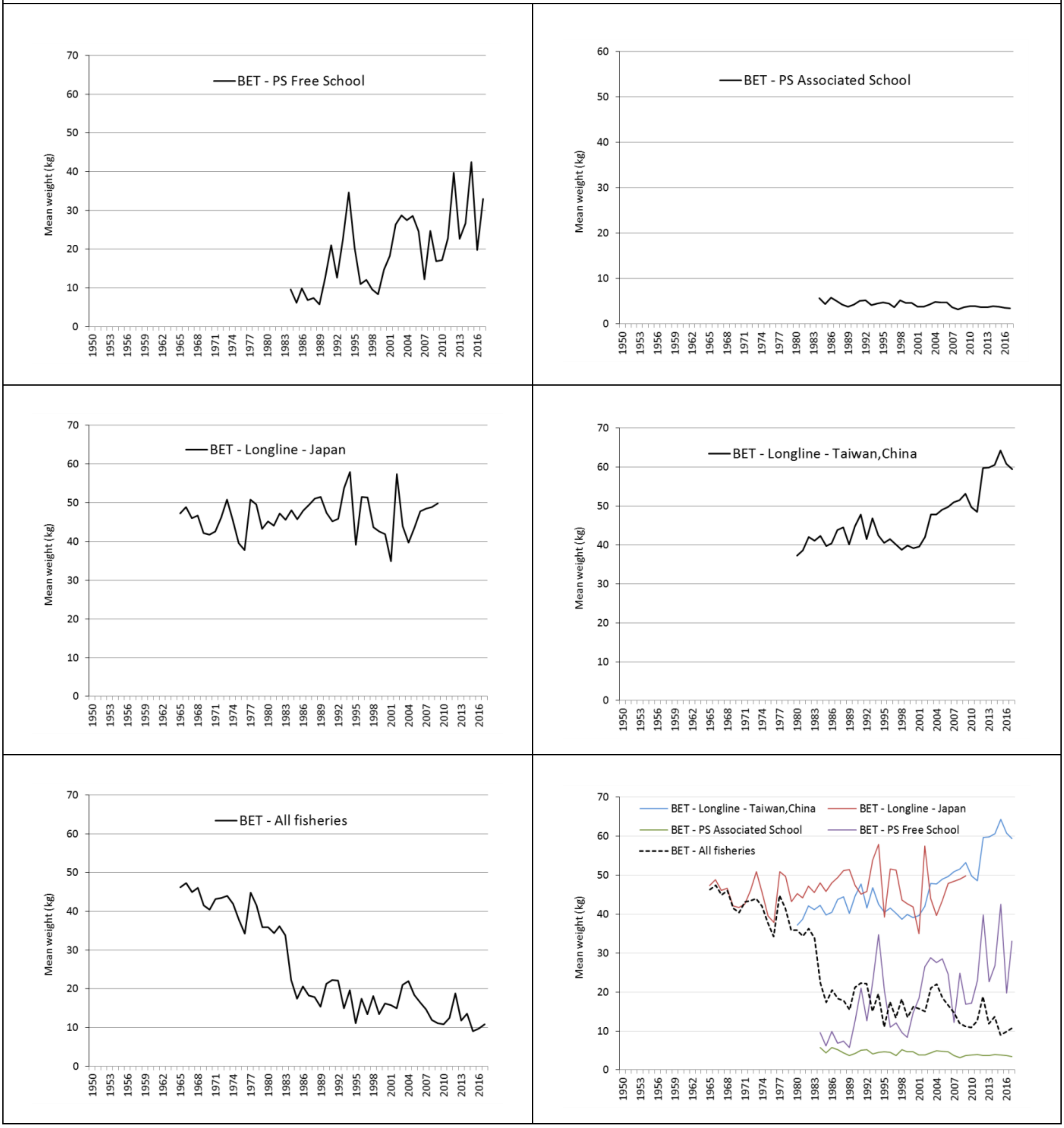
Fig. 9. Bigeye tuna: densities of releases (in red) and recoveries (in blue). The black line represents the stock assessme areas. Includes specimens tagged during the IOTTP and also Indian Ocean (Maldivian) tagging programmes during th 1990s.

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

Bigeye tuna (BET)

Figure: 10 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)



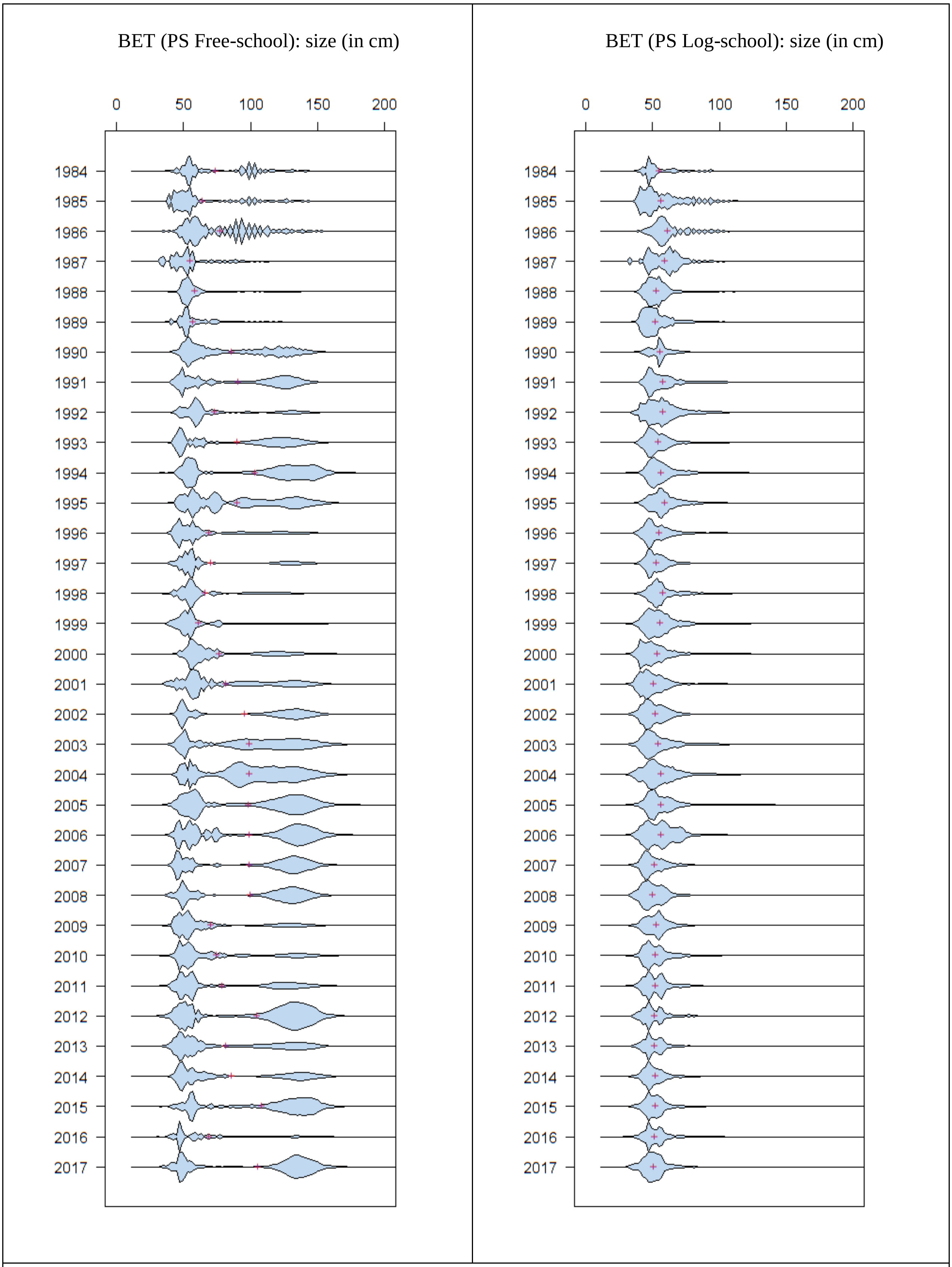


Figure 11. Bigeye tuna (purse seine): **Left:** length frequency distributions for BET PS Free school fisheries (by 2 length class). **Right**: Length frequency distributions for BET PS Associated (log) school fisheries (by 2 cm length cla
Source: IOTC database.

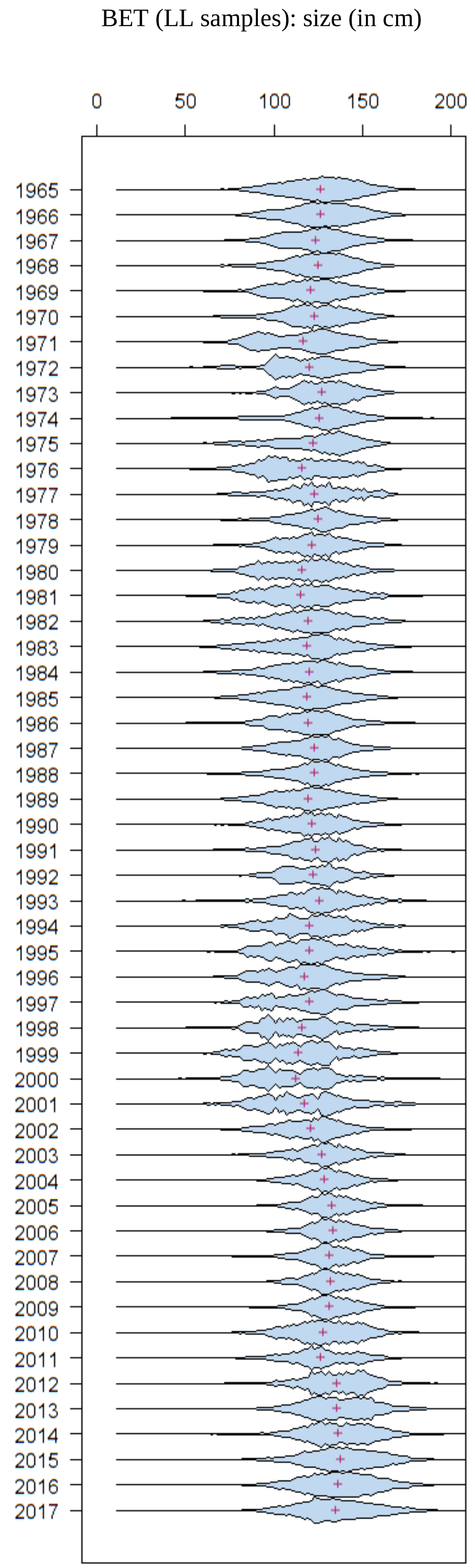


Figure 12; Bigeye tuna (longline): Length frequency distributions for longline fisheries (by 2 cm length class) derived from data available at the IOTC Secretariat. Source: IOTC database.

APPENDIX IVC
MAIN STATISTICS OF SKIPJACK TUNA

(Extracts from IOTC–2017–WPTT19–07)

Fisheries and main catch trends

- Main fishing gear (2013–17): skipjack tuna are mostly caught by industrial purse seiners (≈34%), gillnet (≈22%) and pole-and-line (≈21%) (**Table 4; Fig. 10**).

- Main fleets (and primary gear associated with catches): percentage of total catches (2013–17):

  Over 70% of catches are accounted for by four fleets (**Fig. 12**):

  - Indonesia (coastal purse seine, troll line, gillnet): 19%; Maldives (pole-and-line): 16%; EU-Spain (purse seine): 15%; Sri Lanka (gillnet-longline): 12%; Seychelles (purse seine): 10%.

- 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 total catches (across all fisheries) have declined to around 340,000 t in 2012 – the lowest catches recorded since 1998 – although since 2013 catches have increased sharply to over 520,000 t mostly driven by the purse seine (log-school) fisheries.

  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*:** There have been no major changes to the catch series since the WPTT meeting in 2017.

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 (2008–2017), 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 2018.

Fishery	By decade (average)						By year (last ten years)									
	1950s	**1960s**	**1970s**	**1980s**	**1990s**	**2000s**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
BB	9,000	12,800	19,275	35,459	67,760	100,496	85,584	65,018	71,585	52,489	51,134	72,583	67,301	68,965	68,712	88,617
FS	0	0	0	13,658	25,197	24,342	14,863	9,498	8,708	8,930	2,924	5,625	6,467	7,535	6,560	5,735
LS	0	0	0	30,673	107,845	153,298	117,835	135,797	139,770	120,115	77,992	117,046	118,856	118,785	175,716	195,201
OT	6,015	14,067	27,642	50,290	118,867	198,114	220,143	227,486	203,928	201,557	212,304	242,609	236,118	209,929	223,424	234,730
Total	**15,015**	**26,867**	**46,918**	**130,080**	**319,670**	**476,251**	**438,425**	**437,799**	**423,991**	**383,091**	**344,354**	**437,862**	**428,742**	**405,214**	**474,412**	**524,282**

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 (2008–2017), in tonnes. Catches by decade represent the average annual catch. Data as of September 2018.

	By decade (average)						By year (last ten years)									
	1950s	**1960s**	**1970s**	**1980s**	**1990s**	**2000s**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
R1	4,524	9,951	19,330	34,877	80,744	118,318	139,937	151,486	154,434	153,882	155,406	171,217	149,052	131,236	116,968	115,262
R2	1,492	4,116	8,313	59,744	171,166	257,437	212,903	221,295	197,972	176,720	137,814	194,062	212,388	205,014	288,732	320,404
R2b	9,000	12,800	19,275	35,459	67,760	100,496	85,584	65,018	71,585	52,489	51,134	72,583	67,301	68,965	68,712	88,617
Total	**15,015**	**26,867**	**46,918**	**130,080**	**319,670**	**476,251**	**438,425**	**437,799**	**423,991**	**383,091**	**344,354**	**437,862**	**428,742**	**405,214**	**474,412**	**524,282**

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

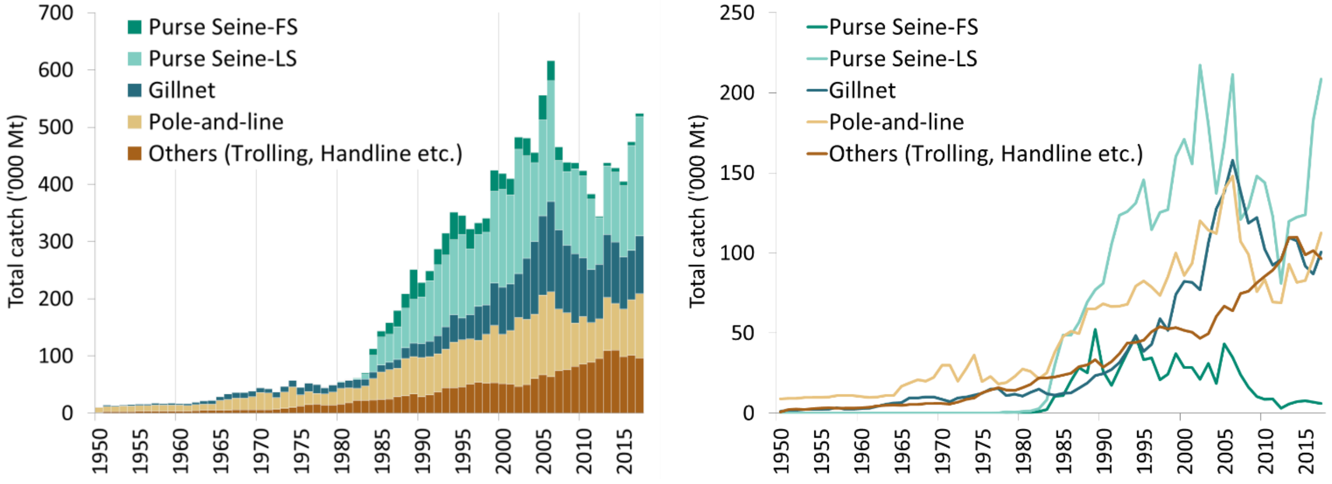


Fig. 13. Annual catches of skipjack tuna by gear (1950–2017). Data as of September 2018.

