Report of the 25th Session of the IOTC Working Party on Tropical Tunas

San Sebastian, Spain, 30 October - 4 November 2023

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ACRONYMS

aFAD	anchored Fish Aggregating Device
ASAP	Age-Structured Assessment Program
ASPIC	A Stock-Production Model Incorporating Covariates
ASPM	Age-Structured Production Model
B	Biomass (total)
BDM	Biomass Dynamic Model
BET	Bigeye tuna
B_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
dFAD	drifting Fish Aggregating Device
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**).

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EXECUTIVE SUMMARY

The 25th Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Tropical Tunas (WPTT), was held at San Sebastian, Spain from 30 October - 4 November 2023. 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 91 participants attended the Session (cf. 113 in 2022, 108 in 2021 and 111 in 2020). The list of participants is provided at Appendix I.

The following are the recommendations from the WPTT25 to the Scientific Committee, which are provided at Appendix VIII.

Skipjack tuna Stock Assessment

WPTT25.01 (para. 87): NOTING the substantial contribution of gillnet fisheries to the total catches of skipjack tuna and the limitations of the purse seine and pole and line indices of skipjack tuna abundance, the WPTT **RECOMMENDED** the SC to develop and implement a workshop on gillnet CPUE, with a major focus on the fleets from I.R. Iran and Sri Lanka, to potentially complement and corroborate the PS and PL CPUE.

WPTT25.02 (para. 96): The WPTT **RECALLED** that IOTC Resolution 21/03, which superseded Resolution 16/02 requires the skipjack tuna stock assessment estimates to be used to as inputs for the Harvest Control Rule (HCR) to calculate the TAC. The WPTT **RECOMMENDED** that the SC endorse the stock assessment and that the median estimates from the model ensemble are used to calculate the TAC for skipjack tuna for 2024-2026 (The TAC calculated using the stock assessment is 628 605 t).

Other tropical tuna

WPTT25.03 (para. 124): The WPTT **RECOMMENDED** that purse seiner observer data protocols include the need to collect FOB material and construction characteristics and that protocols for that collection are harmonized among PS CPCs and adopted by IOTC WPDCS.

WPTT25.04 (para. 138): The WPTT ENCOURAGED interested CPCs to complement ISSF-data and provide sale data information to the IOTC Secretariat under strict confidentiality agreements. In this regard, the WPTT **RECOMMENDED** that external consultancy be made available to IOTC to carry out this analysis under the supervision of the IOTC Secretariat and included in the WPTT program of work.

WPTT25.05 (para. 161): The WPTT NOTED that the yellowfin assessment model has evolved over time, with significant contributions from the independent expert to the model's initial and subsequent design and formulation. The WPTT also NOTED that there are a number of intricate problems with the model's input data, structure, and dynamics. Solving these problems calls for a collaborative approach that synthesises a wide range of expertise, as well as the expert's in-depth historical knowledge. Therefore, the WPTT **RECOMMENDED** that the independent expert continue to be engaged in the enhancement and further development of the yellowfin assessment, with an emphasis on implementing the external review's recommendations.

Revision of the WPTT Program of Work (2024–2028)

WPTT25.06 (para. 208): The WPTT **RECOMMENDED** that the SC consider and endorse the WPTT Program of Work (2024–2028), as provided in Appendix VII.

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

WPTT25.07 (para. 216) The Secretariat will continue to liaise with CPCs to determine their interest in hosting these meetings in the future. The WPTT RECOMMENDED the SC consider late October 2024 as a preferred time period to hold the WPTT26 meeting in 2024.

Review of the draft, and adoption of the report of the 25th session of the WPTT

WPTT25.08 (para. 218): The WPTT **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPTT25, 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 2023 (Figure 1):

- Bigeye tuna (*Thunnus obesus*) – Appendix IV

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

The WPTT also **RECOMMENDED** the SC consider removing from the YFT management advice, references to catch reductions required for rebuilding YFT by 2023

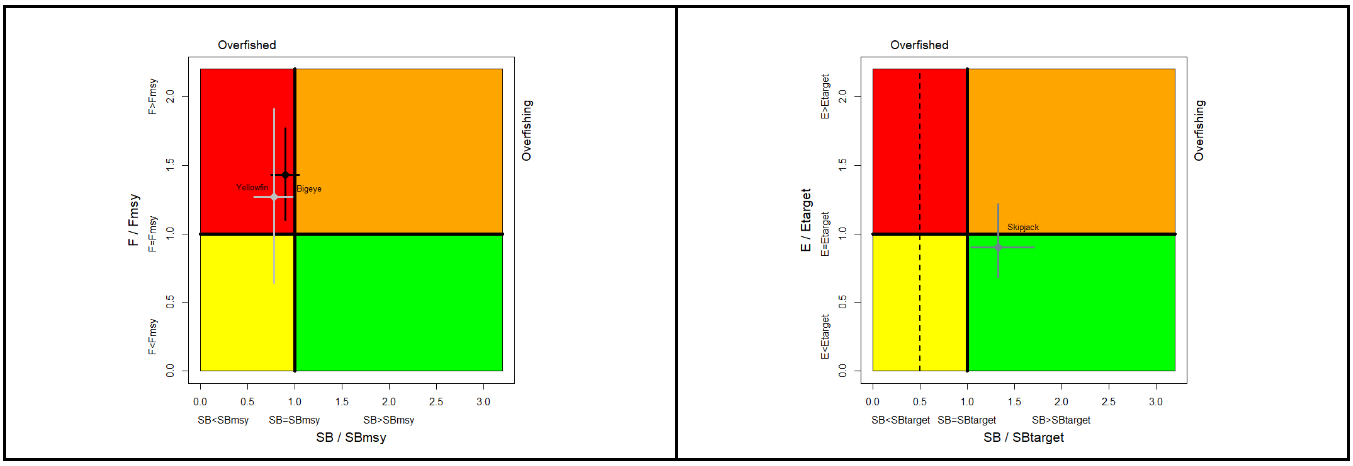

Figure 1. (Left) Combined Kobe plot for bigeye tuna (black: 2022), and yellowfin tuna (grey: 2021) showing the estimates of current stock size (SB) and current fishing mortality (F) in relation to optimal spawning stock size and optimal fishing mortality. (Right) Kobe plot for skipjack tuna showing the estimates of the current stock status (dark grey: 2023). 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		2015	2016	2017	2018	2019	2020	2021	2022	2023	Advice to the Commission
Bigeye tuna *Thunnus obesus*	Catch in 2022 (MT) Average catch 2018–2022 (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)	102,266 92,687 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%**		No new stock assessment was carried out in 2023 and so the advice is based on the 2022 assessment. 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 2022 (MT): Average catch 2018-2022 (MT): $E_{40\%SSB0}$ (MT)**: SB_0 (MT) SB_{2022} (MT) SB_{2022} / SB_0 SB_{2022} / $SB_{40\%SB0}$ SB_{2022} / $SB_{20\%SB0}$ SB_{2022} / SB_{MSY} F_{2022} / F_{MSY} F_{2022} / $F_{40\%SB0}$ MSY (MT)	666 408 613 061 0.55 (0.48–0.65) 2 177 144 (1 869 035–2 465 671) 1 142 919 (842 723–1 461 772) 0.53 (0.42–0.68) 1.33 (1.04–1.71) 2.67 (2.08–3.42) 2.30 (1.57–3.40) 0.49 (0.32–0.75) 0.90 (0.68–1.22) 584 774 (512 228–686 071)			**47%**			**60%**			**70%**	A new stock assessment was carried out for skipjack tuna in 2023 using Stock Synthesis with data up to 2022. The outcome of the 2023 stock assessment model is more optimistic than the previous assessment (2020) despite the high catches recorded in the period 2021-2022, which exceeded the catch limits established in 2020 for this period. The final assessment indicates that: (1) The stock is above the adopted target for this stock (40%SB0) and the current exploitation rate is below the target exploitation rate. Current spawning biomass relative to unexploited levels is estimated at 53%. (2) The spawning biomass remains above SBMSY and the fishing mortality remains below FMSY with a probability of 98.4 %. (3) Over the history of the fishery, biomass has been well above the adopted limit reference point (20%SB0). Subsequently, based on the weight-of-evidence available in 2023, the skipjack tuna stock is determined to be not overfished and not subject to overfishing. The catch limit calculated applying the HCR specified in Resolution21/03 is [628, 605t] for the period 2024-2026. 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 in recent years and a higher stock level relative to the target reference point, possibly due to skipjack life history characteristics and favourable environmental conditions. <Click here for full stock status summary>
Yellowfin tuna *Thunnus albacares*	Catch in 2022 (MT) Average catch 2018–2022 (MT) MSY (1000 MT)(80% CI)) F_{MSY} (80% CI) SB_{MSY} (1000 MT) (80% CI) F_{2020} / F_{MSY} (80% CI) SB_{2020}/ SB_{MSY} (80% CI) SB_{2020} / SB_0 (80% CI)	410,332 429,421 349 (286–412) 0.18 (0.14–0.21) 1,333 (1,018–1,648) 1.32 (0.68–1.95) 0.87 (0.63–1.10) 0.31 (0.24–0.38)		**68%**		**94%**			**68%**			No new stock assessment was carried out for yellowfin tuna in 2023 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>
Stock	**Indicators**		**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**Advice to the Commission**

Bigeye tuna *Thunnus obesus*	Catch in 2022 (MT) Average catch 2018–2022 (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)	102,266 92,687 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%**		No new stock assessment was carried out in 2023 and so the advice is based on the 2022 assessment. 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>
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Yellowfin tuna *Thunnus albacares*	Catch in 2022 (MT) Average catch 2018–2022 (MT) MSY (1000 MT)(80% CI)) F_{MSY} (80% CI) SB_{MSY} (1000 MT) (80% CI) F_{2020} / F_{MSY} (80% CI) SB_{2020}/ SB_{MSY} (80% CI) SB_{2020} / SB_0 (80% CI)	413,679 430,089 394 (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 2023 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 25th Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Tropical Tunas (WPTT), was held in San Sebastian, Spain from 30 October - 4 November 2023. 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 91 participants attended the Session (cf. 113 in 2022, 108 in 2021 and 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 WPTT25 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. The WPTT **NOTED** paper IOTC-2023-WPTT25-04 which provided the main outcomes of the 27th Session of the Commission specifically related to the work of the WPTT.

4. The WPTT **NOTED** (IOTC-2023-S27-R):

   *(Para 23) The Commission **ENQUIRED** as to the status of the report from the recently conducted YFT stock assessment external peer review workshop that was held in February 2023. The SC Chair explained that the report was currently being finalised by the expert panel and would be presented to the WPTT in October. Feedback will be provided to the Commission once the SC has been able to review the expert panel's recommendations. The SC Chair further clarified that the expert panel's recommendations would be used to improve future YFT stock assessments as well as guide future planning for YFT work.*

   *(Para 24) The Commission **NOTED** that the SC was currently prioritising single species MSEs as there was a need to provide robust management advice on a species-by-species basis. However, the SC is also looking into the possibility of developing a multi-species MSE for tropical tunas, considering the nature of the tropical tuna fishery. In addition, the feasibility of incorporating environmental factors and climate change into the MSEs is being assessed.*

5. The WPTT were **INFORMED** that the Commission adopted 9 proposals as Conservation and Management Measures (consisting of 8 Resolutions and 1 Recommendations) in addition to the 2 Resolutions adopted at the Special Session held in February 2023.

6. The WPTT **NOTED** that Resolution 23/02 *On Management of Drifting Fish Aggregating Devices (DFADs) in the IOTC area of competence* will not come into force due to the number of objections received from CPCs.

3.1 Data available at the Secretariat

7. The WPTT **NOTED** papers IOTC–2023–WPTT5–03.1 and IOTC–2023–WPTT25–03.2 which provide a review of the statistical data and fishery trends for tropical tunas and skipjack tuna (respectively), as received by the IOTC Secretariat for the period 1950–2022. The papers cover data on retained catches, catch and effort, size-frequency, and observations at sea performed by scientific observers, and provide a range of fishery indicators, including catch and effort trends and (estimated) average weights for fisheries catching skipjack tuna in the IOTC area of competence.

8. The WPTT **ACKNOWLEDGED** that the information presented includes data for the statistical year 2022 which was received by the Secretariat at various stages after the deadline of 30 June 2023.

9. 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.

10. The WPTT further **NOTED** how statistical data from several important fleets / fisheries for the year 2022 were either reported very late (in some cases just a few days prior to the meeting) or not yet reported, and for this reason **URGED** all concerned CPCs to ensure that future statistical data submissions are provided to the Secretariat according to the deadlines.

11. The WPTT **NOTED** how total catches of tropical tuna from the Indian Ocean have been consistently increasing in recent years, and rank second overall in terms of magnitude across all oceans.

12. Also, the WPTT **ACKNOWLEDGED** how Indian Ocean catches were mostly reported by industrial fisheries (65% of annual totals from vessels >24m LoA) with the recent exception of 2020, when their contribution was lower due to the onset of the CoViD pandemic.

13. The WPTT **NOTED** the peculiarity, in terms of tropical tuna species composition, of the six major fishery groups operating in the Indian Ocean, i.e., longline, purse seine (including coastal purse seines and ringnets), line, gillnet, baitboat, and fisheries using all other gears, and **ACKNOWLEDGED** that skipjack tuna represents the primary species for purse seines, baitboats, and gillnet fisheries, while the species is basically absent from longline fisheries except for the gillnet-longline fisheries of Sri Lanka until 2013.

14. The WPTT also **NOTED** the constant increase in catches of tropical tunas from line fisheries (which include vessels using handlines, coastal longlines, and troll lines) which are now the second largest fisheries in the Indian Ocean after purse seines.

15. In terms of fleets contributing the most to captures of tropical tunas, the WPTT **ACKNOWLEDGED** that almost two thirds (64%) of average annual catches between 2018 and 2022 were accounted for by five fleets, namely Indonesia, EU,Spain, Maldives, Seychelles, and I.R. Iran, with different fisheries contributing to the totals depending on the fleet concerned.

16. The WPTT **NOTED** how in the same period (2018-2022) annual catches from purse seine, gillnet, and baitboat fisheries initially declined before recovering while line and longline fisheries catch increased before later declining.

17. The WPTT **NOTED** that purse seine fisheries, including those operating in coastal waters and using ringnets, are contributing the most to catches of tropical tuna species, and that fleet-specific trends are generally declining within this category, except for Indonesia - whose purse seine catches reached a peak level at almost 130,000 t in 2022.

18. The WPTT **NOTED** that catches on FOB-associated schools from the purse seine fisheries of EU,Spain have decreased to around 110,000 t in 2022, from a peak of almost 200,000 t in 2018, and that this is mostly due to the interim yellowfin tuna rebuilding plan.

19. In terms of main fishing modes, the WPTT **ACKNOWLEDGED** that skipjack tuna continues to be caught mostly on FOB-associated schools, whereas a still significant fraction of bigeye tuna and yellowfin tuna is still caught with purse seines on free-swimming schools.

20. The WPTT **NOTED** with concern that size-frequency data for tropical tunas are still lacking in terms of overall quality and availability, and that several fleets (including some industrial ones) do not reach the minimum level of sampling of one fish measured per metric tonne of catch, as required by Res. 15/02.

21. Furthermore, the WPTT **ACKNOWLEDGED** that the IOTC databases still contain a mix of *raw* and *raised* size-frequency data, and that the Secretariat is actively liaising with data providers to ensure both types of data (including historical time series) are submitted to the Secretariat.

22. The WPTT **NOTED** that only raised size-frequency samples are available for some fleets, which makes it impossible to determine sampling coverage and for assessing the compliance with the target sampling of 1 fish per metric tonne, and **RECALLED** the need for raw samples to be reported from all fisheries.

23. **NOTING** the large interannual variability observed in the size-frequency data reported for skipjack tuna caught on free-swimming schools in the Maldivian baitboat fishery between 2013 and 2022, the WPTT **REQUESTED** the Secretariat to work in collaboration with Maldives and analyse the size-frequency data available from scientific observers deployed on Maldivian baitboats.

24. The WPTT **RECALLED** the availability of revised ROS data reporting forms for pole-and-line and **REQUESTED** that future observer data be submitted using these forms

25. The WPTT **ACKNOWLEDGED** the improvements made by Indonesia regarding the breakdown of their fisheries into *industrial* and *coastal* in the IOTC sense, **NOTING** the undergoing efforts to provide a comprehensive re-estimation of historical catches by fishery and species for the years 2010-2021.

26. The WPTT **NOTED** with concern the significant increases in catches of bigeye tuna between 2021 and 2022, which are in contrast with the advice from the latest stock assessment requesting a reduction in total catches for the species and are well above the TAC adopted for 2024 & 2025 from the bigeye tuna MP (Res. 23/04).

27. The WPTT **RECALLED** the sudden recent increases in catches of yellowfin tuna from the handline fishery of Oman, while further **NOTING** that FAO has also recorded increased catch of other species in some Omani fisheries.

28. The WPTT **ACKNOWLEDGED** that the Secretariat has initiated discussions with Oman regarding the possibility of delivering a technical mission to the country and **NOTED** that this mission will have the purpose of better understanding the national data collection systems and determine if the detected trends in catch time series are due to initial under-estimations or other causes.

29. The WPTT **WELCOMED** this initiative as the review of the yellowfin tuna stock assessment identified the major increase in catches observed in the handline fishery of area R1 as inconsistent with the time series of relative abundance derived from longline fisheries in that area.

30. The WPTT **NOTED** the contraction of the deep-freezing longline fisheries in the western Indian Ocean and the activities of the fresh longline fishery eastern Indian Ocean, **AGREEING** that it might be useful to explore development of standardise CPUE indices from this latter component to provide information on abundance to the model.

31. The WPTT **NOTED** the continued issues in the reporting of geo-referenced catches, efforts, size-frequencies, and FAD-related data from the purse seine fishery of EU-Italy, **ACKNOWLEDGING** that the data have been consistently collected by IRD since 2003 and that the lack of submissions to the Secretariat is due to administrative issues. The WPTT **URGED** the EU Commission to make the necessary arrangements for all historical data to be reported to the Secretariat as soon as possible.

32. The WPTT **ACKNOWLEDGED** that EU,Spain has re-submitted historical purse seine catches for the statistical year 2018, and that these only marginally differ with what provided in 2019, while remaining still substantially different from the estimates performed by the IOTC Secretariat using data from proxy fleets and years (e.g., IOTC-2019-WPDCS15-10_Rev2).

33. **NOTING** how in the Atlantic pole and line catches of bigeye tuna are substantial, the WPTT **QUERIED** about the limited catch of bigeye tuna reported in the Maldivian baitboat fishery. The WPTT **NOTED** that past estimates of the species composition of the catch made throughout the Regional Tuna Tagging Programme indicated that the contribution of bigeye tuna was in the range

3-5% and **ACKNOWLEDGED** Maldives' explanation that their pole and line fisheries operate on free-swimming schools and target large skipjack tuna, and that therefore less bigeye tuna are caught. The WPTT further **NOTED** the suggestion to look at the historical pole and line data to better understand the yellowfin and bigeye tuna catch taken on FADs and free schools, given the importance of CPUE for assessments from that sector.

34. The WPTT **NOTED** how the fraction of skipjack tuna caught by artisanal fisheries (from vessel <24 m LoA) in recent years reached annual levels of around 200,000 t, i.e., almost 30% of total catches for the species.

35. The WPTT **NOTED** the mode appearing at 30 cm fork length in the estimated size distribution of data for individuals caught by all other gears combined (see IOTC-2023-WPTT25(AS)-DATA14_Rev3 for details of 'other' gears), and that this indicates how most of the fish caught by these fisheries would be considered as immature.

36. The WPTT further **NOTED** that it could not be elucidated whether those fish were caught on anchored FADs as most of these small skipjack tunas were reported from Indonesian coastal fisheries for which information on fishing mode has not been reported to the Secretariat, possibly due to the absence of mandatory logbooks for vessels less than 5 GT.

37. The WPTT also **ACKNOWLEDGED** how the observed patterns in the catch-at-size data are the result of a re-estimation process implemented by the Secretariat using spatio-temporal and fleet proxies to account for the paucity of information provided by all concerned CPCs, and that for this reason they may not be fully representative of the fisheries for which they are estimated.

38. The WPTT **NOTED** how information on school association for the geo-referenced catch and effort dataset of skipjack tuna is generally missing for all fisheries other than industrial purse seines, while the same information is available in the size-frequency dataset for the baitboat fishery of Maldives since 2012.

39. **ACKNOWLEDGING** the differences in species composition across fishing modes in the Maldivian baitboat fishery, and the unavailability of information on fishing mode in the geo-referenced catch and effort data reported by Maldives to the IOTC Secretariat, the WPTT also **REQUESTED** Maldives to assess the feasibility of re-estimating the composition of the catch of all IOTC species for each fishing mode for the longest time possible.

