Report of the 24th Session of the IOTC Working Party on Tropical Tunas

Virtual Meeting, 24 - 29 October 2022

DISTRIBUTION:

Participants in the Session
Members of the Commission
Other interested Nations and International Organizations
FAO Fisheries Department
FAO Regional Fishery Officers

BIBLIOGRAPHIC ENTRY

IOTC–WPTT24 2022. Report of the 24th Session of the IOTC Working Party on Tropical Tunas. Online, 24 - 29 October 2022. *IOTC–2022–WPTT24–R[E]: 53 pp.*

Contact details:

Indian Ocean Tuna Commission
Blend Building
PO Box 1011
Providence, Mahé, Seychelles
Ph: +248 4225 494
Fax: +248 4224 364
Email: IOTC-secretariat@fao.org
Website: http://www.iotc.org

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_0	The estimate of the unfished spawning stock biomass
B_{curr}	The estimate of current spawning stock biomass
B_{MSY}	Biomass which produces MSY
B_{thresh}	Threshold level, the percentage of B0 below which reductions in fishing mortality are required
CE	Catch and effort
CI	Confidence Interval
C_{max}	Maximum catch limit
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.
D_{max}	Maximum change in catch limit
EEZ	Exclusive Economic Zone
ENSO	El Niño–Southern Oscillation
E_{targ}	The estimate of the equilibrium exploitation rate associated with sustaining the stock at B_{targ}.
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
I_{max}	Maximum fishing intensity
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**).

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The 24th Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Tropical Tunas (WPTT), was held online using Zoom from 24 - 29 October 2022. The meeting was opened by the Chairperson, Dr Gorka Merino (EU, Spain) who welcomed participants and Vice-Chair, Dr M. Shiham Adam (IPNLF). A total of 113 participants attended the Session (cf. 108 in 2021, 111 in 2020 and 68 in 2019). The list of participants is provided at Appendix I.

The following are the recommendations from the WPTT24 to the Scientific Committee, which are provided at Appendix VIII.

Bigeye Tuna Management Procedure

WPTT24.01 (para. 74): The WPTT **NOTED** that the authors also presented the key data inputs to the MP and the calculation of the TAC. The WPTT **NOTED** that the application of the bigeye management procedure resulted in a recommended TAC of 80,583t per year for 2024 and 2025; which requires a 15% catch reduction from the 2021 catch level. The WPTT **RECOMMENDED** that the SC endorse the TAC advice from the MP.

WPTT24.02 (para. 75): The WPTT also **NOTED** that the paper reviewed evidence for exceptional circumstances as per Resolution 22/03. The review covered information pertaining to i) new knowledge about the stock, population dynamics or biology, ii) changes in fisheries or fisheries operations, iii) changes to input data or missing data, and iv) inconsistent implementation of the MP advice. The WPTT **NOTED** that bigeye stock assessment in 2022 did not provide any new or conflicting information about population trends or stock status and that changes in the data used in the CPUE standardisation, a new growth curve and an alternative natural mortality scenario used in the 2022 stock assessment models were not considered as exceptional circumstances that require changes in the recommended TAC. The WPTT **RECOMMENDED** that based on the review of evidence for exceptional circumstances, the SC should endorse the finding that no reasons to change the advice on TAC were identified.

WPTT24.03 (para. 77): Given the lack of effective catch limits implementation in the IOTC in the past, the WPTT strongly **RECOMMENDED** that the SC advise the Commission to ensure effective implementation of the bigeye management procedure recommended TAC.

Revision of the WPTT Program of Work (2023–2027)

WPTT24.04 (para. 109): The WPTT **RECOMMENDED** that the SC consider and endorse the WPTT Program of Work (2023–2027), as provided in Appendix VII.

Date and place of the 25th and 26th Sessions of the WPTT (Chair and IOTC Secretariat)

WPTT24.05 (para. 112) The WPTT **NOTED** that the global Covid-19 pandemic has resulted in international travel being almost impossible and with no clear end to the pandemic in sight, it was impossible to finalise arrangements for the meeting in 2022. The Secretariat will continue to liaise with CPCs to determine their interest in hosting these meetings in the future as the SC is encouraging a return to physical meetings in 2023. The WPTT **RECOMMENDED** the SC consider late October 2023 as a preferred time period to hold the WPTT24 meeting in 2023.

Review of the draft, and adoption of the report of the 24th session of the WPTT

WPTT24.06 (para. 114): The WPTT **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPTT24, provided at Appendix VIII, 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 2021 (Figure 2):

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

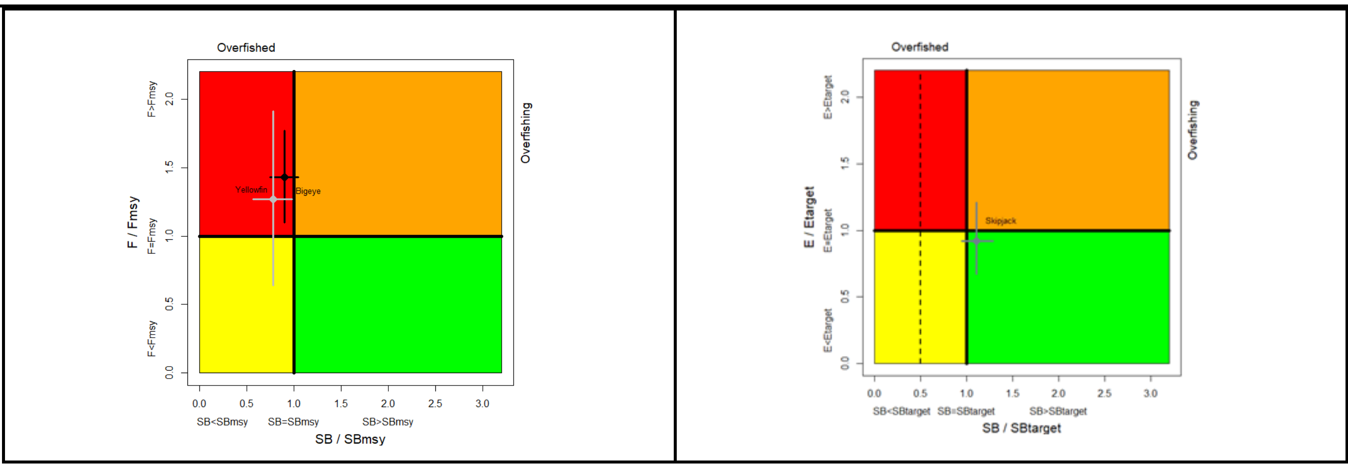

Figure 1. (Left) Combined Kobe plot for bigeye tuna (black: 2022), and yellowfin tuna (grey: 2021) showing the estimates of current stock size (SB) and current fishing mortality (F) in relation to optimal spawning stock size and optimal fishing mortality. (Right) Kobe plot for skipjack tuna showing the estimates of the current stock status (The dashed line indicates the limit reference point at 20%SB0). Cross bars illustrate the range of uncertainty from the model runs with a 80% CI.

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

Stock	Indicators		2014	2015	2016	2017	2018	2019	2020	2021	2022	Advice to the Commission
Bigeye tuna *Thunnus obesus*	Catch in 2021 (MT) Average catch 2017–2021 (MT) MSY (1,000 MT) (80% CI) F_{MSY} (80% CI) SB_{MSY} (1,000 MT) (80% CI) F_{2021} / F_{MSY} (80% CI) SB_{2021} / SB_{MSY} (80% CI) SB_{2021} / SB_0 (80% CI)	94,803 87,488 96 (83 – 108) 0.26 (0.18 – 0.34) 513 (332 – 694) 1.43 (1.10 – 1.77) 0.90 (0.75 – 1.05) 0.25 (0.23 – 0.27)			**84%***			**38%***			**79%***	In 2022 a new stock assessment was carried out for bigeye tuna in the IOTC area of competence to update the stock assessment undertaken in 2019. Two models were applied to the bigeye stock (Statistical Catch at Size (SCAS) and Stock Synthesis (SS3)), with the SS3 stock assessment selected to provide scientific advice. The reported stock status is based on a grid of 24 model configurations designed to capture the uncertainty on stock recruitment relationship, longline selectivity, growth and natural mortality. On the weight-of-evidence available in 2022, the bigeye tuna stock is determined to be **overfished** and subject to **overfishing.** A management procedure for Indian Ocean Bigeye tuna was adopted under Resolution 22/03 by the IOTC Commission in May 2022 and was applied to determine a recommended TAC for Bigeye tuna for 2024 and 2025. The TAC recommended from the application of the MP specified in Resolution 22/03 is 80,583t / year for the period 2024-2025. The recommended TAC is 15% below the 2021 catch. <Click here for full stock status summary>
Skipjack tuna *Katsuwonus pelamis*	Catch in 2021 (MT): Average catch 2017-2021 (MT): $C_{40\%SSB0}$ (MT): C_{2019} / $C_{40\%SSB0}$ (MT): $E_{40\%SSB0}$ (MT)**: E_{2019} / $E_{40\%SSB0}$ SSB_0 (MT) SSB_{2019} (MT) $SSB_{40\%SSB0}$ (MT) $SSB_{20\%SSB0}$ (MT) SSB_{2019} / SSB_0	650,331 580,408 535,964 (461,995–674,536) 1.02(0.81–1.18) 0.59 (0.53–0.66) 0.92 (0.67-1.21) 1,992,089 (1,691,710–2,547,087) 870,461 (660,411–1,253,181) 794,310 (672,825–1,019,056) 397,155 (336,412–509,528) 0.45 (0.38-0.5)				**47%***			**60%***			No new stock assessment was conducted in 2022 and so the advice is based on the 2020 assessment using Stock Synthesis with data up to 2019. The outcome of the 2020 stock assessment model does not differ substantially from the previous assessment (2017) despite the large catches recorded in the period 2018-2019, which exceeded the catch limits established in 2017 for this period. The final overall estimate of stock status indicates that the stock is above the adopted target for this stock and that the current exploitation rate is just below the target. Also, the models estimate that the spawning biomass remains above its SSB_{MSY} and the fishing mortality remains below E_{MSY} (E is the annual harvest rate) with very high probability. Over the history of the fishery, biomass has been well above the adopted limit reference point (0.2*SSB_0). The recent catches have been within the range of estimated target yield. Current spawning stock biomass relative to unexploited levels is estimated at 45%. Thus, on the weight-of-evidence available in 2020, the skipjack tuna stock is determined to be: to (i) **not**

	SSB_{2019} / $SSB_{40\%SSB0}$ SSB_{2019} / SSB_{MSY} MSY (MT) E_{2019} / E_{MSY}	1.11 (0.95-1.29) 1.99 (1.47-2.63) 601,088 (500,131–767,012) 0.48 (0.35-0.81)										**overfished** (SSB2019>SSB40%SSB0); and (ii) **not subject to overfishing** (E2019<E40%SSB0). The catch limit will be calculated applying the HCR specified in Resolution 16/02 for the SC Meeting. The Commission needs to ensure that catches of skipjack tuna in the 2021–2023 period do not exceed the agreed limit. <Click here for full stock status summary>
Yellowfin tuna *Thunnus albacares*	Catch in 2021 (MT) Average catch 2017–2021 (MT) MSY (1000 MT)(80% CI)) F_{MSY} (80% CI) SB_{MSY} (1,000 MT) (80% CI)) F_{2020} / F_{MSY} (80% CI) SB_{2020}/ SB_{MSY} (80% CI) SB_{2020} / SB_0 (80% CI)	416,235 435,225 394 (325–463) 0.18 (0.14–0.21) 1,515 (1,146–1,885) 1.27 (0.64–1.91) 0.78 (0.57–0.98) 0.28 (0.21.–0.34)			68%*		94%*			68%*		No new stock assessment was carried out for yellowfin tuna in 2022 and so the advice is based on the 2021 assessment. The 2021 stock assessment was carried out using Stock Synthesis III (SS3), a fully integrated model that is currently used to provide scientific advice for the three tropical tunas stocks in the Indian Ocean. The model used in 2021 is based on the model developed in 2018 with a series of revisions that were noted during the WPTT in 2018, 2019 and 2020. The model ensemble (a total of 96 models) encompasses a range of stock dynamics. A number of sensitivity runs were conducted to address additional uncertainty. On the weight-of-evidence available in 2021, the yellowfin tuna stock is determined to remain **overfished** and **subject to overfishing.** The increase in catches in recent years has substantially increased the pressure on the Indian Ocean stock, resulting in fishing mortality exceeding the MSY-related levels. The projections were not available during the WPTT23 and will be developed intersessionally prior to the SC in 2021. The critical errors in the projections and estimations for computing probabilities in the K2SM developed in 2018 have been addressed and the updated projections should no longer suffer from the issues previously experienced. As such a new K2SM will be developed that will be suitable for use to provide management advice. Resolution 21/01 *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.
**E is the annual harvest rate

1. Opening of the Meeting

1. The 24th Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Tropical Tunas (WPTT), was held online using Zoom from 24 - 29 October 2022. The meeting was opened by the Chairperson, Dr Gorka Merino (EU, Spain) who welcomed participants and Vice-Chair, Dr M. Shiham Adam (IPNLF). A total of 113 participants attended the Session (cf. 108 in 2021, 111 in 2020 and 68 in 2019). 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 in Appendix II. The documents presented to the WPTT24 are listed in Appendix III.

3. Update of Any New Data Available at the Secretariat for Tropical Tuna Species Since the Data Preparatory Meeting

3.1 Data available at the Secretariat

3. The WPTT **NOTED** papers IOTC–2022–WPTT24–03a, b, c and d which provide updates on the statistical data and fishery trends for tropical tunas as received by the IOTC Secretariat, in accordance with IOTC Resolution 15/02 *on Mandatory statistical reporting requirements for IOTC Contracting Parties and Cooperating Non-Contracting Parties (CPCs)*, for the period 1950–2021.

4. The WPTT **NOTED** that several long-standing issues in terms of data availability and overall quality already presented and discussed during the data preparatory session of this meeting still remain to be addressed and **INVITED** all concerned CPCs to provide updates in this regard.

5. Furthermore, the WPTT **ACKNOWLEDGED** that the IOTC Secretariat has re-estimated the species composition of EU,Spain purse seiners fishing on FOB-associated schools for the year 2018, in agreement with the methodology presented at the WPDCS in 2019 and for stock-assessment purposes only. It was also **NOTED** there are other CPCs for which catch compositions are also re-estimated for stock-assessment purposes

6. The WPTT **ACKNOWLEDGED** how, in comparison to the information presented at the data-preparatory meeting held in May 2022, there is now one extra year of data (2021) globally available to the IOTC Secretariat.

7. The WPTT **NOTED** with concern that several important fleets (e.g., Pakistan, Yemen, Oman) have not officially submitted their latest data as of October 2022 and **ACKNOWLEDGED** that for this reason a non-negligible fraction of annual catches had to be estimated by the Secretariat or recovered from third-party sources, further adding uncertainty to the catch time series used in the current assessment.

8. The WPTT **ACKNOWLEDGED** how new data for the statistical year 2021, while not significantly affecting the overall catch trends, does indeed present important specificities that require additional discussions and clarification, **NOTING** how these mostly concern the species composition of tropical tunas reported by several important purse-seine fisheries.

9. Eventually, the WPTT **NOTED** the change in estimation methodology adopted by Seychelles to calculate their purse-seine catches for 2021 and **ACKNOWLEDGED** the details on the official communication in this regard occurred between Seychelles and the IOTC Secretariat.

10. The WPTT **NOTED** a generalized tendency in the major purse-seine fleets fishing on FOB-associated schools to report a progressive shift in the species composition of catches towards skipjack and bigeye tuna, which in the last few years accounted for around 70% and 8% (respectively) of total tropical tuna catches reported by these fleets.

11. The WPTT **NOTED** how this trend became particularly evident from 2018 onwards and **CONSIDERED** that this might be a consequence of the entry in force of the various IOTC Resolutions requesting a reduction in yellowfin tuna catches, as well as of the increased fraction of fishing operations reported on FOB-associated schools.

12. The WPTT **NOTED** that only limited changes in the fishing grounds exploited by these fleets are evident from the reported geo-referenced catches, and that therefore other factors might come into play to explain the detected shift in species composition.

13. The WPTT **NOTED** also how the CoViD-19 pandemic has reduced dramatically the availability of fisheries data for the year 2020, and in particular the number of fish sampled for length at landing site or by scientific observers, although potential signs of recovery were detected for 2021.

14. The WPTT **ACKNOWLEDGED** again the possible issue with double counting of catches of yellowfin, skipjack, and longtail tuna from vessel fishing in Pakistan and landing in I.R. Iran, **NOTING** that the Secretariat could not verify this information due to the lack of geo-referenced data, although these are confirmed to be collected at national level.

15. For this reason, the WPTT **REQUESTED** Pakistan to take all necessary steps to share geo-referenced catch-and-effort data with the Secretariat and **AGREED** that concerned CPCs should work in collaboration with the IOTC to further clarify the double-counting issue and report back to the WPTT in the future.

16. The WPTT **AGREED** that the use of "*EU-assimilated*" to indicate those purse seine fleets from IOTC coastal states that present similar fishing patterns and statistical methodologies as the EU fleet might be confusing.

17. The WPTT **ACKNOWLEDGED** that while sampling strategies might be similar between the EU and these "*assimilated*" fleets, the fishing effort locations do indeed vary consistently with the fleet and therefore **REQUESTED** that the current nomenclature be updated to further reflect this situation.

18. The WPTT **NOTED** the differences in average weights calculated using a) the catch-and-effort data and b) the size-frequency data reported by Taiwan,China and **ACKNOWLEDGED** that for stock-assessment purposes of both bigeye and yellowfin tuna, only size-frequency data from observers should be included, even though this means considering only a relatively minor fraction of the data reported by Taiwan,China for their longliners.

19. On this same topic, The WPTT **ACKNOWLEDGED** the exclusion of size frequency data from Seychelles deep-freezing longliners from the assessment model, until issues with the original data are properly addressed and data from scientific observers is collected.