Gear definitions: 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).

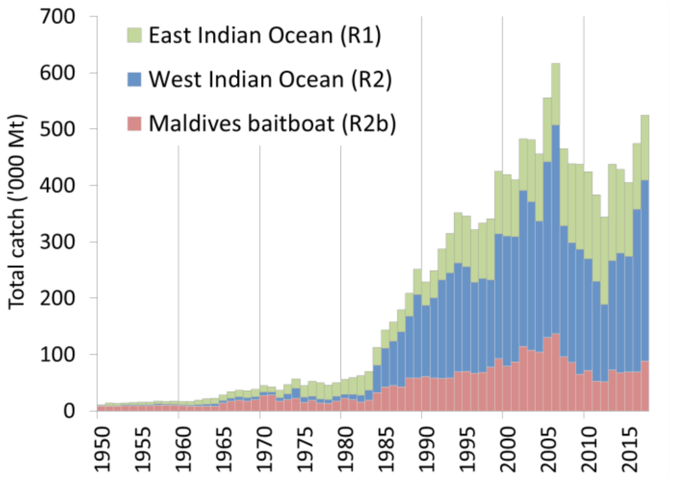


Fig. 14. Skipjack tuna: Catches of skipjack tuna by area by year estimated for the WPTT (1950–2017).
Areas: East Indian Ocean (**R1**); West Indian Ocean (**R2**); Maldives baitboat (**R2b**). Data as of September 2018.

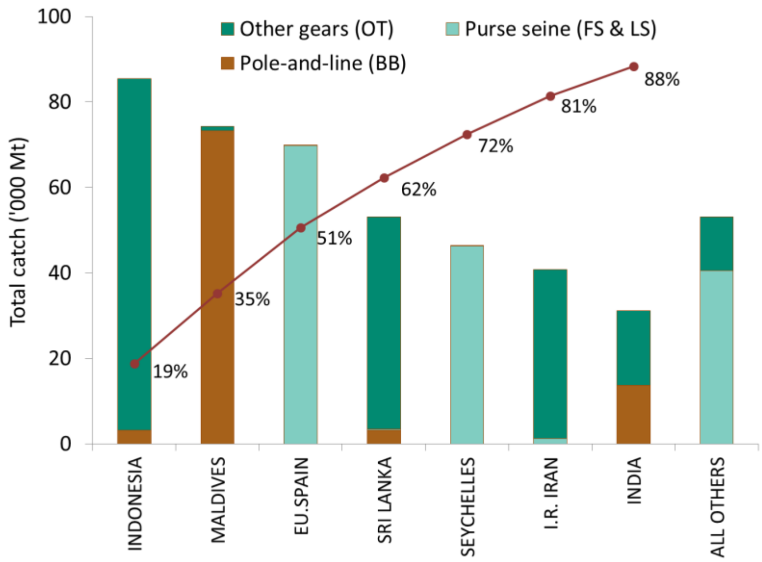


Fig. 15. Skipjack tuna: average catches in the Indian Ocean over the period 2013–17, by country. Countries are ordered from left to right, according to the importance of catches of skipjack reported. The red line indicates the (cumulative) proportion of catches of skipjack for the countries concerned, over the total combined catches of this species reported from all countries and fisheries. Data as of September 2018.

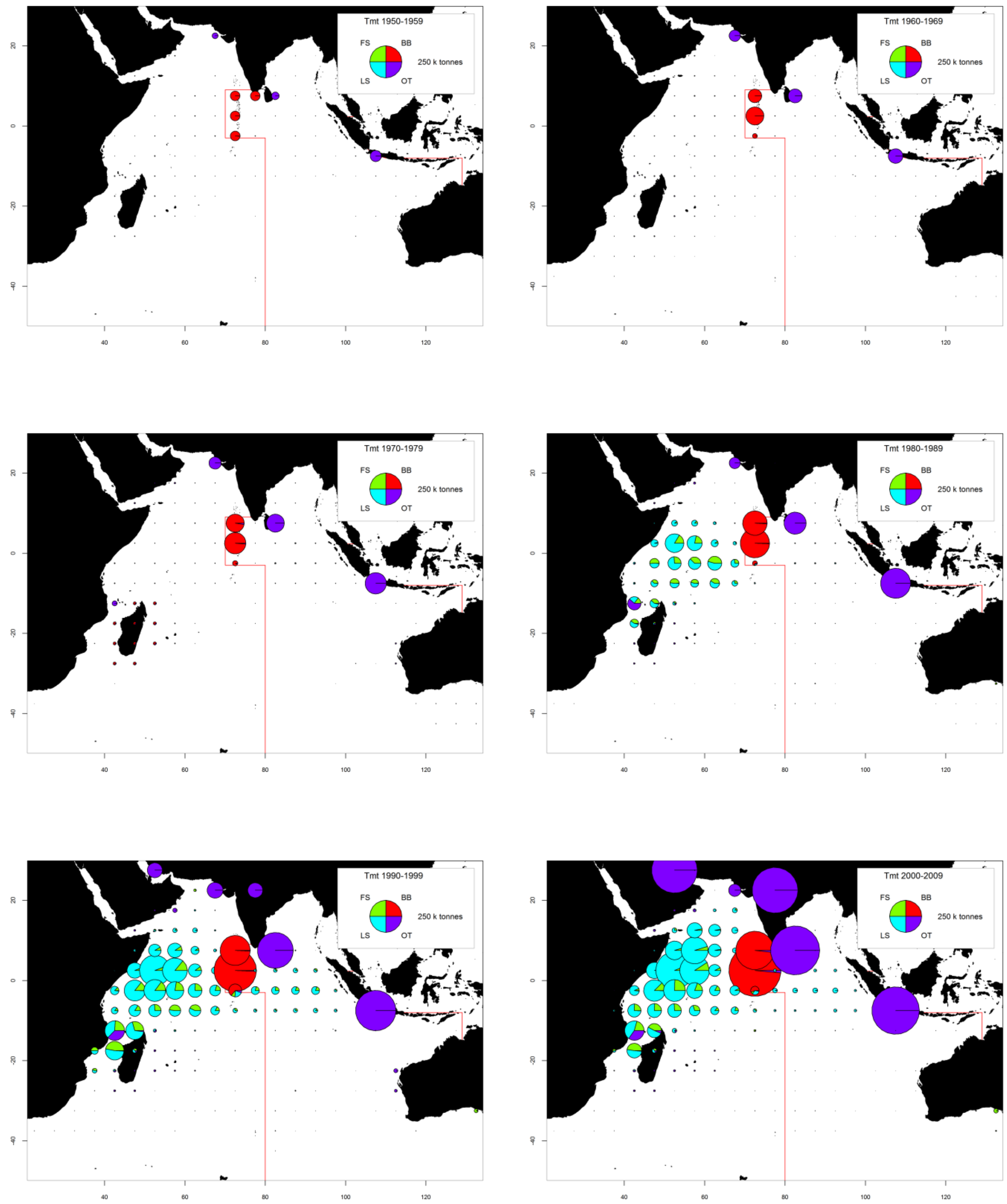


Fig. 16(a-f). Skipjack tuna: Time-area catches (total combined in tonnes) of skipjack tuna estimated for the period 1950–2009, by decade and type of gear. Purse seine free-schools (**FS**), Purse seine associated-schools (**LS**), pole-and-line (**BB**), and other fleets (**OT**), including longline, drifting gillnets, and various coastal fisheries.

Note that the catches of fleets for which the flag countries do not report detailed time and area data to the IOTC are recorded wi the area of the countries concerned (as OT), in particular driftnets of I.R. Iran, gillnet and longline fishery of Sri Lanka, and long and coastal fisheries of Indonesia.

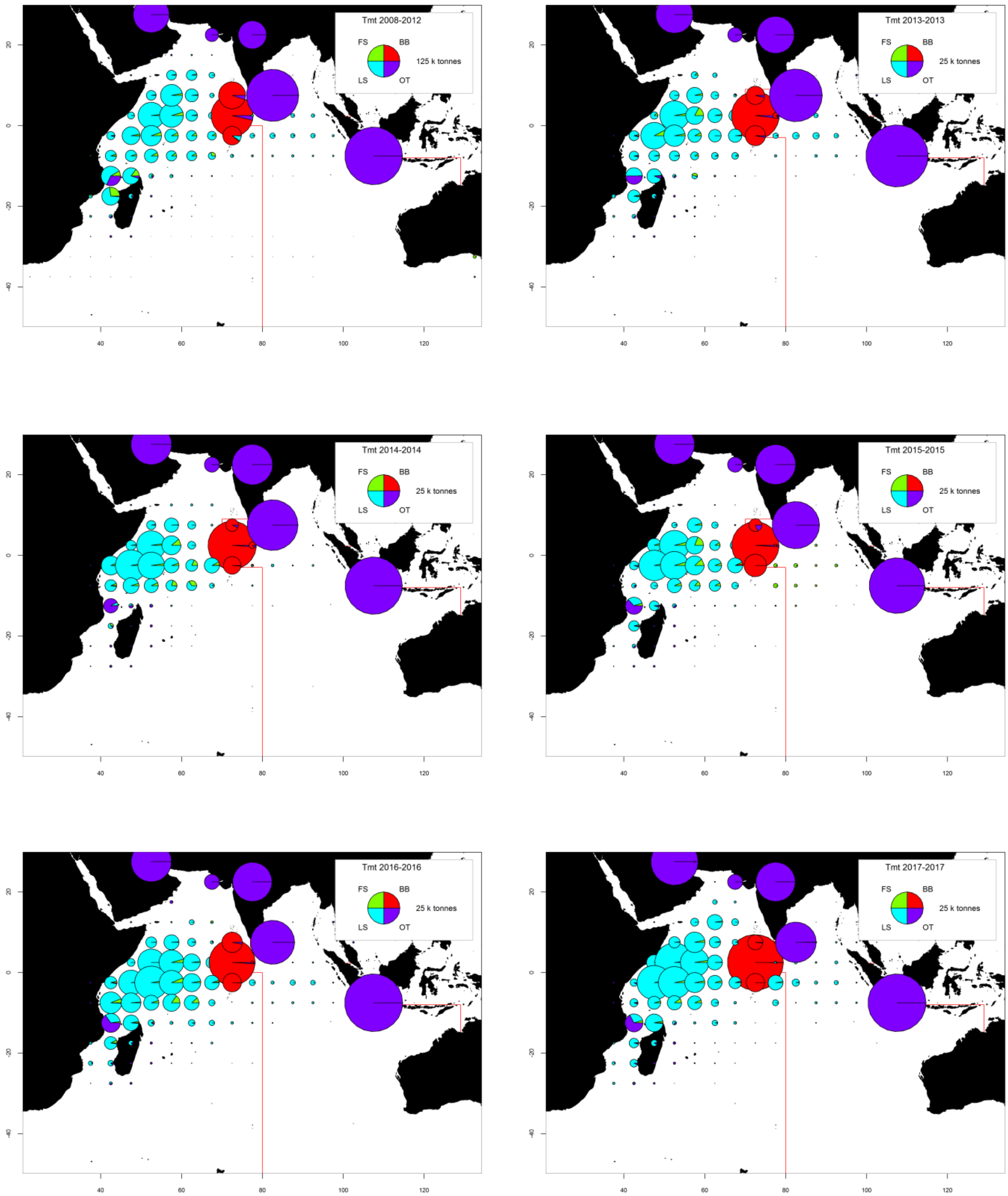


Fig. 17(a-f). Skipjack tuna: Time-area catches (total combined in tonnes) of skipjack tuna estimated for the period 2008–12 by type of gear and for 2013–17, by year and type of gear. Purse seine free-schools (**FS**), Purse seine associated-schools (**LS**), pole-and-line (**BB**), and other fleets (**OT**), including longline, drifting gillnets, and various coastal fisheries.

Note that 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 (as OT), in particular driftnets of I.R. Iran, gillnet and longline fishery of Sri Lanka, and longline and coastal fisheries of Indonesia.

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) and many gillnet fisheries (e.g., Indonesia, Sri Lanka) – although from 2014 Sri Lanka reported size information for its offshore fisheries.

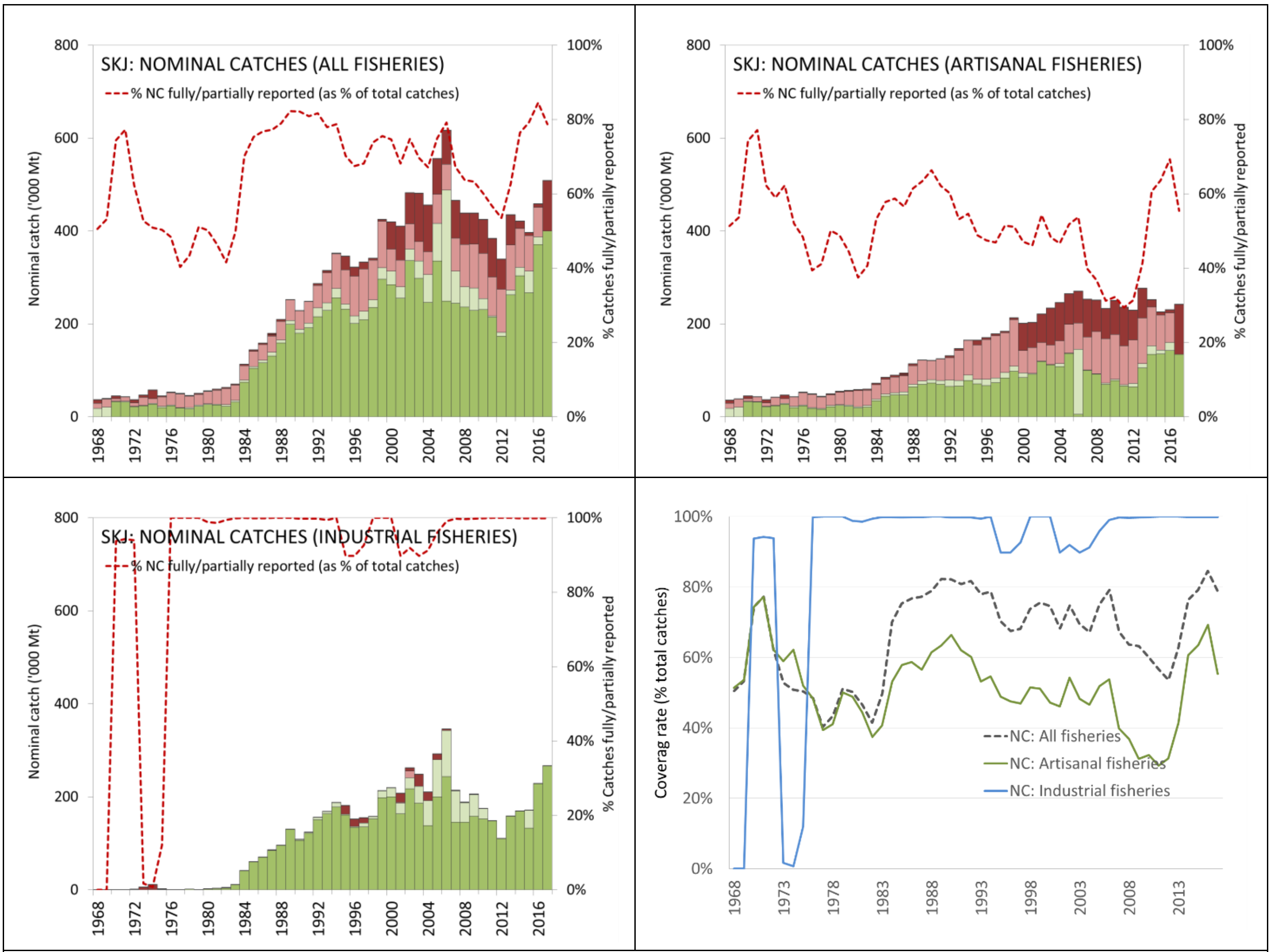


Fig. 18a-d. Skipjack tuna: nominal catches data reporting coverage (1968–2017). The red dotted lines indicated the proportion of catches fully/partially reported according to the IOTC data reporting standards for nominal catches. Data as of September 2018.