4. SKIPJACK STOCK ASSESSMENT

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

40. The WPTT **NOTED** paper IOTC–2023–WPTT25–07 on the reproductive biology of skipjack tuna in northeastern Indian Ocean, including the following abstract:

"Skipjack tuna (Katsuwonus pelamis) is a tropical tuna species and has been historically exploited in the south and western parts of Indonesia waters. The objective of this study was to determine the biological reproductive parameters of female skipjack obtained from the Indonesia Fisheries Management Area 572 and 573 (Northeastern Indian Ocean). Samples were collected from the landing site in southern Java and Bali (Cilacap, Kedonganan, and Benoa), and western Sumatra (Lampulo, Sibolga, and Padang). Catches come from various gears such as handline, purse seine, lift net, and longline. Samples were collected during 2018-2021 and a total of 400 ovaries were obtained from fish with the length ranged between 28.3 - 72 cm FL. The size at first maturity (Lm50) of female skipjack in the northeastern Indian Ocean was 38.2 cm FL. The estimated mean batch fecundity was 0.29±0.18 million oocytes (n=11),

and the mean relative batch fecundity was 107.11±29.26 oocytes/gr. The peak spawning 3 season of skipjack tuna occurred between September and February, spawning every 1.82 days within the spawning period."

41. The WPTT **ACKNOWLEDGED** the work that was presented and **ENCOURAGED** the authors to continue the biological sampling program routinely to ascertain the reproductive biology of skipjack tuna.

42. The WPTT **NOTED** that samples were collected by different gears that may operate in different seasons and areas, with different selectivity, that could impact the estimation of spawning peak and, thus, the WPTT **SUGGESTED** the authors to further investigate possible differences of peak spawning season due to differential seasonal/area fishery operations.

43. The WPTT **WAS INFORMED** of an ongoing reproductive study for skipjack tuna in the western and central Indian Ocean and **NOTED** the possibility of a joint study to have a better understanding of the skipjack tuna reproduction in the Indian Ocean and whether regional differences in reproduction exist.

44. The WPTT **NOTED** paper IOTC–2023–WPTT25–10 on an Evolution of age determination methods for three tuna species, including the following abstract:

"*The age-based stock assessment model is the primary model used in current research on tuna stock assessment. The accuracy of age identification has a direct impact on the development of the stock assessment models. The specific application of age-identification methods for tuna varies widely across species, oceans, and historical periods, however, most methods use hard parts to infer age. There is currently no research on the development and evolution of tuna age-identification methods. Based on literature review, we used the Multinomial Logistic Regression (MLR) model to examine the differences of tuna age identification methods across species, oceans, and historical periods. We found that otoliths and dorsal fin spines analyses were most commonly used in the Pacific Ocean and the Indian Ocean than the Atlantic Ocean. Compared to albacore tuna (Thunnus alalunga), otoliths analysis was more frequently used to age bigeye tuna (Thunnus obesus) and yellowfin tuna (Thunnus albacares). As aging procedures advanced, fin spines and otoliths became the main aging materials. It is recommended that age and growth studies in the Indian Ocean should be intensified, especially for albacore tuna*".

45. The WPTT **SUGGESTED** a comparative analysis using different hard structures for each species to evaluate if there is a persistent difference in terms of age-length estimation depending on the structure.

46. The WPTT **NOTED** paper IOTC–2023–WPTT25–22 on the environmental signal in skipjack recruitment in the Indian Ocean, including the following abstract:

"A study presented at the WPTT25-Data Preparatory meeting investigated the link between interannual changes in ocean productivity and skipjack recruitment in the Indian Ocean fishery, using the then available recruitment index series produced by the 2020 skipjack stock assessment, with recruitment data up to 2018. With a new recruitment time series produced by the 2023 assessment (until 2021), we redid the analysis both in the western region of the Indian Ocean, and in a large equatorial region stretching from 40°E to 100°E. This new study using the updated recruitment index confirms the main outcome of the previous study i.e. 1) a positive response in recruitment with positive anomalies of sea surface chlorophyll (SSC) which are associated to negative Indian Ocean Dipoles; 2) a less marked response, though towards slightly reduced recruitment, in situations of negative SSC associated to positive Indian Ocean Dipoles. Such responses in recruitment can make a valuable ancillary information in the setting of a management advice for skipjack at the IOTC"

47. The WPTT **ACKNOWLEDGED** this analysis which is particularly important to provide information on environmental drivers in skipjack tuna recruitment and abundance that could also inform the provision of management advice for the coming years.

48. The WPTT **NOTED** that recruitment deviate trends are not identified in all scenarios included in the last skipjack tuna stock assessment grid. For skipjack tuna, across the time series for a single scenario, the recruitment deviates are homogeneously distributed and are not showing significant trends like in YFT where there are positive/negative trends in most scenarios.

49. The WPTT **NOTED** that the skipjack tuna stock assessment uses purse seine and pole-and-line CPUE as a main driver of abundance which is mostly an index signalling yearly recruitment and, thus, it reassures that the CPUE and stock assessment follow the environmental forces and relationships that have been presented in the paper.

50. The WPTT **NOTED** that we are moving towards a lower productivity period in 2023-2024 and, therefore, the WPTT **SUGGESTED** to closely monitor the catch rates in 2023 as soon as possible to check if the low productivity period affects the catches of 2023 and 2024.

51. The WPTT **QUERIED** whether the vertical distribution of prey is affected by the anomalies in chlorophyll associated with differences in the Indian Ocean Dipole (IOD), which will affect the catchability of the fleet if preys are deeper. The WPTT **NOTED** that the IOD also affects the mixed layer depth (MLD) which could be a proxy for the catchability of skipjack tuna due to differential depth accessibility.

52. The WPTT **NOTED** that although there isn't a set procedure in place to include environmental information into management recommendations, this kind of information has historically been given in an executive summary of skipjack tuna. The WPTT also **NOTED** that there would not be projections where this information could be integrated due to the implementation of the Harvest Control Rule for skipjack tuna but agreed to provide qualitative statements of environmental drivers in the executive summary of skipjack tuna as required by Resolution 22/01 on Climate Change.

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

53. The WPTT **NOTED** Paper IOTC–2023–WPTT25–06 which provided the effort standardization of Skipjack tuna in tuna drift gillnet fishery in Sri Lanka, including the following abstract:

> "*Large meshed drift gillnets are widely used in the tuna fishery in Sri Lanka and the key target species for this gear is Skipjack tuna. The fishery conducted by this gear is characterized by the inboard engine fishing vessels, relatively longer fishing trips, use of supplementary fishing gear with gillnets, and harbour-based landings of multispecies catches. The present study was undertaken to standardize the catch per unit effort (CPUE) of skipjack tuna in the tuna drift gillnet fishery in Sri Lanka. Ten years of port sampling data (2013- 2022) were used for the CPUE standardization. A delta-lognormal model comprising a Gaussian-based Generalized Linear Model (GLM) for positive catch rates and a Bernoulli-based GLM for binary data of skipjack tuna was used for the CPUE standardization. The explanatory variables considered for the study include year, month, vessel category, gear used, number of net panels used, trip duration, gear setting time, and fishing area. All variables except the "fishing area" in Gaussian-based GLM were significant at 0.01 level. The abundance index of skipjack tuna is largely influenced by the "vessel category", "gear" and "year" variability. A remarkable variation in the annual abundance index was observed during the studied period. A similar standardized CPUE series obtained for an extended period could perhaps be beneficial in the future when stock assessments of skipjack tuna in the Indian Ocean are conducted*".

54. The WPTT **NOTED** that GPS locations of fishing activity appeared to be bounded at a minimum latitude because all values below the equator were not shown on the map and that the units used for the CPUE are in kg/boat/day. It was suggested that the authors check the latitudinal data in case there is an error in assignment of data below the equator (getting plotted above equator).

55. The WPTT **NOTED** that longline is the most popular gear used along with gillnet. It was clarified that it is not possible to accurately determine which gears specifically contributed to the overall catch and species specific catch each trip but it is assumed that skipjack tuna is almost exclusively caught with gillnets.

56. The WPTT **NOTED** that the large boat class IMUL04 almost exclusively focuses on longline fishing and there are only few data available. Therefore, the WPTT **SUGGESTED** these should be removed from the analysis because they use large mesh panels and catch few skipjack tuna.

57. The WPTT **NOTED** that some vessels can make long fishing trips, up to 45-60 days, and that some of them use many gillnets panels, but that the overall length is below 2.5 km.

58. The WPTT **QUERIED** the possibility of allowing the Secretariat work with Sri Lanka on this dataset including to consider using VMS to model the data on smaller areas, but **NOTED** that it is currently not possible to share data with another party. The WPTT **SUGGESTED** it would be beneficial to explore the possibility of having a workshop for skipjack tuna standardization in the region. The WPTT **NOTED** that it would be better to use length of net as an effort measure than number of panels but the net length information is not available

59. The WPTT **NOTED** paper IOTC–2023–WPTT25–08 which provided an update of CPUE standardization for skipjack tuna from the EU purse-seine fishery on floating objects (FOB) in the Indian Ocean, including the following abstract:

> "*Abundance indices for Katsuwonus pelamis (SKJ) in the Indian Ocean were derived from the European purse seine CPUE series (2010-2021) for fishing operations made on floating objects (FOBs). GAMM and GLMM approach were used to standardize the SKJ catch per floating object set. The GLMM approach has been applied to compare the outputs when using an alternative modelling approach and both approaches have been compared to nominal annual CPUE time series. To account for potential effort creep, additional explanatory variables have been included in the models. FOB sets have been classified to non-followed FOBs (i.e., randomly encounter FOBs for which the purse seiner has no previous information) and followed FOBs with three distinct classes of tracking buoys: without an echosounder, with a one-frequency echosounder and with a two-frequency echosounder.*" – see document for full abstract

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

61. The WPTT **NOTED** that there is strong temporal variability in the long time series, particularly in the early part of the time series. The WPTT **NOTED** that paper IOTC–2023–WPTT25–22 has also shown evidence of environmental forcing as a driver of the variability. The WPTT further **NOTED** the time series is also globally consistent with the pole-and-line series, despite major differences in the way the two fisheries operate and CPUE standardization methodologies .

62. The WPTT **NOTED** that the authors confirmed that there is a large proportion of activities on FADs that are not tracked by the vessels that fish on them, especially early on in the time series.

63. The WPTT **NOTED** that the main source of effort creep is the use of echosounder buoys and dFAD densities as it impacts catch per set over the short time period, both of which are in the model. There are other aspects of effort creep, such as things that alter the number of sets per unit time, but these do not primarily impact catch per set.

64. The WPTT **QUERIED** whether there are other factors that could be impacting perceived abundance, such as density of sets, dFAD time at liberty, and the spatial distribution of deployments (and its relation to size frequency), and if there are better environmental forecast models predicting where to deploy FOBs. The WPTT **NOTED** that (1) the density of sets is not included per se, but density of buoy-equipped FOBs per unit area of ocean is in the model; (2) time at liberty is not in the model, but it is fairly hard to calculate correctly due to changing of buoys attached to objects and the existence of echosounders means that that is not typically the driving factor for fishing as opposed to time at sea; (3) to the author's knowledge, (environmental forecast) models to predict best places to deploy FOBs are not really operational yet and the learning period, at least for the French fleet, for optimizing echosounder gains seems to have been relatively short for 2012-2014 data set.

65. The WPTT **NOTED** that dFADs during its lifetime at sea can be interacted with at multiple times so there is not necessarily a relationship between deployment location and time and the catch in a given set. The WPTT further **NOTED** that PS vessels have access to the echosounder information, thus the estimation of the aggregation underneath, of hundreds of dFADs at any one time so that information seems to be much more important than deployment information at any time. Future work should include local densities of tracked and untracked FOBs to get a handle on the impact of "deployed FOBs" on catch.

66. The WPTT **NOTED** that dFAD densities have been decreasing since 2015, at least from 3FA forms, and that stabilization and decrease is also seen in fine scale buoy trajectory data, but standardization is not just for long term changes in density, but also for local spatio-temporal changes in density.

67. The WPTT **NOTED** that there was a similar increase in skipjack tuna CPUE in the WCPO in recent years and this could be related to change to echosounder buoys (having a common impact on CPUE across oceans). However, it is unlikely that the CPUE increase is entirely due to echosounders for which factors are included in the model to correct for their impact and the increase is similar to that seen in pole-and-line standardized CPUEs, which suggest that such increase is plausible.

68. The WPTT **NOTED** that the 2022 data is not included in the standardization. The work began in early 2023 when 2022 data were not fully validated. For this update, focus was on fixing earlier part of short time series and assessing echosounder effects.

69. The WPTT **QUERIED** why standardisation did not look extensively at changes in the core fishing area over time, but the WPTT **NOTED** that there are no major changes outside of those imposed by Somali piracy in the early years and those imposed by COVID later in the time series. However, it was noted that the consequences of Somali piracy are still partially there as there is no longer any fishing in the EEZ of Somalia.

70. The WPTT **NOTED** that the T3-corrected data is the result of smoothing over large areas and therefore could be biasing the impression of changes (or no change) in fishing areas over time. The WPTT **NOTED** further work plan to look at other models for estimating catch composition but one reason not to focus on that this year is that the fraction of catch that is skipjack has a relatively small correction compared to corrections for yellowfin and bigeye.

71. The WPTT **NOTED** paper IOTC–2023–WPTT25–015 which describes recent developments in the Maldives pole and line tuna fishery trends, including the following abstract:

> "*Maldives pole and line fishery primarily targets skipjack and small yellowfin tuna, both from free-swimming and Anchored Fish Aggregating Devices (AFADs). The fishery spans hundreds of years and constituted the main fishery in the Indian Ocean prior to the arrival of the distant water purse seiners and still remains a key fishery in terms of catch volume. Recent years have*

seen notable developments in the fishery in terms of fleet size, catch and effort and its spatial distribution. The mechanized masdhoni (mechanized fishing vessel) fleet, comprising of pole and line and handline vessels, have grown in number from almost 400 in 2010 to 769 in 2021, with the 22.5 – 27.5 m length category observing the most prominent growth. Catch and effort data on the other hand, indicates a 75% decline in pole and line effort in the 2009 – 2014 period and appears to have stabilized more recently. While the fishery operates entirely within the exclusive economic zone (EEZ) of the Maldives, recent data indicates uneven distribution of fishing effort where it is currently more concentrated in the southern and eastern regions than the northern and western areas. In terms of catch composition, skipjack and yellowfin tuna are the most important species with about 80 and 20% being contributed respectively." – see document for full abstract

72. The WPTT **NOTED** that there are periods where availability of live bait is a limiting factor which reduces fishing opportunities for baitboats.

73. The WPTT **NOTED** that skipjack tuna size frequency seems to be lacking large fish in recent years, putting into question the targeting of free schools (FSC) by large boats. The WPTT **NOTED** that FSC targeting occurred mostly in the south. The WPTT **SUGGESTED** further examining the size-frequency data to understand why they are not seeing the larger fish.

74. The WPTT **NOTED** that the number of trips has been used as fishing effort from the start of the fishery, while number of fishing days is used in the later years. As vessels get larger, they incorporate more crew and can go out to carry multi-day fishing.

75. The WPTT **NOTED** that historically, the number of trips was equal to the number of days (1-day trips), but this may no longer be the case. However, observer data (2014-2021) indicate that average time at sea is around 23 hours, so the average trip duration is still not that different than 1 day.

76. The WPTT **NOTED** that there is likely a fairly reasonable relationship between vessel length and number of poles, and vessel length is accounted in CPUE standardisation. But data from 1999 to 2014 likely do not include any information on the numbers of poles.

77. The WPTT **NOTED** that logbooks contain information on the number of poles and crew that could be used to examine the relationship with vessel length. The WPTT further **NOTED** that logbook data also include the number of poles. The WPTT **AGREED** that consistent reporting of pole and line effort for a long time and the issue of effort units should be further discussed at the WPDCS. The WPTT considered that it will be important to seek and ensure a standard and consistency in the unit of effort being reported for the different fishing gears, across fisheries, in order to accurately standardize CPUE.

78. The WPTT **NOTED** that fishers take advantage of any abandoned, discarded or lost dFAD drifting into the zone.

79. The WPTT **NOTED** that observer effort seems more coastal and westward than fishing effort. It was **NOTED** that vessels are randomly selected, so observers cannot control where they end up fishing. Observer trips in the north were largely on the west side of Maldives, whereas in the south trips were more evenly distributed and often south of the Maldives.

80. The WPTT **NOTED** a yellowfin tuna index from the pole and line fishery was available for the last yellowfin tuna stock assessment, and that it was included in the model, but that it seemed to be conflicting with other indices, so it was used in a sensitivity run of the assessment.

4.3 Stock Assessment Result

81.The WPTT **NOTED** paper IOTC–2023–WPTT25–09 describing the preliminary Indian Ocean Skipjack tuna stock assessment 1950-2022 (stock synthesis), including the abstract:

> *"This report summarises a stock assessment for Indian Ocean Skipjack tuna (Katsuwona pelamis) using Stock Synthesis 3 (SS3). The assessment assumed the Indian Ocean skipjack tuna constitute a single stock and is based on a spatially aggregated and seasonally structured model that integrates several sources of fisheries and biological data. The assessment model covers the period 1950–2022 and represents an update and revision of the 2020 assessment model with the inclusion of updated CPUE indices and length composition data. Standardised CPUE series from Maldives Pole and line fleet 1995 – 2022 and EU associated Purse seine sets 1990 – 2021 were included in the models as relative abundance index of exploitable biomass. An additional index based on associative dynamics of skipjack tuna with floating objects was considered as an alternative index for the abundance trend for more recent years (2013–2022). Tag release and recovery data from the RTTP-IO program were included in the model to inform abundance and fishing mortality rates. Several sensitivity models are presented to explore the impact of key data sets and model assumptions."* - See paper for full abstract

82. The WPTT **NOTED** the assessment has no major structural change to the previous assessment and adopted a model ensemble with a total of 36 models to quantify key uncertainties. The estimate of stock status is provided in Table 2.

Table 2. Estimated Status (with 80% CI) of skipjack tuna in the Indian Ocean from the model ensemble

Catch in 2022 (t):	666 408
Average catch 2018–2022:	613 061
MSY (t)	584 774 (512 228–686 071)
$E_{40\%SSB}$	0.55 (0.48–0.65)
SB_0 (t):	2 177 144 (1 869 035–2 465 671)
SB_{2022} (t):	1 142 919 (842 723–1 461 772)
SB_{MSY} (t)	513 831 (369 187–678 936)
SB_{2022}/SB_0 (80% CI):	0.53 (0.42–0.68)
SB_{2022} / $SB_{40\%SB0}$	1.33 (1.04–1.71)
SB_{2022} / $SB_{20\%SB0}$	2.67 (2.08–3.42)
SB_{2022} / SB_{MSY}	2.30 (1.57–3.40)
F_{2022} / $F_{40\%SB0}$	0.90 (0.68–1.22)
F_{2022} / F_{MSY}	0.49 (0.32–0.75)

83. The WPTT **NOTED** that the assessment has explored different options for including available abundance indices. The assessment model initially proposed to include both PL and PSLS indices (because they are broadly consistent) but the model has shown some lack of fits to the PSLS. It was **NOTED** that the model appears to be mainly driven by the PL index even though both sets of indices were equally weighted. The WPTT further **NOTED** that a relatively small CV (10%) is needed to provide a reasonable fit to the indices.

84. The WPTT **NOTED** that the assessment subsequently fit the CPUE index independently, assuming that they represent alternative scenarios of abundance trends. The WPTT **NOTED** that the model can fit the individual CPUE index adequately with a more realistic CV (0.2), although a smaller CV is still required for the PL index to the pass the Run test due to a few extreme values in the time series.

85. The WPTT **NOTED** that when the skipjack assessment initially started, only the PL index was available. In the meantime, EU has developed the PS index through a dedicated workshop and the standardisations methodology has evolved over time to better qualify the effective effort by accounting for factors such as search time, FAD density and the emerging technology.

86. The WPTT **NOTED** that the assumption of hyperstability in the CPUE due to an index based on a surface fishery having access to much information, may not be substantiated, as all fisheries may suffer similar problems including technology creep. However, the WPTT **AGREED** that it is possible that the hyperstability in the purse seine fishery may not have been addressed adequately.

87. **NOTING** the substantial contribution of gillnet fisheries to the total catches of skipjack tuna and the limitations of the purse seine and pole and line indices of skipjack tuna abundance, the WPTT **RECOMMENDED** the SC to develop and implement a workshop on gillnet CPUE, with a major focus on the fleets from I.R. Iran and Sri Lanka, to potentially complement and corroborate the PS and PL CPUE indices.

88. The WPTT **NOTED** that the seasonality in the PSFS length frequencies (larger fish caught in the 3 and 4th quarter) can be better dealt with using season-specific selectivity. However, the WPTT **NOTED** that this made little differences to model results due to the small amount of catch taken on purse seine free schools.

89. The WPTT **NOTED** that there appeared to be a selectivity change around 2000 in the PSLS fishery where the size distribution has become wider (albeit for only a few years). However, this may be due to the change of data handling method that occurred for the French fleet during the period. The WPTT **NOTED** that a similar change also occurred in later years and therefore suggested examining the fine-scale variability using modelling approach for better understanding potential spatial structure of the size data as well as the sampling processes. The WPTT further **SUGGESTED** this should be done in collaboration with the scientists involved in the collection and management of the data collected from the EU and Seychelles fleets.