20. The WPTT **NOTED** paper IOTC–2022–WPTT24–04, which provided fisheries Indicators for Indian Ocean tropical tuna based on the official (nominal) data received by the IOTC Secretariat, in accordance with IOTC Resolution 15/02.

21. The WPTT **NOTED** that one of these indicators, i.e., the average weight calculated for longline fisheries, is in contrast with the information emerging from the CPUE series and **SUGGESTED** that the reasons for these discrepancies be further investigated.

22. The WPTT **THANKED** the IOTC Secretariat for this draft proposal of a set of fisheries indicators and **REQUESTED** that these be routinely presented at the next sessions of the meeting and further extended as soon as new information becomes available.

4. BIGEYE STOCK ASSESSMENT

4.1 Review any New Information on Bigeye Biology, Stock Structure, Fisheries and Associated Environmental Data Since the Data Preparatory Meeting

23.WPTT **NOTED** paper IOTC–2022–WPTT24–06 on the impacts of phytoplankton availability on bigeye tuna *(Thunnus obesus*) recruitment in the Indian Ocean, including the following abstract:

> *"Continued and substantial recruitment is one of the keys to sustainable fisheries. In the early life stage, fish larvae have extremely high mortality. Foraging success is one of the most important components of recruitment. In this study, we analyzed the influence of phytoplankton availability on the recruitment success of bigeye tuna in the Indian Ocean. Indian ocean was divided into four regions based on the spatial structure of the bigeye tuna stock assessment. The results showed prey availability has a significant positive influence on recruitment, especially in the eastern and southern Indian Ocean."*

24.The WPTT **THANKED** the authors for this interesting paper on factors that influence bigeye tuna recruitment.

25.The WPTT **NOTED** that the successful foraging of larvae would appear to have a positive effect on recruitment. This information was useful for understanding the recruitment characteristics of Bigeye tuna in the Indian Ocean.

4.2 Update on the Nominal and Standardised CPUE Indices Presented at the Data Preparatory Meeting

26.WPTT **NOTED** paper IOTC–2022–WPTT24–07 which provided advice on good practices in CPUE standardization, including the following abstract:

> *"Indices of abundance based on catch-per-unit-effort (CPUE) are important components of many fish stock assessments, particularly when fishery-independent surveys are unavailable. Standardizing CPUE to develop indices requires the analyst to make numerous decisions, which are influenced by factors that include the biology of the study species, the structure of the fishery of interest, the nature of the available data, and the objectives of the analysis (including how standardized data will be used in a subsequent assessment model). Alternative choices can change index trends, and hence stock assessment outcomes. To guide decisions, we provide advice on good practices in 16 areas, focusing on decision points: fishery definitions, exploring and preparing data, misreporting, data aggregation, density and catchability covariates, environmental variables, combining survey and CPUE data, analysis tools, spatial methods, setting up and predicting from the model, uncertainty estimation, error distributions, model diagnostics, model selection, multispecies targeting, and using CPUE in stock assessments."*

27.The WPTT **THANKED** the authors for this presentation and **NOTED** the importance of CPUEs for assessment purposes and therefore the necessity to ensure that they are estimated as correctly as possible.

28. The WPTT **NOTED** that the clustering analysis should be treated with caution. The WPTT **NOTED** that clustering is usually done for an entire time series but that this may potentially increase the risk of confounding targeting with abundance. The authors investigated clustering the data in time blocks but then found that if different variables were determined for each time series, the time series lost its continuity and so there could be abrupt changes in the series between time blocks.

29.The WPTT **NOTED** that standardisation of CPUE should account for effort creep. The WPTT **DISCUSSED** the fact that fisheries are constantly evolving and improving their knowledge and techniques and therefore effort creep is inevitable. The WPM **SUGGESTED** that the WPM could look at this issue and suggest plausible levels of effort creep to be included in standardisation scenarios. The WPTT further **NOTED** that in some cases, the information available for standardisation is not sufficient to be able to account for the effort creep and as such, plausible levels of effort creep external to the standardisation models should be discussed and included in assessments.

30.The WPTT **NOTED** that the selection of covariates in the standardisation process should be guided by a real world understanding of what factors would plausibly affect CPUE. Pure statistical analysis could find relationships that are not realistic due to the confounding affect of the included parameters or alternatively not find a relationship with parameters that clearly would affect the CPUE (such as the vessel effect). The WPTT **AGREED** that standardisations should be conducted by collaborators who understand the statistical models with those who understand the fisheries.

31.The WPTT **SUGGESTED** that Table 1 in the document could be expanded and made available to scientists interested in conducting CPUE standardisations as it provides a useful checklist of best practices.

32.WPTT **NOTED** paper IOTC–2022–WPTT24–08 which provided updated Information on Catch per Unit Effort and Length Distribution of Bigeye Tuna (*Thunnus obesus*) in the Eastern Indian Ocean, including the following abstract:

> *"Bigeye tuna, Thunnus obesus (Lowe, 1839) is one of the main target species for Indonesian tuna longline fishery in the Eastern Indian Ocean. The commercial tuna longline fishery has begun in the 1960s, and the deep longline technique was introduced in the 1980s. Bigeye tuna started as a target when deep longline was introduced. However, little is known about its abundance and size distribution, especially in the northeastern area which is the core fishing ground for Indonesian tuna longline fishery. In this paper, we used the scientific observer data conducted by Research Institute for Tuna Fisheries (RITF) from 2006 to 2021 to provide an update on nominal catch per unit effort (CPUE) and length distribution of bigeye tuna caught by Indonesian tuna longline fishery operating in the Eastern Indian Ocean. The dataset contained 118 trips, 3180 sets, and more than 4 million hooks deployed in total. The number of hooks between floats ranged between 10 – 15 hooks, and the effort was distributed within 0-35oS and 75-130oE. The highest CPUE recorded was in 2014 (0.29±0.05 fish/100 hooks) and the lowest was in 2021 (0.09±0.05 fish/100 hooks). A total of 8204 bigeye tuna were measured with an average length of BET from 2006 to 2021 was 117.11±24.9 cm FL. The size was dominated by fish in the length class of 120-130 cm FL. The CPUEs of bigeye tuna decreased substantially over the years, while the average size of BET increased"*

33.The WPTT **THANKED** the authors for their presentation and **NOTED** the utility of the information provided.

34.WPTT **NOTED** paper IOTC–2022–WPTT24–09 which provided an update on the CPUE standardization of the bigeye tuna caught by the Taiwanese large-scale tuna longline fishery in the Indian Ocean, including the following abstract:

> *"In the present study, the bigeye tuna catch and effort data from the logbook records of the Taiwanese large-scale tuna longline fishing vessels operating in the Indian Ocean from 2005-2021 were analyzed. We used cluster analysis to classify longline sets into groups based on the species composition of the catch, to understand whether cluster analysis could identify distinct fishing strategies. Bigeye tuna CPUE were then standardized. CPUE Indices were estimated using two approaches, delta lognormal and lognormal + constant, but the primary approach was the delta lognormal. All analyses were performed using R source code developed in the Collaborative CPUE Workshop applied to Taiwanese longline operational data. Standardized CPUE series of the bigeye tuna caught by Taiwanese longline fishery showed a decreasing trend with smaller scale in tropical region of Indian Ocean."*

35. The WPTT **THANKED** the authors for the presentations and **ENCOURAGED** them to continue working on the CPUE standardisation.

36. The WPTT **NOTED** paper IOTC-2022-WPM13-14 describing the update of joint CPUE indices for the bigeye tuna in the Indian Ocean based on Japanese, Korean and Taiwanese longline fisheries data up to 2021, including the abstract:

> *"Joint CPUE standardization was conducted for the Indian Ocean bigeye tuna based on Japanese, Korean and Taiwanese longline fisheries data up to 2021 to provide the WPTT with information on abundance indices for use in the 2021 stock assessment for this stock. The intention was to produce combined indices by increasing the spatial and temporal coverage of fishery data. Due to the limitation of remote access to the data, an approach adopted among the three members for the previous analyses of tropical tunas for IOTC and ICCAT was used to share only aggregated data. To account for the inter-annual changes of the target in each fishery, information on the HBF or clustering result was used in each region. For standardizing the catch-per-unit-effort data, the conventional linear models and delta-lognormal linear models were employed for the shared aggregated data of monthly and 1° grid resolution in each region. Broadly, the trend of CPUE was similar to that for the previous stock assessment with some dissimilarity in Region 3. The models were diagnosed by the standard residual plots and influence analyses."*

37. The WPTT **NOTED** the updated standardisation results and **THANKED** the authors for providing this valuable input for the stock assessment model.

4.3 Stock Assessment Result

- **Stock Synthesis**

38. The WPTT **NOTED** paper IOTC–2022–WPTT24–10 describing the preliminary Indian Ocean bigeye tuna stock assessment 1950-2021 (stock synthesis), including the abstract:

> *"This report presents a preliminary stock assessment for Indian Ocean bigeye tuna (Thunnus albacares) using Stock Synthesis 3 (SS3). The assessment uses a spatially structured, age-based model that integrates catch rate indices, length-compositions, and tagging data. The assessment model covers the period 1975–2021 and represents an update and revision of the 2019 assessment model, taking into account newly available information since the previous assessment. The assessment assumes that the Indian Ocean bigeye tuna constitute a single stock, modelled as spatially disaggregated four regions, with 12 fisheries. Standardised CPUE series from the main longline fleets 1975 – 2021 were included in the models as the relative abundance index of exploitable biomass in each region. Standardised indices of bigeye tuna caught by European purse seiners from sets on associated tuna schools (2010 – 2021) in the western tropical region were also included. Tag release and recovery data from the Indian Ocean regional tuna tagging program were included in the model to inform abundance, movement, and mortality rates."* - See paper for full abstract

39. The WPTT **NOTED** that due to the adoption of the MSE for bigeye tuna, the role of the BET stock assessment has now changed to only providing information on stock status rather than also being a tool for providing management advice.

40. The WPTT **NOTED** that the regional scaling factor applied to the model is an externally derived using a standardisation model fitted to observed spatial catch rates. The WPTT **NOTED** that any differences in selectivity between regions has been implicitly accounted for in the estimated regional scaling factors and that if the way that selectivity is modelled is improved then regional scaling factors would become more appropriate as these will help to better explain the catch rates and would lead the model to be a better representation of reality. The WPTT further **NOTED** that

the assessment model needs to ensure that the selectivity for each regional fishery is correctly represented within the model.

41. The WPTT **NOTED** that the new CPUE series that was included in this latest assessment is estimating a higher rate of decline than the previous model was in Region 3

42. The WPTT **NOTED** that there appear to be no major problems with the model fit with no large biases shown with the model fits or estimates.

43. The WPTT **NOTED** that the seasonal fluctuations appear to be more pronounced in Region 3 compared with the other regions. The WPTT **NOTED** that all Regions with the exception of Region 2 passed the model fit test which looked at the randomness of the residuals and further **NOTED** that it is thought that Region 2 did not pass due to the variable trends shown at the beginning of the time series.

44. The WPTT **NOTED** that there is no obvious trend in the recruitment deviates which may be an indication that that there is no obvious model misspecification of productivity parameters and further **NOTED** that there is lots of seasonal variation in the proportion of recruitment into each region which largely reflects the variability in regional catch and/or catch rates.

45. The WPTT **NOTED** the low mixing rates between regions derived from the movement parameter estimates which suggests that the tagging and size data are not very informative estimators of stock movement.

46. The WPTT **NOTED** some issues with the tagging data fit to the model with large differences being shown between the predicted and observed tag recovery rates during purse seine free school operations and to a lesser extent in log school operations. The WPTT **NOTED** that the free school component of the fleet is relatively small for bigeye with a lot more variability in the catches which could be impacting the prediction ability of the model.

47. The WPTT **NOTED** that the issue with the model in Region 1 underestimating the number of tags recovered during purse seine free school operations when compared with the observed tag recoveries was mostly related to the low weighting assigned to the tagging data (lambda =0.1), and that increasing the weighting of the tagging data appears to correct the issue. The WPTT **NOTED** that the tagging data has an effect on the model with a high tag weighting yielding lower estimates of biomass and therefore increases the estimated tag recovery. However, there were found to be some inconsistencies in terms of the number of tags being observed such as tag recoveries in the post-mixing period continuing to increase significantly even though no new tags were released and fishing morality remains similar, which is not consistent with the population dynamics.

48. The WPTT **NOTED** that the model is not fitting the size data for longline fisheries in Regions 2 and 3 very well which leads to the model predicting a decline in the average sizes of fish over time which is not supported by the observed average sizes. The WPTT **NOTED** that this is likely to be due to conflicts between the size and CPUE data. The WPTT therefore **SUGGESTED** that these data are further down-weighted in the model.

49. The WPTT **NOTED** that when the size data were further down-weighted the model trend was more driven by the CPUE series. The WPTT further **NOTED** that the CPUE series in Region 2 is much higher than in other regions in the initial period which may be why the discrepancies between size and CPUE data were more evident in this region.

50. The WPTT **NOTED** that when the size data weighting was increased, the model was better able to capture the fluctuations in the size data in Region 2 but the model then went on to predict lower levels of abundance for the early period and higher catch rates in the later period. However, the weighting (up or down) did not to have a large impact on the biomass estimates suggesting that the model is still driven mostly by the CPUE indices.

51.The WPTT **NOTED** that down-weighting the size data did not have a large impact on the model this time but further **NOTED** that this will continue to cause problems if the data continue to be included in the model so **SUGGESTED** down-weighting or entirely removing these data from the model in the future.

52.The WPTT **NOTED** that the size frequencies from the purse seine free school fishery are poorly fitted, and this is because there is very large annual and seasonal variation in the proportion of fishing modes on small and large size classes in the sample distribution whereas the model had to assume a constant selectivity. The WPTT **NOTED** that for the yellowfin assessment, the size data of the purse seine free school fishery for fishing modes focused on small and large size classes were split and separate selectivity curves were estimated, further **NOTING** that this could be attempted for bigeye to deal with the problem of variable fishing modes in the size composition data.

53.The WPTT **NOTED** the apparent bimodality in the sizes of bigeye and **NOTED** that the reports of very small bigeye caught in free schools is surprising. The WPTT **NOTED** the high catches around the Coco de Mer seamount in previous years which may have been classed as free school catches and questioned whether there may have been some errors in the classification of these sets. The WPTT **NOTED** that the EU have estimated their classification error to be around 10%.

54. The WPTT **RECALLED** the concerns expressed during the Data Preparatory meeting with issues in the CPUE, particularly in the longline CPUE in Region 3 compared to the previous standardisations due to changes in data included and the model used. The WPTT **NOTED** that there is a lot better agreement between the purse seine and longline CPUE series in the same region compared with in the yellowfin assessment and further **NOTED** that including the series when running the assessment does not appear to majorly increase the uncertainty.

55.The WPTT **NOTED** the ABBI index of abundance based on echosounder buoy data that was presented during the data preparatory meeting. The WPTT **NOTED** that this index was included as an index of abundance for a sensitivity analysis and found that it had no influence on the biomass, likely due to the very short time series of this index.

56.The WPTT **NOTED** that the model was not able to fit the very large fluctuations against the purse seine log school index, further **NOTING** that the developer of the index plan to look at the differences between these two indices in the future.

57.The WPTT **NOTED** the new alternative estimates of natural mortality based on the Lorenzen Curve included in the sensitivity models, which are higher than the base value used in the assessment. The WPTT **NOTED** issues with the oldest fish being used for estimates in the Hamel and Cope (in review) paper from which the natural mortality estimates were taken **NOTING** that the oldest fish found in the Indian Ocean was in fact 16 years (slightly higher than the value of 14.7 originally estimated by Farley et al. 2021[1]) which is very close to the 17 years used in the Atlantic Ocean.

58.The WPTT **NOTED** that likelihood profiles were run during the development of the model but it was found that these profiles were not very informative, **NOTING** that some key questions that can normally be answered with likelihood profiles can also be answered with other diagnostic analyses.

59.The WPTT **NOTED** that the impact of purse seine CPUE is firstly assessed in a sensitivity analysis of the diagnostic model and is then included in all models in the final model ensemble. The WPTT further **NOTED** that recruitment variance is linked to the purse seine CPUE that primarily monitors the juvenile fish.

---

[1] Farley, J., Krusic-Golub, K., Eveson, P., Clear, N., Luque, P.L., Artetxe-Arrate, I., Fraile, I., Zudaire, I., Vidot, A., Govinden, R., Ebrahim, A., Romanov, E., Chassot, E., Bodin, N., Murua, H., Marsac, F., Merino, G. 2021. Estimating the age and growth of bigeye tuna (Thunnus obesus) in the Indian Ocean from counts of daily and annual increments in otoliths. IOTC-2021-WPTT23-BET growth.

60.The WPTT **NOTED** that the stock is clearly moving towards the red quadrant of the Kobe plot where the stock would be considered to be overfished and subject to overfishing. The WPTT **NOTED** that the previous assessment concluded that overfishing was occurring, so this overfishing trend has been occurring for some time. The WPTT further **NOTED** a period of low recruitment in the bigeye stock in recent years which may have contributed to the drop in biomass to a level below MSY.

61.The WPTT **NOTED** that the results of this assessment would not trigger exceptional circumstances.

62.The WPTT **NOTED** that a pass/fail system was used with the various diagnostics and a combined average was used to calculate the weighting values **NOTING** that this is an effective way to represent which model is performing better than others.

63.The WPTT **NOTED** that a hindcasting approach for selection criteria was suggested by the WPM, but the WPTT further **NOTED** the recent paper by Carvalho et al. (2021)[2] which suggested that it is better to use most diagnostics in combination rather than in isolation and **NOTED** that this combined approach was taken.

64.Overall, the group **NOTED** that the diagnostics of the reference model grid suggested an overall good performance of the majority of the models.