Data reporting scores:

	0
	2
	4
	6
	8

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

- **Score: 0** indicates the amount of nominal catch associated with each dataset fully reported according to IOTC standards.
- **Score: 2 – 6** indicates the amount of nominal catches associated with each dataset partially reported by gear and/or species (i.e., adjusted by gear and species by the IOTC Secretariat or for any of the other reasons provided in the document).
- **Score: 8** indicates the amount of nominal catches associated that is fully estimated by the IOTC Secretariat (i.e., nominal catches) or data that is not available (i.e., catch-and-effort or size data).

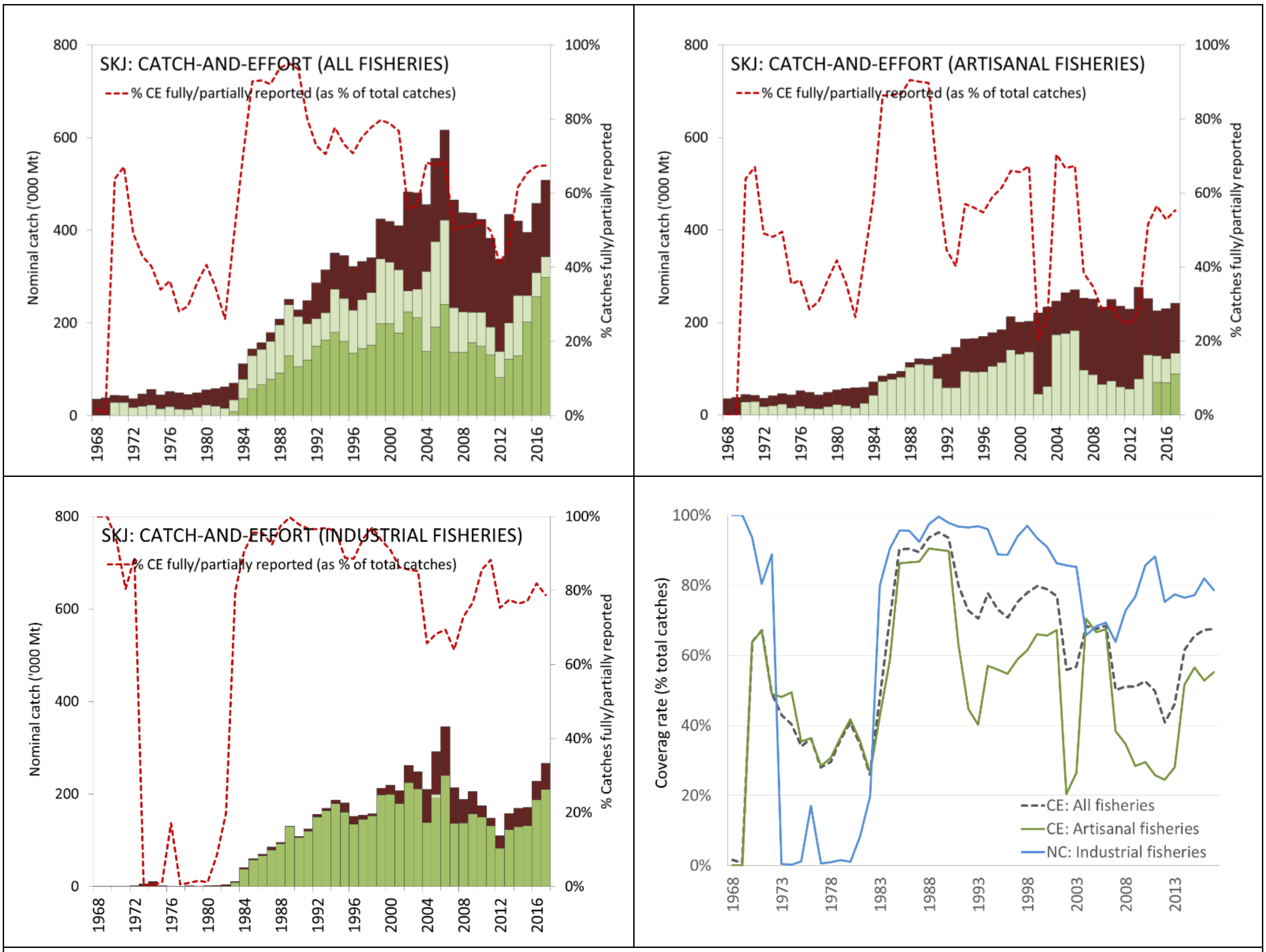


Fig. 18e-h. Skipjack tuna: catch-and-effort data reporting coverage (1968–2017). The red dotted lines indicated the proportion of catches fully/partially reported according to the IOTC data reporting standards for catch-and-effort. Data as of September 2018.

Data reporting scores:

	0
	2
	4
	6
	8

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

- **Score: 0** indicates the amount of nominal catch associated with each dataset fully reported according to IOTC standards.
- **Score: 2 – 6** indicates the amount of nominal catches associated with each dataset partially reported by gear and/or species (i.e., adjusted by gear and species by the IOTC Secretariat or for any of the other reasons provided in the document).
- **Score: 8** indicates the amount of nominal catches associated that is fully estimated by the IOTC Secretariat (i.e., nominal catches) or data that is not available (i.e., catch-and-effort or size data).

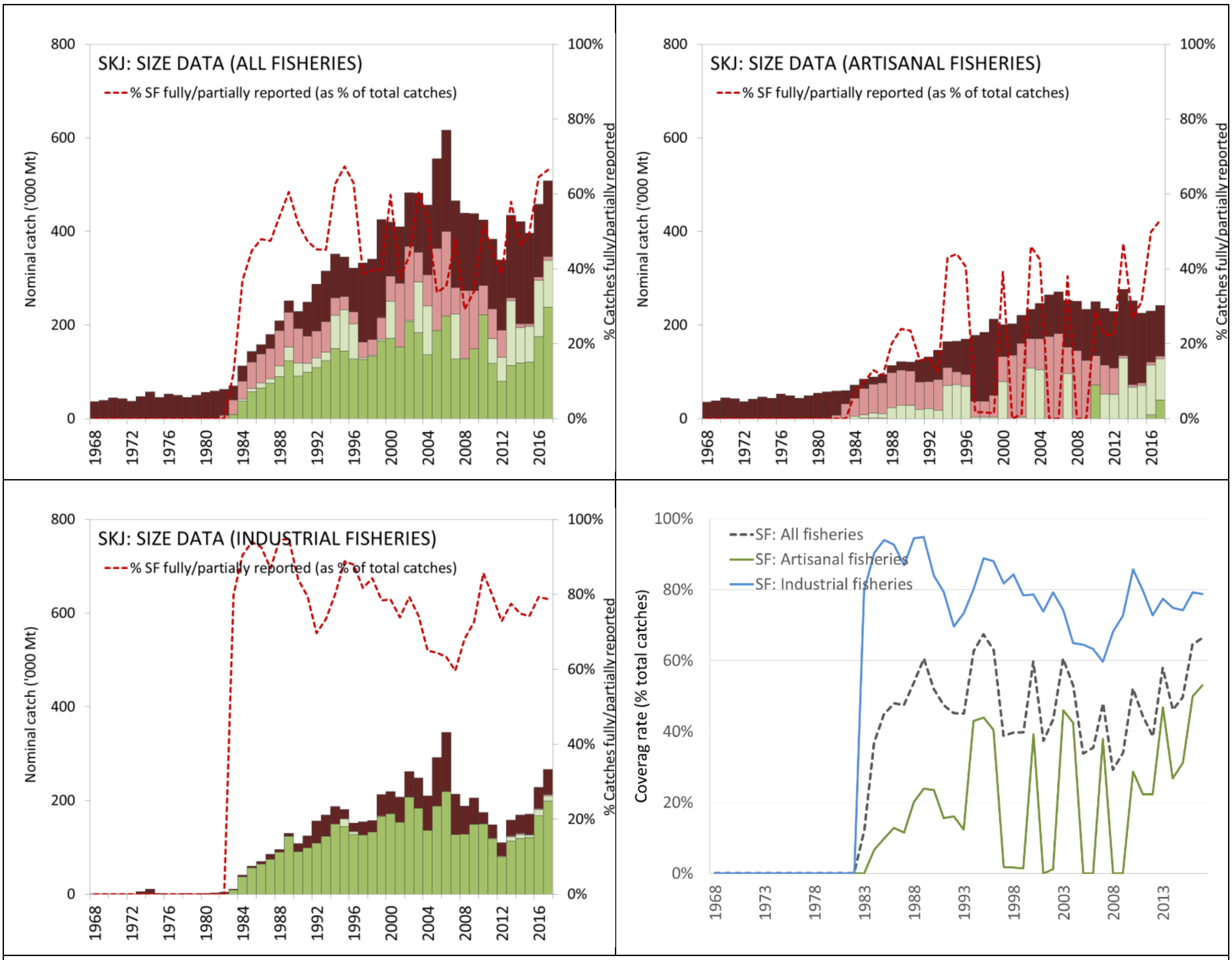


Fig. 18i-l. Skipjack tuna: size frequency data reporting coverage (1968–2017). The red dotted lines indicated the proportion of catches fully/partially reported according to the IOTC data reporting standards for size data. Data as of September 2018.

Data reporting scores:

	0
	2
	4
	6
	8

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

- **Score: 0** indicates the amount of nominal catch associated with each dataset fully reported according to IOTC standards.
- **Score: 2 – 6** indicates the amount of nominal catches associated with each dataset partially reported by gear and/or species (i.e., adjusted by gear and species by the IOTC Secretariat or for any of the other reasons provided in the document).
- **Score: 8** indicates the amount of nominal catches associated that is fully estimated by the IOTC Secretariat (i.e., nominal catches) or data that is not available (i.e., catch-and-effort or size data).

Skipjack tuna: Tagging data

- A total of 115,693 skipjack (representing 53% of the total number of fish tagged) were tagged during the Indian Ocean Tuna Tagging Programme (IOTTP), of which ≈68% were released during the main Regional Tuna Tagging Project-Indian Ocean (RTTP-IO) 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, 17,669 specimens (15% of releases for this species), have been recovered and reported to the IOTC Secretariat. Around 70% of the recoveries were from the purse seine fleets operating from the Seychelles, and around 29% 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.

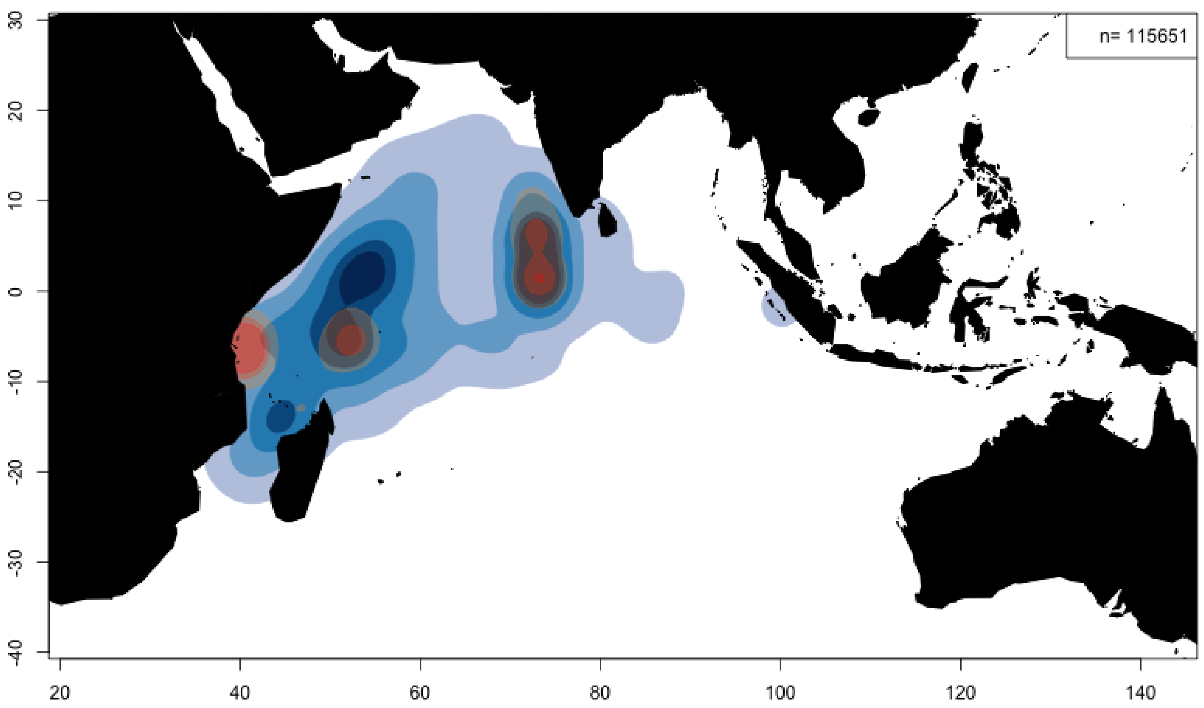
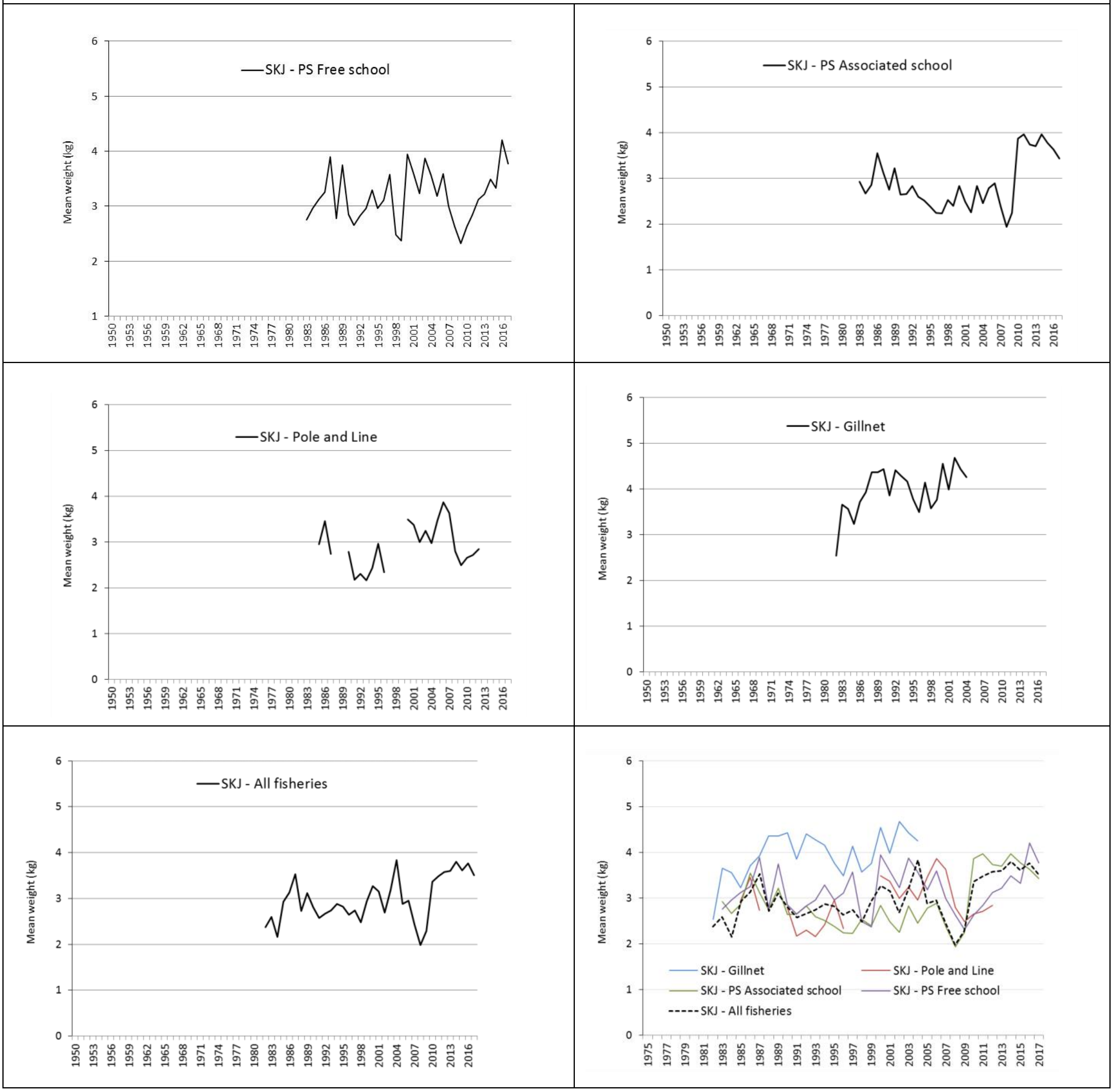


Fig. 19. Skipjack tuna: Densities of releases (in red) and recoveries (in blue). Includes specimens tagged during the IOT and also Indian Ocean (Maldivian) tagging programmes during the 1990s.