90. The WPTT **NOTED** that the length frequencies from the Maldivian PL fishery have two distinctive modes, which were known to be associated with different type of fishing mode (smaller fish from FADs and larger fish from free schools). The multimodal distribution had a large impact on the estimated selectivity and the associated fishing mortality for the PL fleet. The WPTT **NOTED** that in more recent years, vessels have been fishing in wider areas and targeting free schools more often but that the change has not been reflected in the sampling distribution which appears to be counter intuitive. The WPTT **NOTED** that sampling from different locations ought to be weighted by the catch to reduce bias and further that length data associated different fishing modes should be treated as different fisheries. However, The WPTT **NOTED** that while the length data has limited information on fishing modes, the catches are currently able to be segregated by fishing modes. The WPTT **REQUESTED** the secretariat worked with the Maldives to update the historical record accordingly.

91. The WPTT **NOTED** that the longline length data has a considerable proportion of skipjack tuna greater than 80 cm which can only be explained by a larger Linf parameter than currently assumed by the growth model. The WPTT further **NOTED** that the growth estimates were based on tagging data where very few large/older fish were recovered. The WPTT **AGREED** that the Linf parameter represents a key source of uncertainty in the assessment model.

92. The WPTT **NOTED** a constant M of 0.8 was used in the assessment, and further **NOTED** that external analysis of tagging data has not been successful in estimating M for juveniles but has shown an average estimate of about 0.8 for adults. The WPTT **QUERIED** what bias it might induce if the potential high juvenile mortality was ignored and **NOTED** that the total M across all ages is

more important in determining stock estimates, but high juvenile mortality typically impacts estimates of yields and impact of fishing, particularly for fisheries that catch juvenile.

93. The WPTT **NOTED** that the small-scale tagging data have been included in the previous assessments either as part of the model grid or as sensitivities. The WPTT **NOTED** that the small-scale data were restricted to Maldivian waters with relatively low dispersion rates and very little recoveries made outside the region, and that most tags were recovered within a short time-at-liberty. However, the WPTT **NOTED** that past analysis had shown the small-scale tagging data appear to have better information on juvenile natural mortality.

94. The WPTT **NOTED** that the model predicted a slower decline in the tag recoveries over time than what has been observed. The WPTT **NOTED** that this is because the tagging data supported an estimate of higher fishing mortally and lower abundance, and conversely the length composition data supported an estimate of lower fishing morality and high abundance. The WPTT further **NOTED** that the conflict between the tagging data and length composition data has also been evidenced from the analysis of likelihood profiles.

95. The WPTT **NOTED** that a model ensemble was used for quantifying the status of the stock which included alternative CPUE indices (PL, PSLS, and/or behaviour indices), alternative assumptions on CPUE catchability trends (annual increase of 0 or 1%), alternative values of SRR steepness (0.7, 0.8, or 0.9), and alternative growth parameter options (Linf fixed or estimated). Estimates of stock status were combined across the 36 models and incorporated uncertainty from individual models as well as across the model ensemble. A description of the model options is provided in Table 3.

Table 3: Description of the final model options for the 2023 assessment.

Model options	**Description**
CPUE option	• **U1 –** PL 1995 – 2022 index is included
	• **Ua –** Only PSLS 1991 – 2021 index is included
	• **Ub** – PSLS 1991 – 2021 index (update to first two quarters of 2021) and the index based on the associative behavior 2013 – 2022
CPUE catchability	• **q0** – no annual catchability change
	• **q1**– annual catchability increases of 1.25% (both PL and PSLS)
Steepness	• **h70** – Stock-recruitment steepness parameter 0.7
	• **h80** – Stock-recruitment steepness parameter 0.8
	• h90 – Stock-recruitment steepness parameter 0.9
Growth	• **L70** – L^{∞} parameter fixed at 70 cm as of Eveson et al. 2012
	• **Linf** – L^{∞} parameter estimated

96. The WPTT **RECALLED** that IOTC Resolution 21/03, which superseded Resolution 16/02 requires the skipjack tuna stock assessment estimates to be used to as inputs for the Harvest Control Rule (HCR) to calculate the TAC. The WPTT **RECOMMENDED** that the SC endorse the stock assessment and that the median estimates from the model ensemble are used to calculate the TAC for skipjack tuna for 2024-2026 (The TAC calculated using the stock assessment is 628 605 t).

97. The WPTT **NOTED** paper IOTC-2023-WPTT25-14 on estimate populations dynamics of tropical tunas using ecosystem modelling in the Indian Ocean including the following abstract:

"With the development of fisheries research, there has been a gradual shift from a single-species management model to an ecosystem-based fisheries management model (EBFM). The concept of EBFM is increasingly accepted by researchers and regional fisheries management organizations, but there is little relevant research and application in Indian Ocean tuna fisheries. In this study, a multi-species ecological model (LeMaRns) based on body-length structure was constructed based on publicly available data and studies from the Indian Ocean Tuna Commission (IOTC) to analyse the effects of different fishing fleets on stock status and ecosystem structure under different fishing effort. The results of the study showed that an increase in fishing effort resulted in a decrease in population biomass and that predatory and competitive relationships between species also influenced changes in population biomass." – see document for full abstract

98. The WPTT **NOTED** that the LeMaRns model used in the analysis is a length-based fish community model which is able to represent a suite of species and their length structure. The WPTT **NOTED** it is important to consider carefully whether the model is adequate for tuna species where there is lot of gear and species interactions. The WPTT **AGREED** that the modelling is a good first step to taking ecosystem perspectives and **ENCOURAGED** the authors to further develop the model taking into consideration of species, gear interactions, and length-based predation. The WPTT also **SUGGESTED** the work to be considered by the WPEB.

4.4 Selection of Stock Status Indicators for skipjack tuna

99. The WPTT **ADOPTED** the stock status advice developed for skipjack tuna as provided in the draft resource stock status summary and **REQUESTED** that the IOTC Secretariat update the draft stock status summary for skipjack tuna with the latest 2022 catch data (if necessary), and for the summary to be provided to the SC as part of the draft Executive Summary, for its consideration:

- Skipjack tuna (*Katsuwonus pelamis*) – Appendix V

In providing its input to the draft Executive summary, the WPTT **AGREED** that the use of the depletion based TRP for Skipjack tuna to define stock status should be reviewed before the next assessment, as part of a broader review of the application of Resolution 15/10, which lacks clarity regarding when MSY or depletion-based reference points should be applied, and the role of the interim LRPs within the management framework.

4.5 Development of Management Advice for skipjack tuna

100. The WPTT **NOTED** that the management advice for skipjack tuna comes directly from the adopted skipjack tuna Management Procedure (Res 21/03). This is comprehensively covered in the draft Executive Summary.

5. BIGEYE TUNA MANAGEMENT PROCEDURE

5.1 CONSIDERATION OF EXCEPTIONAL CIRCUMSTANCES

101. The WPTT **NOTED** paper IOTC-2023-WPM14-11 (presented to WPM14) which reviewed the evidence available in 2023 for exceptional circumstances for the bigeye tuna MP, including the following abstract:

"The IOTC adopted the bigeye tuna management procedure (MP) in 2022, which is used to recommend the Total Allowable Catch (TAC). As part of the MP schedule, the Commission has adopted an annual review of evidence for exceptional circumstances, to check for conditions 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., changes in the knowledge of stock or fishery uncertainties against which the MP was tested. The Exceptional Circumstances Guidelines (IOTC–2021–SC24 Appendix 6A) provide a scientific process for developing appropriate management responses to exceptional circumstances and, hence, provide transparency in TAC decision-making by the Commission. The MP was run in 2022. 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 items identified as potential exceptional circumstances in 2022. Severity and impact were considered low for these items and no actions were recommended. No new exceptional circumstances were detected in 2023, and therefore, no research or management actions are recommended."

102. The WPTT **NOTED** that the reported catch in 2021 (96,175 t) and 2022 (102,266 t) are above the catch assumed for these years in the MSE for the period before MP implementation, but concluded that these catches are within the range of catches for the past 10 years (80,099 – 113,810 t) and therefore would not significantly affect the range of population dynamics incorporated into the MSE and are not considered to be exceptional circumstances.

103. The WPTT **NOTED** 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 items identified as potential exceptional circumstances in 2022. Severity and impact were considered low for these items and no actions were recommended.

104. The WPTT **NOTED** that from the evidence presented and discussed, there are no new exceptional circumstances detected in 2023 and **AGREED** that there is no need to adjust the TAC for bigeye tuna for 2024 and 2025, as calculated from running the MP in 2022.

105. The WPTT **NOTED** that the bigeye tuna MP is scheduled to be run again in 2024 to recommend the TAC for 2026-2028, and therefore the standardised CPUE and catch data will need to be updated in 2024 for running the MP. The WPTT also **NOTED** that CPUE data would be needed for the next stock assessment and **AGREED** that the CPUE standardised would be updated again in 2025.

6. Other Tropical Tunas

106. The WPTT **NOTED** that paper IOTC–2023–WPTT25–16, providing a comparison between industrial and artisanal tuna fishery in Kenya, was not presented during the meeting.

107. The WPTT **NOTED** paper IOTC–2023–WPTT25–17, which provided a summary of tropical tuna landings in Thai fishing ports during 2013 - 2022, including the following abstract:

"*Tuna products are Thailand's highest export product and have a high value. Thailand is the world's leading producer of tuna products. Most tuna is imported from both the Indian Ocean and the Pacific Ocean. There are many species of imported tuna, including tropical tuna such as Skipjack tuna Yellowfin tuna and bigeye tuna, which are imported as the main proportion of the total volume. Most imports are frozen and chilled tuna. During the period 2013 - 2022, the highest volume of imported was skipjack tuna followed by yellowfin tuna and bigeye tuna, which is related to the import value. In 2022, a total of 755,589.70 tons of tropical tuna was imported, valued at more than 1,475 million US dollars. The imported proportion was 81.21% of skipjack tuna, followed by yellowfin tuna at 15.04% and bigeye tuna at 3.74%, respectively*".

108. The WPTT **NOTED** that a large component of the tropical tuna processed in Thailand may come from other oceans than the Indian Ocean.

109. The WPTT **NOTED** IOTC–2023–WPTT25-18 which provided a preliminary analysis of observer data on the presence of mesh in floating objects used by the French purse seine fleets in the Atlantic and Indian Oceans including the following abstract:

"*We conducted an initial analysis using data from observers aboard French PS vessels in the Atlantic and Indian Oceans of the composition of FOBs deployed, fished and encountered by the French fleet focusing on the use of netting. Data before 2019 are insufficient for assessing the presence of netting as fields for noting this type of information were only added to observer data protocols and data entry platforms in 2019. There are also a number of important caveats to using this data for assessing the prevalence of netting in FOBs, including the data collection protocol used by observers on French vessels not instruction them to collect detailed data on FOB compositions, the non-zero data entry error rate in observer data, and observed differences in rates of FOBs with netting as a function of observer program and observer country of origin. Nevertheless, our observations are globally consistent with both independent analyses of dFAD composition in the Indian Ocean and more anecdotal observations of dFADs found in coastal environments in the Indian Ocean. Non-negligible numbers of FOBs with netting were recorded in 2019-2020, but rates decline significantly in 2021-2022, with average observed rates of FOBs with netting across observer programs being on the order of 3-5% for both oceans and both years.*"- see document for full abstract.

110. The WPTT **THANKED** the authors for the work which followed a request by the WGFAD and provides some useful information on the trends in dFAD design used in the French purse seine fishery.

111. The WPTT **QUESTIONED** the origin of characterizing the netting material with a 7 cm-s or 2.5 inches as a threshold for different entanglement risk in the ISSF non-entangling and biodegradable FAD guidelines. It was noted that the ISSF category of non-entangling FADs is when the FAD is constructed without netting materials. It was explained that this threshold was adopted by ISSF to facilitate transition towards non-entanglement FADs in 2012 (ISSF, 2012[1]) to distinguish between lower entanglement risk (i.e., <7 cm-s or 2.5 inches stretched mesh size) and high entanglement risk (i.e., >7 cm-s or 2.5 inches stretched mesh size) based on gear technologist expertise and different mesh size of tuna purse seiners (> 7cm/2.5 inches and higher risk of entanglement) and small pelagic purse seiners (< 7 cm/2.5 inches with lower entanglement risk).

112. The WPTT **NOTED** that there is a large variability on the data quality collected by observers and, therefore, the need of qualifying the quality of observer data was commented. The WPTT **NOTED** that it is important to develop harmonized and standardized internal protocols, forms with definitions, checks and corrections of observer data to ensure quality observer data.

113. The WPTT **NOTED** that the workload of observers is high and mostly focused on bycatch estimations and that the observers are not all the time in the upper deck to observe FAD material and characteristics at deployment. Moreover, the WPTT **NOTED** that during the FAD visits, FADs are generally under the water and, therefore, non-visible for observers to compile material/construction characteristics.

[1] ISSF (2012). Guide for non-entangling FADs

114. The WPTT **NOTED** that the collection of data on the structure (design and materials) of FOBs has not been part of the IRD-Ob7 protocol of observers onboard French and associated purse seiners, as other data components have been identified as a priority (i.e., general activity, fishing sets, bycatch and discards). Unlike other observer data fields, information on the materials used/found in FOBs is included in the ObServe v7 but has not been validated in French data collection protocols and had never been explored prior to the study.

115. The WPTT **RECALLED** that the collection of these components is part of annex III of the IOTC Res. 19/02 ("Dimension and material of the floating part and of the underwater hanging structure"), **ACKNOWLEDGING** that this represents a substantial workload for both observers (for data collection and entry in ObServe) and IRD-Ob7 (for data validation).

116. The WPTT **NOTED** that the information on materials (including the use of mesh and the mesh size used) and FAD characteristics have been collected in the Spanish observer program since 2015 on a regular basis. The data collection of the Spanish program has followed clear guidelines and definitions of different materials (mesh or not) and characteristics of the materials and FAD construction (mesh size if any, FAD dimensions, etc.), which is collected in the ObServe v7 software and included in the Spanish data collection guidelines.

117. The WPTT **NOTED** that in the Spanish case the identification of materials is done regularly during deployment. It was also **NOTED** that "non observed cases" also occur but in a lower percentage as in around 70–75% of the cases the FADs characteristics are observed when leaving the FAD in the water as a result of a deployment or after the visit (with or without a set). Not observed cases (inability to proceed with evaluations) are related to deployments made at night (in case of physical observers) and in FADs that are visited and not lifted from the water. In the specific case of the Indian Ocean many FADs are submerged and when they are visited are not lifted from the water, and therefore the material cannot be identified.

118. The WPTT **QUESTIONED** the large percentage of "netting not visible" category during FAD deployments in the Indian Ocean collected by French observers which seems to be strange as the FAD characteristics are clearly visible during deployment. The WPTT further **NOTED** that some information collected by the observers appeared to be inconsistent or inaccurate in some cases (e.g. onboard observers reporting they could not observe the structure of dFADs at deployment though this is impossible, presence of meshed materials on dFADs deployed when only non-meshed materials was delivered by the fishing companies to the vessels to build dFADs), indicating the need for clear guidelines and more checks to verify the data and particularly the structure of FOBs reported with mesh.

119. The WPTT **NOTED** that although there are a number of potential caveats regarding the interpretation of French PS observer data in terms of the use of netting in dFADs, the results are globally consistent with other data that in 2019-2020 netting was used in a some dFADs, but the use of nets decrease significantly in 2021-2022, though there are still few observations of dFADs using nets in the Indian Ocean.

120. The WPTT **ACKNOWLEDGED** that confusion regarding the origin of FOBs could be avoided, and entanglement risk reduced if PS vessels did not attach tracking buoys to FALOGs (i.e., artificial logs of fishery origin not deployed by PS vessels) which are mostly composed of all fishing nets and **ENCOURAGED** all CPCs with purse seine fisheries to recommend their removal from the water when possible regarding their high risk of entanglement, further **NOTING** that the FAD management plan of EU,France already includes such recommendation to provide precision on the nets component and risk of entanglement.

121. The WPTT **URGED** EU,France to develop a formal protocol for the collection of detailed data, including use of netting, on FOB materials, and to strengthen the training of the observers to augment and improve the collection of data on dFADs.

122. The WPTT **REQUESTED** other CPCs with purse seine fisheries (in particular EU,Spain and Seychelles) to conduct similar analysis using observer data to be presented at the next WGFADs and WPTT.

123. The WPTT **AGREED** that the comparison of French observer data with other sources of information, such as logbook and observer data from the Spanish fleet and interviews with observers could be instrumental to understand their data collection approach and improve the understanding of materials categories.

124. The WPTT **RECOMMENDED** that purse seiner observer data protocols include the need to collect FOB material and construction characteristics and that protocols for that collection are harmonized among PS CPCs and adopted by IOTC WPDCS.

125. The WPTT **NOTED** that electronic monitoring could be used to collect FAD information on materials and characteristics while deploying the FADs, unless the FAD deployments are done at night. The WPTT **WAS INFORMED** that EM system is adapted to collect this type of information during deployment in EU purse seiners.

126. The WPTT **NOTED** IOTC–2023–WPTT25-24 on managing a multi-species fishery in distant waters: the case of the Spanish-flagged purse seine fishery targeting tropical tuna in the Indian Ocean including the following introduction:

> *"The main objective of this document is to present the regulations that the Government of Spain has deployed in response to these measures to rebuild the stock of yellowfin tuna in the Indian Ocean. We discuss how such measures represent a unique case within the tuna fisheries; and their usefulness to manage multi-species fisheries"* - see document for full introduction.

127. The WPTT **NOTED** that EU,Spain has implemented a new methodology to derive the species composition of the catch of its Indian Ocean purse seine fishery since 2018, which resulted in major deviations with the annual estimates derived from the T3 (Traitement des Thons Tropicaux) processing methodology used since the 1990s which relies on port samples.

128. The WPTT **NOTED** that, in order to accommodate for those changes, the Spanish administration may have to report two distinct time series of annual and geo-referenced catch data: T3 data for scientific purpose, and official data (*FIDES*) for administrative and compliance purposes (e.g., annual contributions to the IOTC, verification of YFT and BET catch limits, etc.).

129. The WPTT **NOTED** that maintaining two separate data sets of annul catches would be problematic for both EU,Spain and the Secretariat. Therefore the WPTT **SUGGESTED** that EU,Spain submits the best scientific estimates of catch data (currently based on the T3 methodology) routinely (by June 30th each year) and provide, by the same date, only a subset of the official data for their purse seine fishery, and namely its total annual catches by species and fishing mode. It was noted that while EU,Spain could decide which data series are official, T3 data should continue to be used for stock assessment purposes (since the methodology could be run for the combined PS catch in the Indian Ocean, and it can be added in an aggregated manner to the rest of the PS fleet). However, the WPTT also **NOTED** with concern both the precedent that this approach sets and the challenges to verifying FIDES data due to data confidentiality restrictions.

130. Subsequently, to account for the changes in methodology implemented by EU,Spain starting with the statistical year 2018, the WPTT **REQUESTED** that EU,Spain re-submit the T3 data series

from 2018 until 2022, including a) the derived annual total catches by fishing mode, IO area, quarter, and species, b) the geo-referenced catches and effort by fishing mode, 1x1 grid, month, and species, and c) size-frequency data (both raised and unraised) by fishing mode, month, 5x5 grid, and species, to allow the Secretariat to revise the species composition of tropical tunas for the years and fishery concerned. However, the WPTT **NOTED** that the EU,Spain stopped using the T3 system as of right now because it was deemed unsuitable for vessel catch monitoring and unable to produce accurate estimates of catch (Abascal 2022[2])

131. The WPTT **NOTED** that EU,Spain implement a regulation to address the limit set on the total allowable catch of yellowfin tuna through IOTC resolutions 19/01 and 21/01, which combines an individual limit of total catch defined for each purse seiner with a fleet-wide maximum ratio of yellowfin tuna in the total catch set at 28% computed as the average composition observed in the catch between 2017 and 2019.

132. The WPTT **NOTED** that specific information on the nature and frequency of the checks and controls (e.g., inspections in port) resides with the Spanish administration and the sharing of this information is governed by the Spanish Administration' data protection law.

133. The WPTT **ENCOURAGED** EU,Spain to undertake verification of the composition of yellowfin and bigeye tuna by examining electronic logbook data from vessel and authorized fisheries inspectors.

134. Furthermore, the WPTT **NOTED** that ISSF-affiliated companies have been providing information on tuna purchases by fishery, species, and quarter starting from 2010 to the IOTC Secretariat which constitutes a complementary source of independent information that could be analysed to corroborate and cross-verify the information recorded in logbooks.

135. The WPTT **ACKNOWLEDGED** that receipt data from tuna processing factories may provide insight into the species composition of purse seine catch and be useful for comparison with the estimations made by EU,Spain as well as using the T3 methodology which relies on multispecies size-frequency samples collected by enumerators at unloading sites.