65.The WPTT **DISCUSSED** the possibility of doing model weighting based on diagnostics or based on equal weighting as has been done so far. The WPTT **NOTED** there are various viewpoints regarding the proposed weighting strategy using the pass/fail system based on the range of diagnostics from Carvalho et al. (2021). In particular, the WPTT **NOTED** that that most proposed diagnostics are not likelihood-based and so do not provide a measure of the model's plausibility from a probability perspective; secondly, while co-joining weighted values from an ensemble of models can provide an estimate for the range of reference quantities or parameters, it is less obvious how they can provide a meaningful measure of the probability distribution of these quantities, as the underlying distribution of these quantities is unknown and may be different across models. As such, the WPTT **AGREED** that this approach needs to be discussed in more detail at the next WPM to give more weight to the method. The WPTT further **NOTED** that the upcoming Centre for the Advancement of Population Assessment Methodology (CAPAM) workshop will focus on the topic of model weighting.

- **Other models**

66.The WPTT **NOTED** paper IOTC–2022–WPTT24–11 on using data-limited approaches to assess data-rich Indian Ocean bigeye tuna: Data quantity evaluation and critical information for management implications, including the abstract:

> *"The majority of fishery stocks in the world are data limited, which limits formal stock assessments. Identifying the impacts of input data on stock assessment is critical for improving stock assessment and developing precautionary management strategies. We compare catch advice obtained from applications of various data-limited methods (DLMs) with forecasted catch advice from existing data-rich stock assessment models for the Indian Ocean bigeye tuna (Thunnus obesus). Our goal was to evaluate the consistency of catch advice derived from data-rich methods and data-limited approaches when only a subset of data is available."* - See paper for full abstract.

67.The WPTT **THANKED** the authors for their paper.

[2] Carvalho, F., Winker, H., Courtney, D., Kapur, M., Kell, L., Cardinale, M., Schirripa, M., Kitakado, T., Yemane, D., Piner, K.R., Maunder, M.N., Taylor, I., Wetzel, C.R., Doering, K., Johnson, K.F., Methot, R.D., 2021. A cookbook for using model diagnostics in integrated stock assessments. Fish. Res. 240, 105959. https://doi.org/https://doi.org/10.1016/j.fishres.2021.105959

68.The WPTT **NOTED** paper IOTC-2022-WPTT24-INF02 on Preliminary stock assessments of Indian Ocean bigeye tuna using Statistical-Catch-At-Size (SCAS) (1950-2021), no abstract was provided by the authors.

69.The WPTT **THANKED** the authors for their paper.

4.4 Selection of Stock Status Indicators for bigeye tuna

70.The WPTT **ADOPTED** the stock status advice developed for bigeye tuna 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 2021 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 IV

4.5 Development of Management Advice for bigeye tuna

71.The WPTT **NOTED** that the management advice for bigeye tuna comes directly from the adopted bigeye tuna Management Procedure (Res 22/03). This is comprehensively covered in the draft Executive Summary.

5. Bigeye Tuna Management Procedure

72.The WPTT **NOTED** paper IOTC–2022–WPTT24–12 which outlined the consideration of exceptional circumstances in running the IOTC Bigeye tuna MP for 2022, including the following abstract:

> *"The IOTC has adopted a management procedure (MP) which will be used to recommend the Total Allowable Catch (TAC) of bigeye tuna in the Indian Ocean. As part of the MP schedule, the Commission has adopted an annual review of evidence for exceptional circumstances that could make the implementation of the TAC advice risky to the stock or fishery. The Exceptional Circumstances Guidelines specify a three-stage process: (i) examining evidence for exceptional circumstances, (ii) determining severity and impact, and (iii) recommending any management or research action that should be taken. A wide range of information is reviewed to examine if there is evidence for exceptional circumstances, e.g., the data inputs to the MP, changes in the knowledge of stock or fishery uncertainties against which the MP was tested, and implementation of MP TAC advice."* – see paper for full abstract

73.The WPTT **NOTED** the Resolution 22/03 on bigeye management procedure is the first fully-specified MP to be adopted in the IOTC. The WPTT **NOTED** that the adopted MP schedule requires the MP to be run by the IOTC Scientific Committee in 2022, through the Working Party on Methods and Working Party on Tropical Tunas, including a review of exceptional circumstances, to recommend a TAC for 2024 and 2025 for IOTC Commission consideration.

74.The WPTT **NOTED** that authors also presented the key data inputs to the MP and the calculation of the TAC. The WPTT **NOTED** that the application of the bigeye management procedure resulted in a recommended TAC of 80,583t per year for 2024 and 2025; which requires a 15% catch reduction from the 2021 catch level. The WPTT **RECOMMENDED** that the SC endorse the TAC advice from the MP.

75.The WPTT also **NOTED** that the paper reviewed evidence for exceptional circumstances as per Resolution 22/03. The review covered information pertaining to i) new knowledge about the stock, population dynamics or biology, ii) changes in fisheries or fisheries operations, iii) changes to input data or missing data, and iv) inconsistent implementation of the MP advice. The WPTT **NOTED** that bigeye stock assessment in 2022 did not provide any new or conflicting information about population trends or stock status and that changes in the data used in the CPUE standardisation, a new growth curve and an alternative natural mortality scenario used in the 2022 stock assessment models were not considered as exceptional circumstances that require changes in the recommended TAC. The WPTT **RECOMMENDED** that based on the review of evidence for exceptional circumstances, the SC should endorse the finding that no reasons to change the advice on TAC were identified.

76. The WPTT **DISCUSSED** whether the current fishing mortality value resulting from the last stock assessment, which is above the Flim, could be considered as an exceptional circumstance. The WPTT **NOTED** that these F values were also tested during the bigeye MP Management Strategy Evaluation and that the objective of the MP, and hence resultant recommended TAC, is to achieve the management objective adopted in the MP of achieving 60% for being in the Kobe green quadrant by 2034-38 which will reduce the F on the stock.

77. Given the lack of effective catch limits implementation in the IOTC in the past, the WPTT strongly **RECOMMENDED** that the SC advise the Commission to ensure the effective implementation of the bigeye management procedure recommended TAC.

78. The WPTT **NOTED** that the Fmsy ratio included in the MP is not Fmsy but the MSY over virgin biomass or K (i.e., -log(1-MSY/K) of the production model.

6. Other Tropical Tunas

- **General**

79. The WPTT **NOTED** paper IOTC–2022–WPTT24–14 on a scientific catch estimation for the global FAD tropical tuna purse seine fishery in the Indian Ocean, including the following abstract:

> *"This analysis compared IOTC catch data in the public domain with an alternative estimation for associated (log school) catches based on port sampling data from the European Union sampling program aggregated by 5º square or statistical area, year and quarter. The underlying assumption is that any fleet fishing in the same spatio-temporal strata and on log schools will have on average, the same catch composition. Species composition distribution in the sampled strata (year, quarter and 5x5º cell or statistical area) was estimated by bootstrapping across the catch by species derived from each sample and was applied to the total catch (aggregated across flags) reported in these strata. For unsampled strata, a correction factor was estimated by comparing the species composition reported and estimated in sampled strata on a yearly basis. This correction factor was then applied to the total catch on log school in each unsampled strata. As expected, the results indicate significant deviations in the total catch between the current estimates and the public domain data in 2018. Moreover, it also indicates some deviations in the early time series and in the most recent years."* – see document for full abstract.

80. The WPTT **NOTED** that the methodology proposed used commercial categories under the assumption of accurate reporting. The WPTT also **NOTED** that some problems were identified with logbook reported data suggesting that this approach needs to be tested.

81. The WPTT **NOTED** a significant reduction in the number of samples for the year 2020 which accounts with a 60.42 % of the total catch corrected.

82. The WPTT **NOTED** that ISSF participant company cannery receiptsare available at the IOTC Secretariat although not currently in public domain. The WPTT **AGREED** that this information could be used to validate the proposed estimations and develop further investigations.

83. The WPTT **NOTED** that the use of sales data has been discussed at WCPFC and IATTC and suggest investigating the way to ensure (e.g., through specific MoUs) this data is used for this type of analysis.

Tropical Tuna Recruitment

84.The WPTT **NOTED** paper IOTC–2022–WPTT24–15 which provided information on the management implications of recruitment deviate trends for tropical tunas, including the following abstract:

"The stock assessments of tropical tunas contain scenarios with significant trends in process error that have been overlooked. However, the implications of these trends remain unquantified. In this document we address the trends in recruitment deviates of the 2021 stock assessment of Indian Ocean yellowfin. We use recent average recruitment and deviates' estimates in forward projections and discard models with significant trends in recruitment deviates to evaluate their management implications. With these, we provide a range of catch levels that would allow recovering the stock towards management targets and compare it with the management advice developed during the 2021 stock assessment."

85.The WPTT **NOTED** the recruitment was determined by the S-R relationship before the recruitment deviates were estimated. The WPTT **NOTED** that time-series models (such as random walks) can be used to model the trend in recruitment deviates and to predict recruitment variations in the projection. However, the WPTT **NOTED** that the recruitment sub-model in the projection is often constrained by the capability of the modeling platform (for example, SS3 doesn't have the option for randomly sample historical recruitment deviates), whereas a customized-assessment model can be more flexible in generating recruitment in the projection.

86. The WPTT agreed that rather than relying exclusively on the recruitment trend, it is more appropriate to apply a variety of diagnostics to identify model-misspecification. The WPTT **NOTED** that when employing some of the other widely used diagnostics, it is typically discovered that models with substantial recruitment trends perform worse (e.g., there are greater divergence in biomass trends between model estimates and the estimates from the age-structured-production analysis).

Nominal Catches of Tropical Tunas by Artisanal and Industrial Fisheries

87.The WPTT **NOTED** paper IOTC–2022–WPTT24–16 which detailed approaches for estimating natural mortality in tuna stock assessments: application to global yellowfin tuna stocks, including the following abstract:

"The values used for natural mortality (M) are very influential in stock assessment models, affecting model outcomes and management advice. Natural mortality is one of the most difficult demographic parameters to estimate, and there is often limited information about the true levels. Here, we summarise the evidence used to estimate natural mortality at age for the four main stocks of yellowfin tuna (Indian, Western and Central Pacific, Eastern Pacific, and Atlantic Oceans), and identify important issues and information gaps. We describe the history of natural mortality values used in stock assessments by the tuna Regional Fisheries Management Organisations responsible for managing each stock and assess the evidence supporting these values. In June 2021, an online meeting was held by the Center for the Advancement of Population Assessment Methodology (CAPAM), to provide advice and guidance on practices for modelling natural mortality in fishery assessments. Based on approaches presented and discussed at the meeting, we develop a range of yellowfin tuna natural mortality prior distributions for each stock. We also recommend future research to improve these estimates of natural mortality."

88.The WPTT **NOTED** that the document presented develops a proposal for several alternative natural mortality ogives to consider as prior distributions and/or fixed values in yellowfin tuna stock assessments. The proposal combines alternative patterns for representing natural mortality at age with the results of an empirical meta-analysis of the relationship between the maximum observed age and natural mortality estimates from a database of over 200 stocks.

89. The WPTT **NOTED** that most of the proposed mean values of natural mortality are lower than those in recent assessments of most stocks, and outside the range of the values considered in most

assessments suggesting that these lower M estimates are a direct consequence of new aging methods.

90.The WPTT **NOTED** that bias exists in estimates of M for which asymmetric risks analysis and Mean Absolute Scaled Error (MASE) indicator could be considered.

91.The WPTT **NOTED** that local growth was used in the analysis and sizes were very similar between oceans with not likely to have a significant effect.

- **Yellowfin Tuna**

Stock Assessment Review

92.The WPTT **NOTED** paper IOTC–2022–WPTT24–17 which provided a review of 2021 WPTT Indian Ocean yellowfin tuna stock assessment and feasibility of alternative assessment, including the following abstract:

> *Recent IOYT Assessment. The most recent Indian Ocean Yellowfin Tuna (IOYT) stock assessment (Fu et al 2021) estimated the 2020 IOYT stock as slightly overfished at 78% of BMSY, with 68% probability that overfishing occurring (fishing mortality at 127% of FMSY). These results are found by integrating over a grid of 96 equally weighted stock assessment models (Stock Synthesis v3) that are intended to span the range of plausible states of nature for the IOYT stock."*

93.The WPTT **NOTED** the various issues raised in the review, including spatial structure, fitting to the tagging and length data, and model weighting, which has also been looked at during the assessment process. The WPTT **NOTED** that spatial models are often quite complicated and that there are currently many approaches with differing levels of complexity. For example, IATTC assessments often do not use explicitly structured spatial models whereas assessments in the WCPFC tend to use models with many spatial regions despite the limitation of tagging data.

94. The WPTT **NOTED** that, in the authors' view, building complicated spatial models that are consistent and backed by data is more acceptable. Otherwise, there is a chance that the model will bias the results or overfit the data. In addition, it was highlighted that the tagging data for the yellowfin assessment currently provide very limited information about movement rates, and it is unknown how bias in movement rate may affect estimates of spatial reference points within the Stock Synthesis model.

95.The WPTT discussed that given the identified issues, whether it would be better for the yellowfin assessment to concentrate on developing the best model and that a large model grid might disguise some problems because the models wouldn't be thoroughly examined. The WPTT **NOTED** that the model grid approach is thought to be better for assessing structural uncertainty. The evaluation could start by concentrating on creating the best model that addresses the fundamental issues and then serves as basis for constructing a wider model ensemble.

96. The WPTT **NOTED** that there are no specific requirements under the current IOTC process for accepting an assessment model, and that a variety models are encouraged to be developed and presented to the working group. The relevant working group is responsible of analyzing the assessment to see if the model(s) are reliable and suitable for providing management advice.

97. The WPTT **NOTED** that in addition to redeveloping the YFT assessment using a customized model, there are also plans to re-evaluate the input data, including the CPUE standardization using spatial and temporal models. The WPTT **NOTED** the proposed budget, work schedule, and call for collaboration from IOTC scientists. The WPTT **RECALLED** that a formal external peer-review of the YFT assessment will take place in February 2023 which could consider the various issues identified by the study.

Close Kin Mark Recapture (CKMR).

98. The WPTT **NOTED** the presentation on a work plan for an Indian Ocean yellowfin tuna close-kin mark-recapture design study. The original paper IOTC-2022-WPM13-12 was presented to the WPM13.

99. The WPTT **NOTED** that some fish may forego reproducing in some years. The WPTT further **NOTED** that a more random pattern of age gaps between half-sibling pairs (HSP) may be indicative of lack of evidence for fish skipping spawning, and if fish do skip spawning, equal age gaps between HSP are more likely to be observed than odd age gaps.

100. The WPTT **NOTED** that while the CKMR by itself typically does not provide information on stock depletion, it can be combined with other data into an augmented assessment model, where it can be utilized to predict reference points like depletion. There have been many important applications of CKMR in various well-known fisheries, such as the integration of CMKR into the stock assessment and management processes for southern blue fin tuna.

101. The WPTT **NOTED** that the current cost of CKMR sampling is about $15 per sample. While the study is focusing primarily on sample size, the WPTT **NOTED** that full project expenditures including genotyping, model development, and analysis, should be considered in the budget.

102. The WPTT **NOTED** that the CKMR design study indicated that 30,000 samples over the course of five years would probably be sufficient for yellowfin. The WPTT **NOTED** that there are more than enough length samples of yellowfin available from all fisheries in the IOTC database to meet the demands of a CKMR study. However, sampling on this scale requires a lot of coordination, knowledge from a wide range of people, and experience from prior projects or programs that are done at the ocean-basin level. A feasibility analysis of the logistics of sampling, including the associated costs, should be done. The WPTT **SUGGESTED** that a cooperative sample group be established, starting with smaller projects, to examine the viability of sampling various nations and fleets and to gain better understanding of some of the logistical issues.

103. The WPTT **AGREED** that the design study is technically sound and robust, and that the CKMR model has a strong potential of improving yellowfin tuna abundance estimates. The WPTT NOTED that there have been proven cases of how CKMR significantly improve the precision of assessment and robustness of management advice. Given the importance and extent of the fisheries, the WPTT advised that the project be given consideration for further advance noting the logistical challenges in sampling

- **Skipjack Tuna**

104. The WPTT **NOTED** paper IOTC–2022–WPTT24–18 which provided information on the distribution and abundance of skipjack tuna along the Pakistan coast, including the following abstract:

> *"Skipjack tuna (Katsuwonus pelamis) is second most important tropical tuna species after yellowfin tuna (Thunnus albacares) which is caught by about 700 gillnet vessels that operate on coastal and offshore waters of Pakistan. Annual landings of tropical tuna in Pakistan have increased by 8.04 % in 2021 as compared to landings of 2020. Higher catches of skipjack tuna were recorded in 2016 and 2017 which has steadily decreased since then. Catches to skipjack tuna have increased by 13.76 % in the same period. Studies of distribution and abundance of skipjack tuna indicates overall higher catches during January to April whereas its catches was combatively lower during post monsoon months (October to December). Higher catch (11.190 m. tons) of skipjack tuna was recorded by an observer in September 2018."*

105. The WPTT **THANKED** the author for the presentation and **NOTED** the interesting data provided on Skipjack tuna along the Pakistan coast.

7. WPTT Program of Work

7.1 Revision of the WPTT Program of Work (2023–2027)

106. The WPTT **NOTED** paper IOTC–2022–WPTT24–05, which provided the WPTT24 with an opportunity to consider and revise the WPTT Program of Work (2023–2027), by taking into account the specific requests of the Commission, Scientific Committee, and the resources available to the IOTC Secretariat and CPCs.

107. 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)

108. 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.

109. The WPTT **RECOMMENDED** that the SC consider and endorse the WPTT Program of Work (2023–2027), as provided in Appendix VII.

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

110. The WPTT **NOTED** that unfortunately although several experts had been contacted, none had been available to participate in the current WPTT meeting.

111. 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 2020, 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 input information base, historical data series and indicators for tropical tuna species for stock assessment purposes.

8. Other Business

8.1 Date and place of the 25th and 26th Sessions of the WPTT

112. The WPTT **NOTED** that the global Covid-19 pandemic has resulted in international travel being almost impossible and with no clear end to the pandemic in sight, it was impossible to finalise arrangements for the meeting in 2022. The Secretariat will continue to liaise with CPCs to determine their interest in hosting these meetings in the future as the SC is encouraging a return to physical meetings in 2023. The WPTT **RECOMMENDED** the SC consider late October 2023 as a preferred time period to hold the WPTT24 meeting in 2023.