Skipjack tuna (SKJ)

Fig. 20. 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)



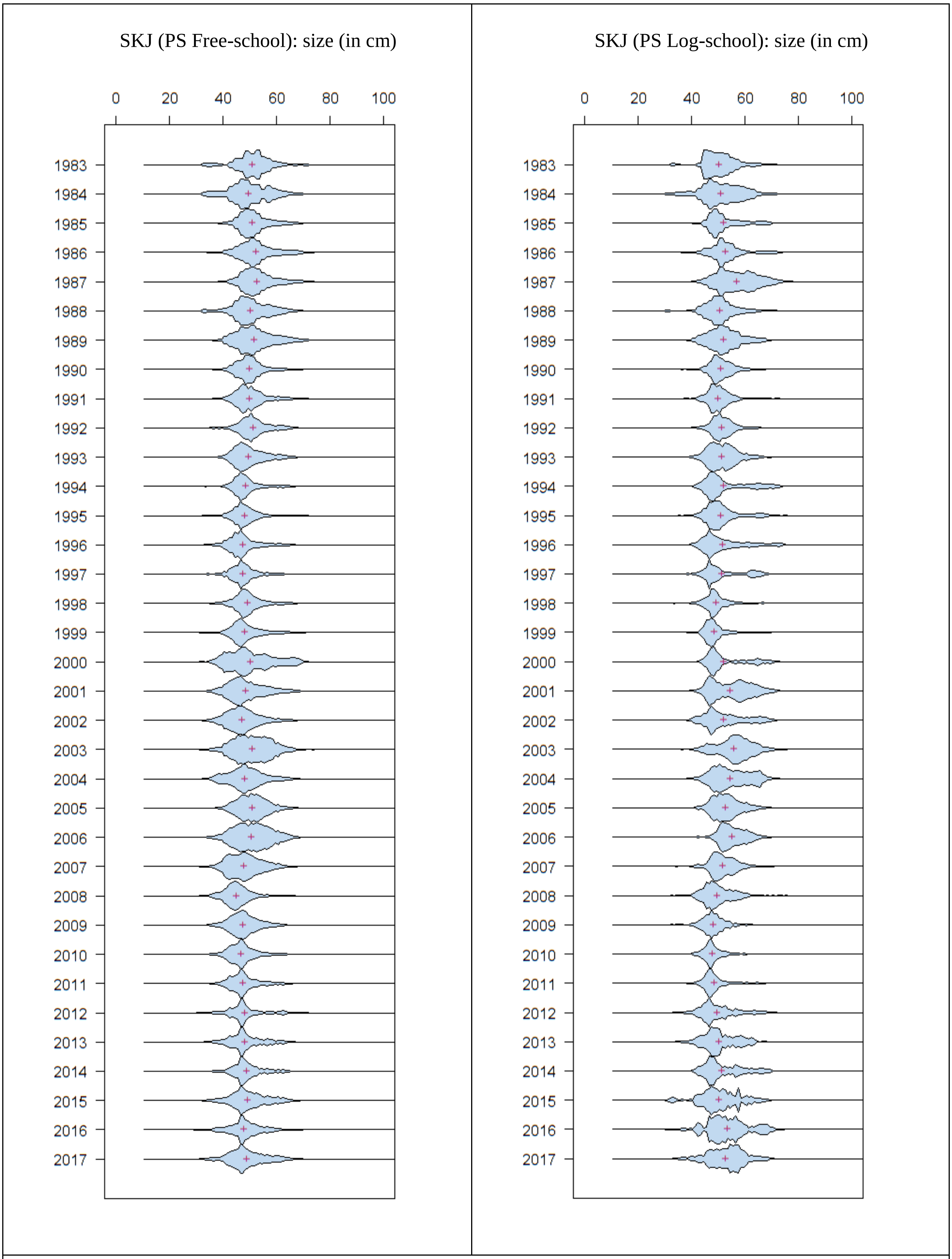


Fig. 21. Skipjack tuna (purse seine): Left: length frequency distributions for SKJ PS Free school fisheries (by 2 cm ler class). Right: Length frequency distributions for SKJ PS Associated (log) school fisheries (by 2 cm length class). Source: IOTC database.

APPENDIX IVD
MAIN STATISTICS OF YELLOWFIN TUNA

(Extracts from IOTC–2017–WPTT19–07)

Fisheries and main catch trends

- Main fishing gear (2013–17): 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 (2013–17):

  EU-Spain (purse seine): 14%; Maldives (handline, pole-and-line): 13%; I.R. Iran (gillnet): 11%; Seychelles (purse seine): 11%; Sri Lanka (gillnet, coastal longliners): 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 current 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 2017.

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 (2008–2017), 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 2018.

Fishery	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
FS	0	0	18	31552	64938	89204	74986	36048	32136	36453	64594	34472	47427	63962	49460	50700
LS	0	0	17	17597	56279	61890	41539	51352	73382	76658	66165	101886	86418	78394	99267	94424
LL	21990	41352	29589	33968	66318	56878	26039	20003	18746	20668	19671	16010	15608	17854	19359	17941
LF	166	1258	2374	7960	58987	55608	58102	49884	50485	43455	44695	47271	50594	40486	46278	54377
BB	2111	2318	5810	8295	12803	16072	18279	16826	14105	14010	15512	24055	20541	17642	12392	20298
GI	1567	4109	7928	12005	39539	49393	47871	41908	51118	49278	63460	56167	71390	71153	64723	75136
HD	619	636	2915	7373	18996	34337	30558	28373	34083	59401	79672	70501	71418	73769	85920	68568
TR	1012	1834	4239	7337	12287	16508	17328	15184	19982	19567	28585	32604	22256	16614	22063	14560
OT	80	193	454	1871	3379	5402	6557	7359	7703	7870	8223	8983	11402	11709	9957	13146
Total	**27,544**	**51,699**	**53,344**	**127,958**	**333,525**	**385,291**	**321,259**	**266,937**	**301,740**	**327,360**	**390,577**	**391,949**	**397,054**	**391,583**	**409,419**	**409,150**

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 (2008–2017), in tonnes. Catches by decade represent the average annual catch. The areas are presented in Fig. 18(a). Data as of September 2018.

Fishery	By decade (average)						By year (last ten years)									
	1950s	1960s	1970s	1980s	1990s	2000s	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
R1	1,992	4,480	8,630	19,792	74,590	84,934	71,256	59,847	70,900	100,769	131,930	119,195	129,995	135,073	144,017	139,202
R2	12,260	24,036	22,127	73,396	142,289	180,674	134,831	99,730	115,121	121,166	145,359	155,445	162,341	164,542	167,331	164,063
R3	658	7,350	4,283	7,357	21,776	23,604	19,871	18,426	18,263	18,988	17,090	20,664	8,769	14,404	18,588	20,059
R4	918	1,800	1,356	1,085	3,411	2,485	571	810	1,356	517	586	779	487	1,466	514	416
R5	11,716	14,034	16,949	26,329	91,459	93,593	94,730	88,124	96,100	85,920	95,612	95,866	95,462	76,098	78,969	85,410
Total	**27,544**	**51,699**	**53,344**	**127,958**	**333,525**	**385,291**	**321,259**	**266,937**	**301,740**	**327,360**	**390,577**	**391,949**	**397,054**	**391,583**	**409,419**	**409,150**

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**).

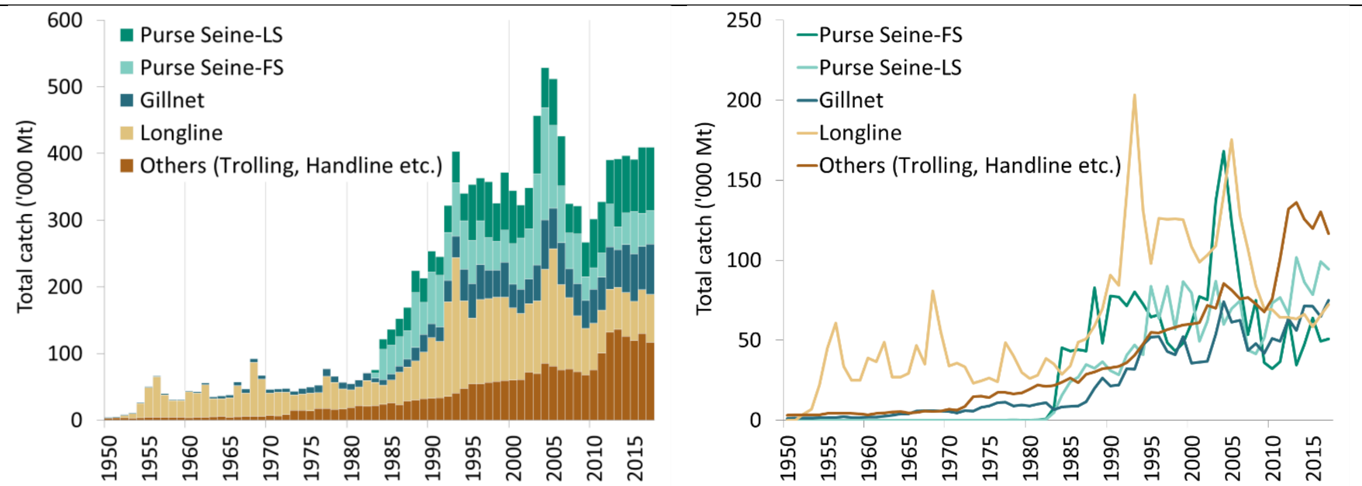


Fig. 22. Annual catches of yellowfin tuna by gear (1950–2017). Data as of September 2018.

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**).

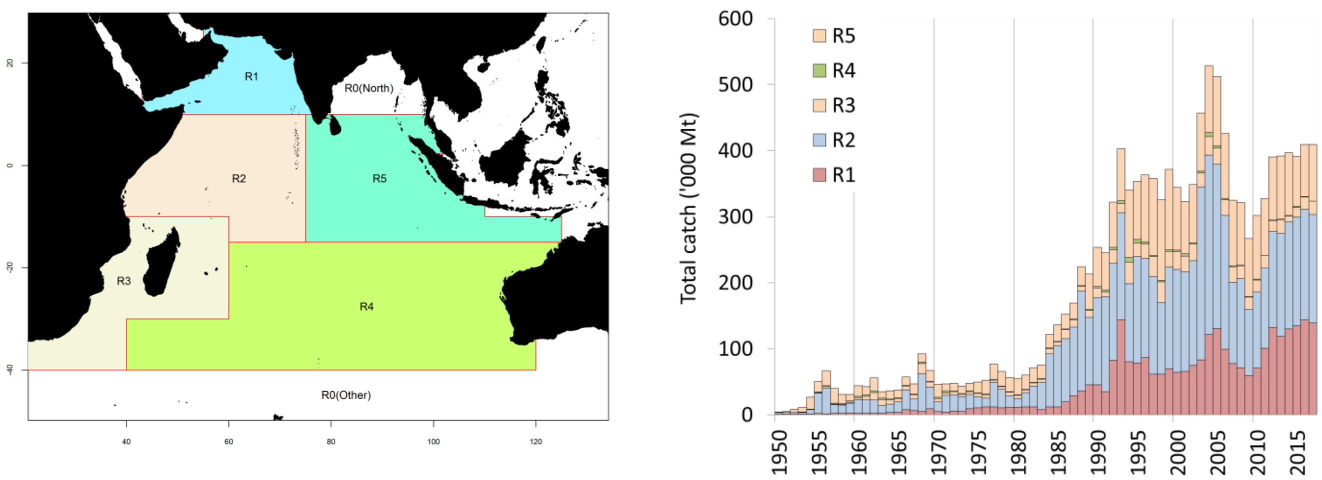


Fig. 23(a-b). Yellowfin tuna: Catches of yellowfin tuna by area by year estimated for the WPTT (1950–2017). Catches in areas R0 were assigned to the closest neighbouring area for the assessment. Data as of September 2018.

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**).

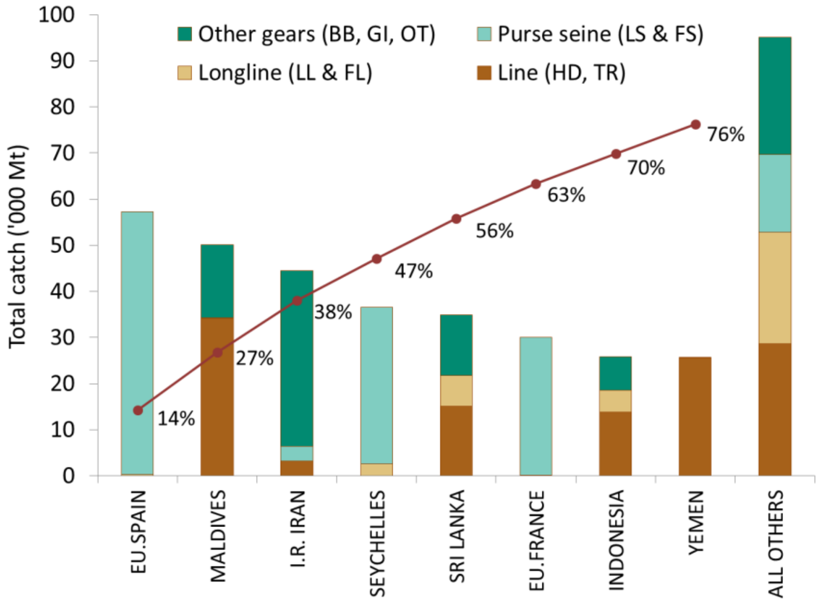


Fig. 24. Yellowfin tuna: average catches in the Indian Ocean over the period 2013–17, by country. Countries ordered from left to right, according to the importance of catches of yellowfin reported. The red line indic the (cumulative) proportion of catches of yellowfin for the countries concerned, over the total combined cat of this species reported from all countries and fisheries. Data as of September 2018.