136. The WPTT **NOTED** that ISSF data are not comprehensive and may provide an incomplete view of the species composition of the catch due to vessels also selling tuna to non-ISSF affiliated companies.

137. **NOTING** how sale data are already used by the WCPFC and IATTC as part of their data validation process, the WPTT **SUGGESTED** to further investigate how ISSF data as well as data provided by CPCs could be used for this type of analysis (e.g., through specific MoUs), and how this work could be further expanded to CPCs and processing factories currently not affiliated to ISSF.

138. The WPTT **ENCOURAGED** interested CPCs to complement ISSF-data and provide sale data information to the IOTC Secretariat under strict confidentiality agreements. In this regard, the WPTT **RECOMMENDED** that external consultancy be made available to IOTC to carry out this analysis under the supervision of the IOTC Secretariat and included in the WPTT program of work.

Yellowfin tuna

[2] Abascal, D. Kaplan, V. Rojo, D. Gaertner, M.L. Ramos, A. Duparc, M. Depetris & J.C. Báez (2022) Scientific catch estimation for the global FAD tropical tuna purse seine fishery in the Indian Ocean. IOTC-2022-WPTT24-14_Rev1

139. The WPTT **NOTED** presentation IOTC–2023–WPTT25–11 which provided a description of age validation of yellowfin tuna in the Indian Ocean using post-peak bomb radiocarbon chronologies, , including the following abstract:

"*Yellowfin tuna (Thunnus albacares) stock assessments use age-structured models; therefore, accurate methods for ageing the catch are required. Age estimation techniques need to be validated at the population level to ensure accuracy. However, otolith-based age estimates of yellowfin tuna have never been validated in the Indian Ocean. The current study provides the first age validation for Indian Ocean yellowfin tuna using the post-peak decline period of the bomb radiocarbon (^{14}C) chronometer. A ^{14}C reference chronology based on accelerator mass spectrometry assays of known-age yellowfin tuna otoliths was consistent with published regional coral records, with all showing similar rates of decline during the 2000 to 2019 study period. After back-calculating the birth years of sub-adult and adult yellowfin tuna from otolith increment counts, $\Delta^{14}C$ values measured in the early growth portion of the otolith were compared with the observed decline slope of the reference chronology. There were no significant differences between the birth years of validation and reference samples, supporting the otolith increment age determination methodology between the ages of 2.2 and 10.5 years. The validation of age and growth estimates is expected to benefit the assessment models for Indian Ocean yellowfin tuna. We recommend that otoliths from large fish continue to be collected to expand the validation to older fish. Greater precision in the validation results will also require a larger reference chronology*".

140. The WPTT **THANKED** the authors for the study which provided evidence of the deposit of annual increments in otoliths of yellowfin tuna.

141. The WPTT **NOTED** that while there seemed to be two distinct relationships between time and radiocarbon variability between the two corals considered as baselines in the study (i.e., Watamu and Kadmat), the differences were not found to be statistically significant.

142. The WPTT **NOTED** that there were two components of error accounted for in the estimation and that the average ageing error was 0.5 years, further **NOTING** that errors in age could be estimated for each individual.

143. The WPTT **NOTED** that the validation method is limited by the radiocarbon decline rate and that the main source of uncertainty in the technical protocol may come from the extraction process of materials from the core otolith which requires a quantity of ~3 mg.

144. The WPTT **NOTED** that the paper was in review in a scientific journal and would be shared as soon as published.

145. The WPTT **ACKNOWLEDGED** the interest in estimating the maximum lifespan of yellowfin tuna from maximum observed ages to derive estimates of natural mortality, further **NOTING** that newly developed methods based on epigenetic ageing could validate/or and complement ageing based on otoliths and only require soft tissue samples (see IOTC–2023–WPTT25–03).

146. The WPTT **NOTED** paper IOTC–2023–WPTT25–12 which provided an investigation of the recruitment dynamics of Indian Ocean yellowfin tuna, including the following abstract:

"*A review of the IO yellowfin tuna stock assessment was conducted in February 2023. The review highlighted the divergent trends in regional recruitment, particularly since the mid 2000s. This study investigated the influence of key data sets in the estimation of regional recruitment to improve the understanding of the model dynamics in advance of the next stock assessment scheduled for 2024*".

147. The WPTT **NOTED** that the yellowfin assessment model estimated limited movement between R1 and R4, which was considered counterintuitive given the wider Indian oceanic circulations. The analysis provided some insight on the connectivity between the west and east of Indian Ocean by investigating the different levels of decline in CPUE and associated recruitment trends. The WPTT further NOTED that there is a lot of variation across the years in the data and that there is also conflicting signal between different data sources.

148. The WPTT **NOTED** that the analysis examined longline CPUE trends and how they are related to some of the changes in effort distributions. It was **NOTED** there has been many changes in operations of longline fisheries since when they were affected by the piracy, including the shift in spatial distribution and changes in targeting and selectivity. The WPTT **AGREED** that it is very important for the standardisation process to examine these factors and also be cautious about the interpretations of the trends.

149. The WPTT **NOTED** that Purse seine index, particularly those derived from FAD schools and/or from echo sounder could be a useful juvenile/recruitment index.

150. The WPTT discussed the spatial stratification between R1/R2 along the Mozambique channel (MOZ) in the current assessment model. The WPTT **NOTED** that MOZ is currently being treated as part of R2, based on different oceanic conditions and fishing operations in the Channel. The WPTT further **NOTED** that while the dynamics may have been different between R1 and R2 but the conditions may have changed over the last 10 to 20 years. The WPTT **NOTED** that the 2021 assessment has also investigated an alternative stratification that include MOZ as part of R1.

151. The WPTT **NOTED** that while VAST model may be useful for standardising fine spatial scale data, these data may suffer the same issues as aggregated data because these models often assume spatial effects are constant, but they often change overtime. In Particular factors such as piracy effect is very difficult to quantify and spatial heterogenenity in fishing operation and sampling may be difficult to adequately account for.

152. The WPTT **NOTED** that Arabian sea is an important region and the length composition data from the gillnet fishery operating in this area has a very large influence on recruitment. The WPTT NOTED that Iranian Gillnet fishery has reasonable spatial information for vessels fishing inside their EEZ but may lack geo-reference effort data for vessels operating outside their EEZ. The WPTT NOTED that the Secretariat is working with Iranian fishery Organisation to further clarify the quality and availability of geo-reference data of their offshore fleets.

153. The WPTT **NOTED** that the analysis suggested the positive Indian Ocean Dipole index (DMI) has a possible effect on yellowfin productivity, this appears to be opposite to skipjack tuna, where a different study (IOTC–2023–WPTT25-22) has shown that a positive DMI is related to high SST and low productivity of skipjack. The reason is not clear but it is hypothesized that the larger area with warmer conditions associated with a positive DMI may have help extended favourable habitat for yellowfin recruitment.

154. The WPTT **NOTED** that the yellowfin assessment model has very complex spatial and recruitment dynamics which are not yet fully understood and some modelling decisions such as spatial stratification were based on limited information. The WPTT agreed that a more collaborative approach for modelling is needed, which should utilise the WPTT(DP) for making sound modelling decisions.

155. The WPTT **NOTED** paper IOTC–2023–WPTT25–13 which provided a review of 2021 WPTT Indian Ocean yellowfin tuna stock assessment, including the following abstract:

"The Independent Review Panel conducted a review of the 2021 assessment of yellowfin tuna in the Indian Ocean from 6 and 10 February 2023 at the FAO Headquarters, Rome, Italy. The assessment authors presented a summary of the main issues, an overview of the assessments of the last 10 years, the catches and length frequencies, the inputs to the stock assessment model, and the results. The Panel identified several requests for additional model runs and data analyses that the analysts addressed between meeting sessions. During the subsequent days, the Panel evaluated the responses to its requests and reviewed the background documents. The conclusions and recommendations from the draft report were presented to the analysts on 10 February 2023, and this meeting report was finalized after the review meeting. Several areas of priority research were identified." – see document for full abstract

156. The WPTT **THANKED** the independent expert panel for the excellent and comprehensive review of the 2021 yellowfin stock assessment. The WPTT **NOTED** that the external review provided recommendations for improving the assessment, including data inputs, model configuration, biological parameters, modelling approach and treatment of uncertainty. The WPTT further **NOTED** that the review has suggested improvement options for 2024 stock assessment and provision of management advice.

157. The WPTT **NOTED** the review identified several key issues in the 2021 assessment model, including

- Reliance on regional 4 LL CPUE indices and associated assumptions (constant selectivity, catchability).
- Uncertainty in key biological parameters, including growth.
- Divergence in LL abundance index L1 and L2 from 2003. Not adequately fitted in model.
- Divergent trends in R1 and R4 recruitment from early 2000s. Recruitment estimation link to spatial structure and movement parameterisation.
- Limited length data to inform model regarding recruitment variation beyond R1. High sampling error means limited utility of the length data.
- Limited data available from a number of important fisheries HD 1a and LF4.
- Poor fit to tagging release/recovery data (mixing assumptions). Potentially under-estimates abundance in late 2000s.

158. The WPTT **NOTED** that some progresses were made regarding issue 4 (alternative recruitment dynamics) and 5 (limited length data) were thoroughly investigated via a supplementary analysis conducted by the independent consultant post the review meeting (IOTC–2023–WPTT25–12).

159. The WPTT **NOTED** that the review panel considered that Including the tagging data in the assessment model is problematic and has recommended that it should be evaluated outside the stock assessment using a fine scale spatial temporal model. This is because the practicalities of tagging limit the spatial distribution of tags and the tags are not initially fully mixed with the population, and it is not clear how long does it take for the tags to become fully mixed if at all. The current practice of using a mixing period of several quarters reduces the information content of the tag data and further reduces the current model fit to the tagging data.

160. The WPTT **NOTED** that the review made several recommendations for improving the 2024 assessment model, including

- Alternative abundance indices required to corroborate or replace LL CPUE. Review assumptions associated with LL CPUE indices. Global tuna RFMO meeting to progress common issues with LL CPUE.

- Improve biological parameters (esp. growth, maturity, natural mortality). Age sampling over a broader geographic range.
- Implement a simple single region model (R1 only) to evaluate key data inputs.
- Evaluate information available to inform spatial structure and recruitment estimation.
- Model alternative spatial structures to investigate sensitivity of assumptions regarding spatial configuration (including recruitment, movement dynamics).
- Improve model data weighting, primarily individual LF observations.
- Length comp "survey" (constant selectivity) and fishery (variable selectivity).
- Sensitivity to alternative catches from key fisheries.
- Data preparatory meeting in 2024 prior to WPTT.

161. The WPTT **NOTED** that the yellowfin assessment model has evolved over time, with significant contributions from the independent expert to the model's initial and subsequent design and formulation. The WPTT also **NOTED** that there are a number of intricate problems with the model's input data, structure, and dynamics. Solving these problems calls for a collaborative approach that synthesises a wide range of expertise, as well as the expert's in-depth historical knowledge. Therefore, the WPTT **RECOMMENDED** that the independent expert continue to be engaged in the enhancement and further development of the yellowfin assessment, with an emphasis on implementing the external review's recommendations.

162. The WPTT **NOTED** paper IOTC–2023–WPTT25–20 which provided an update on the estimation of age and growth of yellowfin tuna in the Indian Ocean using otoliths, including the following abstract:

"This paper provides an update on yellowfin tuna (Thunnus albacares) otolith ageing activities in the western Indian Ocean that have occurred since Farley et al. (2021). Age estimates were obtained for 136 yellowfin tuna, using both daily (n=46) and annual (n=90) ageing methods. The youngest was aged 44 days and the oldest was 11.4 years. The new age data were combined with age data obtained in the 'GERUNDIO' project[1] (Farley et al. 2021), providing a total of 386 age estimates for analysis. Four growth models were fit to the age and length data (von Bertalanffy (VB), Richards, VB log k, and 2-stage VB), with the 2-stage VB model providing the best fit, particularly for small fish (< ~55 cm fork length, FL). The length-at-otolith weight data (which is independent of the age estimation method) showed a change in otolith growth at ~55 cm FL, which is consistent with the length-at-age data and lends support to the 2-stage VB model. Overall, our analysis shows that fish grow rapidly after birth, reaching ~60 cm FL by age 1 and ~95 cm FL by age 2." – see document for full abstract

163. The WPTT **CONGRATULATED** the authors for the progress accomplished on the growth of yellowfin tuna which is one of the recommendations that arose from the review.

164. The WPTT **NOTED** that the model shows a relationship between otolith weight and age with a high goodness of fit suggesting that otolith weight may be a good indicator of age, particularly for small/young fish.

165. The WPTT **NOTED** that distinctive two growth stages were identified in the growth analysis with a transition between two VB growth phases at age 0.82 years (53 cm FL), with a very high growth rate parameter in the first phase (k1 = 3.1) followed by a lower growth rate parameter in the second phase (k2 = 0.39).

166. The WPTT **NOTED** that a further increase of samples from northern and eastern regions of the Indian Ocean will be useful for assessing the potential for inter-annual variation in length at age

affecting estimation of the growth curve as well to confirm that there are no regional differences in growth as suggested by this study.

167. The WPTT **ACKNOWLEDGED** the major progress made on yellowfin tuna growth and **NOTED** that the new growth will be reviewed and considered at the next Data Preparatory meeting of the WPTT for inclusion in the stock assessment model.

168. The WPTT **NOTED** paper IOTC–2023–WPTT25–21 which described limited east to west connectivity of yellowfin tuna in the Indian Ocean based on Otolith stable isotopes, including the following abstract:

"*For stock assessment purposes in the Indian Ocean, a single stock of yellowfin is considered by the Indian Ocean Tuna Commission (IOTC). However, the degree of connectivity and mixing rates are still uncertain, although this information is essential for developing effective and sustainable management strategies. This study uses otolith oxygen and carbon stable isotope composition (δ18O and δ13C) of young-of-the-year yellowfin tuna from "known" nursery areas in the equatorial Indian Ocean to establish a reference east/west baseline of isotopic signatures. This baseline was then used to determine the origin of adolescent and adult yellowfin tuna individuals captured in three fishery regions of the western Indian Ocean: R1A, R1B and R2. Results from this study suggest limited east to west connectivity of yellowfin tuna in the Indian Ocean, with west nurseries being the mayor source of contribution to the western fisheries.*" – see document for full abstract

169. The WPTT **THANKED** the authors for the presentation and **NOTED** that the authors focused their work on oxygen and carbon as they found a large spatio-temporal variability in the values of other elements such as baryum or magnesium.

170. The WPTT **NOTED** information paper IOTC-2023-WPTT25-INF02 which provided sensitivity analysis of the 2021 WPTT Indian Ocean yellowfin tuna stock assessment within Stock Synthesis

Bigeye tuna

171. The WPTT **NOTED** paper IOTC-2023-WPTT25-19 which investigates the impact of climate change on distribution shifts of the Indian Ocean bigeye tuna, including the following abstract:

"To respond to the resolution 22/01 of IOTC, we explored the long term changes of spatial distribution of bigeye tuna from 1975 to 2021 in this preliminary study. Climate change and fishing pressure are put forward to explain the changes. Over the past 4 7 y ears, bigeye tuna overall shift ed from northern Indian Ocean tropical area to central Indian Ocean temperate area in latitude The centre of gravity CO G of longitude shifted to the eastward during 1978~ 1981 and 1996~2000, followed by a significant western shift in 2011~2012. Despite these periods, the COGs of longitude mainly distributed around 75°. The fishing pressure and spawning biomass are the main variables explained the distribution shifts. DMI could explain the latitudinal change and the longitude seasonal change, however the r 2 is lower than other variables. SST is a significant predictor for latitude and longitude seasonal change ENSO didn't show a significant relationship with latitudinal and longitudinal shifts"

172. The WPTT **ACKNOWLEDGED** the authors for their contribution and research carried out to a better understanding of the relationship between climate change, tuna fisheries and tuna stocks in support of the Resolution 22/01.

173. The WPTT **NOTED** that the study aims to understand which environmental and climatic variables along with abundance and fishing pressure variables might be predictors of the big eye tuna distribution shifts using sea surface temperature, Indian Ocean Dipole (IOD) index and ENSO

index as climatic variables and SSB and fishing pressure were extracted from the 2022 bigeye tuna stock assessment models.

174. The WPTT **NOTED** that the use of annual and seasonal averages leads to smoothed r values in the model and it is therefore **SUGGESTED** to test the climatic variables at the times of the year when they show the greatest variability according to previous studies on regional indexes.

175. The WPTT **NOTED** that it would be interesting to explore long-term change in longline fisheries in relation to other species, as well as the use of non-fishery dependent data.

176. The WPTT **NOTED** presentation IOTC-2023-WPM14-23 which describes bigeye tuna connectivity in the Indian Ocean based on genome wide genetic markers.

177. The WPTT **NOTED** that the study identified potential adaptive markers for the identification of fish stocks and also **NOTED** that particularly the outlier markers can be used to distinguish between locally adapted populations as well to understand geographic connectivity.

178. The WPTT **NOTED** that the study supports that the Atlantic population is isolated from the Pacific and Indian Ocean population whereas between Indian and Pacific, as well within Indian population, there is connectivity and gene flow.

179. The WPTT **NOTED** that the results on Indian Ocean suggest that the northern region seems to be more differentiated although there exists a temporal spacing of the samples, that were taking during tree different years but not for all the locations, and in a wide range of environmental conditions.

180. The WPTT **THANKED** the authors for their excellent work and encouraged them to expand the samples to the edge of Arabian Sea and Bengal areas with the aim to obtain a better picture of the Indian Ocean variability.

7. Update on MSE For Tropical Tunas

181. The WPTT **NOTED** paper IOTC–2023–WPM15–16 on the Status of skipjack OM development (the paper was discussed in the WPM15 meeting)

182. The WPTT **ACKNOWLEDGED** the update on the status of the skipjack Management Strategy Evaluation development and **NOTED** its advanced stage.

183. Following one of the requests of 2023 TCMP, the WPTT **NOTED** that the skipjack tuna MSE developer has tried to use a biomass dynamic model within the Management Procedure but **NOTED** that the biomass dynamic model does not adjust skipjack population dynamics as it cannot estimate depletion levels due to a positive relationship between catches and the CPUE trends. The biomass dynamic model was also shown not to work the updated CPUE indices.

184. Therefore, the WPTT **NOTED** that a model-based MP using a biomass dynamic model (BDM) appears to be inviable, unless additional data are included or strong assumptions are made on prior parameter values (e.g., carrying capacity), and, therefore, the WPTT **AGREED** to use empirical or data-based Management Procedure for skipjack tuna.

185. The WPTT was informed that updating the skipjack OMs with the new 2023 skipjack assessment will not require much time/resources and, therefore, the WPTT **REQUESTED** the developers to update skipjack OMs with the updated 2023 skipjack assessment and evaluate the current empirical MPs against the new OMs for 2024 TCMP presentation. The WPTT **NOTED** that this will facilitate communication, and potential recommendations by TCMP to the Commission in 2024 of a preferred MP.

186. The WPTT **NOTED** that the standardized CPUE without effort creep included in the MP evaluation is converted to depletion levels based on different OM's relationship between CPUE (without and with effort creep) and biomass depletion level. Therefore, unless this relationship changes in the future, effort creep is taken into account during the project period of MP evaluation. Thus, the WPTT **AGREED** to use in the MP the standardized CPUE without effort creep as a reference case but to include a robustness scenario of 1% of increase catchability for both CPUEs.

187. The WPTT **NOTED** the need to specify a minimum catch level in the new Harvest Control Rule and suggested testing a minimum catch of 10% of the historical maximum catch (i.e., 666408 tons) in the MP evaluation.

188. The WPTT **NOTED** paper IOTC-2023-WPM14-08 which outlined a proposal for a yellowfin tuna close-kin mark-recapture (CKMR) pilot study.

189. The WPTT **NOTED** that it is not necessary to understand the population structure before implementing CKMR, but that it is important not to miss any potential spawning areas with the sampling. The WPTT **NOTED** that in the early stages of the proposed project, the intent is to ensure that there is very broad spatial coverage of sampling to provide information on the spatial structure of the population and potential connectivity that can then be used to fine-tune sampling efforts in different areas and fisheries going forward.

190. The WPTT **NOTED** that there may be a possibility to leverage the sampling for the CKMR project to answer additional research questions outside of the estimates of abundance, mortality and connectivity provided by CKMR, but that endeavours to do this should be careful not to impact negatively on the collection of samples for the primary CKMR purposes.

191. The WPTT **NOTED** that a new epigenetic method for ageing has been developed that has the potential to allow for the efficient collection of large amounts of age data that would eliminate the need for the collection of otoliths which is more logistically challenging for samplers and more expensive. As such, single tissue samples from a fish can be used to generate close kin, age and sex information.

192. The WPTT **NOTED** that the prediction power of epigenetics to estimate the age of fish obtained from otoliths has significantly improved in recent times as a result of application of shape-constrained generalised additive models.

193. The WPTT **NOTED** the importance of epigenetic ageing for the implementation of CKMR for yellowfin tuna and **SUGGESTED** that the epigenetic clock for the Indian Ocean be developed in the first year of the project rather than the third year as outlined in the current proposal.