113. As usual it was also **AGREED** that the WPTT Assessment meeting should continue to be held back-to-back with the WPM, with the WPM taking place before the WPTT in 2022.

8.2 Review of the draft, and adoption of the Report of the 24th Session of the WPTT

114. The WPTT **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPTT24, provided at Appendix VIII, 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 2021 (Figure 1):

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

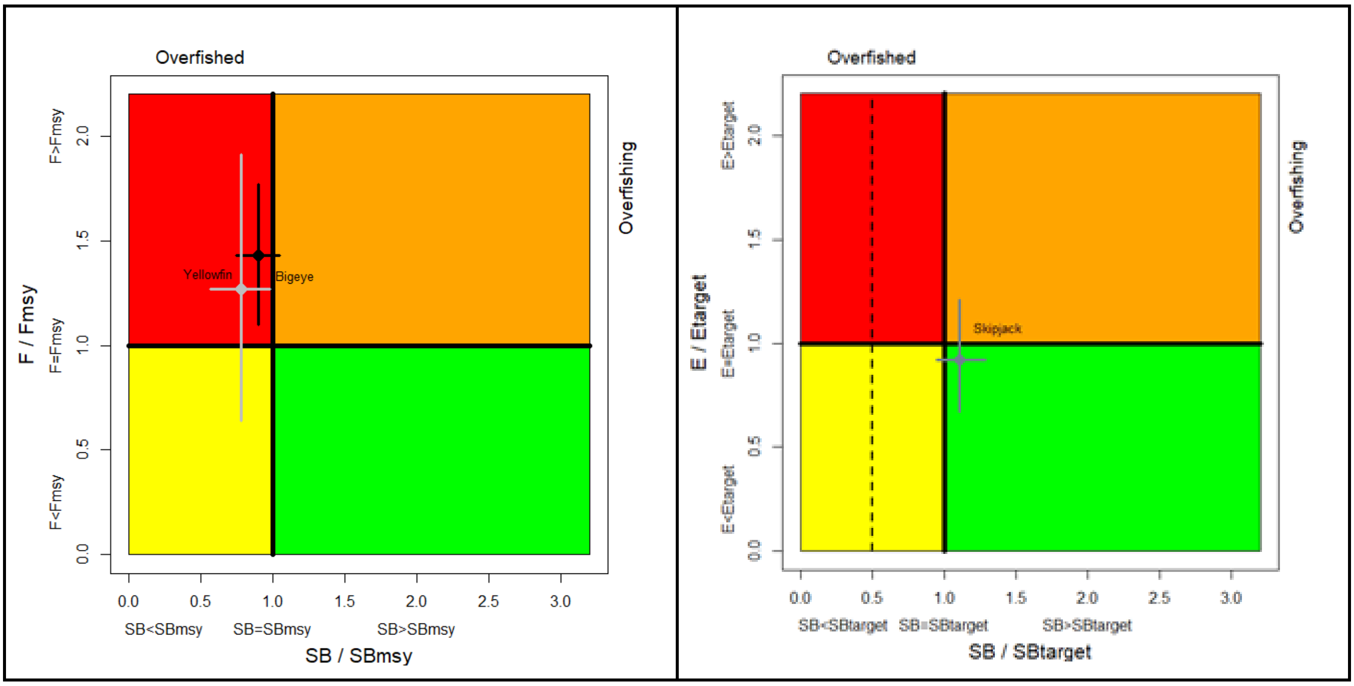

Figure 1. (Left) Combined Kobe plot for bigeye tuna (black: 2022), and yellowfin tuna (grey: 2021) showing the estimates of current stock size (SB) and current fishing mortality (F) in relation to optimal spawning stock size and optimal fishing mortality. (Right) Kobe plot for skipjack tuna showing the estimates of the current stock status (The dashed line indicates the limit reference point at 20%SB0). Cross bars illustrate the range of uncertainty from the model runs with a 80% CI.

115. The report of the 24th Session of the Working Party on Tropical Tunas Meeting (IOTC–2022–WPTT24–R) was **ADOPTED** by correspondence.

Appendix I
List Of Participants

Chairperson
Dr Gorka **Merino**
AZTI
gmerino@azti.es

Vice-Chairperson
Dr M. Shiham **Adam**
International Pole and Line Foundation
shiham.adam@ipnlf.org

Other Participants

Dr. Francisco Javier **Abascal Crespo**
CSIC-Spanish Institute of Oceanography
francisco.abascal@ieo.csic.es

Dr. E.M. **Abdusamad**
CMFRI
emasamadg@gmail.com

Mr. Mohamed **Ahusan**
Maldives Marine Research Institute
mohamed.ahusan@mmri.gov.mv

Dr. Nekane **Alzorriz**
ANABAC
nekane@anabac.org

Mr. Siva **Anandhan**
Fishery Survey of India
anandhan.siva@fsi.gov.in

Mr. Kevin **Aringo**
Kenya Fisheries Service
karingo@kefs.go.ke

Dr. Iraide **Artetxe-Arrate**
AZTI
iraide.artetxe@azti.es

Ms. Cindy **Assan**
Seychelles Fishing Authority
cassan@sfa.sc

Dr. Jose Carlos **Baez**
IEO
josecarlos.baez@ieo.csic.es

Mr. Carlos **Barciela Segura**
European Union
cbarciela@orpagu.com

Dr. Ali **Beigi Keleshteri**
Shilat
alibeigi2014@gmail.com

Dr. Ashleen **Benson**
Europêche
abenson@landmarkfisheries.com

Dr. Franco **Biagi**
DG MARE
Franco.Biagi@ec.europa.eu

Dr. Don **Bromhead**
Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES)
Don.Bromhead@agriculture.gov.au

Mr. John **Burton**
SFACT
john.burton@sustainablefisheriesandcommunitiestrust.org

Dr. Ian **Butler**
Australian Bureau of Agricultural Resource Economics and Sciences
ian.butler@agriculture.gov.au

Dr. Manuela **Capello**
IRD
manuela.capello@gmail.com

Pr. Massimiliano **Cardinale**
SLU
massimiliano.cardinale@slu.se

Mr. Shoukot Kabir **Chowdhury**
Department of Fisheries and Livestock, Ministry of Fisheries and Livestock
shoukot2014@gmail.com

Dr. Sean **Cox**
Europêche
spcox@landmarkfisheries.com

Mr. Ming-Yuan **Cui**
Shanghai Ocean University
470235020@qq.com

Dr. Ansuman **Das**
Fishery Survey of India
1006ansu@gmail.com

Dr. Antoine **Duparc**
IRD
antoine.duparc@ird.fr

Dr. Charles **Edwards**
IOTC Consultant
cescapecs@gmail.com

Ms. Paige **Eveson**
CSIRO
paige.eveson@csiro.au

Dr. Esther **Fondo**
KMFRI
efondo@kmfri.go.ke

Dr. Shunji **Fujiwara**
OFCF
roku.pacific@gmail.com

Mrs. Veronique **Garrioch**
IBL Seafood
vgarrioch@iblseafood.com

Dr. Michel **Goujon**
ORTHONGEL
mgoujon@orthongel.fr

Dr. Maitane **Grande**
AZTI
mgrande@azti.es

Ms. Riana **Handayani**
Ministry of Marine Affairs and Fisheries
daya139@yahoo.co.id

Dr. Sisira **Haputhantri**
National Aquatic Resources Research and Development Agency (NRRA)
sisirahaputhantri@yahoo.com

Mr. Ignatius Tri **Hargiyatno**
National Research and Innovation Agency of the Republic of Indonesia
igna.prpt@gmail.com

Mrs. Hety **Hartaty**
National Research and Innovation Agency
hety001@brin.go.id

Mrs. Udari Ayeshya **Herath Mudiyanselage**
National Aquatic Resource Research and Developmental Agency
ayeshya22@gmail.com

Mr. Miguel **Herrera**
OPAGAC
miguel.herrera@opagac.org

Dr. Rich **Hillary**
CSIRO
rich.hillary@csiro.au

Dr. Glen **Holmes**
The Pew Charitable Trusts
gholmes@pewtrusts.org

Dr. Simon **Hoyle**
NIWA
simon.hoyle@gmail.com

Mrs. Hanista **Jhumun-Foolheea**
Ministry of Blue Economy, Marine Resources, Fisheries and Shipping
hfoolheea@govmu.org

Dr. Samuel **Johnson**
Europêche
samuelj@sfu.ca

Dr. David **Kaplan**
IRD
david.kaplan@ird.fr

Dr. Farhad **Kaymaram**
I.F.S.R.I
farhadkaymaram@gmail.com

Mr. Muhammad Moazzam **Khan**
WWF-Pakistan
mmoazzamkhan@gmail.com

Ms. Beatrice **Kinyua**
Sustainable Fisheries and Communities Trust
beatrice.kinyua@sfact.org

Dr. Toshihide **Kitakado**
Tokyo University of Marine Science and Technology
kitakado@kaiyodai.ac.jp

Dr. Mohammed **Koya**
CMFRI-India
koya313@gmail.com

Mr. Roy **Kurniawan**
National Research and Innovation Agency of the Republic of Indonesia
roykurniawanhrp@gmail.com

Mrs. Ane **Laborda**
AZTI
alaborda@azti.es

Dr. Patrica **Lastra**
AZTI
plastra@azti.es

Mr. Anthony **Lazazzara**
Thai Union
Tony.lazazzara@thaiunion.com

Dr. Mi Kyung **Lee**
National Institute of Fisheries Science
ccmklee@korea.kr

Dr. Haewon **Lee**
National Institute of Fisheries Science
roundsea@korea.kr

Mr. Xiaodong **Li**
Shanghai Ocean University
lixiaodong2019310@163.com

Ms. Yanan **Li**
Shanghai Ocean University
liyananxiada@yeah.net

Mrs. Clivy **Lim Shung**
Ministry of Blue Economy, Marine Resources, Fisheries and Shipping
clivilim@yahoo.com

Ms. Qinqin **Lin**
Shanghai Ocean University
qinqinlin_lucky@yeah.net

Mrs. Juliette **Lucas**
Seychelles Fishing Authority
jlucas@sfa.sc

Mr. Paul Lukhwenda **Kenya**
Fisheries Services
alex@kefs.go.ke

Dr. Qiuyun **Ma**
Shanghai Ocean University
qyma@shou.edu.cn

Dr. Francis **Marsac**
IRD
francis.marsac@ird.fr

Dr. Takayuki **Matsumoto**
Fisheries Resources Institute
matumot@affrc.go.jp

Ms. Anne-France **Mattlet**
Europêche
anne-france.mattlet@europeche.org

Dr. Alexandra **Maufroy**
ORTHONGEL
amaufroy@orthongel.fr

Ms. Effarina **Mohd Faizal**
Government
effarinamohdfaizal@yahoo.com

Ms. Elizabeth **Mueni**
Kenya Fisheries Service
emueni@gmail.com

Dr. Hilario **Murua**
ISSF
hmurua@iss-foundation.org

Mr. Rui **Mutombene**
Mozambique Fisheries Research Institute
ruimutombene@gmail.com

Mr. Stephen **Ndegwa**
Kenya Fisheries Service
ndegwafish@yahoo.com

Ms. Grace **Nduku**
Kenya Fisheries Service
gracen.mutua@gmail.com

Dr. Tom **Nishida**
Fisheries Resources Institute
aco20320@par.odn.ne.jp

Dr. Gladys **Okemwa**
Kenya Marine and Fisheries Research Institute
gladysokemwa@gmail.com

Ms. Sri **Patmiarsih**
Ministry of Marine Affairs and Fisheries of the Republic of Indonesia
sripatmiarsih@gmail.com

Dr. Toby **Patterson**
CSIRO
toby.patterson@csiro.au

Mr. Dinesh **Peiris**
Department of Fisheries and Aquatic Resources
dineshdfar@gmail.com

Mr. Alejandro **Pérez San Juan**
IPD-IEO Seychelles
alex.psj85@gmail.com

Ms. Ann **Preece**
CSIRO
ann.preece@csiro.au

Mr. Panca Berkah **Putra**
Ministry of Marine Affairs and Fisheries of the Republic of Indonesia
pancazz37@gmail.com

Dr. Sethuraman **Ramachandran**
Fishery Survey of India
marineramc1974@gmail.com

Mrs. Lourdes **Ramos**
IEO.CSIC
mlourdes.ramos@ieo.csic.es

Ms. Jessica **Rattle**
Blue Marine Foundation
jess@bluemarinefoundation.com

Mr. Stuart **Reeves**
Cefas
stuart.reeves@cefas.gov.uk

Dr. Jan **Robinson**
SIOTI
janrobinson71@gmail.com

Ms. Surya **S**
CMFRI
revandasurya@gmail.com

Dr. Lilis **Sadiyah**
National Research and Innovation Agency
sadiyah.lilis2@gmail.com

Ms. Saraswati **Saraswati**
Ministry of Marine Affairs and Fisheries of the Republic Indonesia
cacasaras@gmail.com

Dr. Fayakun **Satria**
National Research and Innovation Agency
fsatria70@gmail.com

Mr. Ian **Scott**
SIOTI
ianroyscott@yahoo.com

Mr. Bram **Setyadji**
National Research and Innovation Agency
bram.setyadji@gmail.com

Mr. Umair **Shahid**
WWF
ushahid@wwf.org.pk

Ms. Mariyam **Shama**
Maldives Marine Research Institute
mariyam.shama@mmri.gov.mv

Mr. Chris **Shearlock**
Princes Limited
chris.shearlock@princes.co.uk

Ms. Yiqian **Shi**
Shanghai Ocean University
Shiyiqian_SHOU@163.com

Ms. Elisa **Socrate**
Seychelles Fishing Authority
esocrate@sfa.sc

Pr. Liming **Song**
Shanghai Ocean University
lmsong@shou.edu.cn

Ms. Ririk **Sulistyaningsih**
National Research and Innovation Agency of the Republic of Indonesia
ririk.sulistyaningsing@kkp.go.id

Ms. Laura **Tremblay-Boyer**
CSIRO
Laura.Tremblay-Boyer@csiro.au

Dr. Wen-Pei **Tsai**
National Kaohsiung University of Science and Technology
wptsai@nkust.edu.tw

Dr. Yuji **Uozumi**
Japan Tuna Fisheries Co-operative Association
uozumi@japantuna.or.jp

Dr. Agurtzane **Urtizberea**
AZTI
aurtizberea@azti.es

Dr. Sijo P **Varghese**
Fishery Survey of India
varghesefsi@hotmail.com

Mr. Kelvin **Wachira**
Kenya Fisheries Service
kwachira@kefs.go.ke

Ms. Yang **Wang**
Shanghai Ocean University
shouwyh@163.com

Dr. Sheng-Ping **Wang**
National Taiwan Ocean University
wsp@mail.ntou.edu.tw

Mr. Agustinus Purwanto **Widodo**
National Research and Innovation Agency of the Republic of Indonesia
anungwd@yahoo.co.id

Dr. Ashley **Williams**
CSIRO
ashley.williams@csiro.au

Mr. Ashley **Wilson**
The Pew Charitable Trusts
awilson@pewtrusts.org

Pr. Wudianto **Wudianto**
National Research and Innovation Agency of the Republic of Indonesia
wudianto59@gmail.com

Ms. Shiyu **Yang**
Shanghai Ocean University
yangshiyu_shou@163.com

Dr. Jiangfeng **Zhu**
Shanghai Ocean University
jfzhu@shou.edu.cn

Dr. Iker Zudaire
AZTI
izudaire@azti.es

IOTC Secretariat

Dr Paul **De Bruyn**
Paul.DeBruyn@fao.org

Mr Fabio **Fiorellato**
Fabio.Fiorellato@fao.org

Mr Dan **Fu**
Dan.Fu@fao.org

Dr Emmanuel **Chassot**
Emmanuel.chassot@fao.org

Ms. Lauren Nelson
Lauren.nelson@fao.org

Ms Cynthia **Fernandez-Diaz**
Cynthia.FernandezDiaz@fao.org

Ms. Lucia **Pierre**
Lucia.pierre@fao.org

APPENDIX II

AGENDA FOR THE 24TH WORKING PARTY ON TROPICAL TUNAS, ASSESSMENT MEETING

Date: 24- 29 October 2022

Location: Online

Time: 12:00 – 16:00 (Seychelles time)

Chair: Dr Gorka Merino (European Union); **Vice-Chair:** Dr Shiham Adam (IPNLF)

1. OPENING OF THE MEETING (Chair)

2. ADOPTION OF THE AGENDA AND ARRANGEMENTS FOR THE SESSION (Chair**)**

3. UPDATE OF ANY NEW DATA AVAILABLE AT THE SECRETARIAT FOR TROPICAL TUNA SPECIES SINCE THE DATA PREPARATORY MEETING (IOTC Secretariat**)**

3.1 Data available at the Secretariat
3.2 Fishery Indicators

4. BIGEYE STOCK ASSESSMENT (Chair)

4.1 Review any new information on bigeye biology, stock structure, fisheries and associated environmental data since the data preparatory meeting (all)
4.2 Update on the nominal and standardised CPUE indices presented at the data preparatory meeting
4.3 Stock assessments results
- Stock Synthesis (SS3)
- Other models

4.4 Selection of Stock Status indicators for bigeye tuna
4.5 Development of management advice for bigeye tuna (all)
4.6 Update of bigeye tuna Executive Summary for the consideration of the Scientific Committee (all)

5. BIGEYE TUNA MANAGEMENT PROCEDURE

6. OTHER TROPICAL TUNAS

- General
- Yellowfin
- Skipjack

7. WPTT PROGRAM OF WORK

7.1 Revision of the WPTT Program of Work (2023–2027)
7.2 Development of priorities for an Invited Expert at the next WPTT meeting

8. OTHER BUSINESS

8.1 Date and place of the 25th and 26th Sessions of the WPTT (Chair and IOTC Secretariat)
8.2 Review of the draft, and adoption of the Report of the 24TH Session of the WPTT (Chair)