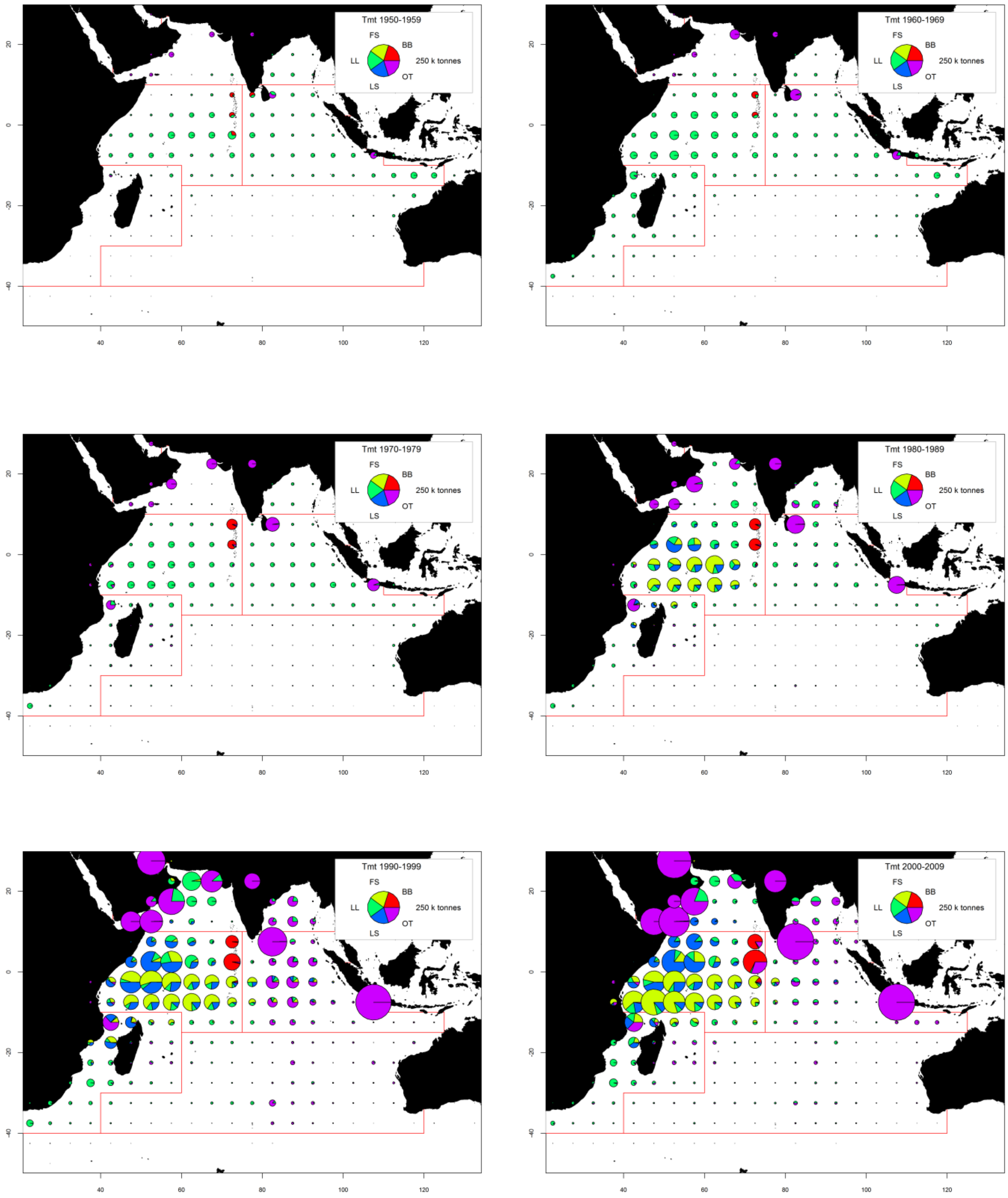


Fig. 25(a-f). Yellowfin tuna: Time-area catches (total combined in tonnes) of yellowfin tuna estimated for the period 1950–2009, by decade and type of gear. Longline (**LL**), Purse seine free-schools (**FS**), Purse seine associated-schools (**LS**), pole-and-line (**BB**), and other fleets (**OT**), including drifting gillnets, and various coastal fisheries.

Note that 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 (as OT), in particular driftnets of I.R. Iran, gillnet and longline fishery of Sri Lanka, and longline and coastal fisheries of Indonesia.

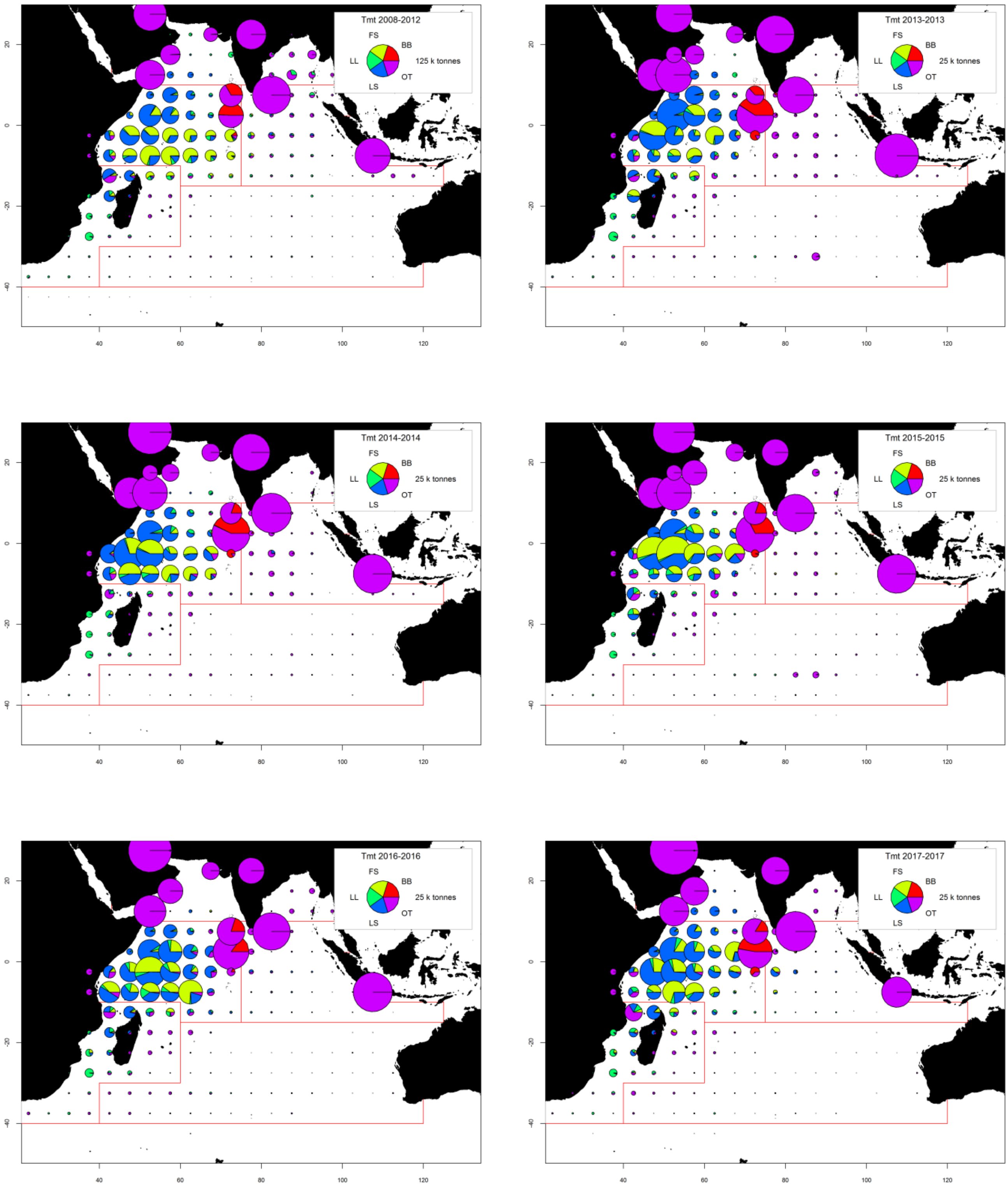


Fig. 26(a-f). Time-area catches (total combined in tonnes) of yellowfin tuna estimated for the period 2008–2012 by type of gear and for 2013–2017, by year and type of gear. Longline (**LL**), Purse seine free-schools (**FS**), Purse seine associated-schools (**LS**), pole-and-line (**BB**), and other fleets (**OT**), including drifting gillnets, and various coastal fisheries.

Note that 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 (as OT), in particular driftnets of I.R. Iran, gillnet and longline fishery of Sri Lanka, and longline and coastal fisheries of Indonesia.

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;
  - the gillnet fishery of Pakistan;
  - Non-reporting industrial purse seiners and longliners (NEI), and longliners of India.

Catch-per-unit-effort (CPUE) trends

- Availability: 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)

- Average fish weight: 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.

- Catch-at-Size (Age) table: 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).

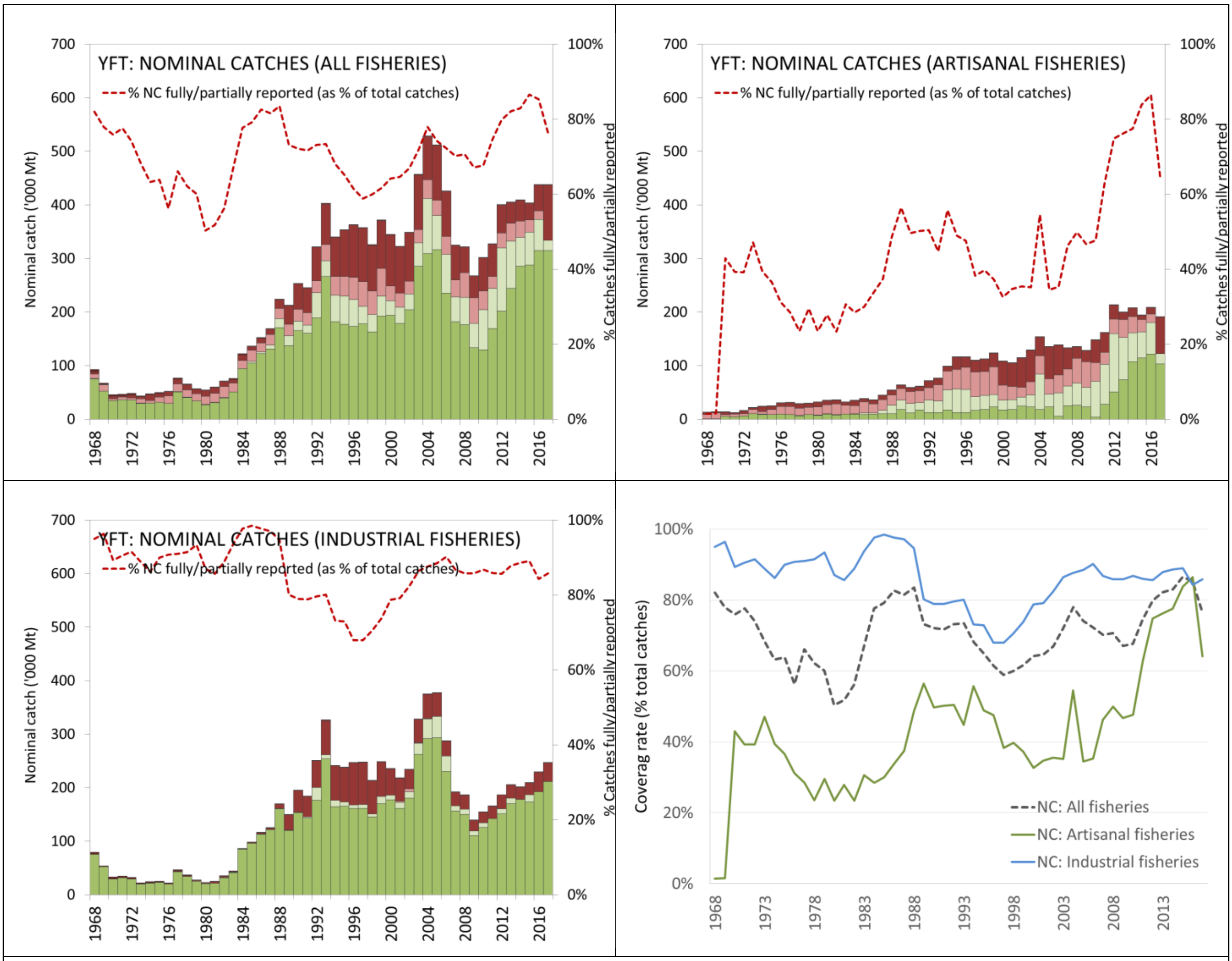


Fig. 27a-d. Yellowfin tuna: nominal catches data reporting coverage (1968–2017). The red dotted lines indicate the proportion of catches fully/partially reported according to the IOTC data reporting standards for nominal catches. Data as of September 2018.

Data reporting scores:

	0
	2
	4
	6
	8

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

- **Score: 0** indicates the amount of nominal catch associated with each dataset fully reported according to IOTC standards.
- **Score: 2 – 6** indicates the amount of nominal catches associated with each dataset partially reported by gear and/or species (i.e., adjusted by gear and species by the IOTC Secretariat or for any of the other reasons provided in the document).
- **Score: 8** indicates the amount of nominal catches associated that is fully estimated by the IOTC Secretariat (i.e., nominal catches) or data that is not available (i.e., catch-and-effort or size data).

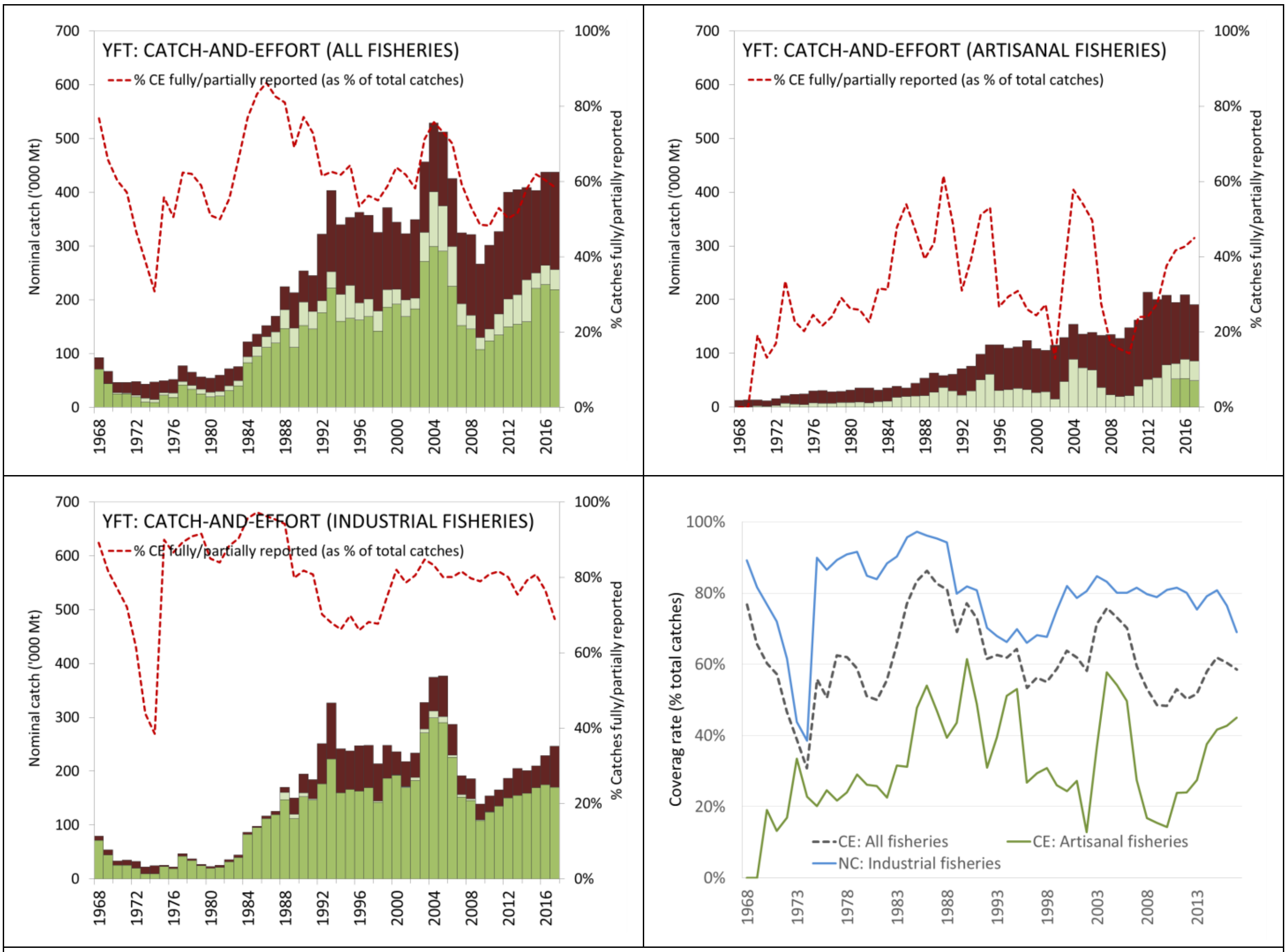


Fig. 27e-h. Yellowfin tuna: catch-and-effort data reporting coverage (1968–2017). The red dotted lines indicate the proportion of catches fully/partially reported according to the IOTC data reporting standards for catch-and-effort data. Data as of September 2018.