194. The WPTT **NOTED** that the CKMR design study evaluated annual sampling scenarios up to 5 years in length but did not evaluate longer sample periods. To determine the number of samples that would need to be collected each year over a longer period would require rerunning the CKMR design model with longer sampling periods.

195. The WPTT **NOTED** the importance of having estimates of age for CKMR so that birth years can be assigned to each fish samples, and that the length of yellowfin tuna may provide a reasonable proxy for age. However, the WPTT **NOTED** the high variability in size-at-age, and that length may only be useful proxy for age for the very small fish (<50 cm FL).

196. The WPTT **NOTED** that the intent for the CKMR project would be initially to estimate key parameters such as absolute biomass, mortality, and connectivity from a CKMR model that is independent to the stock assessment model, but the CKMR data could be integrated into future yellowfin tuna stock assessment models if desired. The WPTT was referred to paper IOTC-2022-

WPM13-12 that was presented to the WPM in 2022 for more details of the CKMR population model. Similarly, there is also the potential for CKMR information to be incorporated into the management procedure for this stock in future.

197. The WPTT **NOTED** that a sampling strategy with 70% juveniles and 30% adults (70:30) provides the optimum results in terms of precision of biomass estimates. However, the WPTT **NOTED** that a similar precision could be obtained with an 80:20 sampling strategy, and that this might be easier to achieve in terms of sampling. The WPTT was informed that while the design study found similar precision for a 70:30 and 80:20 sampling strategy for biomass, other important parameters estimated from the model, such as adult mortality and other age-dependent metrics, a 70:30 sampling strategy provides a better precision and is the best sampling to achieve the overall goals of CKMR for yellowfin tuna.

198. The WPTT **NOTED** the significant effort required to implement a CKMR pilot project and suggested that the proposed project be set up as a 2-stage project, whereby a full implementation (5-year project) could be initiated as soon as the pilot study indicates it would be feasible. This would avoid a year or more gap between the sampling from the pilot study and the commencement of the implementation of a 5-year sampling program. The WPTT **NOTED** its strong support for the project and **ENCOURAGED** the further development of the pilot project.

8. Update from The Working Group on FADs

199. The WPTT **NOTED** that the 5th Working Group on FADs meeting (WPFAD05) was held online 4th to 6th October. The WPTT endorsed all the recommendations from the WPFAD05 including the revised FOB data reporting form.

200. The WPTT **NOTED** document IOTC-2023-WPTT25-INF08, which presents responses of tuna stocks to temporal closures in the Indian Ocean. The authors provided the following summary:

> "*Implementing temporal closures is a potential management tool to control the fishing pressure and for stock rebuilding plans. In the Indian Ocean, the yellowfin and bigeye stocks are estimated to be overfished and subject to overfishing, and the Commission has requested to investigate diverse management measures to improve the status of these stocks. In this study, the assessment models implemented in Stock Synthesis 3 (SS3) were used to evaluate the impacts on the future stock status of different closure strategies for yellowfin, bigeye, and skipjack. Preliminary analyses were presented to the 5th WGFADs and the WGFAD recommended (see Recommendations once the report is adopted). In addition, new refined analyses were presented to the WPTT. The main difference of the current analyses is that it evaluates the combined impact of implementing the recommended TAC limits for the three stocks in addition to the different modalities of closures and that assumes the reallocation of PSLS catch entirely to PSFS in the same closure periods*".

201. The WPTT **NOTED** the results on the stock status after 10 years of projections under different modalities of closure and assuming no changes from the status quo catch values, including different gears, catch reallocation and closure duration scenarios that resulted in a recovery for the threes stocks (yellowfin, bigeye and skipjack tuna) in the projected time period, for the three stocks (Appendix IX).

202. The WPTT **ENCOURAGED** further refinement of the analysis with emphasis on the reallocation between PSLS and PSFS (e.g., species differences), as the current analyses assumes that the catch from PSLS could be replaced by catch of PSFS, which may be possible for yellowfin tuna but not for bigeye and skipjack tunas.

203. Also, the WPTT **NOTED** that PL fishery is defined in SS3 models by including PL and small PS fleets operating in AFADs, which increases the impact of PL in the bigeye tuna fishery impact plot and, therefore, the WPTT **NOTED** that this should be revisited.

204. The WPTT **NOTED** that the scenarios considered for the reallocation between fisheries (i.e., between PSLS and PSFS) is for catch not for effort. The WPTT **NOTED** this might overestimate the impact as the transfer may not be practical in reality. However, the WPTT agreed that the simulations covered the basis so that the impact of transfer can be evaluated. The WPTT **SUGGESTED** it would be useful to see experiences in other oceans to come up with what would be a more realistic rate of reallocation.

9. WPTT PROGRAM OF WORK

9.1 REVISION OF THE WPTT PROGRAM OF WORK (2024–2028)

205. The WPTT **NOTED** paper IOTC–2023–WPTT25–05, which provided the WPTT25 with an opportunity to consider and revise the WPTT Program of Work (2024–2028), by taking into account the specific requests of the Commission, Scientific Committee, and the resources available to the IOTC Secretariat and CPCs.

206. 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).*

207. 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.

208. The WPTT **RECOMMENDED** that the SC consider and endorse the WPTT Program of Work (2024–2028), as provided in Appendix VII.

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

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

210. 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 2024, by an Invited Expert:

- **Expertise**: Stock assessment; including from regions other than the Indian Ocean; and CPUE standardization, familiarity with the Indian Ocean yellowfin stock assessment.
- **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.

10. OTHER BUSINESS

Chairperson

211. The WPTT **NOTED** that the second term of the current Chairperson, Dr Gorka Merino, is due to expire at the end of the current WPTT meeting and, as per the IOTC Rules of Procedure (2014), participants are required to elect a new Chairperson for the next biennium.

212. The WPTT **THANKED** Dr Gorka Merino for his Chairmanship over the past four years and looked forward to his continued engagement in the activities of the WPTT in the future.

213. **NOTING** the Rules of Procedure (2014), the WPTT **CALLED** for nominations for the newly vacated position of Chairperson of the IOTC WPTT. No new nomination was received. Dr Gorka Merino (EU,Spain) was therefore renominated, seconded and elected as Chairperson of the WPTT for the next biennium.

Vice-Chairperson

214. The WPTT **NOTED** that the second term of the current Vice-Chairperson, Dr Shiham Adam (Maldives), is due to expire at the closing of the current WPTT meeting and, as per the IOTC Rules of Procedure (2014), participants are required to elect a new Vice-Chairperson for the next biennium.

215. **NOTING** the Rules of Procedure (2014), the WPTT **CALLED** for nominations for the position of the Vice Chairperson of the IOTC WPTT. No new nomination was received. Dr Shiham Adam (Maldives) was therefore renominated, seconded and elected as Vice-Chairperson of the WPTT for the next biennium.

10.1 Date and place of the 26th and 27th Sessions of the WPTT

216. The Secretariat will continue to liaise with CPCs to determine their interest in hosting these meetings in the future. The WPTT **RECOMMENDED** the SC consider late October 2024 as a preferred time period to hold the WPTT26 meeting in 2024.

217. 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 2024.

10.2 Review of the draft, and adoption of the Report of the 25th Session of the WPTT

218. The WPTT **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPTT25, 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 2023 (Figure 1):

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

WPTT also **RECOMMENDED** the SC consider removing from the YFT management advice, references to catch reductions required for rebuilding YFT by 2023

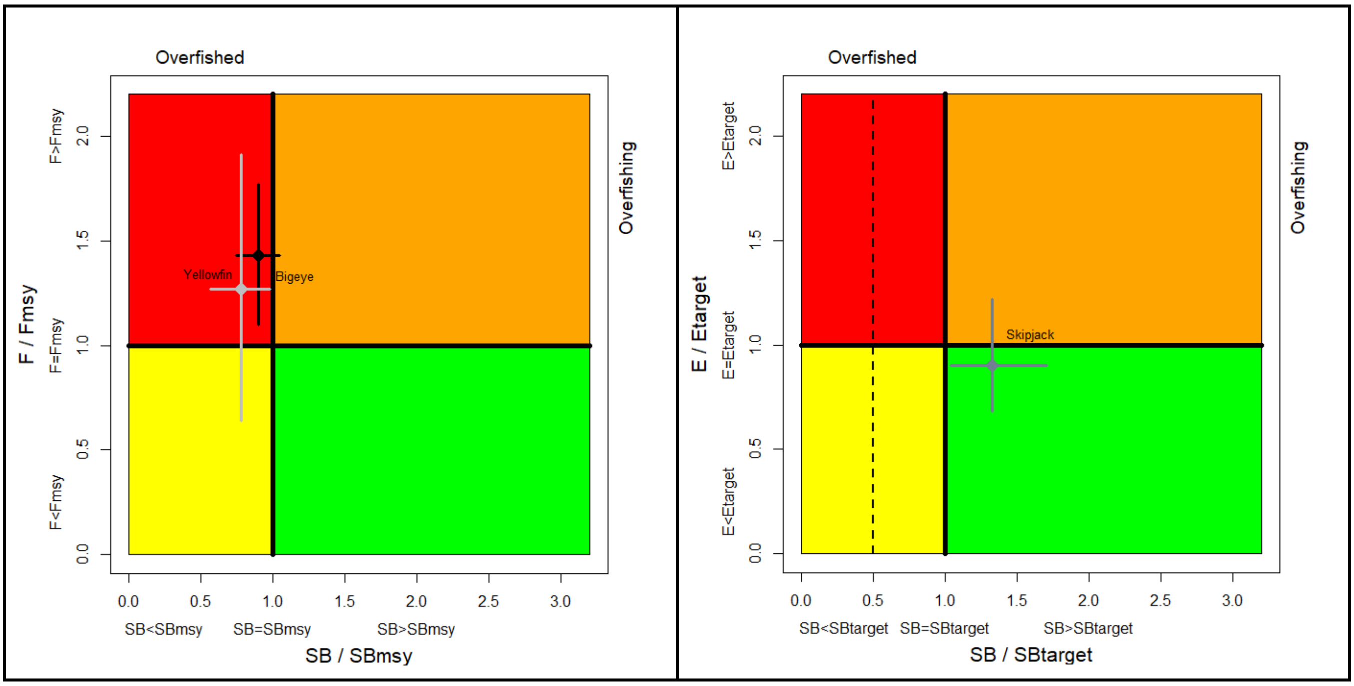

Figure 1. (Left) Combined Kobe plot for bigeye tuna (black: 2022), and yellowfin tuna (grey: 2021) showing the estimates of current stock size (SB) and current fishing mortality (F) in relation to optimal spawning stock size and optimal fishing mortality. (Right) Kobe plot for skipjack tuna showing the estimates of the current stock status in 2023 (The dashed line indicates the limit reference point at 20%SB0). Cross bars illustrate the range of uncertainty from the model runs with an 80% CI.

219. The report of the 25th Session of the Working Party on Tropical Tunas Meeting (IOTC–2023–WPTT25 –R) will be adopted by correspondence.

APPENDIX I
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APPENDIX II

AGENDA FOR THE 25TH WORKING PARTY ON TROPICAL TUNAS, ASSESSMENT MEETING

Date: 30 October – 4 November 2023

Location: San Sebastian, Spain

Time: 09:00 – 17:00 (Spain 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. SKIPJACK STOCK ASSESSMENT (Chair)

4.1 Review any new information on skipjack 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 skipjack tuna
4.5 Development of management advice for skipjack tuna (all)
4.6 Update of skipjack tuna Executive Summary for the consideration of the Scientific Committee (all)

5. BIGEYE TUNA MANAGEMENT PROCEDURE

5.1 Consideration of exceptional circumstances

6. OTHER TROPICAL TUNAS

- Yellowfin
- Bigeye

7. UPDATE ON MSE FOR TROPICAL TUNAS

- Skipjack
- Yellowfin

8. UPDATE FROM THE WORKING GROUP ON FADS

9. WPTT PROGRAM OF WORK

9.1 Revision of the WPTT Program of Work (2024–2028)
9.2 Development of priorities for an Invited Expert at the next WPTT meeting

10. OTHER BUSINESS

10.1 Election of the Chairperson and Vice-Chairperson of the WPTT for the next biennium (Secretariat)
10.2 Date and place of the 26th and 27th Sessions of the WPTT (Chair and IOTC Secretariat)

11. ADOPTION OF THE REPORT

11.1 Review of the draft, and adoption of the Report of the 25TH Session of the WPTT (Chair)

APPENDIX III
LIST OF DOCUMENTS FOR THE 25TH WORKING PARTY ON TROPICAL TUNAS

Document	Title
IOTC–2023–WPTT25–01a	Draft: Agenda of the 25th Working Party on Tropical Tunas
IOTC–2023–WPTT25-01b	Draft: Annotated agenda of the 25th Working Party on Tropical Tunas
IOTC–2023–WPTT25-02	Draft: List of documents for the 25th Working Party on Tropical Tunas
IOTC–2023–WPTT25-3.1 IOTC–2023–WPTT25-3.2	Overview of Indian Ocean tropical tuna fisheries (Secretariat) Review of Indian Ocean skipjack tuna statistical data (Secretariat)
IOTC–2023–WPTT25–04	Outcomes of the 27th Session of the Commission (IOTC Secretariat)
IOTC–2023–WPTT25-05	Revision of the WPTT program of work (IOTC Secretariat)
IOTC–2023–WPTT25-06	Effort standardization of Skipjack tuna in tuna drift gillnet fishery in Sri Lanka (Haputhantri S, Jayasinghe G, Gunasekara S)
IOTC–2023–WPTT25–07	Updated Reproductive Biology of Skipjack Tuna 1 (Katsuwonus pelamis) in Northeastern Indian Ocean (Hartaty H, Setyadji B, Sadiyah L, Satria F)
IOTC–2023–WPTT25–08	CPUE standardization for skipjack tuna (Katsuwonus pelamis) of the EU purse-seine fishery on floating objects (FOB) in the Indian Ocean (Kaplan D, Grande M, Morón G, Lourdes M, Alonso R, Báez J, Uranga J, Duparc A, Imzilen T, Floch L, Santiago J)
IOTC–2023–WPTT25–09	Indian ocean skipjack tuna stock assessment 1950-2022 (stock synthesis) (Fu D)
IOTC–2022–WPTT25–10	Evolution of age determination methods for three tuna species (Lu D, Zhang F, Zhu J)
IOTC–2023–WPTT25-11	Age validation of yellowfin tuna (Thunnus albacares) in the Indian Ocean using post-peak bomb radiocarbon chronologies (Fraile I, Luque P, Campana S, Farley J, Krusic-Golub K, Clear N, Eveson P, Artetxe-Arrate I, Zudaire I, Murua H, Merino G)
IOTC–2023–WPTT25-12	An investigation of the recruitment dynamics of Indian Ocean yellowfin tuna (Langley A)
IOTC–2023–WPTT25-13	Independent review of recent IOTC yellowfin tuna assessment (Maunder M, Langley A, Howell D, Minte-Vera C)
IOTC–2023–WPTT25-14	Estimate populations dynamics of tropical tunas using ecosystem modelling in the Indian Ocean (Li x, Zhu J, Li Y)
IOTC–2023–WPTT25-15	Recent Developments in the Maldives Pole and Line Tuna Fishery - Fleet Trends, Catch and Effort and Spatial Patterns (Ahusan M, Adam S and Jauharee AR)
IOTC–2023–WPTT25-16	Comparison between industrial and artisanal tuna fishery in Kenya (Ndegwa S, Ogari Z, Lukhwenda A, Mueni A, Wambiji N, Okeri M)
IOTC–2023–WPTT25-17	Tropical tuna landings in Thai fishing ports during 2013 – 2022 (Prasertsook O, Yeamubon S)
IOTC–2023–WPTT25-18	Preliminary analysis of observer data on the presence of mesh in floating objects used by the French purse seine fleets in the Atlantic and Indian Oceans (Kaplan D, Cauquil P, Duparc A, Imzilen T , Sabarro, P)
IOTC–2023–WPTT25-19	Understanding the impact of climate change on distribution shifts of the Indian Ocean bigeye tuna (Wang Y, Geng Z, Zhu J , Wu F)
IOTC–2023–WPTT25-20	Updating the estimation of age and growth of yellowfin tuna (Thunnus albacares) in the Indian Ocean using otoliths (Farley J, Krusic-Golub K, Eveson P, Luque P, Fraile I, Artetxe-Arrate I, Zudaire I, Romanov E, Shahid U, Abdul Razzaque S, Parker D, Clear N, Murua H, Marsac F, Merino G)
IOTC–2023–WPTT25-21	Otolith stable isotopes suggest limited east to west connectivity of yellowfin tuna (Thunnus albacares) in the Indian Ocean (Artetxe-Arrate I, Fraile I, Lastra-

	Luque P, Farley J, Urtizberea A, Shahid U, Razzaque S, Clear N, Marsac F, Murua H, Merino G, Zudair I)
IOTC–2023–WPTT25-22	Environmental signal in skipjack recruitment in the Indian Ocean: An updated analysis using the SS3-assessment outputs of 2023 (Marsac F)
IOTC–2023–WPTT25-23	Bigeye (*Thunnus obesus*) tuna connectivity in the Indian Ocean based on genome wide genetic markers (Diaz N et al.)
IOTC–2023–WPTT25-24	Managing a multi-species fishery in distant waters: the case of the Spanish-flagged purse seine fishery targeting tropical tuna in the Indian Ocean (Baez J, Ramos M, Abaunza P)
Information documents	
IOTC–2023–WPTT25-INF01	Advances in the development age reading methods from fin spines and otoliths for Indian Ocean skipjack tuna (Luque P, Krusic-Golub K, Farley J, Artetxe-Arrate I, Fraile I, Zudaire I)
IOTC–2023–WPTT25-INF02	Sensitivity analysis of the 2021 WPTT Indian Ocean yellowfin tuna stock assessment within Stock Synthesis 3 (Landmark Fisheries Research)
IOTC–2023–WPTT25-INF03	Update on epigenetic ageing of tuna (Mayne B, Lloyd-Jones L, Anderson C, Bravington M, Aulich J, Potter N, Farley J, Davies C)
IOTC–2023–WPTT25-INF04	Joint Submission: Updated Indian Ocean Yellowfin Tuna Management Advice (WWF)
IOTC–2023–WPTT25-INF05	Review of Indian Ocean bigeye tuna statistical data (IOTC Secretariat)
IOTC–2023–WPTT25-INF06	Review of Indian Ocean yellowfin tuna statistical data (IOTC Secretariat)
IOTC–2023–WPTT25-INF07	Complementary information on the Associative Behavior-Based abundance Index (ABBI) for western Indian Ocean skipjack tuna (*Katsuwonus pelamis*) obtained from echosounder buoys data (Baidai Y, Dupaix A, Duparc A, Dagorn L Deneubourg JL, Capello M)
IOTC–2023–WPTT25-INF08	Responses of tuna stocks to temporal closures in the Indian Ocean (Correa G, Merino G, Santiago J, Urtizberea A)

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

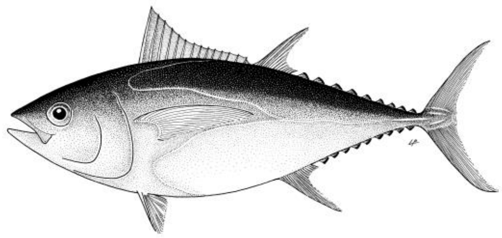

Table 1. Status of bigeye tuna (*Thunnus obesus*) in the Indian Ocean

Area[1]	Indicator	Value	Status[4]
Indian Ocean[1]	Catch in 2022 (t)[2]	102,266	79%*
	Average catch 2018-2022 (t)[3]	92,687	
	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 2022 catch fully or partially estimated by IOTC Secretariat: 19%

[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. No new stock assessment was carried out for bigeye tuna in 2023 and so the advice is based on the 2022 assessment. In the 2022 assessment, 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 FMSY level. Considering the characterized uncertainty, the assessment indicates that SB2021 is below SBMSY and that F2021 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 2018-2022)**: bigeye tuna are caught using purse seine (45.7%), followed by longline (34.4%) and line (12.8%). The remaining catches taken with other gears contributed to 7% of the total catches in recent years (**Fig. 1**).
- **Main fleets (mean annual catch 2018-2022)**: the majority of bigeye tuna catches are attributed to vessels flagged to Indonesia (24.9%) followed by EU (Spain) (18%) and Seychelles (14.4%). The 29 other fleets catching bigeye tuna contributed to 42.5% of the total catch in recent years (**Fig. 2**).