APPENDIX III
LIST OF DOCUMENTS FOR THE 24TH WORKING PARTY ON TROPICAL TUNAS

Document	Title
IOTC–2022–WPTT24–01a	Draft: Agenda of the 24th Working Party on Tropical Tunas
IOTC–2022–WPTT24–01b	Draft: Annotated agenda of the 24th Working Party on Tropical Tunas
IOTC–2022–WPTT24–02	Draft: List of documents for the 24th Working Party on Tropical Tunas
IOTC–2022–WPTT24–03	Review of the statistical data and fishery trends for (a) tropical tunas (b) bigeye tuna (c) skipjack tuna and (d) yellowfin tuna. (IOTC Secretariat)
IOTC–2022–WPTT24–04	Fisheries Indicators for Indian Ocean tropical tuna. (IOTC Secretariat)
IOTC–2022–WPTT24–05	Revision of the WPTT Program of Work (2023–2027) (IOTC Secretariat)
IOTC–2022–WPTT24–06	Impacts of phytoplankton availability on bigeye tuna (*Thunnus obesus*) recruitment in the Indian Ocean (Wang Y et al.)
IOTC–2022–WPTT24–07	Good practices in CPUE standardization (Hoyle S, Campbell R, Ducharme-Barth N, Grüss A, Moore B, Thorson J, Tremblay-Boyer L, Winker H, Zhou S, Maunder M)
IOTC–2022–WPTT24–08	Updated Information on Catch per Unit Effort and Length Distribution of Bigeye Tuna (*Thunnus obesus*) in the Eastern Indian Ocean (Hartaty H, Setyadji B, Sadiyah L, Satria F)
IOTC–2022–WPTT24–09	Update on the CPUE standardization of the bigeye tuna caught by the Taiwanese large-scale tuna longline fishery in the Indian Ocean (Tsai W-P, Wang S-P, Wu H-S, Chang S-T)
IOTC–2022–WPTT24–10	Preliminary Indian Ocean bigeye tuna stock assessment 1950-2021 (stock synthesis) (Fu D, Merino G and Winker H)
IOTC–2022–WPTT24–11	Using data-limited approaches to assess data-rich Indian Ocean bigeye tuna: Data quantity evaluation and critical information for management implications (Li Y, Zhu J, Dai X, Dan F)
IOTC–2022–WPTT24–12	Consideration of exceptional circumstances in running the IOTC Bigeye tuna MP for 2022 (William A et al)
IOTC–2022–WPTT24–13	Withdrawn
IOTC–2022–WPTT24–14	Scientific catch estimation for the global FAD tropical tuna purse seine fishery in the Indian Ocean (Abascal F, Kaplan D, Rojo V, Gaertner D, Ramos ML, Duparc A, Depetris M, Baez JC)
IOTC–2022–WPTT24–15	Management implications of recruitment deviate trends for tropical tunas (Merino G et al)
IOTC–2022–WPTT24–16	Approaches for estimating natural mortality in tuna stock assessments: application to global yellowfin tuna stocks (Hoyle S, Williams A, Minte-Vera C, Maunder M)
IOTC–2022–WPTT24–17	Review of 2021 WPTT Indian Ocean yellowfin tuna stock assessment and feasibility of alternative assessment (Johnson S, Cox S, Benson A)
IOTC–2022–WPTT24–18	Distribution and abundance of skipjack tuna along the Pakistan coast (Moazzam M)
Documents from other meetings	
IOTC–2022–WPM13–14	Update of joint CPUE indices for the bigeye tuna in the Indian Ocean based on Japanese, Korean and Taiwanese longline fisheries data up to 2021 (Kitakado T et al)
Information papers	
IOTC–2022–WPTT24–INF01	Updating of standardization of bigeye tuna CPUE by Japanese longline fishery in the Indian Ocean (Matsumoto T)
IOTC–2022–WPTT24–INF02	Preliminary stock assessment of Indian Ocean bigeye tuna using Statistical-Catch-At-Size (SCAS) (1950-2021) (Nishida T, Kitakado T)
IOTC–2022–WPTT24–INF03	Human demographic considerations for the certification of seafood from developing countries: Food security and the tuna fishery in Indonesia, a case study (Anon)

Document	Title
IOTC–2022–WPTT24–INF04	Natural mortality ogives for the Indian Ocean bigeye and yellowfin tuna stock assessments (Hoyle S)

APPENDIX IV
DRAFT RESOURCE STOCK STATUS SUMMARY
BIGEYE TUNA (BET : THUNNUS OBESUS)

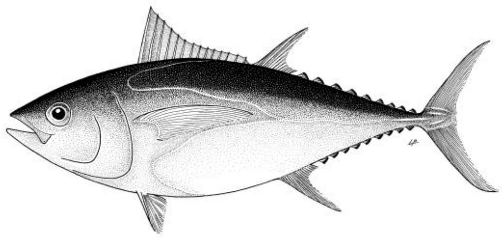

Table 1. Status of bigeye tuna (*Thunnus obesus*) in the Indian Ocean

Area[1]	Indicator	Value	Status[4]
Indian Ocean[1]	Catch in 2021 (t)[2]	94,803	79%*
	Average catch 2017-2021 (t)[3]	87,488	
	MSY (1,000 t) (80% CI)	96 (83 –108)	
	F_{MSY} (80% CI)	0.26 (0.18–0.34)	
	SB_{MSY} (1,000 t) (80% CI)	513 (332–694)	
	F_{2021} / F_{MSY} (80% CI)	1.43 (1.10–1.77)	
	SB_{2021} / SB_{MSY} (80% CI)	0.90 (0.75–1.05)	
	SB_{2021} / SB_0 (80% CI)	0.25 (0.23–0.27)	

[1]Boundaries for the Indian Ocean stock assessment are defined as the IOTC area of competence
[2]Proportion of 2020 catch fully or partially estimated by IOTC Secretariat: 20.4%
[3]Including re-estimations of EU PS species composition for 2018 (requested for stock assessment purposes)
[4]The stock status refers to the most recent years' data used in the assessment conducted in 2019, i.e., 2018
*Estimated probability that the stock is in the respective quadrant of the Kobe Plot (**Table 2**), derived from the confidence intervals associated with the current stock status.

Table 2. Probability of stock status with respect to each of four quadrants of the Kobe plot. Percentages are calculated as the proportion of model terminal values that fall within each quadrant with model weights taken into account

	Stock overfished (SB_{2021} / SB_{MSY}<1)	Stock not overfished (SB_{2021} / SB_{MSY}≥ 1)
Stock subject to overfishing (F_{2021} / F_{MSY}≥ 1)	79%	17%
Stock not subject to overfishing (F_{2021} / F_{MSY}≤ 1)	2%	2%
Not assessed / Uncertain		

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. In 2022 a new stock assessment was carried out for bigeye tuna in the IOTC area of competence to update the stock assessment undertaken in 2019. Two models were applied to the bigeye stock (Statistical Catch at Size (SCAS) and Stock Synthesis (SS3)), with the SS3 stock assessment selected to provide scientific advice. The reported stock status is based on a grid of 24 model configurations designed to capture the uncertainty on stock recruitment relationship, longline selectivity, growth and natural mortality. Spawning biomass in 2021 was estimated to be 25% (80% CI: 23-27%) of the unfished levels in 2021 (**Table 1**) and 90% (75-105%) of the level that can support MSY. Fishing mortality was estimated at 1.43 (1.1-1.77) times the F_{MSY} level. Considering the characterized uncertainty, the assessment indicates that SB2021 is below SBMSY that F_{2021} is above FMSY (79%). On the weight-of-evidence available in 2022, the bigeye tuna stock is determined to be **overfished** and **subject to overfishing** (**Table 1**).

As IOTC agreed on a bigeye Management Procedure (Res. 22/03) it should be noted that the stock assessment is not used to provide a recommendation on the TAC.

Management Procedure. A management procedure for Indian Ocean Bigeye tuna was adopted under Resolution 22/03 by the IOTC Commission in May 2022 and was applied to determine a recommended TAC for Bigeye tuna for 2024 and 2025. A review of evidence for exceptional circumstances, was also conducted following the adopted guideline (ref SC 2021 report appendix 6A) as per the requirements of Resolution 22/03. The review covered information pertaining to i) new knowledge about the stock, population dynamics or biology, ii) changes in fisheries or fisheries operations, iii) changes to input data or missing data, and iv) inconsistent implementation of the MP advice. The evaluation concluded that there were no exceptional circumstances requiring either further research or management action on the TAC calculated by the MP. Application of the MP in 2022 results in a recommended TAC of 80,583t per year for 2024 and 2025.

Outlook. Catch in 2021 (94,803 t) of bigeye tuna is above the recommended TAC for 2024 and 2025 from the application of the bigeye tuna MP. Achieving the objectives of the Commission for this stock will require effective implementation of the MP TAC advice by the Commission going forward, a requirement further emphasised by the current status of the stock estimated from the stock assessment to be overfished and subject to overfishing.

Management advice. The TAC recommended from the application of the MP specified in Resolution 22/03 is 80,583t / year for the period 2024-2025. The recommended TAC is 15% below the 2021 catch.

The following key points should also be noted:

- **Main fisheries (mean annual catch 2017-2021)**: bigeye tuna are caught using purse seine (41.7%), followed by longline (37%) and line (13.5%). The remaining catches taken with other gears contributed to 7.8% of the total catches in recent years (**Fig. 1**).
- **Main fleets (mean annual catch 2017-2021)**: the majority of bigeye tuna catches are attributed to vessels flagged to Indonesia (23.7%) followed by Taiwan,China (15.4%) and Seychelles (15.3%). The 30 other fleets catching bigeye tuna contributed to 45.8% of the total catch in recent years (**Fig. 2**).

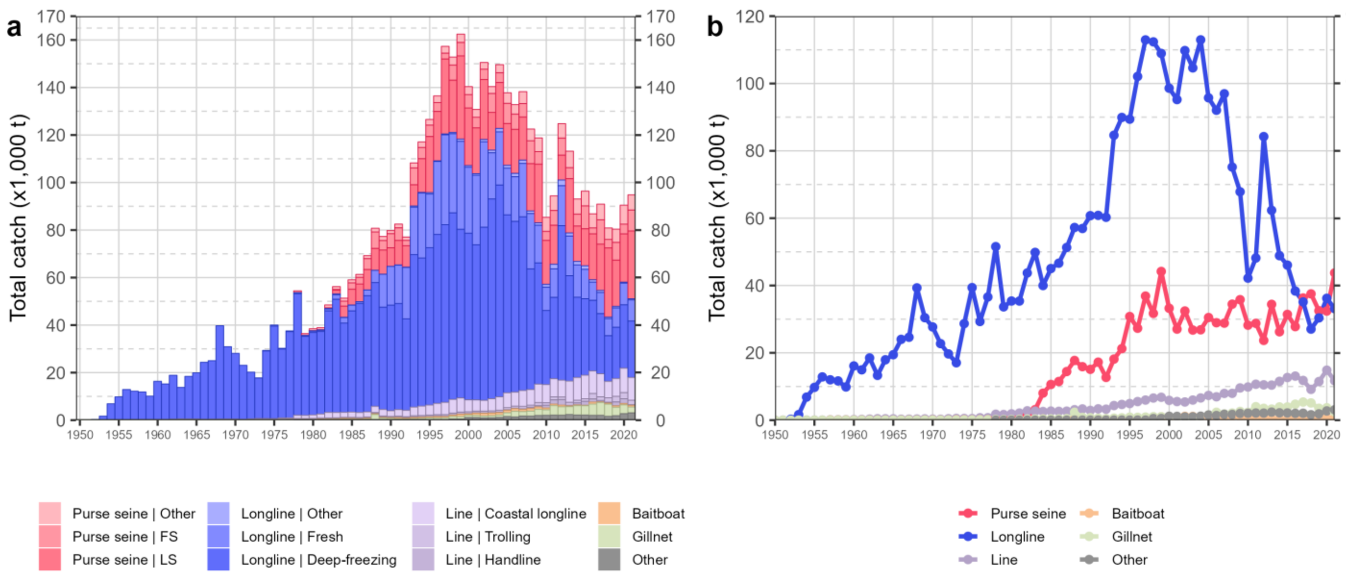

Fig. 1. Annual time series of (a) cumulative nominal catches (metric tonnes; t) by fishery group and (b) individual nominal catches (metric tonnes; t) by fishery for bigeye tuna during 1950–2021. FS = free-swimming school; LS = schools associated with drifting floating objects; Purse seine | Other: coastal purse seine, purse seine of unknown school association type, ring net; Longline | Other: swordfish and sharks-targeted longlines; Other: all remaining fishing gears

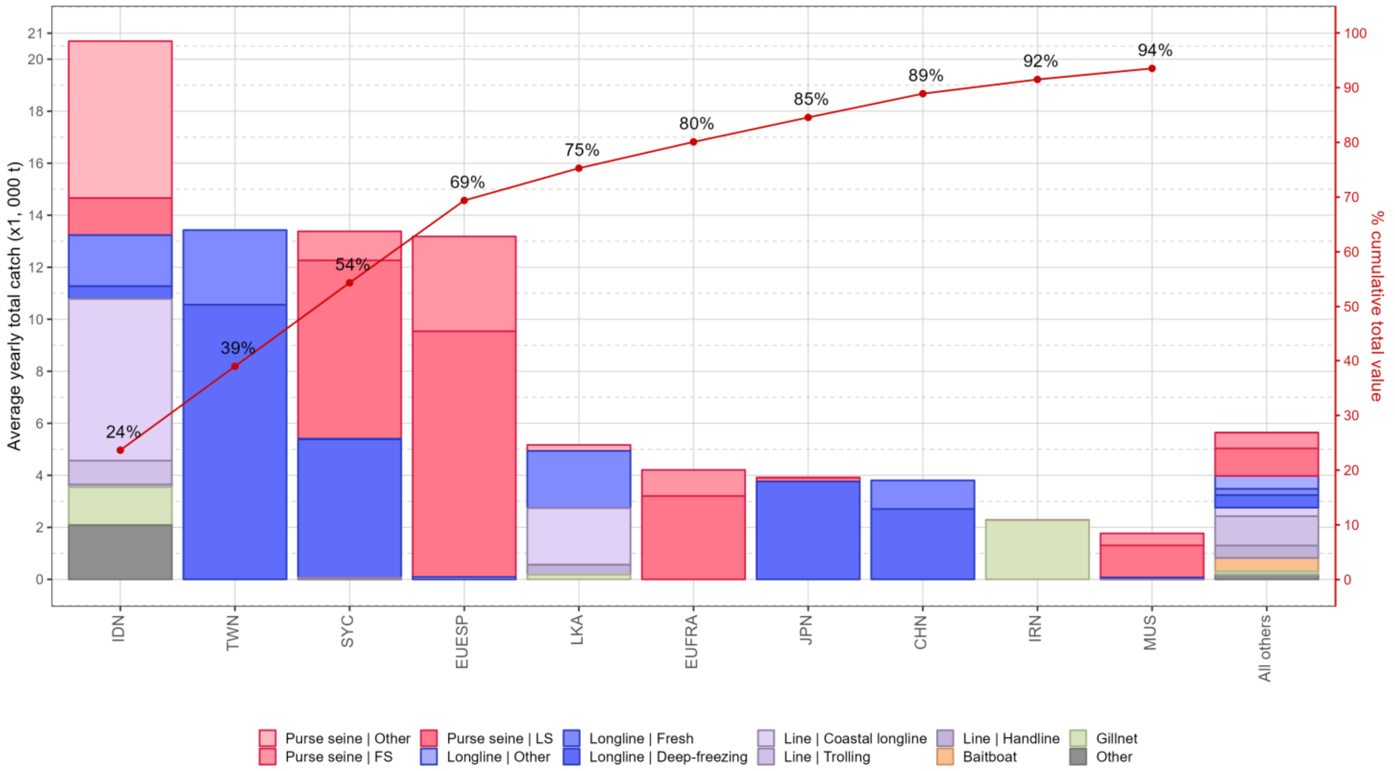

Fig. 2. Mean annual catches (metric tonnes; t) of bigeye tuna by fleet and fishery between 2017 and 2021, with indication of cumulative catches by fleet. FS = free-swimming school; LS = school associated with drifting floating objects. Purse seine | Other: coastal purse seine, purse seine of unknown association type, ring net; Longline | Other: swordfish and sharks-targeted longlines; Other: all remaining fishing gears

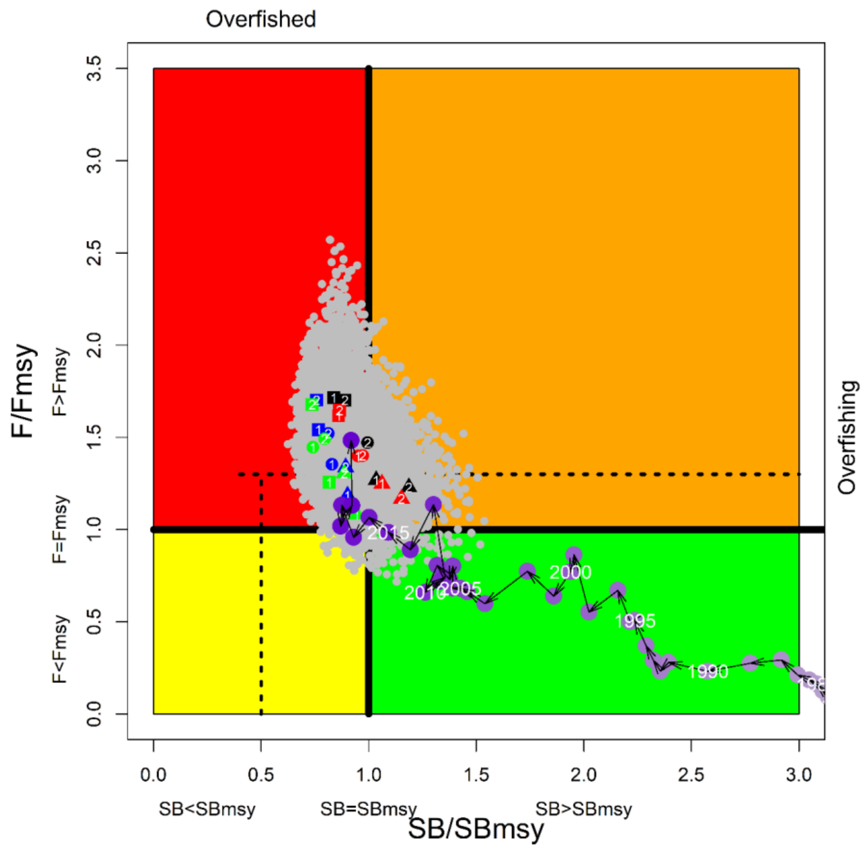

Fig. 3. Bigeye tuna: SS3 Aggregated Indian Ocean assessment Kobe plot. The coloured points represent stock status estimates from the 24 model options. Coloured symbols represent Maximum posterior density (MPD) estimates from individual models: square, circle, and Triangles represents alternative steepness options; black, red, blue, and green represents alternative growth and natural mortality option combination; 1,2, represents alternative selectivity options. The purple dot and arrowed line represent estimates of the reference model. Grey dots represent

uncertainty from individual models. The dashed lines represent limit reference points for IO yellowfin tuna (SBlim = 0.5 SBMSY and Flim = 1.4 FMSY)