Data reporting scores:

	0
	2
	4
	6
	8

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

- **Score: 0** indicates the amount of nominal catch associated with each dataset fully reported according to IOTC standards.
- **Score: 2 – 6** indicates the amount of nominal catches associated with each dataset partially reported by gear and/or species (i.e., adjusted by gear and species by the IOTC Secretariat or for any of the other reasons provided in the document).
- **Score: 8** indicates the amount of nominal catches associated that is fully estimated by the IOTC Secretariat (i.e., nominal catches) or data that is not available (i.e., catch-and-effort or size data).

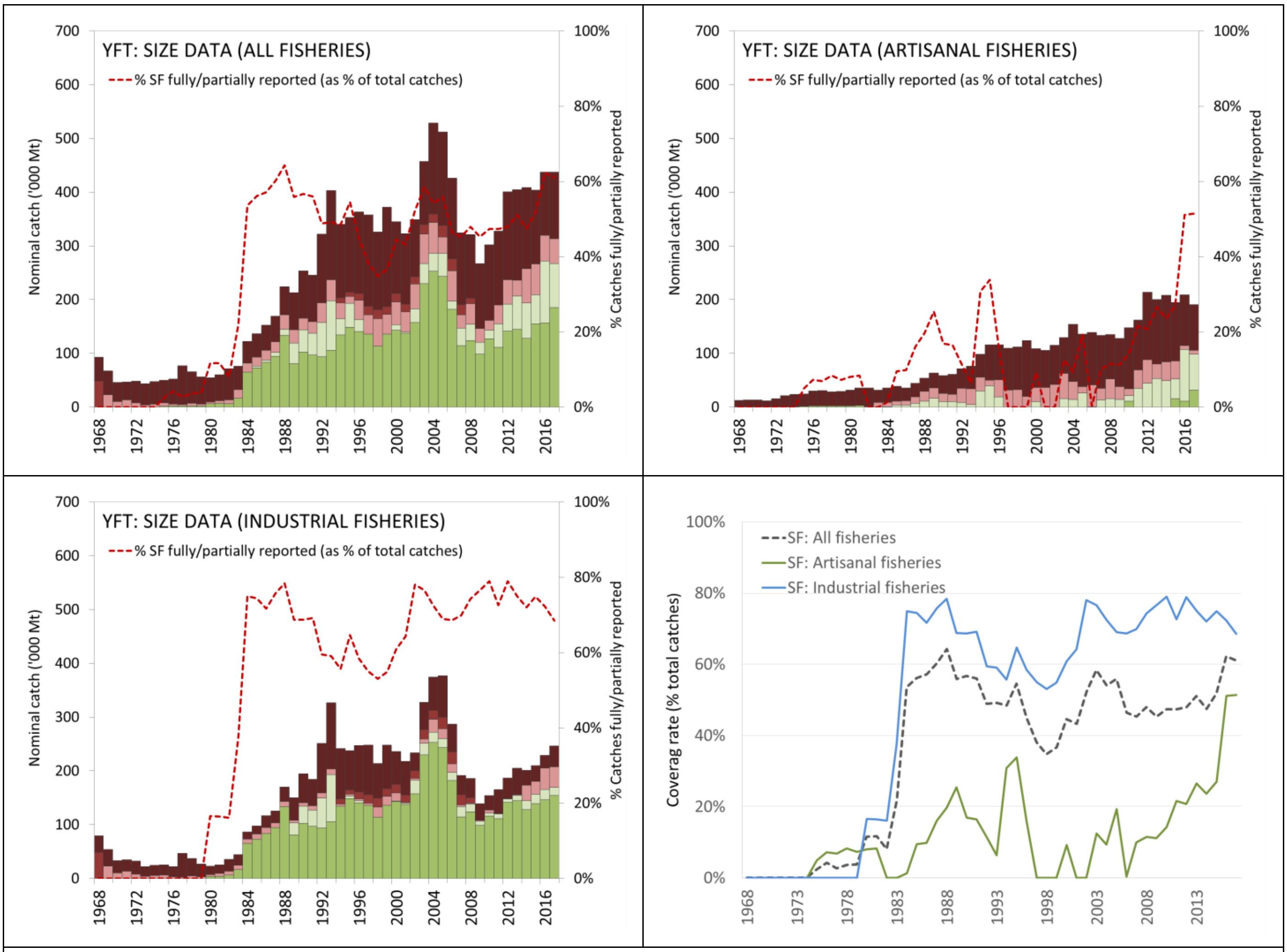


Fig. 27i-l. Yellowfin tuna: size frequency data reporting coverage (1968–2017). The red dotted lines indicate the proportion of catches fully/partially reported according to the IOTC data reporting standards for size data. Data as of September 2018.

Data reporting scores:

	0
	2
	4
	6
	8

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

- **Score: 0** indicates the amount of nominal catch associated with each dataset fully reported according to IOTC standards.
- **Score: 2 – 6** indicates the amount of nominal catches associated with each dataset partially reported by gear and/or species (i.e., adjusted by gear and species by the IOTC Secretariat or for any of the other reasons provided in the document).
- **Score: 8** indicates the amount of nominal catches associated that is fully estimated by the IOTC Secretariat (i.e., nominal catches) or data that is not available (i.e., catch-and-effort or size data).

Yellowfin tuna: tagging data

- A total of 66,543 yellowfin tuna (representing 30% of the total number of fish tagged) were tagged during the Indian Ocean Tuna Tagging Programme (IOTTP). Most of the tagged specimens (82%) 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 10,842 specimens (16% of releases for this species), have been recovered and reported to the IOTC Secretariat. More than 86% of these recoveries we made by the purse seine fleets operating in the Indian Ocean, while around 9% 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.

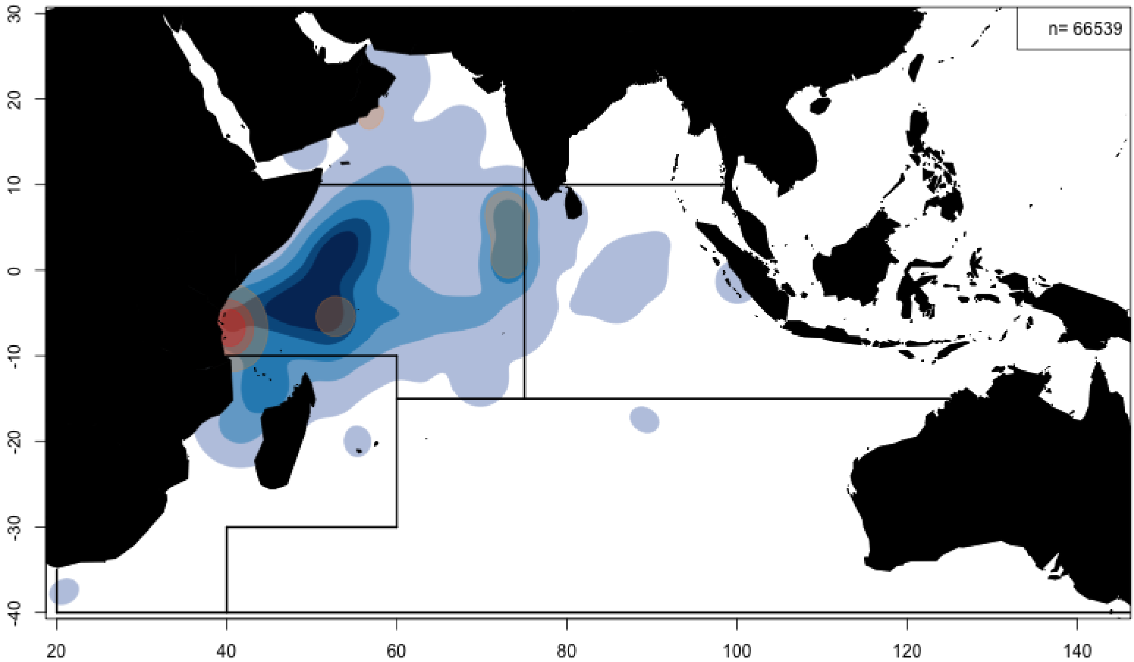
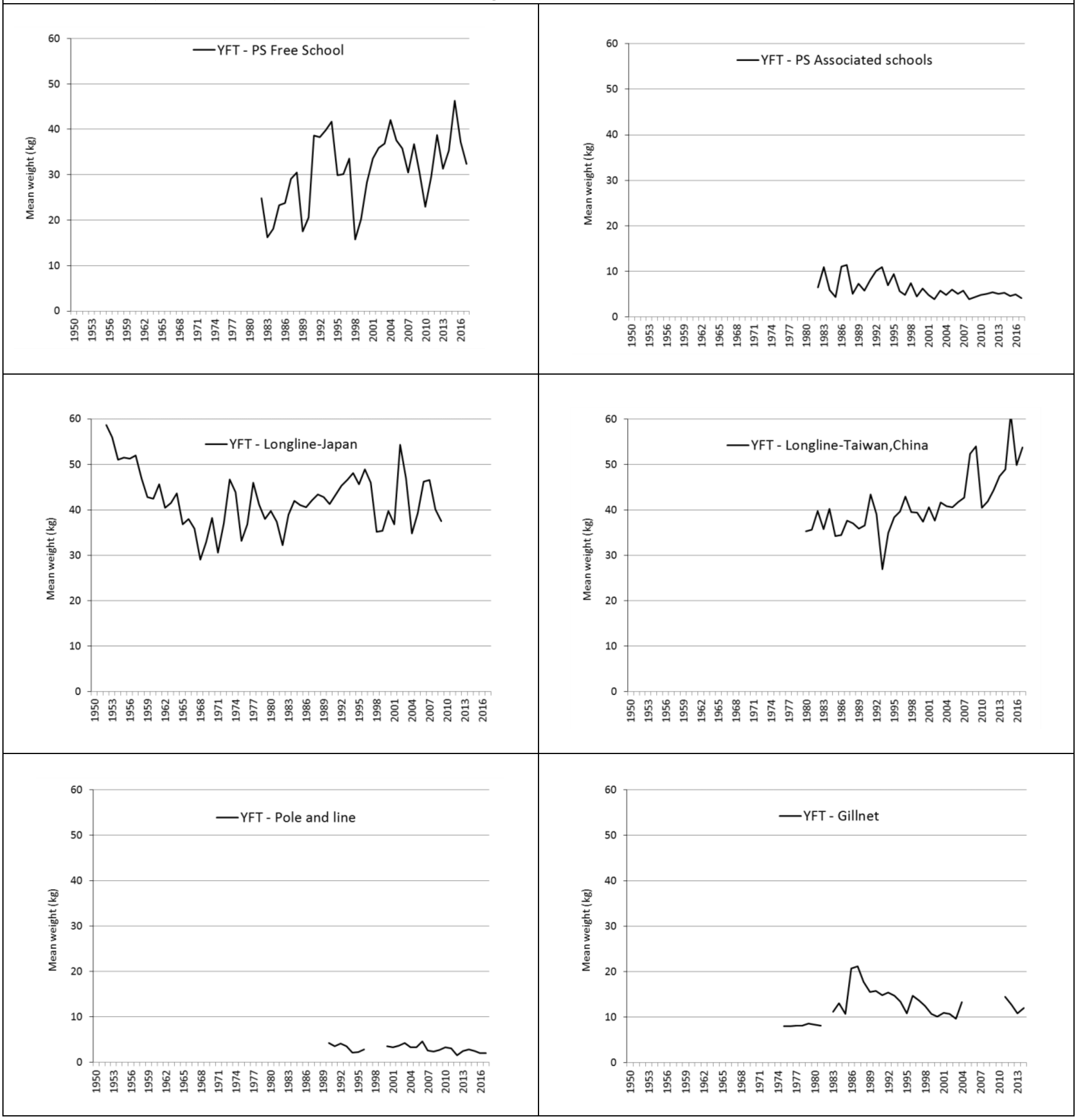


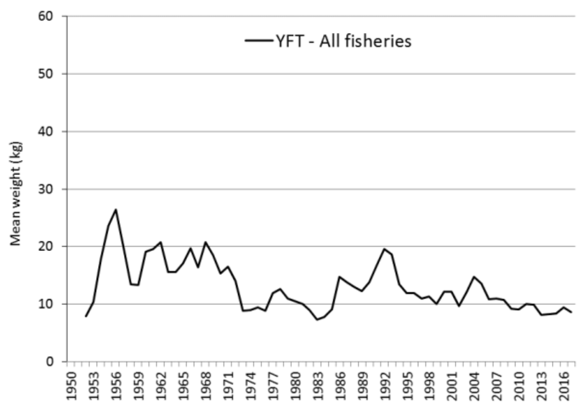
Fig. 28. Yellowfin tuna: Densities of releases (in red) and recoveries (in blue). The black line represents the st assessment areas. Includes specimens tagged during the IOTTP and also Indian Ocean (Maldivian) tagging program during the 1990s.