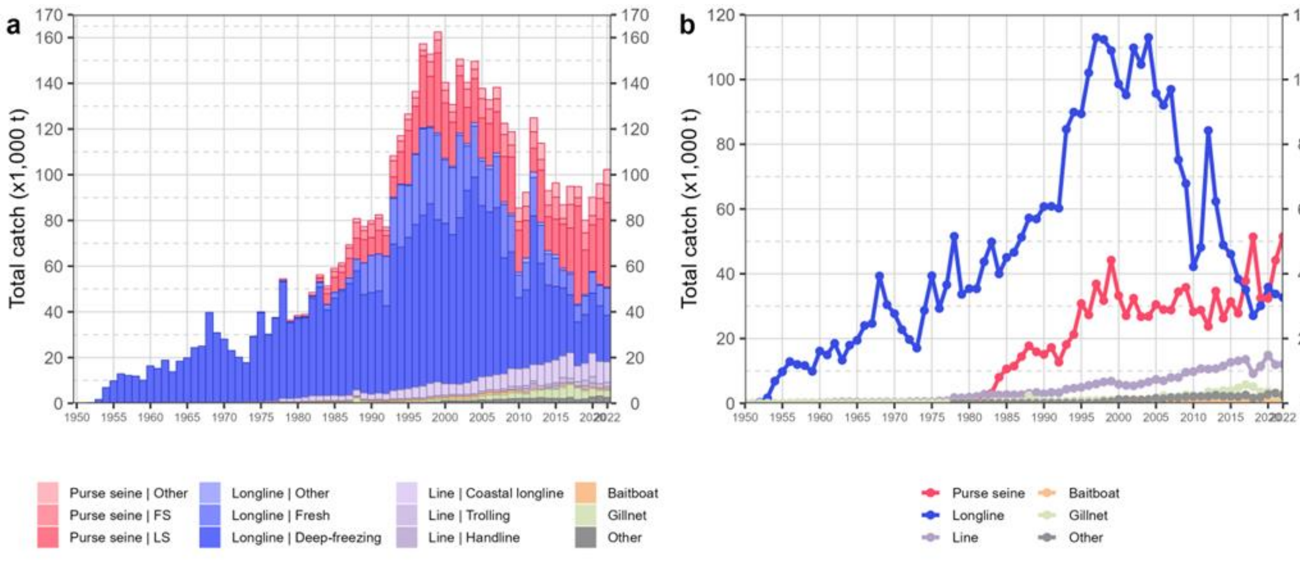

Fig. 1. Annual time series of (a) cumulative nominal catches (metric tonnes; t) by fishery and (b) individual nominal catches (metric tonnes; t) by fishery group for bigeye tuna during 1950-2022. FS = free-swimming school; LS = school associated with drifting floating objects. Purse seine | Other: coastal purse seine, purse seine of unknown association type, ring net; Longline | Other: swordfish and sharks-targeted longlines; Other: all remaining fishing gears

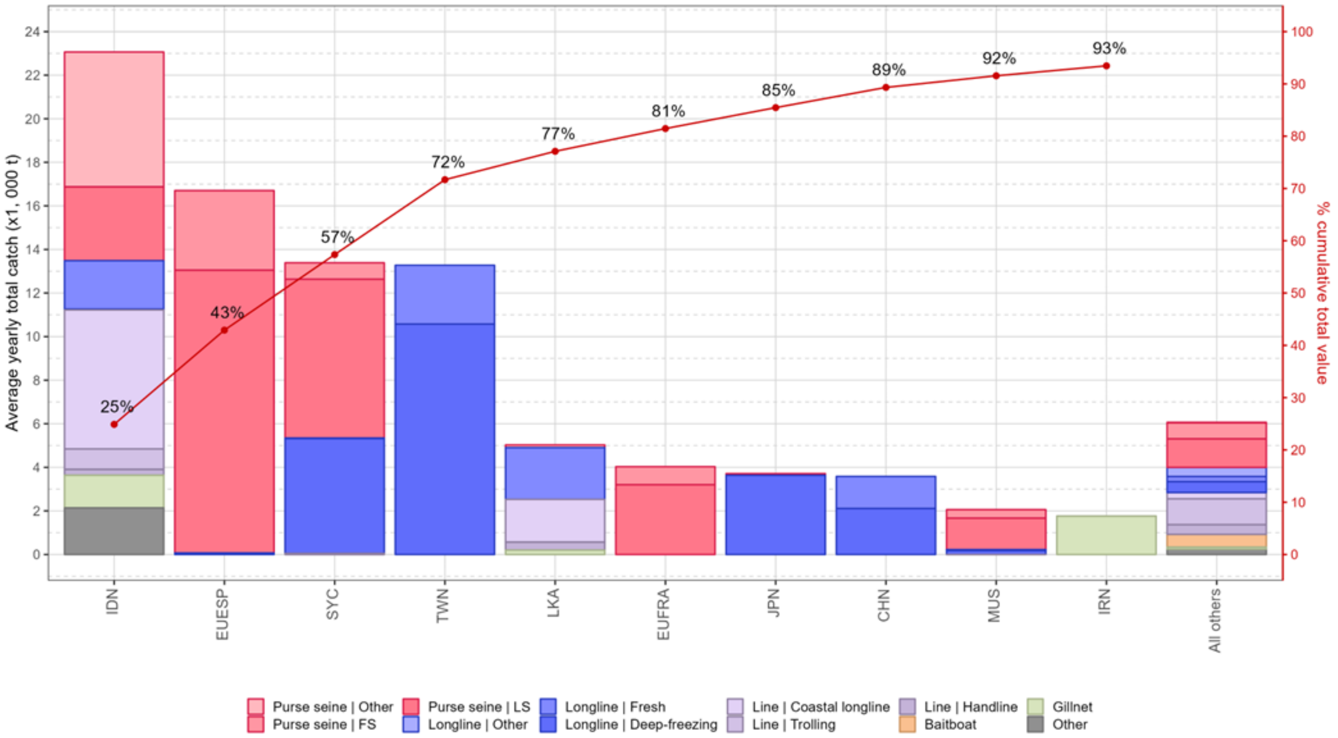

Fig. 2. Mean annual catches (metric tonnes; t) of bigeye tuna by fleet and fishery between 2018 and 2022, with indication of cumulative catches by fleet. FS = free-swimming school; LS = school associated with drifting floating objects. Purse seine | Other: coastal purse seine, purse seine of unknown association type, ring net; Longline | Other: swordfish and sharks-targeted longlines; Other: all remaining fishing gears

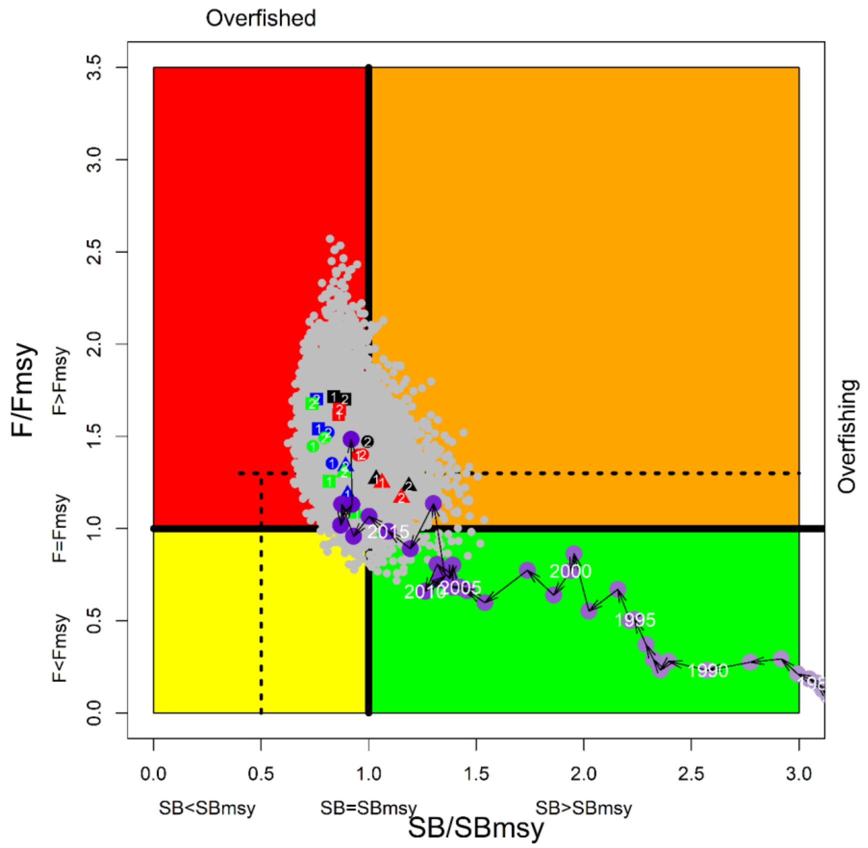

Fig. 3. Bigeye tuna: SS3 Aggregated Indian Ocean assessment Kobe plot. The coloured points represent stock status estimates from the 24 model options. Coloured symbols represent Maximum posterior density (MPD) estimates from individual models: square, circle, and Triangles represents alternative steepness 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)

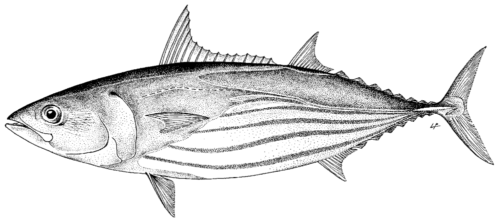

Table 1. Status of skipjack tuna (*Katsuwonus pelamis*) in the Indian Ocean

Area[1]	Indicator	Value	Status[3]
Indian Ocean	Catch in 2022 (t)[2]	666 408	70%*
	Average catch 2018-2022 (t)	613 061	
	$E_{40\%SB0}$ [4] (80% CI)	0.55 (0.48–0.65)	
	SB_0 (t) (80% CI)	1 992 089 (1 691 710–2 547 087)	
	SB_{2022} (t) (80% CI)	1 142 919 (842 723–1 461 772)	
	SB_{2022} / SB_0 80% CI)	0.53 (0.42–0.68)	
	SB_{2022} / $SB_{40\%SB0}$ (80% CI)	1.33 (1.04–1.71)	
	SB_{2022} / $SB_{20\%SB0}$ (80% CI)	2.67 (2.08–3.42)	
	SB_{2022} / SB_{MSY} (80% CI)	2.30 (1.57–3.40)	
	F_{2022} / F_{MSY} (80% CI)	0.49 (0.32–0.75)	
	F_{2022} / $F_{40\%SSB0}$ (80% CI)	0.90 (0.68–1.22)	
	MSY (t) (80% CI)	584 774 (512 228–686 071)	

[1]Boundaries for the Indian Ocean stock assessment are defined as the IOTC area of competence

[2] Proportion of 2022 catch fully or partially estimated by IOTC Secretariat: 18.1%

[3]The status refers to the most recent years' data used in the assessment conducted in 2023, i.e., 2022

[4] $E_{40\%SB0}$ 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 21/03. Note that Resolution 21/03 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 (defined in resolution 21/03 and 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, as defined in resolution 21/03

	Stock overfished (SB_{2022} / $SB_{40\%SB0}$<1)	Stock not overfished (SB_{2022} / $SB_{40\%SB0}$≥ 1)
Stock subject to overfishing (F_{2022} / $F_{40\%SB0}$≥ 1)	8%	21%
Stock not subject to overfishing (F_{2022} / $F_{40\%SB0}$< 1)	1%	70%
Not assessed / Uncertain		

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. A new stock assessment was carried out for skipjack tuna in 2023 using Stock Synthesis with data up to 2022. The outcome of the 2023 stock assessment model is more optimistic than the previous assessment (2020) despite the high catches recorded in the period 2021-2022, which exceeded the catch limits established in 2020 for this period.

The final assessment indicates that:

i. The stock is above the adopted target for this stock (40%SB_0) and the current exploitation rate is below the target exploitation rate. Current spawning biomass relative to unexploited levels is estimated at 53%.
ii. The spawning biomass remains above SB_{MSY} and the fishing mortality remains below F_{MSY} with a probability of 98.4 %
iii. Over the history of the fishery, biomass has been well above the adopted limit reference point (20%SB_0).

Subsequently, based on the weight-of-evidence available in 2023, the skipjack tuna stock is determined to be **not overfished** and **not subject to overfishing**.

Outlook.

There has been a substantial increase of fishery dependent abundance index in recent years: the CPUE from the Pole and line fishery increased by 75% from 2019 to 2022, and the PSLS also increased by over 30% between 2019 and 2021. Total catches in 2022 were 30% larger than the resulting catch limit from the skipjack HCR for the period 2021-2023 (513,572 t). The increase in abundance despite catches exceeding the recommended limits was primarily driven by an increase in recent recruitment which was estimated to be well above the long-term average. Environmental conditions (such as sea surface productivity (chlorophyll)) are believed to significantly influence recruitment of skipjack tuna and can produce high variability in recruitment levels between years. The high recruitment anomaly estimated in 2022 appears to be supported by the strong increasingly positive phase of sea surface productivity which began from a below average level in 2015. Climate model predictions suggest that the positive productivity phase will end by the start of 2024 resulting in a period of lower productivity. There is also considerable uncertainty in the stock assessment models due to the potential caveats of using PL and PSLS CPUE as index of basin-level abundance and uncertainty in stock productivity parameters of skipjack tuna (e.g., steepness and growth, natural mortality). The model runs analyzed illustrate a wide range of stock status (SB_{2022} / SB_0) to be between 35% and 78%.

- **Management advice.** The catch limit calculated applying the HCR specified in Resolution21/03 is [628, 605t] for the period 2024-2026. 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 in recent years and a higher stock level relative to the target reference point, possibly due to skipjack life history characteristics and favorable environmental conditions. Noting that the environmental conditions are predicted to enter a less favorable period, it is important that the Commission ensures that catches of skipjack tuna during this period do not exceed the agreed limit, as occurred in recent years. In addition, the [SC] recognizes the potential impact on other associated stocks (bigeye and yellowfin) of exceeding the catch limits of skipjack. 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 (superseded by Resolution 21/03)*.
- **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 2018-2022)**: skipjack tuna are caught using purse seine (54.4%), followed by baitboat (19.2%) and gillnet (17.9%). The remaining catches taken with other gears contributed to 8.6% of the total catches in recent years (**Fig. 1**).
- **Main fleets (mean annual catch 2018-2022)**: the majority of skipjack tuna catches are attributed to vessels flagged to Indonesia (19.6%) followed by Maldives (17.6%) and EU (Spain) (16.9%). The 31 other fleets catching skipjack tuna contributed to 45.8% of the total catch in recent years (**Fig. 2**).

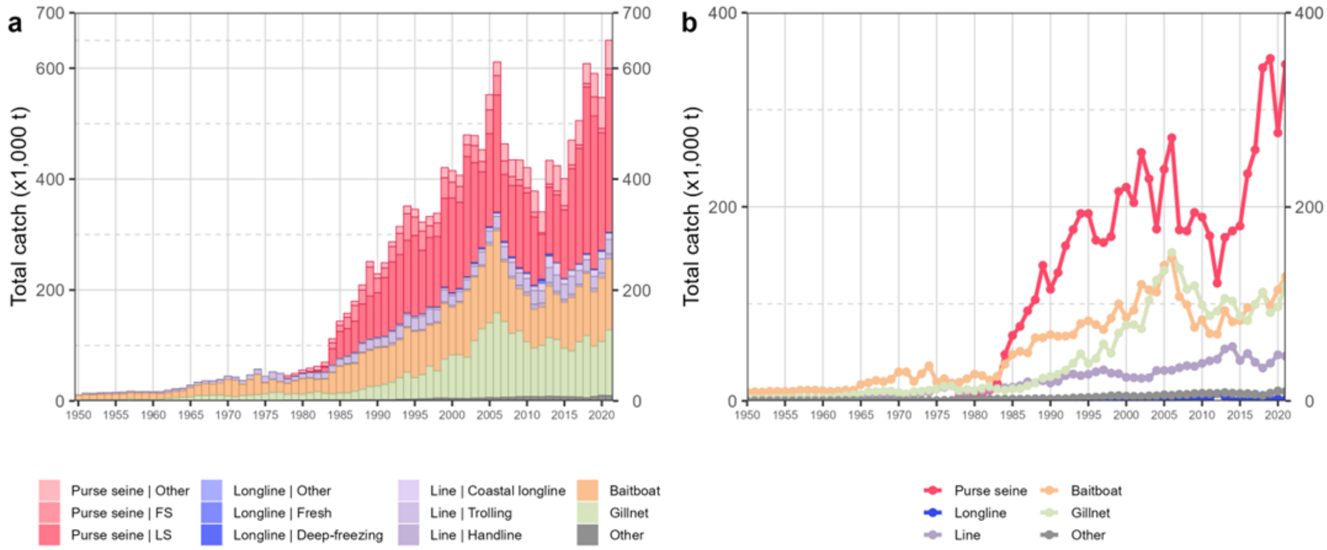

Fig. 1. Annual time series of (a) cumulative nominal catches (metric tonnes; t) by fishery and (b) individual nominal catches (metric tonnes; t) by fishery group for skipjack tuna during 1950-2022. FS = free-swimming school; LS = school associated with drifting floating objects. Purse seine | Other: coastal purse seine, purse seine of unknown association type, ring net; Longline | Other: swordfish and sharks-targeted longlines; Other: all remaining fishing gears

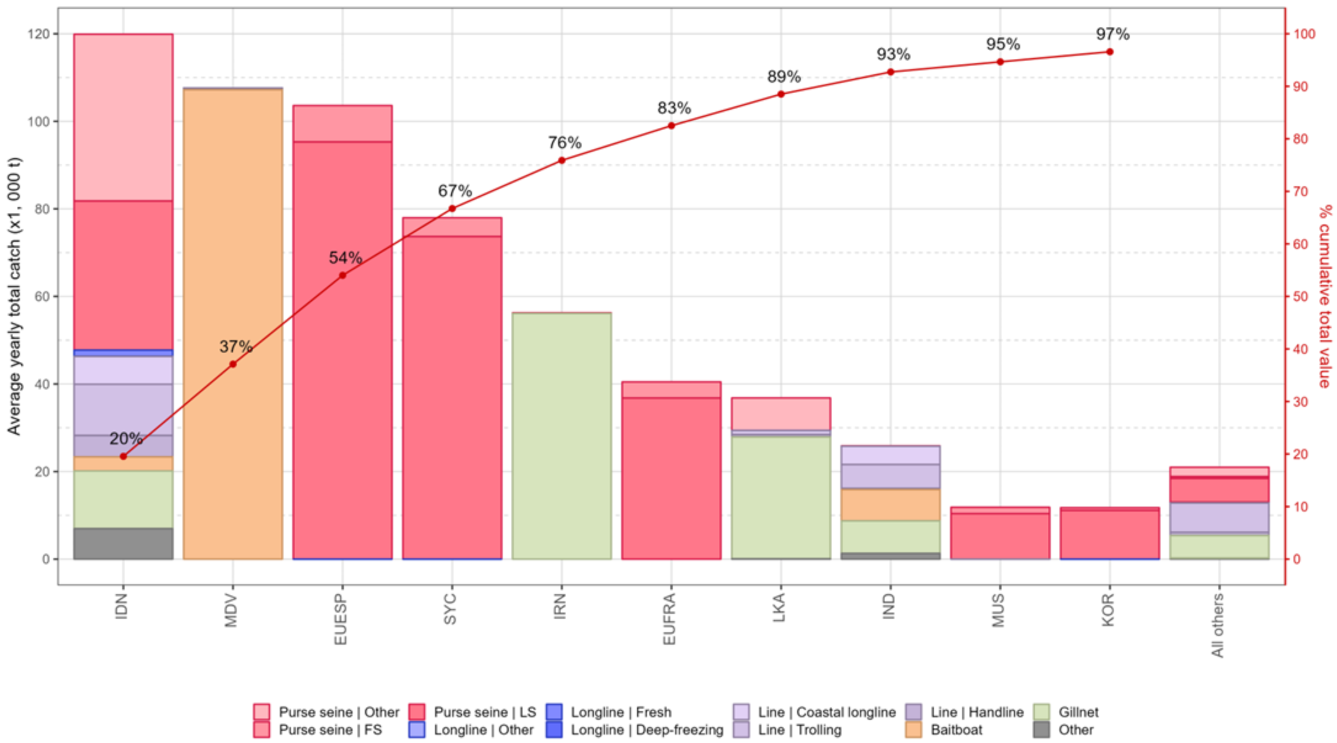

Fig. 2. Mean annual catches (metric tonnes; t) of skipjack tuna by fleet and fishery between 2018 and 2022, with indication of cumulative catches by fleet. FS = free-swimming school; LS = school associated with drifting floating objects. Purse seine | Other: coastal purse seine, purse seine of unknown association type, ring net; Longline | Other: swordfish and sharks-targeted longlines; Other: all remaining fishing gears

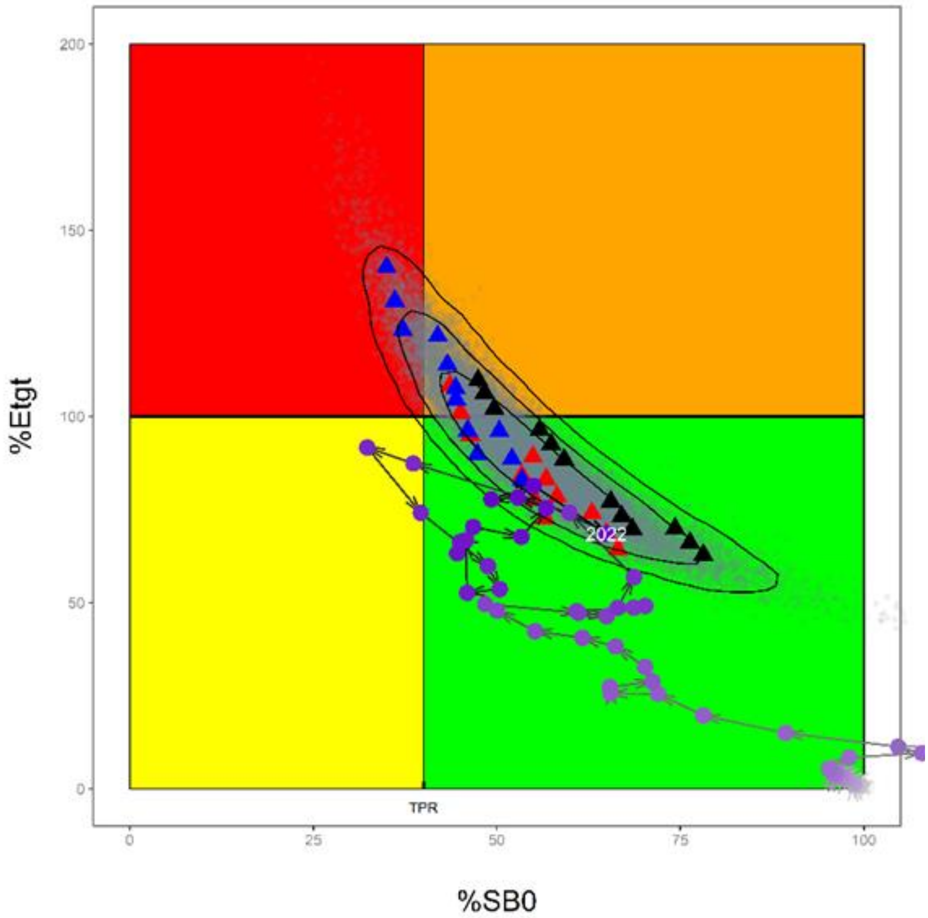

Fig. 3. Skipjack tuna: SS3 Aggregated Indian Ocean assessment Kobe plot of the 2023 uncertainty grid. Left - current stock status, relative to SB0 and F (x-axis) and $F_{40\%B0}$ (y-axis) reference points for the final model grid.. TPR indicates 40% B0; Triangles represent MPD estimates from individual models (black, models based on PL index; red, models based on PSLS index; blue, models based on and both PSLS and ABBI index). Grey dots represent uncertainty from individual models. The arrowed line represents time series of historical stock trajectory for model PSLS. Contours represents 50, 80, and 90% confidence region.