APPENDIX V
DRAFT RESOURCE STOCK STATUS SUMMARY
SKIPJACK TUNA (SKJ: KATSUWONUS PELAMIS)

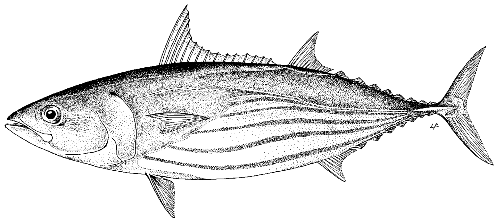

Table 1. Status of skipjack tuna (*Katsuwonus pelamis*) in the Indian Ocean

Area[1]	Indicator	Value	Status[34]
Indian Ocean	Catch in 2021 (t)[2]	650,331	60.4%*
	Average catch 2017-2021 (t)[3]	580,408	
	$C_{40\%SB0}$ (t) (80% CI)	535,964 (461,995–674,536)	
	C_{2019} / $C_{40\%SB0}$ (80% CI)	1.02 (0.81–1.18)	
	$E_{40\%SB0}$ [5] (80% CI)	0.59 (0.53–0.66)	
	E_{2019} / $E_{40\%SB0}$ (80% CI)	0.92 (0.67-1.21)	
	SB_0 (t) (80% CI)	1,992,089 (1,691,710–2,547,087)	
	SB_{2019} (t) (80% CI)	870,461 (660,411–1,253,181)	
	$SB_{40\%SB0}$ (t) (80% CI)	794,310 (672,825–1,019,056)	
	$SB_{20\%SB0}$ (t) (80% CI)	397,155 (336,412–509,528)	
	SB_{2019} / SB_0 (80% CI)	0.45 (0.38-0.5)	
	SB_{2019} / $SB_{40\%SB0}$ (80% CI)	1.11 (0.95-1.29)	
	SB_{2019} / SB_{MSY} (80% CI)	1.99 (1.47-2.63)	
	MSY (t) (80% CI)	601,088 (500,131–767,012)	
	E_{2019} / E_{MSY} (80% CI)	0.48 (0.35-0.81)	

[1]Boundaries for the Indian Ocean stock assessment are defined as the IOTC area of competence
[2]Proportion of 2020 catch fully or partially estimated by IOTC Secretariat: 17.7%
[3]Including re-estimations of EU PS species composition for 2018 (requested for stock assessment purposes)
[4]The status refers to the most recent years' data used in the assessment conducted in 2020, i.e., 2019
[5] $E_{40\%SB0}$ is the equilibrium annual exploitation rate (Etarg) associated with the stock at Btarg, and is a key control parameter in the skipjack harvest control rule as stipulated in Resolution 16/02. Note that Resolution 16/02 did not specify the exploitation rate associated with the stock at Blim
*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

Table 2. Probability of stock status with respect to each of four quadrants of the Kobe plot. Percentages are calculated as the proportion of model terminal values that fall within each quadrant with model weights taken into account

	Stock overfished (SB_{2019} / $SB_{40\%SB0}$<1)	Stock not overfished (SB_{2019} / $SB_{40\%SB0}$≥ 1)
Stock subject to overfishing (E_{2019} / $E_{40\%SB0}$≥ 1)	19.5%	19.5%
Stock not subject to overfishing (E_{2019} / $E_{40\%SB0}$≤ 1)	0.6%	60.4%
Not assessed / Uncertain		

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. No new stock assessment was conducted in 2022 and so the advice is based on the 2020 assessment using Stock Synthesis with data up to 2019.. The outcome of the 2020 stock assessment model does not differ substantially from the previous assessment (2017) despite the large catches recorded in the period 2018-2019, which exceeded the catch limits established in 2017 for this period.

The final overall estimate of stock status indicates that the stock is above the adopted target for this stock and that the current exploitation rate is just below the target. Also, the models estimate that the spawning biomass remains above its SB_{MSY} and the fishing mortality remains below E_{MSY} with very high probability. Over the history of the fishery, biomass has been well above the adopted limit reference point ($0.2*SB_0$). The recent catches have been within the range of estimated target yield (see $C_{40\%SB0}$). Current spawning biomass relative to unexploited levels is estimated at 45% (**Table 1**). Thus, on the weight-of-evidence available in 2020, the skipjack tuna stock is determined to be: (i) above the adopted biomass target reference point; (ii) **not overfished** ($SB_{2019}>SB_{40\%SB0}$); (iii) with fishing mortality below the adopted target fishing mortality, and (iv) **not subject to overfishing** ($E_{2019}<E_{40\%SB0}$) (**Table 2**).

Outlook. Total catches in 2018 were 30% larger than the resulting catch limit from the skipjack HCR for the period 2018-2020 (470,029 t), which raises concern in the WPTT. It is important to note that reaching the management objectives defined in Resolution 16/02 requires that the catch limits adopted by the skipjack HCR are implemented effectively. It should be noted that skipjack catches for most gears have increased from 2017 to 2018 (+44% for purse seine (log/FAD-associated), +12% for gillnet and +13% for pole-and-line). In 2019, catch was reduced considerably compared to 2018. Due to its specific life history attributes, skipjack can respond quickly to ambient foraging conditions driven by ocean productivity, which seem to have been favourable in recent years. Environmental indicators should be closely monitored to inform on the potential increase/decrease of stock productivity. There remains considerable uncertainty in the assessment: The assumption of two hypotheses for the effort creep since 1995 for the standardized European purse seine CPUE was included in the model grid. The range of runs analysed illustrate a range of stock status to be between 36% and 51% of SB_{2019} / SB_0 based on all runs examined. It is important to note the differences between the runs that apply an additional effort creep parameter to the standardized series of CPUE (median SB_{2019}/SB_0=0.44) and those that do not (median SB_{2019} / SB_0=0.45). Also, there was contrast between runs that fully weighted tagging information (median SB_{2019} / SB_0=0.42) and those that reduced their influence (median SB_{2019}/SB_0=0.48).

Management advice. The catch limit calculated applying the HCR specified in Resolution 16/02 is 513,572 t for the period 2021-2023. The SC noted that this catch limit is higher than for the previous period. This is attributed to the new stock assessment which estimates a higher productivity of the stock and a higher stock level relative to the target reference point, possibly due to skipjack life history characteristics and favourable environmental conditions. Thus, it is likely that the recent catches that have exceeded the limits established for the period 2018-2020 have been sustained by favourable environmental conditions. Therefore, the Commission needs to ensure that catches of skipjack tuna during this period do not exceed the agreed limit.

The following key points should also be noted:

- **Reference points**: Commission in 2016 agreed to Resolution 16/02 on *harvest control rules for skipjack tuna in the IOTC area of competence*.
- **Biomass**: Current spawning biomass was considered to be above the target reference point of 40% of SB_0, and above the limit reference point of $0.2*SB_0$ as per Resolution 16/02 (**Fig. 2**).
- **Main fisheries (mean annual catch 2017-2021)**: skipjack tuna are caught using purse seine (54.4%), followed by baitboat (19%) and gillnet (17.8%). The remaining catches taken with other gears contributed to 8.8% of the total catches in recent years (**Fig. 1**).
- **Main fleets (mean annual catch 2017-2021)**: the majority of skipjack tuna catches are attributed to vessels flagged to Indonesia (18.4%) followed by EU (Spain) (17.8%) and Maldives (17.2%). The 31 other fleets catching skipjack tuna contributed to 46.3% of the total catch in recent years (**Fig. 2**).

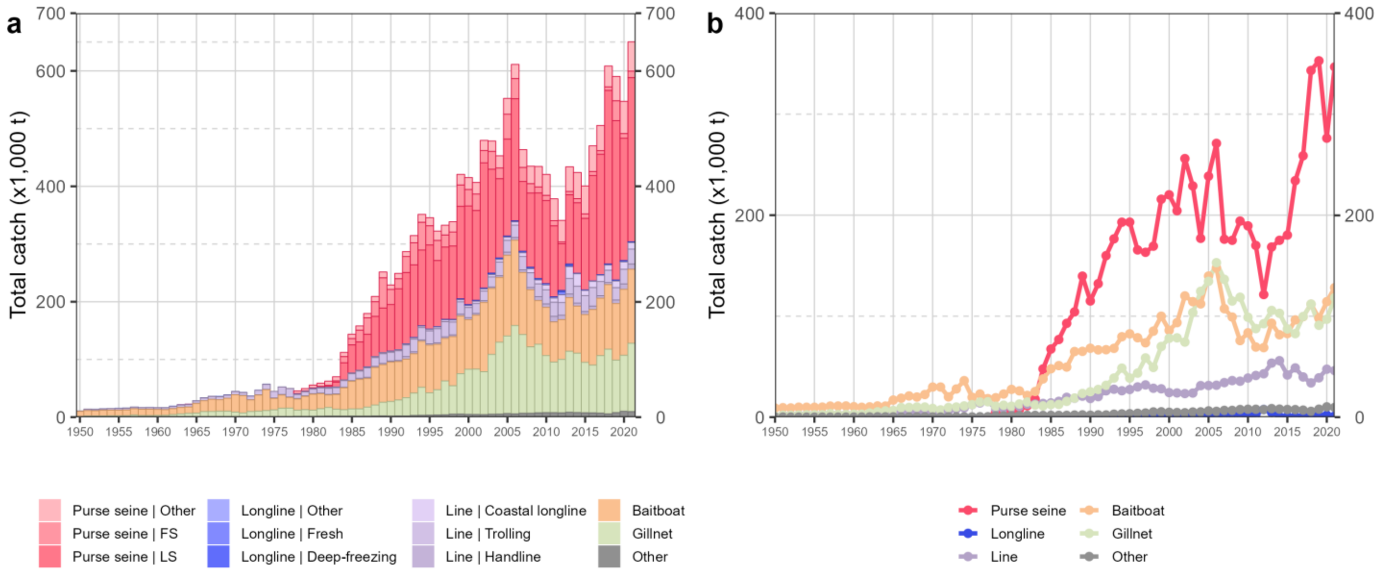

Fig. 1. Annual time series of (a) cumulative nominal catches (metric tonnes; t) by fishery and (b) individual nominal catches (metric tonnes; t) by fishery group for skipjack tuna during 1950–2021. FS = free-swimming schools; LS = schools associated with drifting floating objects. Purse seine | Other: coastal purse seine, purse seine of unknown association type, ring net; Longline | Other: swordfish and sharks-targeted longlines; Other: all remaining fishing gears

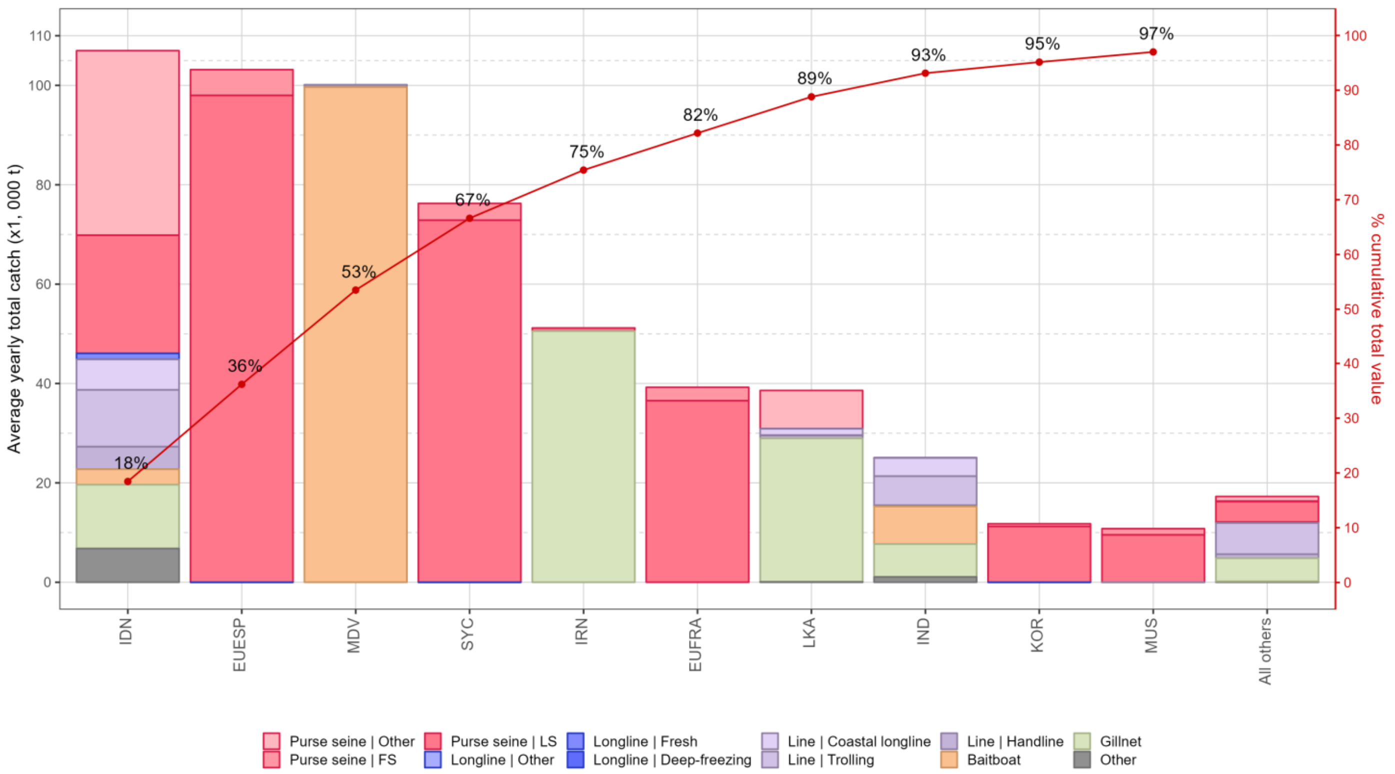

Fig. 2. Mean annual catches (metric tonnes; t) of skipjack tuna by fleet and fishery between 2017 and 2021, with indication of cumulative catches by fleet. FS = free-swimming schools; LS = schools associated with drifting floating objects. Purse seine | Other: coastal purse seine, purse seine of unknown association type, ring net; Longline | Other: swordfish and sharks-targeted longlines; Other: all remaining fishing gears

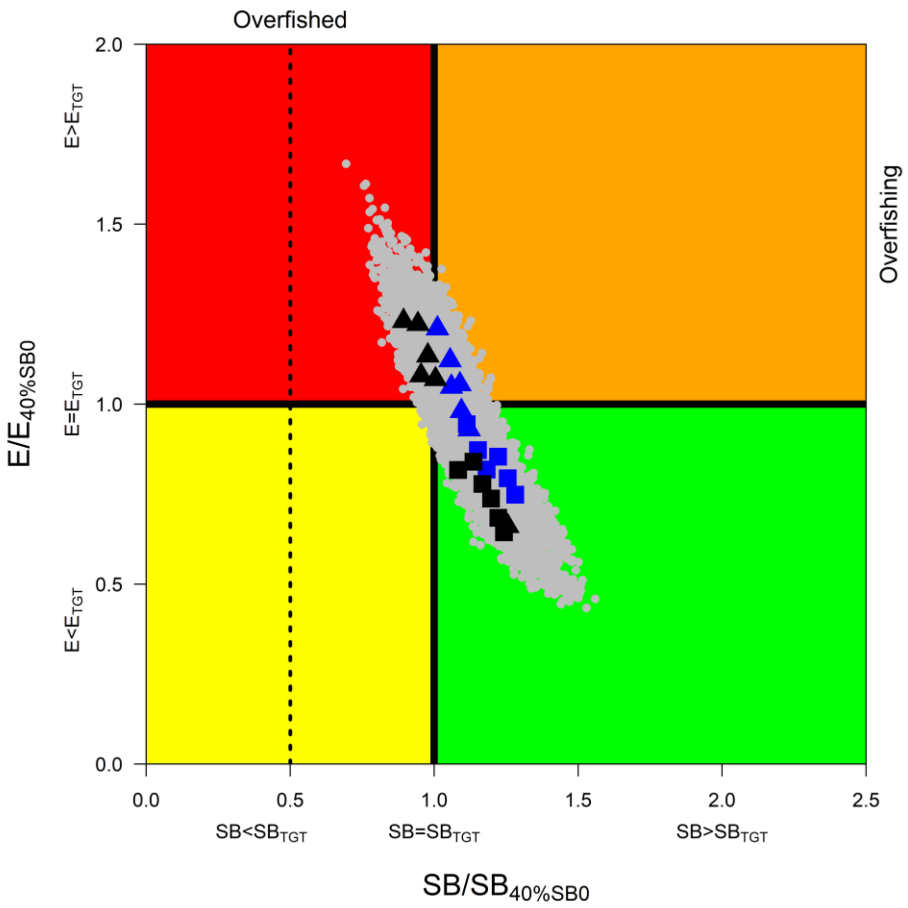

Fig. 3. Skipjack tuna: SS3 Aggregated Indian Ocean assessment Kobe plot of the 2020 uncertainty grid. Symbols represent Maximum posterior density (MPD) estimates of current stock status relative to $SB_{40\%SB0}$ (x-axis) and $E_{40\%SB0}$ (y-axis) for the individual models (blue, no effort creep; black, additional effort creep; triangle, full weighting of tagging data; square, tagging data downweighted). Grey dots represent uncertainty from individual models. The vertical dashed line represents the limit reference point for Indian Ocean skipjack tuna (SB_{lim} = 20%SB_0)