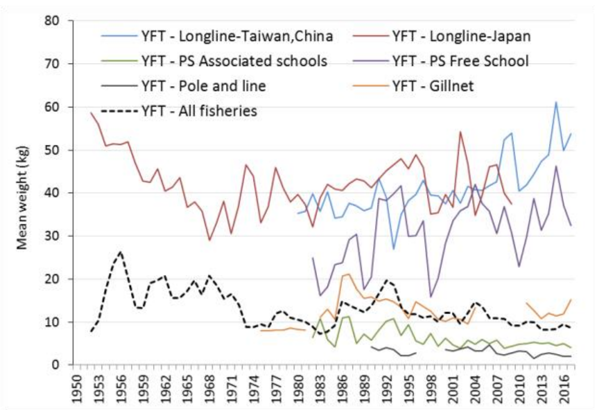
Yellowfin tuna (YFT)

Fig. 29. 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)




YFT - All fisheries
Mean weight (kg)


YFT - Longline-Taiwan,China
YFT - Longline-Japan
YFT - PS Associated schools
YFT - PS Free School
YFT - Pole and line
YFT - Gillnet
YFT - All fisheries
Mean weight (kg)

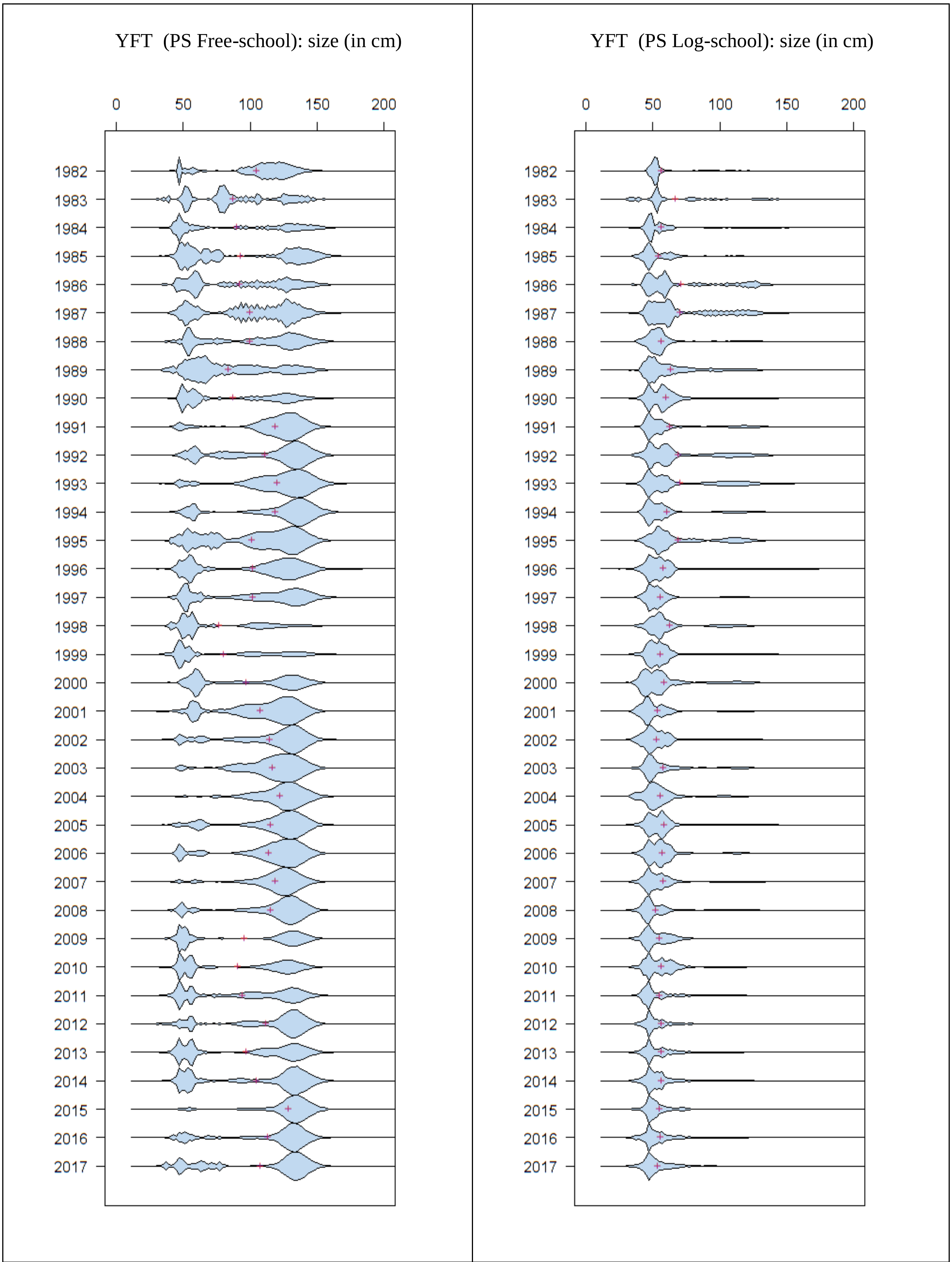


Fig. 30. Yellowfin tuna (purse seine): **Left:** length frequency distributions for YFT PS Free school fisheries (by 2 cm length class). **Right**: Length frequency distributions for YFT PS Associated (log) school fisheries (by 2 cm length class). Source: IOTC database.

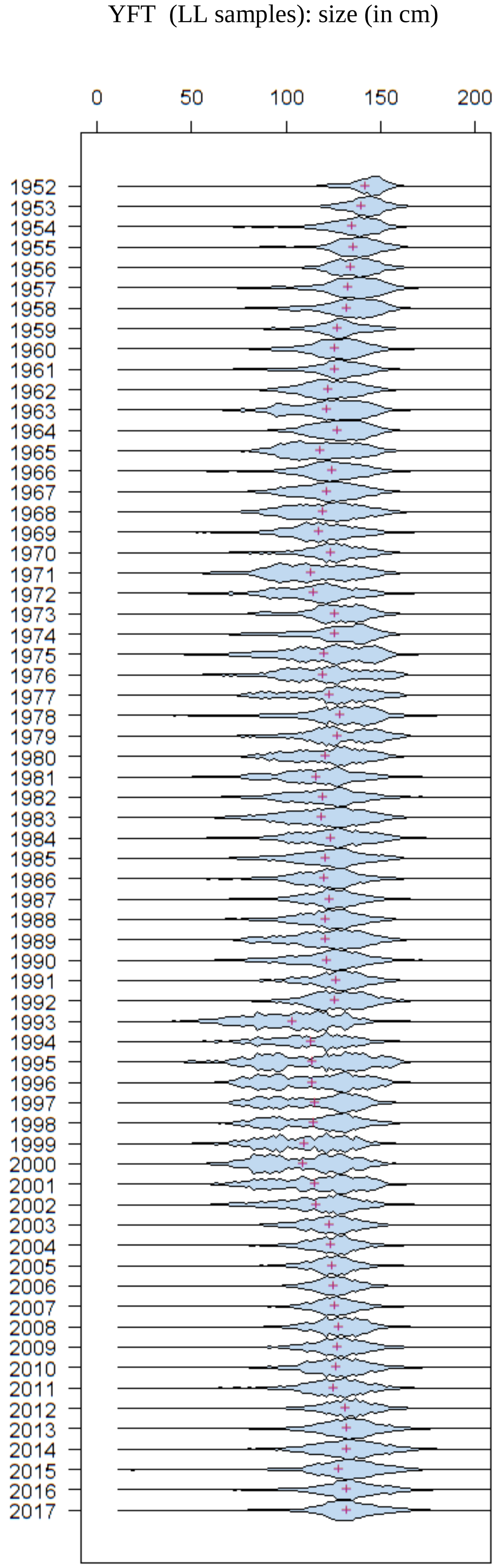


Fig. 31. Yellowfin tuna (longline): Length frequency distributions for longline fisheries (total amount of fish measur by 2 cm length class) derived from data available at the IOTC Secretariat. Source: IOTC database.

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 I.R. Iran for years prior to 2012 by 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[3] (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.

[3] 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 prior to 2013 (i.e., prior to the introduction of Resolution 13/11, superseded by Resolutions 15/06 and 17/04[4]). Discards of tropical tunas are thought to be significant during some earlier 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.

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 *IOTC Mandatory statistical requirements* and of limited value in deriving indices of abundance:

- <u>I.R. Iran (coastal and offshore fisheries)</u>: I.R. Iran ranks sixth largest in terms of total catches of tropical tunas (accounted for mostly by drifting gillnets), however until recently, catch-and-effort have not been reported according to IOTC standards, in particular for vessels operating outside of its EEZ. Following an IOTC Data Compliance mission in November 2017, I.R. Iran has now begun to submit catch-and-effort data in a new data reporting format, in accordance to the reporting requirements of Resolution 15/02. This should lead to substantial improvements in the data available for the Iranian fisheries in the IOTC database in the near future.
- <u>Sri Lanka (gillnet-longline)</u>: Until 2014 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. For this reason, time-area catches prior to 2014 are considered to be uncertain.
- <u>Indonesia (longline)</u>: 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.
- <u>Pakistan (drifting gillnet)</u>: no catch-and-effort reported for the gillnet fishery, in particular for vessels that operate outside the EEZ of Pakistan. WWF-Pakistan has been a implementing a crew-based observer programme for over two years, which includes information on total enumeration of catches and fishing location (for sampled vessels), and could be used to estimate catch-and-effort for Pakistan gillnet vessels in the absence of a national logbook program. The IOTC Secretariat is currently liaising with WWF-Pakistan to evaluate the quality of the observer data collected.
- <u>India (longline)</u>: 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)*

- <u>Japan and Taiwan,China (longline fisheries)</u>: 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].

  A consultancy is planned for 2019 to work directly the individual national fisheries organizations concerned to resolve the current issues with longline issues.

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[4] Resolution 17/04 *On a ban on discards of bigeye tuna, skipjack tuna, yellowfin tuna, and non-targeted species caught by purse seine vessels in the IOTC area of competence.*

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

- In addition, the number of specimens sampled for length on-board longliners flagged in Japan in recent years remains below the minimum 1 fish per metric ton of catch recommended by the IOTC – although size data is now being reported as part of Japan's Regional Observer Scheme data submissions.
- 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:

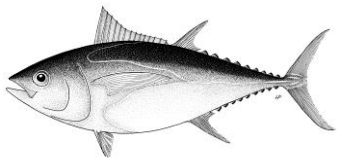
  The IOTC database does not contain enough data to allow for the estimation of statistically robust length-weight keys or non-standard size to standard length keys for tropical tuna species, due to the general lack of biological data available from the Indian Ocean.

  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		2018 stock status[3] determination
Indian Ocean	Catch in 2017[2]: Average catch 2013–2017:	90,050 t 95,997 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 for catches in 2017: 21%
[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 2018, thus, stock status is determined on the basis of the 2016 assessment and other indicators presented in 2018. 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 2017 (≈90,050 t) remain lower than the estimated MSY values from the stock assessment conducted in 2016. The average catch over the previous five years (2013–17; ≈95,997 t) also remains below the estimated MSY. Thus, on the weight-of-evidence available in 2018, 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, Taiwanese 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 a level of 90,500 t (2017 catches) (Table 2).

Management advice. The stock status determination did not qualitatively change in 2018. If catches remain 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 Indian Ocean stock is 104,101 t with a range between 87,000–121,000 t for SS3 (Table 1). The average 2013-2017 catches of ≈95,997 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. 2**).
    - **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. 2**).
- **Main fishing gear** (Average catch 2013–17): Longline ≈48%; Purse seine ≈26% (FAD associated school (LS) ≈19%; free swimming school (PS) ≈7%); All other (artisanal) gears ≈26% (**Fig 1**).
- **Main fleets** (Average catch 2013–17): Indonesia ≈27%; Taiwan,China ≈18%; European Union ≈17% (EU-Spain: ≈12%; EU-France: ≈5%); Seychelles ≈13%.

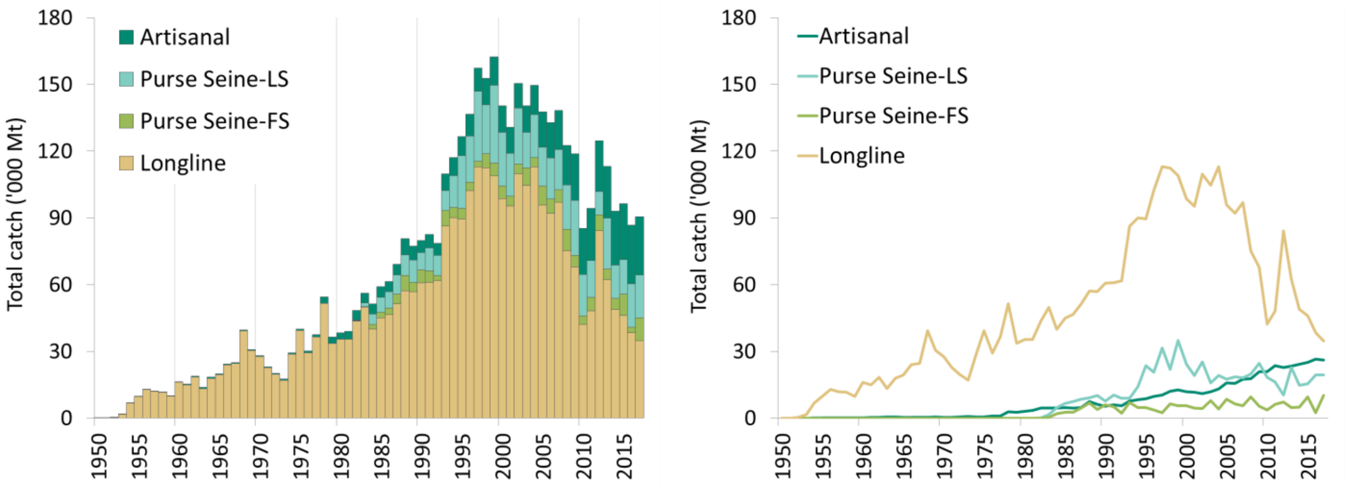


Fig. 1(a-b). Annual catches of bigeye tuna by gear (1950–2017). Data as of September 2018.

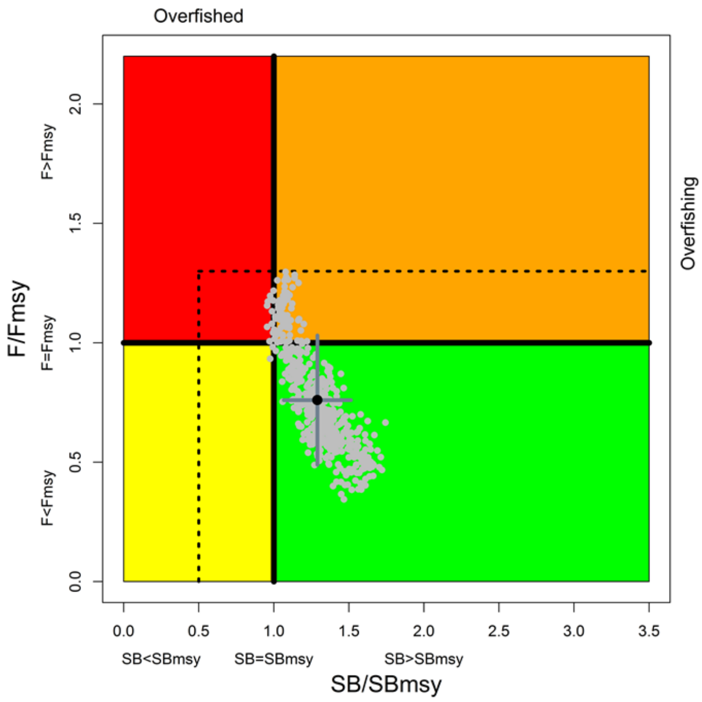


Fig. 2. Bigeye tuna: SS3 Aggregated Indian Ocean assessment Kobe plot. Dotted black lines are the interim limit reference points adopted by the Commission via Resolution 15/10. The grey points represent 500 estimates of 2015 stock status from the six SS3 scenarios. The black point represents the average of the six SS3 scenarios with associated 80% confidence interval.

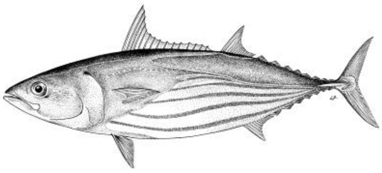
TABLE 2. Bigeye tuna: Stock Synthesis base case Indian Ocean assessment Kobe II Strategy Matrix. Probability (percentage) of violating the MSY-based target (top) and limit (bottom) reference points for constant catch projections (relative to catches from 2015* (93,040t), ± 20%, + 40%) projected for 3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

Reference point and projection timeframe	**Alternative catch projections (relative to the catch level from 2015*) and weighted probability (%) scenarios that violate MSY-based target 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**		**2018 stock status**[4] **determination**
Indian Ocean	Catch 2017[2]: Average catch 2013–2017:	524,282 t 454,103 t	**47%***
	$Yield_{40\%SSB}$ (1000 t) (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): $E^3_{40\%SSB}$ (80% CI): SB_0 (80% CI):	510.1 (455.9–618.8) 0.88 (0.72-0.98) 796.66 (582.65-1,059.29) 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)	

[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 2017: 21%
[3] E is the annual harvest rate.
[4] The stock status refers to the most recent years' data used in the last assessment conducted in 2017.
* 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.