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

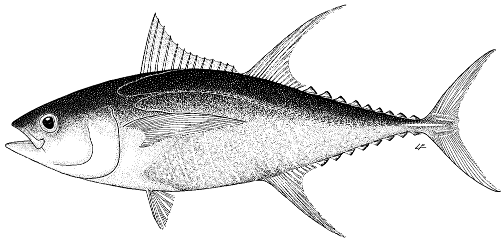

Table 1. Status of yellowfin tuna (*Thunnus albacares*) in the Indian Ocean

Area[1]	Indicator	Value	Status[4]
Indian Ocean	Catch in 2022 (t)[2]	410,332	68%*
	Average catch 2017-2021 (t)[3]	429,421	
	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 2022 catch fully or partially estimated by IOTC Secretariat: 17.2%
[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 2023 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[1] 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 2021 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

[1] 2020 catch levels indicate the nominal catch available to the WPTT at its session in October 2021 (WPTT23).

The following key points should also be noted:

- 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 2017-2021 average catches (435,225 t) were above the estimated MSY level. Although catch in 2021 reduced by 3% compared to the 2020 level, the last year catch remained 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 2018-2022)**: yellowfin tuna are caught using line (38.1%), followed by purse seine (32.5%) and gillnet (16.5%). The remaining catches taken with other gears contributed to 12.9% of the total catches in recent years (**Fig. 1**).
- **Main fleets (mean annual catch 2018-2022)**: the majority of yellowfin tuna catches are attributed to vessels flagged to Sultanate of Oman (13.2%) followed by I. R. Iran (11.5%) and EU (Spain) (10.2%). The 33 other fleets catching yellowfin tuna contributed to 65% 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

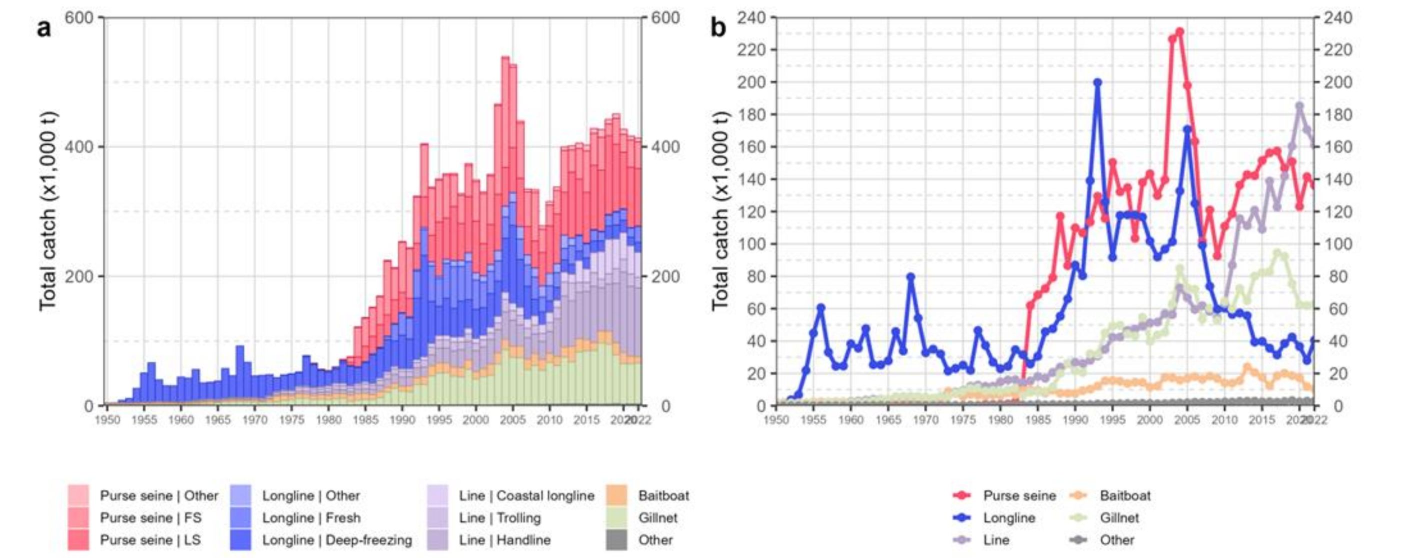

Fig. 1. Annual time series of (a) cumulative nominal catches (metric tonnes; t) by fishery and (b) individual nominal catches (metric tonnes; t) by fishery group for yellowfin tuna during 1950–2022. FS = free-swimming school; LS = school associated with drifting floating objects. Purse seine | Other: coastal purse seine, purse seine of unknown association type, ring net; Longline | Other: swordfish and sharks-targeted longlines; Other: all remaining fishing gears

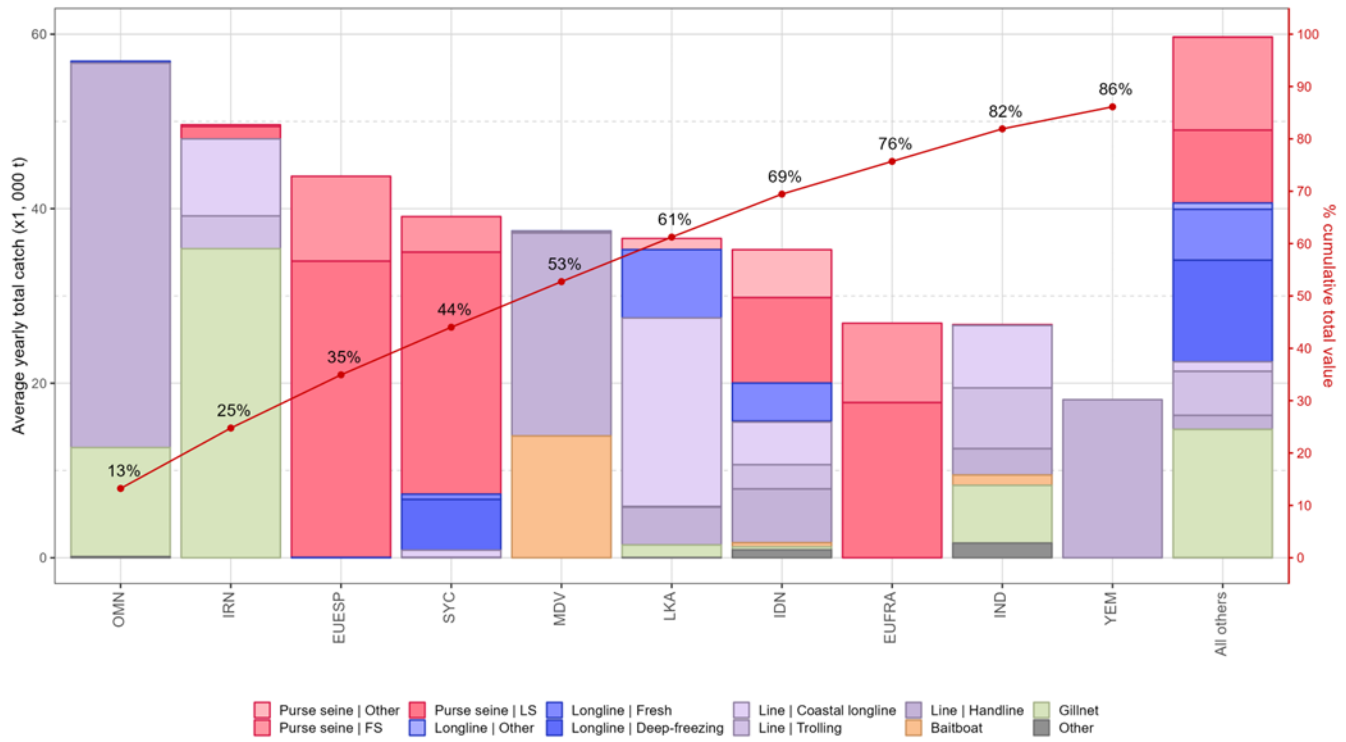

Fig. 2. Mean annual catches (metric tonnes; t) of yellowfin tuna by fleet and fishery between 2018 and 2022, with indication of cumulative catches by fleet. FS = free-swimming school; LS = school associated with drifting floating objects. Purse seine | Other: coastal purse seine, purse seine of unknown association type, ring net; Longline | Other: swordfish and sharks-targeted longlines; Other: all remaining fishing gears

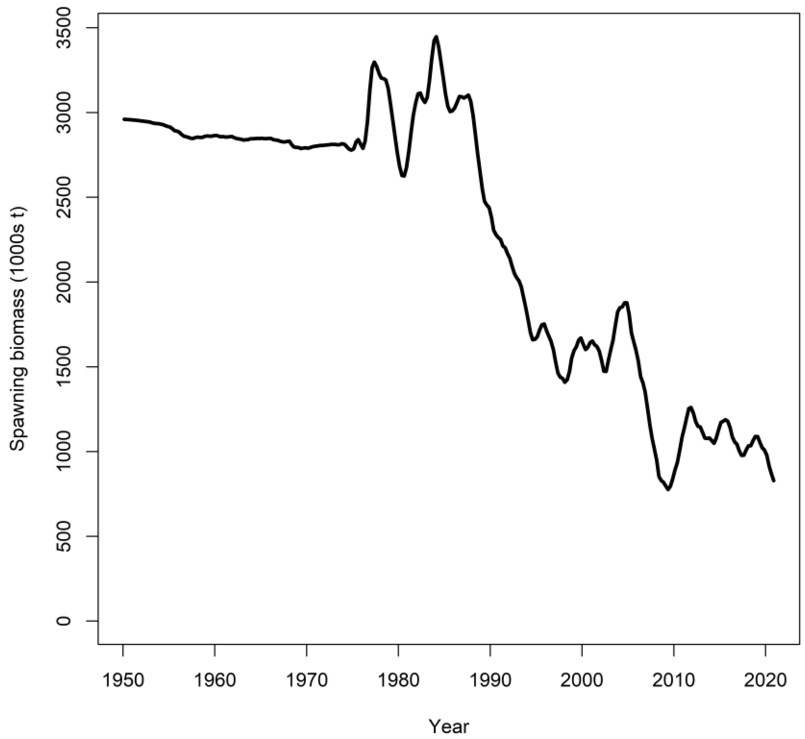

Fig 3. Estimated time series (1950-2020) of total spawning biomass of yellowfin tuna (left) from the reference model of the 2020 assessment.

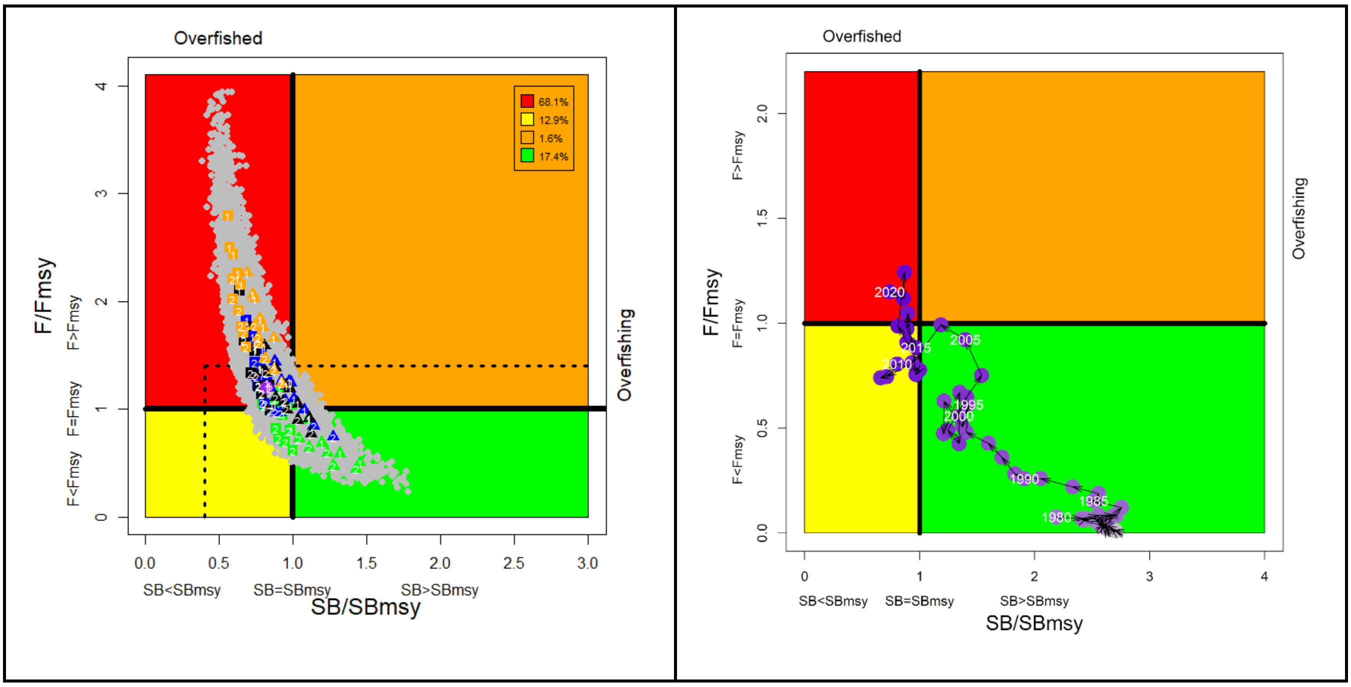

Fig. 4. Yellowfin tuna: SS3 Indian Ocean assessment Kobe plot: (left): current stock status, relative to SB_{MSY} (x-axis) and F_{MSY} (y-axis) reference points for the final model options. Coloured symbols represent Maximum posterior density (MPD) estimates from individual models: square and Triangles 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

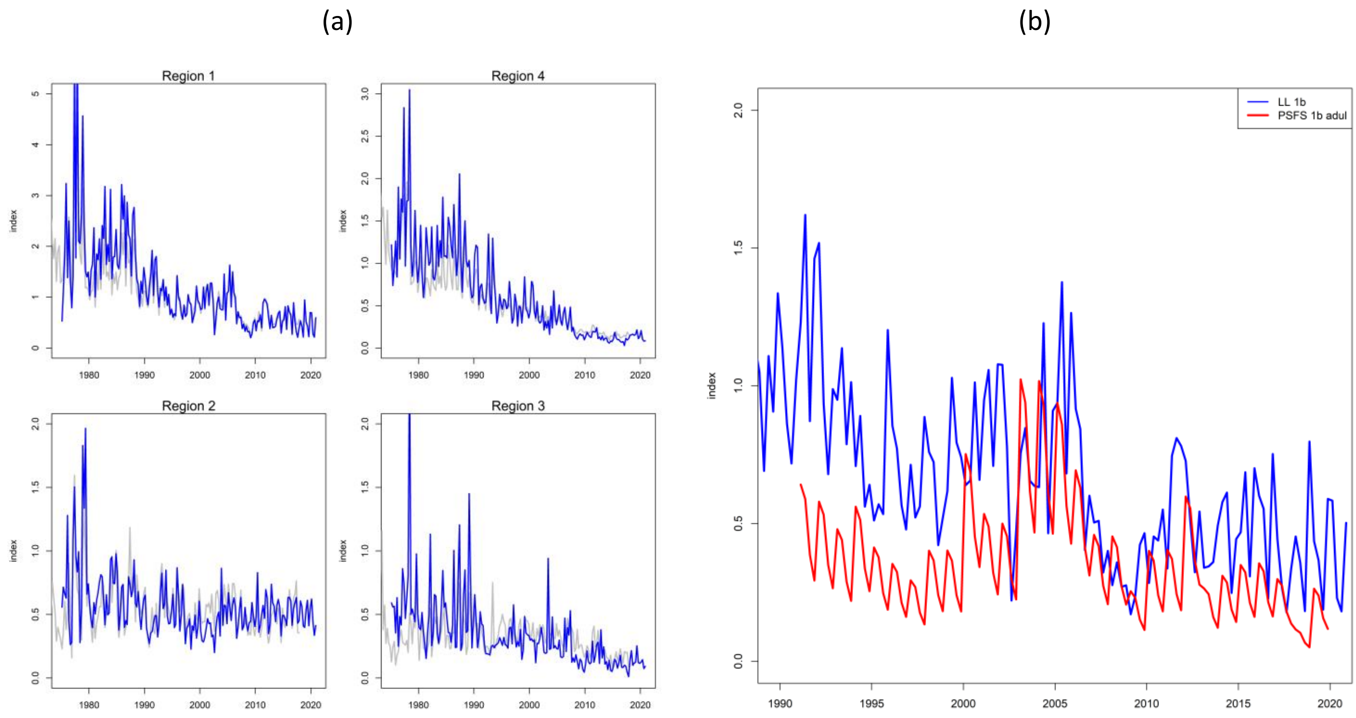

Fig 5. Standardised CPUE indices used in the final assessment models: (a) Joint longline CPUE indices by region 1975-2020 (The grey lines are indices used in 2018 assessment 1972 – 2017), and (b) EU Purse seine free school CPUE on adults (≥10 kg) (overlaid with the longline CPUE in region 1

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 (2024–2028)

The following is the Draft WPTT Program of Work (2024–2028) 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**				
		2024	**2025**	**2026**	**2027**	**2028**
Stock assessment priorities	Address the issues identified as priorities by the yellowfin tuna peer review panel (February 2023)					
Abundance indices development	In view of the coming assessments of yellowfin, bigeye, and skipjack develop abundance time series for each tropical tuna stock for the Indian Ocean • Continue to develop CPUE indices from Longline, PS, Pole and line fisheries, and fishery independent indices of abundance such as those derived from echosounder buoys. • Explore and support the development of gillnet CPUE indices for fleets (e.g., Iran, Pakistan and Sri Lanka) • Evaluate effect of changes of spatial coverage on the longline CPUE through the Joint CPUE workshop and estimate spatial temporal abundance distribution through VAST modelling approach					
Analysis of tagging data	Analyze data from IOTC tagging programs outside stock assessment models and evaluate its utility and impact on stock assessments.					
Analyse recommendations from independent review	Carry out analyses recommended by the independent review of the yellowfin tuna stock assessment. Explore options, for example, for spatial structure, recruitment trends, movement dynamics, data weighting, selectivity before the 2024 WPTT Data Preparatory meeting.					