APPENDIX VI
DRAFT RESOURCE STOCK STATUS SUMMARY
YELLOWFIN TUNA (YFT: *THUNNUS ALBACARES*)

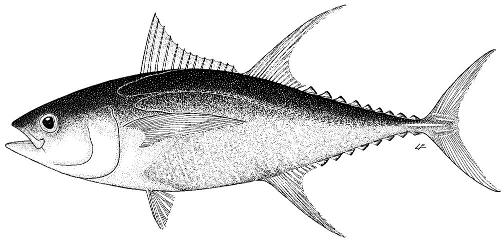

Table 1. Status of yellowfin tuna (*Thunnus albacares*) in the Indian Ocean

Area[1]	Indicator	Value	Status[4]
Indian Ocean	Catch in 2021 (t)[2]	416,235	68%*
	Average catch 2017-2021 (t)[3]	435,225	
	MSY (1,000 t) (80% CI)	349 (286-412)	
	F_{MSY} (80% CI)	0.18 (0.15-0.21)	
	SB_{MSY} (1,000 t) (80% CI)	1,333 (1,018-1,648)	
	F_{2020} / F_{MSY} (80% CI)	1.32 (0.68-1.95)	
	SB_{2020} / SB_{MSY} (80% CI)	0.87 (0.63-1.10)	
	SB_{2020} / SB_0 (80% CI)	0.31 (0.24-0.38)	

[1]Boundaries for the Indian Ocean stock assessment are defined as the IOTC area of competence
[2]Proportion of 2021 catch fully or partially estimated by IOTC Secretariat: 18%
[3]Including re-estimations of EU PS species composition for 2018 (requested for stock assessment purposes)
[4]The stock status refers to the most recent years' data used in the assessment conducted in 2021, i.e., 2020
*Estimated probability that the stock is in the respective quadrant of the Kobe Plot (**Table 2**). Median and quantiles calculated from the uncertainty grid taking into account of weighting on models

Table 2. Probability of stock status with respect to each of four quadrants of the Kobe plot. Percentages are calculated as the proportion of model terminal values that fall within each quadrant with model weights taken into account

	Stock overfished (SB_{2020} / SB_{MSY}<1)	Stock not overfished (SB_{2020} / SB_{MSY}≥ 1)
Stock subject to overfishing (F_{2020} / F_{MSY}≥ 1)	68%	2%
Stock not subject to overfishing (F_{2020} / F_{MSY}≤ 1)	13%	17%
Not assessed / Uncertain		

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. No new stock assessment was carried out for yellowfin tuna in 2022 and so the advice is based on the 2021 assessment.. The 2021 stock assessment was carried out using Stock Synthesis III (SS3), a fully integrated model that is currently used to provide scientific advice for the three tropical tunas stocks in the Indian Ocean. The model used in 2021 is based on the model developed in 2018 with a series of revisions that were noted during the WPTT in 2018, 2019 and 2020. The model uses four types of data: catch, size frequency, tagging and CPUE indices. The proposed final assessment model options correspond to a combination of model configurations, including alternative assumptions about the spatial structure (2 options), longline CPUE catchability (2 options on the effect of piracy), weighting of the tagging dataset (lambda = 0.1 or 1), steepness values (0.7, 0.8, and 0.9), natural mortality values (2 options), and growth parameters (2 options). The model ensemble (a total of 96 models) encompasses a range of stock dynamics.

A number of sensitivity runs were conducted to address additional uncertainty, including two new natural mortalities (based on maximum age of 10.9 and 18, respectively), a new growth curve (based on the most recent aging study), an assumed longline catchability increase (1% per year), as well as a model that includes only the Japanese size data for the Longline fishery. The results of these models generally indicate a more pessimistic stock status and would lower the estimated median biomass if included in the final grid of models. However, the results from the sensitivity runs were within the range of uncertainty estimated by the model grid. The sensitivity models still require further exploration to ensure uncertainty is being captured appropriately and models are not mis-specified. Other key uncertainties (for example, catch levels) were not explored.

The new model grid represents a marked improvement over the previous results available in 2018 and incorporates a far wider range of uncertainty. According to the information available in 2021, the total catch has remained above the estimated MSY since 2012 (i.e., between 399,000 t and 448,642 t), with the 2019 catch (448,642 t) being the largest since 2010 (for details see WPTT23 report).

Overall stock status estimates do not differ substantially from the previous assessment. Spawning biomass in 2020 was estimated to be 31% on average of the unfished (1950) levels (**Table 1**). Spawning biomass estimates have been generally declining over time and particularly since 2011 (**Fig. 3)**. Spawning biomass in 2020 was estimated to be 87% of the level that supports the maximum sustainable yield (SB_{2020}/SB_{MSY} = 0.87). Current fishing mortality is estimated to be 32% higher than F_{MSY} (F_{2020}/F_{MSY} = 1.32). The probability of the stock being in the red Kobe quadrant in 2020 is estimated to be 68%. On the weight-of-evidence available since 2018, the yellowfin tuna stock is determined to remain **overfished** and **subject to overfishing** (**Table 1** and **Fig. 4**).

It is noted that the estimated productivity of the stock (MSY) was very low for some of the scenarios of the reference grid. Their plausibility and reasons for this low productivity are yet to be fully investigated. It is noted that there is also considerable uncertainty in the reported catches by some fisheries. In particular, several artisanal fisheries have increased their catches substantially in recent years, the implication of which should be further investigated. There was a lack of information to explain this sharp increase in catch. Inconsistencies in the biomass trend by region also remain unresolved and this also deserves further investigation.

Outlook. The increase in catches in recent years has substantially increased the pressure on the Indian Ocean stock, resulting in fishing mortality exceeding the MSY-related levels. The critical errors in the projections and estimations for computing probabilities in the K2SM developed in 2018 have been addressed and the updated projections no longer suffer from the issues previously experienced.

Management advice

For each catch scenario, the probability of the biomass being below the SB_{MSY} level and the probability of fishing mortality being above F_{MSY} were determined over the projection horizon using the delta-MVLN estimator (Walter & Winker 2020), based on the variance-covariance derived from estimates of SB/SB_{MSY} and F/F_{MSY} across the model grid. According to the K2SM (**Table 3**),

- If catches are reduced to 60% of 2020 levels[3] there is >50% probability of being above SB_{MSY} levels by 2023.
- if catches are reduced to < 80% of 2020 levels there is a >50% probability of being above SB_{MSY} in 2030.
- if catches are reduced to less than 80% of 2020 levels there would be a >50% probability of ending overfishing ($F<F_{MSY}$) by 2023 and also by 2030.
- The probability of breaching the biological limit reference point ($0.4SB_{MSY}$) with 2020 catches is 7% by 2023 and 64% by 2030. The probability of breaching the F limit reference point ($1.4\ F_{MSY}$) with 2020 catch is 52% by 2023 and 78% by 2030.

The Commission has an interim plan for the rebuilding the yellowfin stock, with catch limitations based on 2014/2015 levels (Resolution 21/01 which superseded 19/01, 18/01 and 17/01). Some of the fisheries subject to catch reductions have achieved a decrease in catches in 2020 in accordance with the levels of reductions specified in the Resolution; however, these reductions were offset by increases in the catches from CPCs exempt from and some CPCs subject to limitations on their catches of yellowfin tuna.

The following key points should also be noted:

[3] 2020 catch levels indicate the nominal catch available to the WPTT at its session in October 2021 (WPTT23).

- Maximum Sustainable Yield (MSY): estimate for the Indian Ocean stock is 349,000 t with a range between 286,000-412,000 t (**Table 1**). The 2016-2020 average catches (434,383 t) were above the estimated MSY level. The last year (2020) catch has been substantially higher than the median MSY.
- **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**: 2020 fishing mortality is considered to be 32% above the interim target reference point of F_{MSY}, and below the interim limit reference point of 1.4*F_{MSY} (**Fig. 4**).
- **Biomass**: 2020 spawning biomass is considered to be 13 % below the interim target reference point of SB_{MSY} and above the interim limit reference point of 0.4*SB_{MSY} (**Fig. 4**).
- **Catch data uncertainty:** the overall quality of the nominal catches of yellowfin tuna shows some large variability between 1950 and 2020. In some years, a large portion of the nominal catches of yellowfin tuna had to be estimated, and catches reported using species or gear aggregates had to be further broken down. The data quality was particularly poor between 1994 and 2002 when less than 70% of the nominal catches were fully or partially reported, with most reporting issues coming from coastal fisheries. The reporting rate has generally improved over the last decade however detailed information on data collection procedures, which determines the quality of fishery statistics, is still lacking.
- **Main fisheries (mean annual catch 2017-2021)**: yellowfin tuna are caught using line (35.4%), followed by purse seine (33.6%) and gillnet (18.3%). The remaining catches taken with other gears contributed to 12.7% of the total catches in recent years (**Fig. 1**).
- **Main fleets (mean annual catch 2017-2021)**: the majority of yellowfin tuna catches are attributed to vessels flagged to I. R. Iran (12.2%) followed by EU (Spain) (11.3%) and Sultanate of Oman (10.4%). The 35 other fleets catching yellowfin tuna contributed to 66.1% of the total catch in recent years (**Fig. 2**).

References

Walter, J., Winker, H., 2020. Projections to create Kobe 2 Strategy Matrices using the multivariate log-normal approximation for Atlantic yellowfin tuna. Collect. Vol. Sci. Pap. ICCAT, 76(6): 725-739

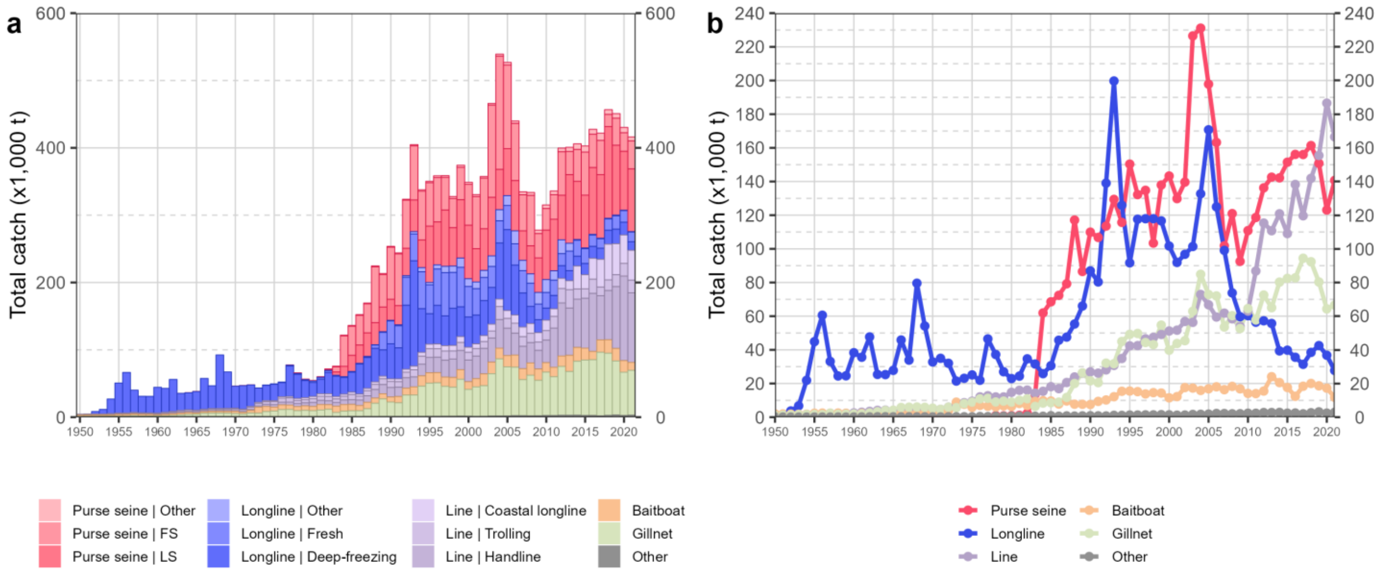

Fig. 1. Annual time series of (a) cumulative nominal catches (metric tonnes; t) by fishery and (b) individual nominal catches (metric tonnes; t) by fishery group for yellowfin tuna during 1950–2021. FS = free-swimming school; LS = school associated with drifting floating objects. Purse seine | Other: coastal purse seine, purse seine of unknown association type, ring net; Longline | Other: swordfish and sharks-targeted longlines; Other: all remaining fishing gears

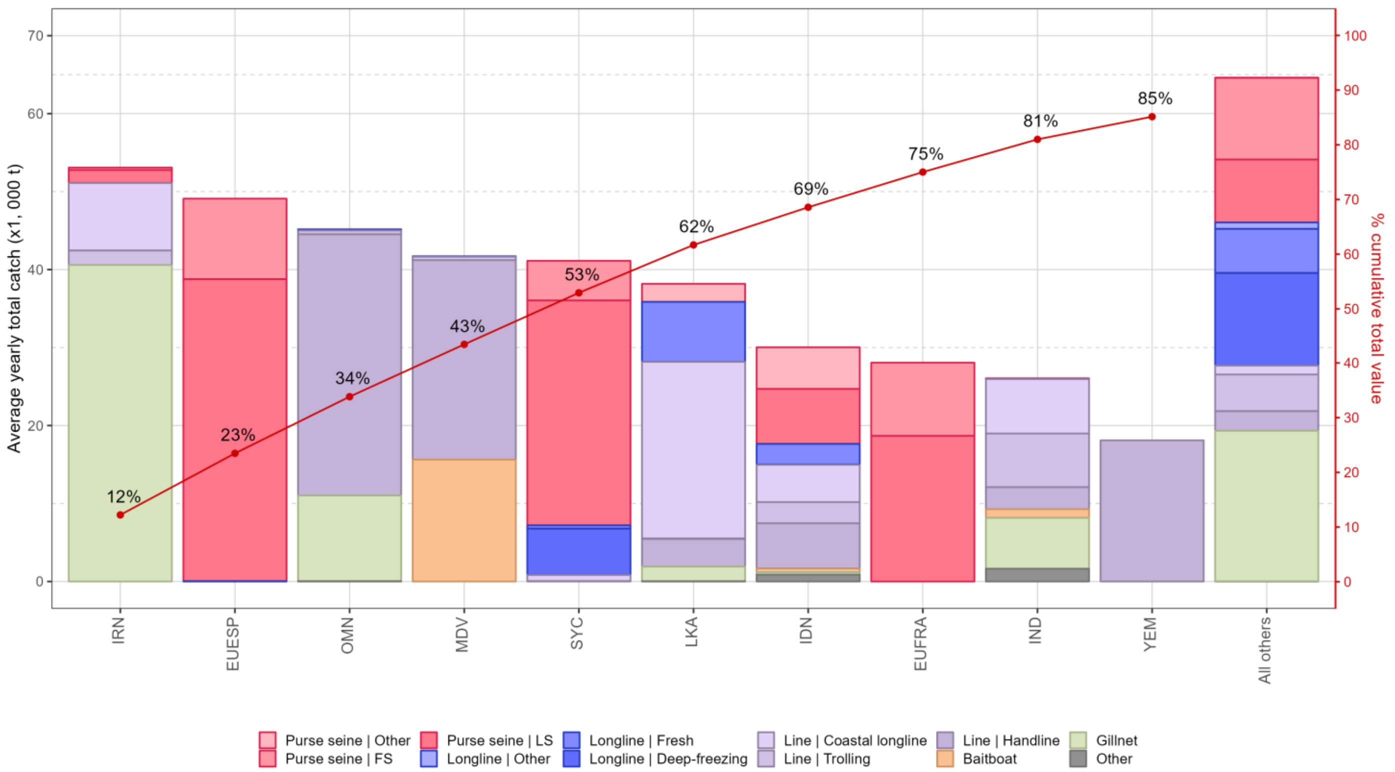

Fig. 2. Mean annual catches (metric tonnes; t) of yellowfin tuna by fleet and fishery between 2017 and 2021, with indication of cumulative catches by fleet. FS = free-swimming school; LS = school associated with drifting floating objects. Purse seine | Other: coastal purse seine, purse seine of unknown association type, ring net; Longline | Other: swordfish and sharks-targeted longlines; Other: all remaining fishing gears

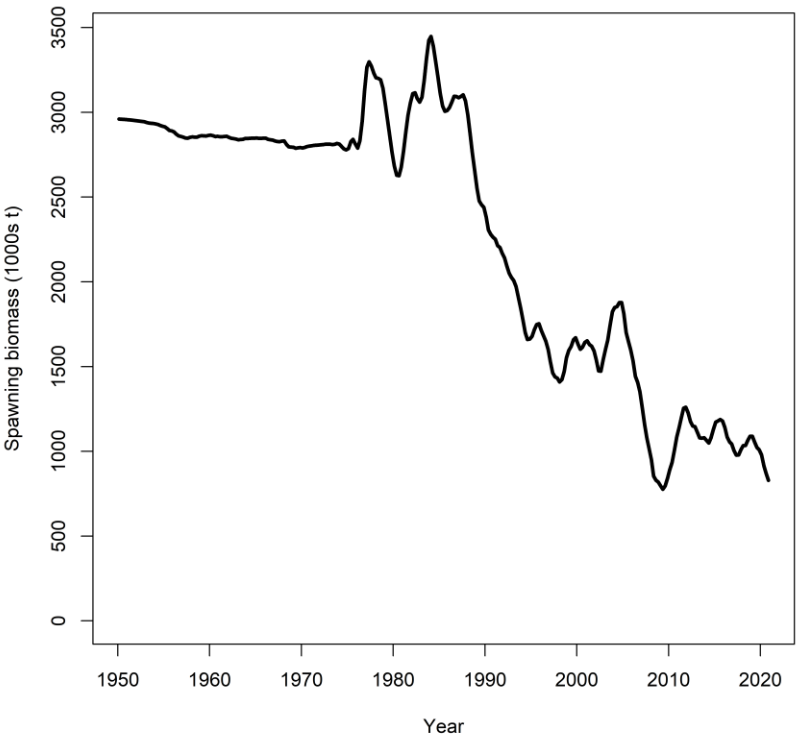

Fig 3. Estimated time series (1950-2020) of total spawning biomass of yellowfin tuna (left) from the reference model of the 2020 assessment.