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

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. No new stock assessment was carried out for skipjack tuna in 2018, thus, stock status is determined on the basis of the 2017 assessment and other indicators presented in 2018. 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 catches 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). While reported catches in 2017 (≈524,282 t) are higher than the estimated range of $C_{SB40\%}$ (Table 1) and the TAC set by the harvest control rule, the average catches over the previous five years (2013–17; ≈ 454,103 t) are below the estimated range of $C_{SB40\%}$. Thus, on the weight-of-evidence available in 2018, 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 the requirement 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.

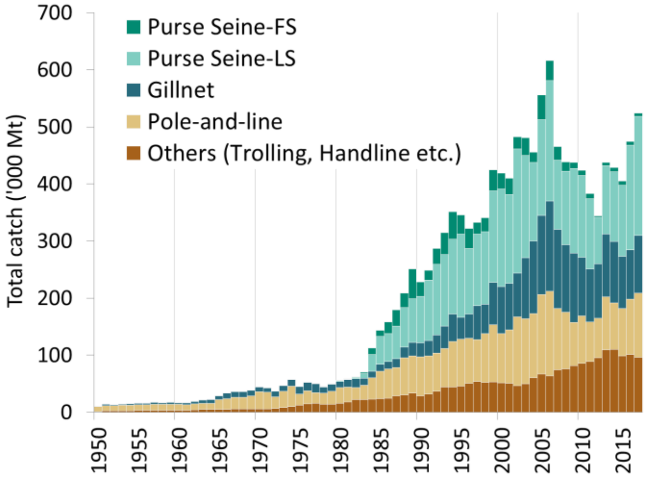
The following key points should also be noted:

- There is no evidence of any exceptional circumstance that may impede the application of the *harvest control rule* specified in Resolution 16-02. The spawning biomass is above the limit reference point.
- As agreed by the Commission, the application of the HCR provides a total annual catch limit for 2018-2020 using the following values estimated from the 2017 skipjack stock assessment. For each value, the reported median from the reference grid adopted by the Scientific Committee for advising the Commission is used:
  - The median of SB_{2016}/SB_0 = 0.40;
  - The estimate median of current spawning stock biomass (SB_{curr}) is 796,660 tons;
  - The estimate of the equilibrium exploitation rate associated with sustaining the stock at SBtarg is Etarg = 0,59;
  - As current spawning biomass (SB_{curr}) is estimated to be at or above the threshold spawning biomass i.e., SB_{curr} >= $0.4B_0$, then the fishing intensity parameter (I) corresponds to Imax (1);

Following Resolution 16/02, the catch limit is calculated as [I_{max} x E_{targ} x B_{curr}] = 1 * 0.59 * 796,660 t which results in an annual overall catch limit of 470,029 t. for the period 2018-2020.

The SC has included in its programme of work further development of Management Strategy Evaluation (MSE) for the IOTC Skipjack tuna fishery including, but not limited to refinement of operating model(s) used, specifications for the assessment and data to be used, and alternative management procedures.

- **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, and also below the limit reference point (**Fig. 2**) as per Resolution 15/10,.
  - **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. 2**) as per Resolution 15/10,
- **Main fishing gear** (average catches 2013–17): Purse seine ≈35% (FAD associated school ≈33% and free swimming school ≈1%); Gillnet ≈22%; Pole-and-line ≈21%; Other ≈23% (**Fig. 1(a-c)**).
- **Main fleets** (average catches 2013–17): Indonesia ≈19%; European Union ≈20% (EU-Spain: ≈15%; EU-France: ≈5%); ≈Maldives 16%; Sri Lanka ≈12%; Seychelles ≈10%; ≈I.R. Iran 9%.



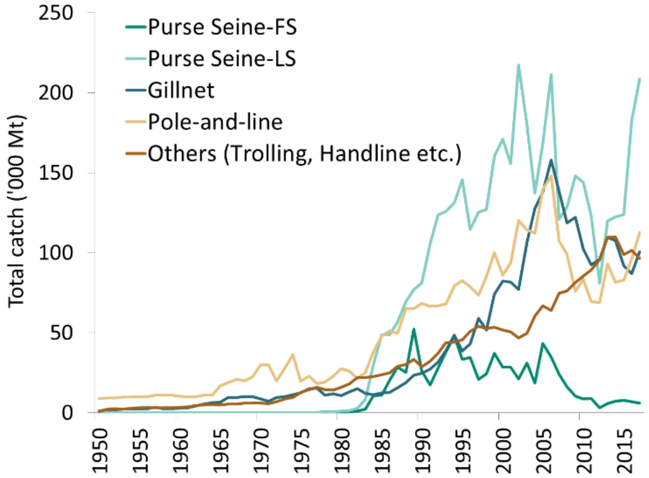


Fig. 1(a-b). Annual catches of skipjack tuna by gear (1950–2017). Data as of September 2018.

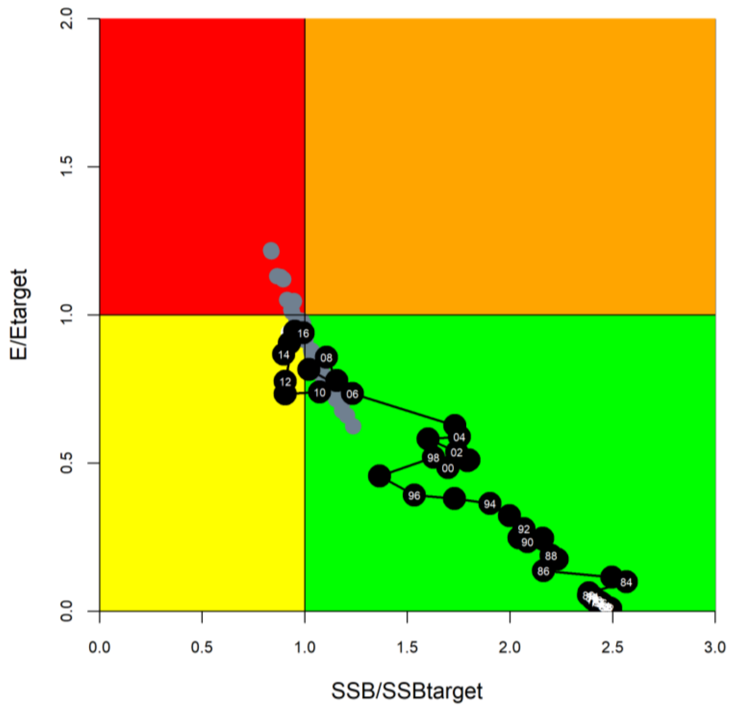
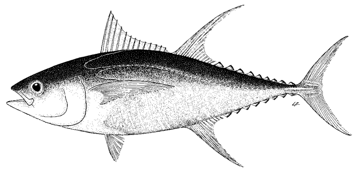


Fig. 2. Skipjack tuna: SS3 Aggregated Indian Ocean assessment Kobe plot of the 2017 uncertainty grid. Black circles indicate the trajectory of the median estimates for the SB/SB_{target} ratio and E/E_{target} ratio across all models of the 2017 uncertainty grid for each year 1950–2016; grey dots are the estimates for year 2016 from individual models.

APPENDIX VII

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		2018 stock status determination
Indian Ocean	Catch 2017[2]: Average catch 2013–2017:	409,101 t 399,830 t	
	MSY (1000 t) (80% CI): F_{MSY} (80% CI): SB_{MSY} (1,000 t) (80% CI): F_{2017}/F_{MSY} (80% CI): SB_{2017}/SB_{MSY} (80% CI): SB_{2017}/SB_0 (80% CI):	403 (339–436) 0.17 (0.13–0.17) 1069 (789–1387) 1.20 (1.00–1.71) 0.83 (0.74–0.97) 0.30 (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 for catches in 2017: 24%
* 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_{2017}/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}≥ 1)
Stock subject to overfishing(F_{year}/F_{MSY}> 1)	93.8%	2.1%
Stock not subject to overfishing (F_{year}/F_{MSY}≤ 1)	4.2%	0%
Not assessed/Uncertain		

Detailed management advice was not provided during the assessment meeting as projections had not yet been conducted. This will be done intersessionally and provided and discussed during the 21st session of the Scientific Committee. Thereafter, this executive summary will be updated and completed.

APPENDIX IX
WORKING PARTY ON TROPICAL TUNAS PROGRAM OF WORK (2019–2023)

The following is the Draft WPTT Program of Work (2019–2023) and is based on the specific requests of the Commission and Scientific Committee, and will need to be modified to incorporate topics identified during the WPTT20. 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				
					2019	2020	2021	2022	2023
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.	Ongoing	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				
					2019	2020	2021	2022	2023
	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 Biological sampling								
	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 with secretariat	US$?? (TBD)					
	2.1.2 Collect gonad samples from tropical tunas to confirm the spawning periods and location of the spawning area that are presently hypothesised for each tropical tuna species.	High		US$?? (TBD)					
3. Historical data review	3.1 Changes in fleet dynamics need to be documented by fleet								
	3.1.1 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	Medium	CPCs and secretariat	US$TBD					

Topic	Sub-topic and project	Priority ranking	Lead	Est. budget (potential source)	TIMING 2019	2020	2021	2022	2023
	status of tropical tunas based upon most recent stock assessments.								
4 CPUE standardisation	4.1 Develop standardised CPUE series for each tropical tuna fleet/fishery for the Indian Ocean								
	4.1.1 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	Ongoing	SC and consultants	US$40K (IOTC)					
	4.1.2 That standardised CPUE index for juvenile yellowfin tuna and bigeye tuna caught by the EU purse seiner fleets, be estimated and submitted to the WPTT before the next round of stock assessments of tropical tunas.	Ongoing	CPCs directly	US$?? (EU Grant)					
	4.1.3 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.	Ongoing	CPCs directly	US$?? (TBD)					
	4.1.4 Vessel identity information for the Japanese fleets for the period prior to 1979 should be obtained either from the original logbooks or from some other source, to the greatest extent possible to allow estimation of catchability change during this period and to permit cluster analysis using vessel level data.	Ongoing	Japan	US$?? (TBD)					
	Bigeye tuna: High priority fleets	High	CPCs directly						
	Skipjack tuna: High priority fleets	High	CPCs directly						
	Yellowfin tuna: High priority fleets	High	CPCs directly						

Topic	Sub-topic and project	Priority ranking	Lead	Est. budget (potential source)	TIMING				
					2019	2020	2021	2022	2023
	4.1.5 Gillnet CPUE standardization including further investigate and use of gillnet CPUE series from Sri Lankan gillnet fishery	High	CPCs directly	TBD					
	4.2 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 IOTC-2017-WPTT19-R).	High	Consultant and CPCs directly	US$?? (TBD)					
	4.3 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)					
5 Stock assessment / stock indicators	5.1 Develop and compare multiple assessment approaches to determine stock status for tropical tunas	Medium	Consultant and CPCs directly						
	5.2 Scoping of ongoing age composition data collection for stock assessment	Medium							
	5.3 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 IOTC-2017-WPTT19-R).	Ongoing	CPC directly						
	5.4 Stock assessment priorities – 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), 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. Organisation of expert group to investigate tagging mortality* *iv. Re-estimation of M using updated tagging data.*	High	Consultant and secretariat						

	Topic	Sub-topic and project	Priority ranking	Lead	Est. budget (potential source)	TIMING				
						2019	2020	2021	2022	2023
6	Fishery independent monitoring	6.1 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 iii. Aerial surveys, potentially using remotely operated or autonomous drones iv. Studies (research) on flux of tuna around anchored FAD arrays to understand standing stock and independent estimates of the stock abundance. v. Scoping study to investigate 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	 Ongoing High Medium Medium High	Consultant and CPCs directly	US$?? (TBD) US$60K US$?? (TBD)					

Topic	Sub-topic and project	Priority ranking	Lead	Est. budget (potential source)	TIMING				
					2019	2020	2021	2022	2023
	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 vi. Investigate the possibility of conducting ongoing ad hoc, low level tagging in the region								
7 Target and Limit reference points	7.1 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	**2019**	**2020**	**2021**	**2022**	**2023**
Bigeye tuna	**Full assessment**	Indicators	Indicators	**Full assessment**	Indicators
Skipjack tuna	Indicators	**Full assessment**	Indicators	Indicators	**Full assessment**
Yellowfin tuna	Indicators	Indicators	**Full assessment**	Indicators	Indicators

APPENDIX X

CONSOLIDATED RECOMMENDATIONS OF THE 20TH SESSION OF THE WORKING PARTY ON TROPICAL TUNAS

Note: Appendix references refer to the Report of the 20th Session of the Working Party on Tropical Tunas (IOTC–2018–WPTT20–R)

Review new information on fisheries and associated environmental data

WPTT20.01 (para. 81): The WPTT **ACKNOWLEDGED** the importance of the proposed harmonisation of FOB types and FOB activity definitions and **RECOMMENDED** that the concept of harmonisation be taken up by the WPDCS and Scientific Committee with the aim of harmonising IOTC definitions with those used by other tRFMOs in the context of the joint tRFMO Working Group on FADs.

Review of the statistical data available for skipjack tuna

WPTT20.02 (para. 129): The WPTT **NOTED** that total catches in 2017 (524,282 t) were more than 10% higher than the catch limit generated by the Harvest Control Rule (470,029 t) which applies to the years 2018–2020, and that there has been an increasing trend in catches over the past 3 years. The WPTT **RECOMMENDED** that the Scientific Committee advise the Commission of the urgent need to monitor catches of skipjack in the 2018–2020 period to ensure catches do not exceed the limit.

Review of new information on the status of yellowfin tuna

WPTT20.03 (para. 200): The WPTT **RECOMMENDED** the continuation of CPUE standardization analyses as this is a critical input to the bigeye tuna and yellowfin tuna stock assessments .

Yellowfin tuna: Stock Assessments

WPTT20.04 (para. 222): The WPTT **RECOMMENDED** that the in the future, model diagnostics, including retrospective analyses, jittering and likelihood profiling be conducted to increase confidence that the models are reaching a global minima during fitting and to look for major conflict in data sources.

Future yellowfin assessments: issues for consideration

WPTT20.05 (para. 225): 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.

Development of management advice for yellowfin tuna

WPTT20.06 (paras. 228): The WPTT **RECOMMENDED** that final management advice be developed from the SS3 models including the reference grid given a relative weight of 75% to Q1 CPUE scenario compared to 25 % weight to Q2 in the grid results. The estimates from the grid are provided in Table 3 While the biomass and reference point trajectories are included in Figure 1. The Kobe strategy matrix derived from the 24 models in the grid is provided in Figure 2. These results indicate that the stock is currently overfished and subject to overfishing

Revision of the WPTT Program of Work (2019–2023)

WPTT20.07 (paras. 253): The WPTT **RECOMMENDED** that the SC consider and endorse the WPTT Program of Work (2019-2023), as provided at Appendix IX.

Review of the draft, and adoption of the report of the 20th session of the WPTT

WPTT20.08 (para. 263): The WPTT **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPTT20, 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 2018 (Fig.7):

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

APPENDIX XI

STATEMENT BY MAURITIUS

The Republic of Mauritius reiterates the position conveyed in the statements made by the Republic of Mauritius at the 22nd session of the Indian Ocean Tuna Commission meeting and contained in report 'IOTC/2018/S22' at Appendix II.