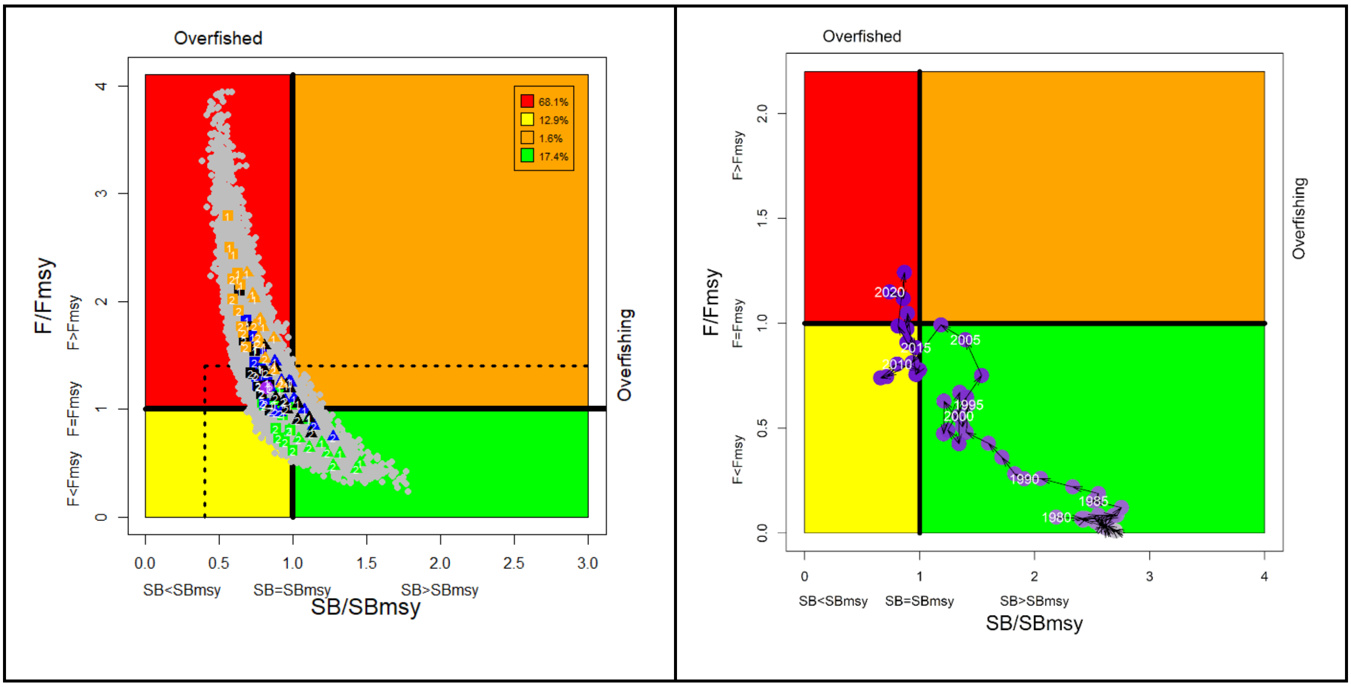

Fig. 4. Yellowfin tuna: SS3 Indian Ocean assessment Kobe plot: (left): current stock status, relative to SB_{MSY} (x-axis) and F_{MSY} (y-axis) reference points for the final model options. Coloured symbols represent Maximum posterior density (MPD) estimates from individual models: square and Triangles and represents LL CPUE catchability options q1 and q2 respectively; green, blue, black, and orange represents growth and natural mortality option combination Gbase_Mbase, GDortel_Mbase, Gbase_Mlow, and GDortel_Mlow respectively; 1,2, represents spatial structure option io and sp respectively. The purple dot represents the base model. Grey dots represent uncertainty from individual models. The dashed lines represent limit reference points for IO yellowfin tuna (SBlim = 0.4 SB_{MSY} and Flim = 1.4 F_{MSY}); (right) stock trajectory from the base model

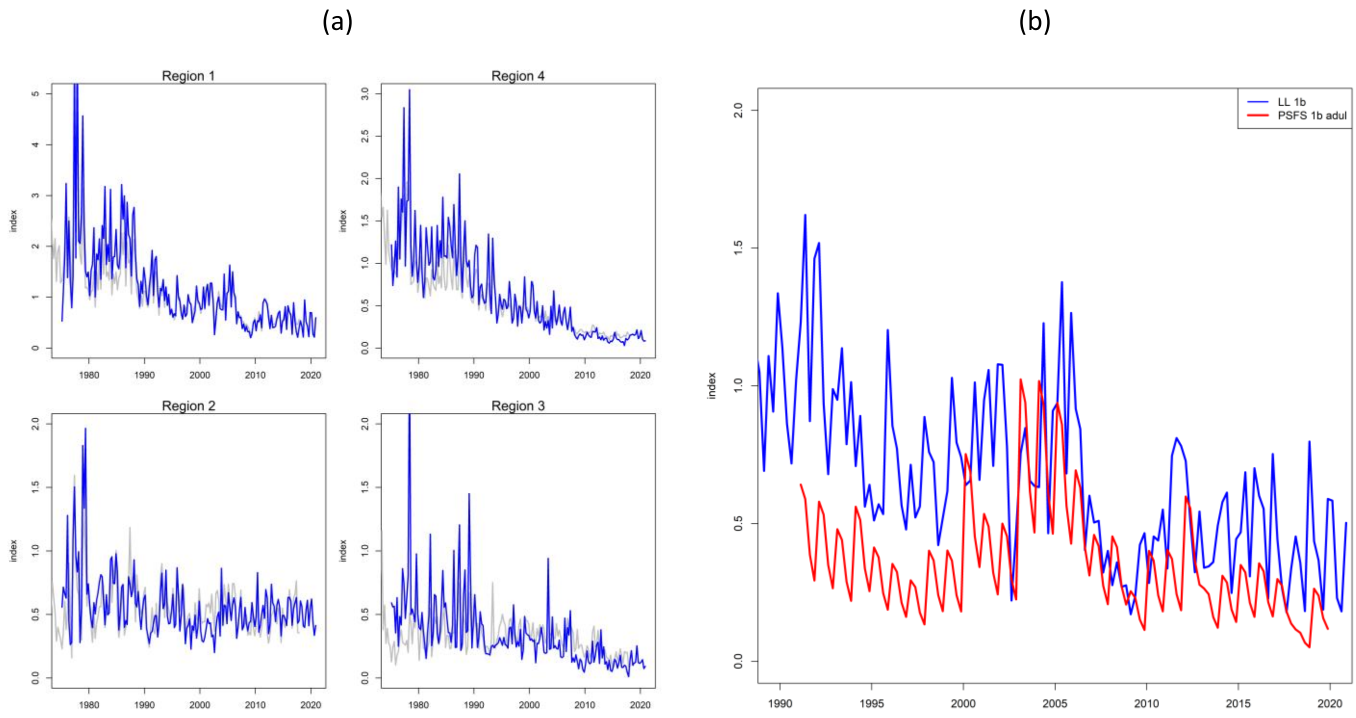

Fig 5. Standardised CPUE indices used in the final assessment models: (a) Joint longline CPUE indices by region 1975-2020 (The grey lines are indices used in 2018 assessment 1972 – 2017), and (b) EU Purse seine free school CPUE on adults (≥10 kg) (overlaid with the longline CPUE in region 1

TABLE 3. Yellowfin tuna: Stock synthesis assessment Kobe II Strategy Matrix. Probability of violating the MSY-based target (top) and limit (bottom) reference points for constant catch projections (relative to the catch level from 2020 -40%, - 30%, -20%, -10%, 0%, +10%, +20%) projected for 3 and 10 years

Alternative catch projections (relative to the catch level from 2020) and probability of violating MSY-based target reference points ($SB_{targ} = SB_{MSY}$; $F_{targ} = F_{MSY}$)							
Reference point and projection timeframe	60%	70%	80%	90%	100%	110%	120%
$SB_{2023} < SB_{MSY}$	0.45	0.56	0.68	0.74	0.76	0.82	0.88
$F_{2023} > F_{MSY}$	0.13	0.30	0.53	0.63	0.72	0.82	0.91
$SB_{2030} < SB_{MSY}$	0.1	0.33	0.54	0.76	0.93	0.99	1
$F_{2030} > F_{MSY}$	0.07	0.31	0.49	0.69	0.84	0.97	0.99
Alternative catch projections (relative to the catch level from 2020) and probability of violating MSY-based limit reference points ($SB_{lim} = 0.4\ SB_{MSY}$; $F_{Lim} = 1.4\ F_{MSY}$)							
Reference point and projection timeframe	60%	70%	80%	90%	100%	110%	120%
$SB_{2023} < SB_{Lim}$	0	0	0	0.05	0.07	0.1	0.16
$F_{2023} > F_{Lim}$	0.03	0.11	0.25	0.43	0.52	0.63	0.78
$SB_{2030} < SB_{Lim}$	0	0	0.01	0.18	0.64	1	1
$F_{2030} > F_{Lim}$	0.02	0.19	0.33	0.60	0.78	0.98	0.98

APPENDIX VII
WORKING PARTY ON TROPICAL TUNAS PROGRAM OF WORK (2023–2027)

The following is the Draft WPTT Program of Work (2023–2027) and is based on the specific requests of the Commission and Scientific Committee. 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 tropical tuna species in the Indian Ocean.

Topic in order of priority	Sub-topic and project	TIMING				
		2023	2024	2025	2026	2027
Stock assessment priorities	Address the issues identified as priorities by the yellowfin tuna peer review panel (February 2023)					
CPUE standardisation	Develop standardised CPUE series for each tropical tuna fleet/fishery for the Indian Ocean • Review period where stock was assessed as being overfished without experiencing overfishing. • Regional scaling parameters • Effect of piracy on CPUE after piracy period					
Fisheries impact analysis	Impact of individual fisheries on stock parameters					

Other Future Research Requirements (not in order of priority)						
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.					
	1.1.1 Population genetic analyses to decipher intraspecific connectivity, levels of gene flow, genetic divergence and effective population sizes based on genome-wide distributed Single Nucleotide Polymorphisms (SNPs).					

	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 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.					
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.					
	2.1.2 Collect gonad samples from tropical tunas to confirm the spawning periods and location of the spawning area that are presently hypothesized for each tropical tuna species.					
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 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					
		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.					
		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.					
		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.					
		Bigeye tuna: High priority fleets					
		Skipjack tuna: High priority fleets					
		Yellowfin tuna: High priority fleets					
		4.1.5 Gillnet CPUE standardization including further investigate and use of gillnet CPUE series from Sri Lankan gillnet fishery					
		4.1.6 Workshops to assist in standardising CPUEs for tropical tuna fleets					
		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).					
		4.3 Investigate the potential to use the Indian longline survey as a fishery-independent index of abundance for tropical tunas.					
5	Stock assessment / stock indicators	5.1 Develop and compare multiple assessment approaches to determine stock status for tropical tunas 5.2 Scoping of ongoing age composition data collection for stock assessment					

	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).					
6 Fishery 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. 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). Used when assessing tropical tuna stock status and when establishing the Kobe plot and Kobe matrices					

8	Fisheries Independent Monitoring	8.1 Use of Close Kin Mark Recapture (CKMR) methods to study fishery independent methods of generating spawner abundance estimates based on genotyping individuals to a level that can identify close relatives (e.g. parent-offspring or half-siblings). 8.2 Plan for a staged approach for implementation of a YFT CKMR project					
9	Fisheries Indicators	9.1 Examination of additional fisheries indicators and their discussion at WP meetings. Perhaps a section in report to accommodate these. See how this is being addressed in other RFMOs.					
10	Peer review	10.1 Plan and ToRs for a peer review to be presented to the SC					

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

Species	2023	2024	2025	2026	2027
Bigeye tuna	Indicators	Indicators **MP to be run**	**Data preparatory meeting** **Full assessment**	Indicators	Indicators
Skipjack tuna	**Data preparatory meeting** **Full assessment**	Indicators	Indicators	**Data preparatory meeting** **Full assessment**	Indicators
Yellowfin tuna	External Review of 2021 Assessment	**Data preparatory meeting** **Full assessment**	Indicators	Indicators	**Data preparatory meeting** **Full assessment**

APPENDIX VIII

CONSOLIDATED RECOMMENDATIONS OF THE 24TH SESSION OF THE WORKING PARTY ON TROPICAL TUNAS

Note: Appendix references refer to the Report of the 24th Session of the Working Party on Tropical Tunas (IOTC–2022–WPTT24–R)

Bigeye Tuna Management Procedure

WPTT24.01 (para. 74): The WPTT **NOTED** that the authors also presented the key data inputs to the MP and the calculation of the TAC. The WPTT **NOTED** that the application of the bigeye management procedure resulted in a recommended TAC of 80,583t per year for 2024 and 2025; which requires a 15% catch reduction from the 2021 catch level. The WPTT **RECOMMENDED** that the SC endorse the TAC advice from the MP.

WPTT24.02 (para. 75): The WPTT also **NOTED** that the paper reviewed evidence for exceptional circumstances as per Resolution 22/03. The review covered information pertaining to i) new knowledge about the stock, population dynamics or biology, ii) changes in fisheries or fisheries operations, iii) changes to input data or missing data, and iv) inconsistent implementation of the MP advice. The WPTT **NOTED** that bigeye stock assessment in 2022 did not provide any new or conflicting information about population trends or stock status and that changes in the data used in the CPUE standardisation, a new growth curve and an alternative natural mortality scenario used in the 2022 stock assessment models were not considered as exceptional circumstances that require changes in the recommended TAC. The WPTT **RECOMMENDED** that based on the review of evidence for exceptional circumstances, the SC should endorse the finding that no reasons to change the advice on TAC were identified.

WPTT24.03 (para. 77): Given the lack of effective catch limits implementation in the IOTC in the past, the WPTT strongly **RECOMMENDED** that the SC advice the Commission to ensure effective implementation of the bigeye management procedure recommended TAC.

Revision of the WPTT Program of Work (2023–2027)

WPTT24.04 (para. 109): The WPTT **RECOMMENDED** that the SC consider and endorse the WPTT Program of Work (2023–2027), as provided in Appendix VII.

Date and place of the 25th and 26th Sessions of the WPTT (Chair and IOTC Secretariat)

WPTT24.05 (para. 112) The WPTT **NOTED** that the global Covid-19 pandemic has resulted in international travel being almost impossible and with no clear end to the pandemic in sight, it was impossible to finalise arrangements for the meeting in 2022. The Secretariat will continue to liaise with CPCs to determine their interest in hosting these meetings in the future as the SC is encouraging a return to physical meetings in 2023. The WPTT **RECOMMENDED** the SC consider late October 2023 as a preferred time period to hold the WPTT24 meeting in 2023.

Review of the draft, and adoption of the report of the 24th session of the WPTT

WPTT24.06 (para. 114): The WPTT **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPTT24, provided at Appendix VIII, 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 2021 (Figure 1):

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

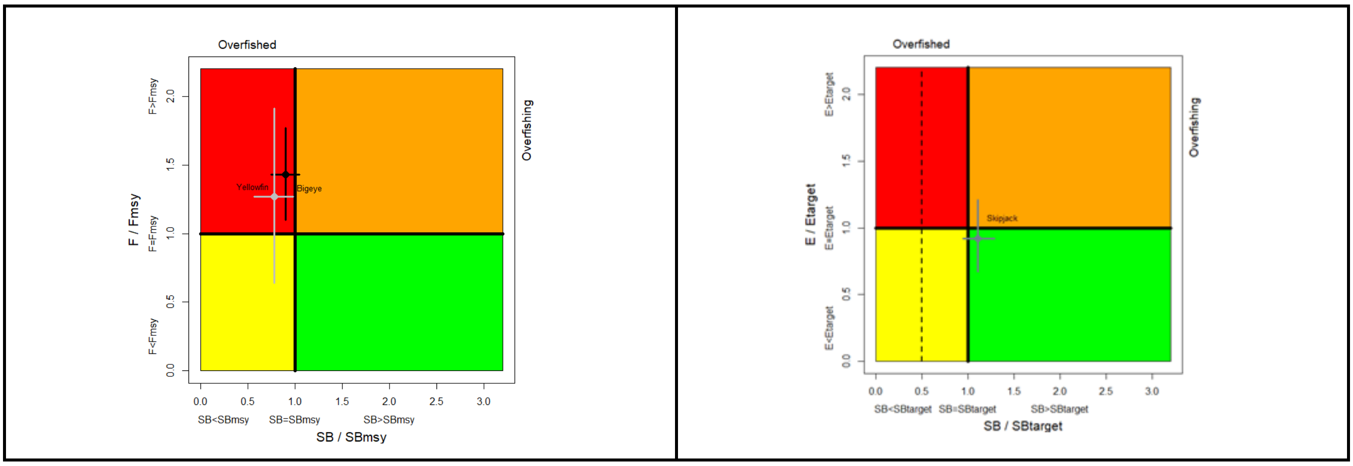

Figure 1. (Left) Combined Kobe plot for bigeye tuna (black: 2022), and yellowfin tuna (grey: 2021) showing the estimates of current stock size (SB) and current fishing mortality (F) in relation to optimal spawning stock size and optimal fishing mortality. (Right) Kobe plot for skipjack tuna showing the estimates of the current stock status (The dashed line indicates the limit reference point at 20%SB0). Cross bars illustrate the range of uncertainty from the model runs with a 80% CI.