Analysis of environmental factors	Evaluate the impact of environmental factors on the dynamics of tropical tuna stocks					

Other Future Research Requirements (not in order of priority)						
1. Fisheries Independent Monitoring	1.1 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). Plan for a staged approach for implementation of a YFT CKMR project					
2. Stock structure (connectivity and diversity)	2.1 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.					
	2.2 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).					
	Connectivity, movements and habitat use					
	2.3 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). 2.4 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.					
3. Biological and ecological information (incl. parameters for stock assessment)	3.1 Biological sampling					
	3.1.1 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.					
	3.1.2 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.					
4. Historical data review	4.1 Changes in fleet dynamics need to be documented by fleet					
	4.1.1 Provide an evaluation of fleet-specific fishery impacts on the stock of bigeye tuna, skipjack tuna and yellowfin tuna. Project potential impact of realizing fleet development plans on the status of tropical tunas based upon most recent stock assessments.					
5. CPUE standardisation	5.1 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).					
	5.11 Investigate the potential to use the Indian longline survey as a fishery-independent index of abundance for tropical tunas.					
6. Stock assessment stock indicators	6.1 Develop and compare multiple assessment approaches to determine stock status for tropical tunas 6.2 Scoping of ongoing age composition data collection for stock assessment 6.3 Develop a high-resolution age structured operating model that can be used to test the spatial assumptions including potential effects of limited tags mixing on stock assessment outcomes (see Terms of Reference, Appendix IXa IOTC-2017-WPTT19-R).					
7. Fishery monitoring	7.1 Develop fishery independent estimates of stock abundance to validate the abundance estimates of CPUE series. All of the tropical tuna stock assessments are highly dependent on relative abundance estimates derived from commercial fishery catch rates, and these could be substantially biased despite efforts to standardise for operational variability (e.g. spatio-temporal variability in operations, improved efficiency from new technology, changes in species targeting). Accordingly, the IOTC should continue to explore fisheries independent monitoring options which may be viable through new technologies. There are various options, among which some are already under test. Not all of these options are rated with the same priority, and those being currently under development need to be promoted, as proposed below: Acoustic FAD monitoring, with the objective of deriving abundance indices based on the biomass estimates provided by echo-sounder buoys attached to FADs					

	7.2 Longline-based surveys (expanding on the Indian model) or "sentinel surveys" in which a small number of commercial sets follow a standardised scientific protocol 7.3 Aerial surveys, potentially using remotely operated or autonomous drones 7.4 Studies (research) on flux of tuna around anchored FAD arrays to understand standing stock and independent estimates of the stock abundance. 7.5 Investigate the possibility of conducting ongoing ad hoc, low level tagging in the region					
8. Target and Limit reference points	8.1 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					
9. Fisheries Indicators	8.2 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.					

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

Species	**2024**	**2025**	**2026**	**2027**	**2028**
Bigeye tuna	Indicators **MP to be run**	**Data preparatory meeting** **Full assessment**	Indicators	Indicators **MP to be run**	**Data preparatory meeting** **Full assessment**
Skipjack tuna	Indicators	Indicators	**Data preparatory meeting** **Full assessment**	Indicators	Indicators
Yellowfin tuna	**Data preparatory meeting** **Full assessment**	Indicators	Indicators	**Data preparatory meeting** **Full assessment**	Indicators

APPENDIX VIII

CONSOLIDATED RECOMMENDATIONS OF THE 25TH SESSION OF THE WORKING PARTY ON TROPICAL TUNAS

Note: Appendix references refer to the Report of the 25th Session of the Working Party on Tropical Tunas (IOTC–2023–WPTT25–R

Skipjack tuna Stock Assessment

WPTT25.01 (para. 87): NOTING the substantial contribution of gillnet fisheries to the total catches of skipjack tuna and the limitations of the purse seine and pole and line indices of skipjack tuna abundance, the WPTT **RECOMMENDED** the SC to develop and implement a workshop on gillnet CPUE, with a major focus on the fleets from I.R. Iran and Sri Lanka, to potentially complement and corroborate the PS and PL CPUE.

WPTT25.02 (para. 96): The WPTT **RECALLED** that IOTC Resolution 21/03, which superseded Resolution 16/02 requires the skipjack tuna stock assessment estimates to be used to as inputs for the Harvest Control Rule (HCR) to calculate the TAC. The WPTT **RECOMMENDED** that the SC endorse the stock assessment and that the median estimates from the model ensemble are used to calculate the TAC for skipjack tuna for 2024-2026 (The TAC calculated using the stock assessment is 628 605 t).

Other tropical tuna

WPTT25.03 (para. 124): The WPTT **RECOMMENDED** that purse seiner observer data protocols include the need to collect FOB material and construction characteristics and that protocols for that collection are harmonized among PS CPCs and adopted by IOTC WPDCS.

WPTT25.04 (para. 138): The WPTT ENCOURAGED interested CPCs to complement ISSF-data and provide sale data information to the IOTC Secretariat under strict confidentiality agreements. In this regard, the WPTT **RECOMMENDED** that external consultancy be made available to IOTC to carry out this analysis under the supervision of the IOTC Secretariat and included in the WPTT program of work.

WPTT25.05 (para. 161): The WPTT NOTED that the yellowfin assessment model has evolved over time, with significant contributions from the independent expert to the model's initial and subsequent design and formulation. The WPTT also NOTED that there are a number of intricate problems with the model's input data, structure, and dynamics. Solving these problems calls for a collaborative approach that synthesises a wide range of expertise, as well as the expert's in-depth historical knowledge. Therefore, the WPTT **RECOMMENDED** that the independent expert continue to be engaged in the enhancement and further development of the yellowfin assessment, with an emphasis on implementing the external review's recommendations.

Revision of the WPTT Program of Work (2024–2028)

WPTT25.06 (para. 208): The WPTT **RECOMMENDED** that the SC consider and endorse the WPTT Program of Work (2024–2028), as provided in Appendix VII.

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

WPTT25.07 (para. 216) The Secretariat will continue to liaise with CPCs to determine their interest in hosting these meetings in the future. The WPTT RECOMMENDED the SC consider late October 2024 as a preferred time period to hold the WPTT26 meeting in 2024.

Review of the draft, and adoption of the report of the 25th session of the WPTT

WPTT25.08 (para. 218): The WPTT **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPTT25, 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 2023 (Figure 1):

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

- Yellowfin tuna (*Thunnus albacares*) – Appendix VI

The WPTT also **RECOMMENDED** the SC consider removing from the YFT management advice, references to catch reductions required for rebuilding YFT by 2023

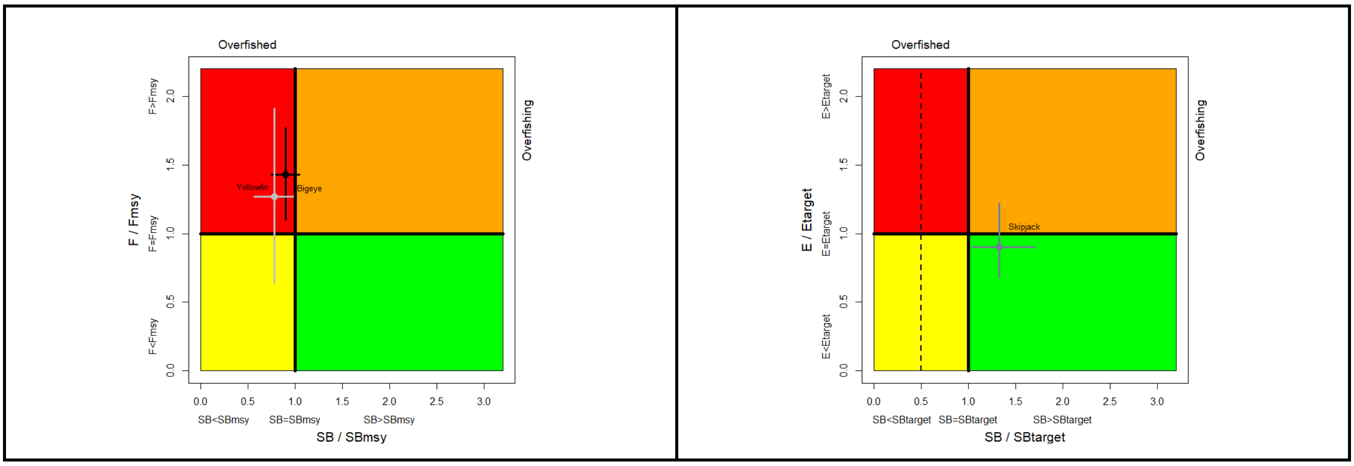

Figure 1. (Left) Combined Kobe plot for bigeye tuna (black: 2022), and yellowfin tuna (grey: 2021) showing the estimates of current stock size (SB) and current fishing mortality (F) in relation to optimal spawning stock size and optimal fishing mortality. (Right) Kobe plot for skipjack tuna showing the estimates of the current stock status (dark grey: 2023). 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.

APPENDIX IX
TEMPORAL FISHERY CLOSURE TABLES

Yellowfin tuna

Table 1: Yellowfin tuna. Impacts of closure scenarios on the stock status by the end of a 10-year projection period. The TAC scenario did not implement any closure. PS-LS = FAD fishery. LS-FS = interaction between FAD and free school purse seine fisheries.

Closed fleet	Closed season	No. months closed	Reallocation (%)	B/Bmsy	F/Fmsy
TAC	-	-	-	0.971	0.934
Baitboat	Q1	1	100	0.972	0.933
Baitboat	Q1	1	50	0.983	0.920
Baitboat	Q1	1	0	0.993	0.909
Baitboat	Q1	2	100	0.973	0.932
Baitboat	Q1	2	50	0.994	0.909
Baitboat	Q1	2	0	1.015	0.886
Baitboat	Q1	3	100	0.974	0.931
Baitboat	Q1	3	50	1.006	0.896
Baitboat	Q1	3	0	1.038	0.863
Baitboat	Q2	1	100	0.971	0.933
Baitboat	Q2	1	50	0.977	0.927
Baitboat	Q2	1	0	0.983	0.920
Baitboat	Q2	2	100	0.971	0.933
Baitboat	Q2	2	50	0.983	0.920
Baitboat	Q2	2	0	0.994	0.908
Baitboat	Q2	3	100	0.971	0.933
Baitboat	Q2	3	50	0.989	0.914
Baitboat	Q2	3	0	1.006	0.895
Baitboat	Q3	1	100	0.970	0.934
Baitboat	Q3	1	50	0.982	0.920
Baitboat	Q3	1	0	0.988	0.915
Baitboat	Q3	2	100	0.970	0.934
Baitboat	Q3	2	50	0.987	0.915
Baitboat	Q3	2	0	1.004	0.897
Baitboat	Q3	3	100	0.970	0.934
Baitboat	Q3	3	50	0.996	0.906
Baitboat	Q3	3	0	1.021	0.879
Baitboat	Q4	1	100	0.970	0.934
Baitboat	Q4	1	50	0.983	0.919
Baitboat	Q4	1	0	0.993	0.909
Baitboat	Q4	2	100	0.969	0.935
Baitboat	Q4	2	50	0.992	0.909
Baitboat	Q4	2	0	1.015	0.885
Baitboat	Q4	3	100	0.967	0.936
Baitboat	Q4	3	50	1.003	0.897

Closed fleet	Closed season	No. months closed	Reallocation (%)	B/Bmsy	F/Fmsy
Baitboat	Q4	3	0	1.039	0.860
PS-FSchool	Q1	1	100	0.971	0.933
PS-FSchool	Q1	1	50	0.976	0.930
PS-FSchool	Q1	1	0	0.981	0.925
PS-FSchool	Q1	2	100	0.971	0.933
PS-FSchool	Q1	2	50	0.981	0.925
PS-FSchool	Q1	2	0	0.991	0.918
PS-FSchool	Q1	3	100	0.972	0.933
PS-FSchool	Q1	3	50	0.986	0.922
PS-FSchool	Q1	3	0	1.001	0.911
PS-FSchool	Q2	1	100	0.971	0.933
PS-FSchool	Q2	1	50	0.980	0.926
PS-FSchool	Q2	1	0	0.985	0.922
PS-FSchool	Q2	2	100	0.971	0.933
PS-FSchool	Q2	2	50	0.985	0.922
PS-FSchool	Q2	2	0	0.999	0.912
PS-FSchool	Q2	3	100	0.972	0.933
PS-FSchool	Q2	3	50	0.993	0.917
PS-FSchool	Q2	3	0	1.014	0.901
PS-FSchool	Q3	1	100	0.971	0.934
PS-FSchool	Q3	1	50	0.975	0.930
PS-FSchool	Q3	1	0	0.981	0.925
PS-FSchool	Q3	2	100	0.971	0.934
PS-FSchool	Q3	2	50	0.980	0.926
PS-FSchool	Q3	2	0	0.989	0.920
PS-FSchool	Q3	3	100	0.970	0.934
PS-FSchool	Q3	3	50	0.984	0.923
PS-FSchool	Q3	3	0	0.998	0.913
PS-FSchool	Q4	1	100	0.971	0.934
PS-FSchool	Q4	1	50	0.973	0.932
PS-FSchool	Q4	1	0	0.975	0.930
PS-FSchool	Q4	2	100	0.970	0.934
PS-FSchool	Q4	2	50	0.974	0.931
PS-FSchool	Q4	2	0	0.978	0.927
PS-FSchool	Q4	3	100	0.970	0.934
PS-FSchool	Q4	3	50	0.976	0.929
PS-FSchool	Q4	3	0	0.982	0.924
Gillnet	Q1	1	100	0.972	0.933
Gillnet	Q1	1	50	0.988	0.918
Gillnet	Q1	1	0	1.006	0.902
Gillnet	Q1	2	100	0.973	0.932
Gillnet	Q1	2	50	1.005	0.904

Closed fleet	Closed season	No. months closed	Reallocation (%)	B/Bmsy	F/Fmsy
Gillnet	Q1	2	0	1.035	0.878
Gillnet	Q1	3	100	0.976	0.930
Gillnet	Q1	3	50	1.022	0.889
Gillnet	Q1	3	0	1.066	0.852
Gillnet	Q2	1	100	0.971	0.933
Gillnet	Q2	1	50	0.987	0.919
Gillnet	Q2	1	0	1.006	0.903
Gillnet	Q2	2	100	0.972	0.932
Gillnet	Q2	2	50	1.003	0.905
Gillnet	Q2	2	0	1.075	0.837
Gillnet	Q2	3	100	0.973	0.932
Gillnet	Q2	3	50	1.020	0.890
Gillnet	Q2	3	0	1.064	0.854
Gillnet	Q3	1	100	0.970	0.934
Gillnet	Q3	1	50	0.990	0.916
Gillnet	Q3	1	0	1.010	0.900
Gillnet	Q3	2	100	0.970	0.934
Gillnet	Q3	2	50	1.010	0.900
Gillnet	Q3	2	0	1.047	0.869
Gillnet	Q3	3	100	0.970	0.934
Gillnet	Q3	3	50	1.030	0.883
Gillnet	Q3	3	0	1.085	0.840
Gillnet	Q4	1	100	0.969	0.935
Gillnet	Q4	1	50	0.989	0.917
Gillnet	Q4	1	0	1.009	0.900
Gillnet	Q4	2	100	0.967	0.936
Gillnet	Q4	2	50	1.008	0.901
Gillnet	Q4	2	0	1.047	0.870
Gillnet	Q4	3	100	0.965	0.937
Gillnet	Q4	3	50	1.026	0.886
Gillnet	Q4	3	0	1.084	0.841
Handline	Q1	1	100	0.972	0.933
Handline	Q1	1	50	0.994	0.917
Handline	Q1	1	0	1.014	0.903
Handline	Q1	2	100	0.977	0.920
Handline	Q1	2	50	1.016	0.902
Handline	Q1	2	0	1.055	0.876
Handline	Q1	3	100	0.976	0.930
Handline	Q1	3	50	1.039	0.885
Handline	Q1	3	0	1.095	0.852
Handline	Q2	1	100	0.971	0.933
Handline	Q2	1	50	0.990	0.920

Closed fleet	Closed season	No. months closed	Reallocation (%)	B/Bmsy	F/Fmsy
Handline	Q2	1	0	1.008	0.907
Handline	Q2	2	100	0.972	0.933
Handline	Q2	2	50	1.008	0.907
Handline	Q2	2	0	1.044	0.882
Handline	Q2	3	100	0.972	0.933
Handline	Q2	3	50	1.027	0.894
Handline	Q2	3	0	1.081	0.860
Handline	Q3	1	100	0.971	0.934
Handline	Q3	1	50	0.980	0.926
Handline	Q3	1	0	0.986	0.922
Handline	Q3	2	100	0.970	0.934
Handline	Q3	2	50	0.986	0.922
Handline	Q3	2	0	1.002	0.911
Handline	Q3	3	100	0.970	0.934
Handline	Q3	3	50	0.994	0.917
Handline	Q3	3	0	1.017	0.901
Handline	Q4	1	100	0.970	0.934
Handline	Q4	1	50	0.982	0.925
Handline	Q4	1	0	0.994	0.917
Handline	Q4	2	100	0.969	0.935
Handline	Q4	2	50	0.993	0.917
Handline	Q4	2	0	1.016	0.901
Handline	Q4	3	100	0.967	0.936
Handline	Q4	3	50	1.005	0.909
Handline	Q4	3	0	1.039	0.886
LL-FrTuna	Q1	1	100	0.976	0.928
LL-FrTuna	Q1	1	50	0.971	0.933
LL-FrTuna	Q1	1	0	0.971	0.933
LL-FrTuna	Q1	2	100	0.976	0.926
LL-FrTuna	Q1	2	50	0.977	0.925
LL-FrTuna	Q1	2	0	0.979	0.923
LL-FrTuna	Q1	3	100	0.988	0.911
LL-FrTuna	Q1	3	50	0.988	0.911
LL-FrTuna	Q1	3	0	0.994	0.903
LL-FrTuna	Q2	1	100	0.973	0.930
LL-FrTuna	Q2	1	50	0.974	0.929
LL-FrTuna	Q2	1	0	0.974	0.928
LL-FrTuna	Q2	2	100	0.981	0.921
LL-FrTuna	Q2	2	50	0.980	0.921
LL-FrTuna	Q2	2	0	0.982	0.918
LL-FrTuna	Q2	3	100	0.987	0.912
LL-FrTuna	Q2	3	50	0.987	0.909

Closed fleet	Closed season	No. months closed	Reallocation (%)	B/Bmsy	F/Fmsy
LL-FrTuna	Q2	3	0	0.988	0.911
LL-FrTuna	Q3	1	100	0.971	0.933
LL-FrTuna	Q3	1	50	0.971	0.934
LL-FrTuna	Q3	1	0	0.971	0.932
LL-FrTuna	Q3	2	100	0.977	0.924
LL-FrTuna	Q3	2	50	0.978	0.923
LL-FrTuna	Q3	2	0	0.981	0.920
LL-FrTuna	Q3	3	100	0.986	0.913
LL-FrTuna	Q3	3	50	0.986	0.914
LL-FrTuna	Q3	3	0	0.988	0.911
LL-FrTuna	Q4	1	100	0.971	0.933
LL-FrTuna	Q4	1	50	0.973	0.931
LL-FrTuna	Q4	1	0	0.972	0.931
LL-FrTuna	Q4	2	100	0.978	0.923
LL-FrTuna	Q4	2	50	0.979	0.923
LL-FrTuna	Q4	2	0	0.979	0.922
LL-FrTuna	Q4	3	100	0.986	0.913
LL-FrTuna	Q4	3	50	0.987	0.909
LL-FrTuna	Q4	3	0	0.987	0.911
LL-DWater	Q1	1	100	0.971	0.933
LL-DWater	Q1	1	50	0.975	0.930
LL-DWater	Q1	1	0	0.980	0.927
LL-DWater	Q1	2	100	0.971	0.933
LL-DWater	Q1	2	50	0.980	0.927
LL-DWater	Q1	2	0	0.988	0.922
LL-DWater	Q1	3	100	0.972	0.933
LL-DWater	Q1	3	50	0.984	0.924
LL-DWater	Q1	3	0	0.997	0.915
LL-DWater	Q2	1	100	0.971	0.933
LL-DWater	Q2	1	50	0.972	0.932
LL-DWater	Q2	1	0	0.978	0.927
LL-DWater	Q2	2	100	0.971	0.933
LL-DWater	Q2	2	50	0.977	0.929
LL-DWater	Q2	2	0	0.982	0.926
LL-DWater	Q2	3	100	0.971	0.933
LL-DWater	Q2	3	50	0.979	0.927
LL-DWater	Q2	3	0	0.988	0.920
LL-DWater	Q3	1	100	0.971	0.934
LL-DWater	Q3	1	50	0.971	0.933
LL-DWater	Q3	1	0	0.972	0.932
LL-DWater	Q3	2	100	0.971	0.934
LL-DWater	Q3	2	50	0.972	0.933

Closed fleet	Closed season	No. months closed	Reallocation (%)	B/Bmsy	F/Fmsy
LL-DWater	Q3	2	0	0.974	0.931
LL-DWater	Q3	3	100	0.971	0.934
LL-DWater	Q3	3	50	0.973	0.932
LL-DWater	Q3	3	0	0.975	0.930
LL-DWater	Q4	1	100	0.970	0.934
LL-DWater	Q4	1	50	0.973	0.932
LL-DWater	Q4	1	0	0.977	0.929
LL-DWater	Q4	2	100	0.970	0.934
LL-DWater	Q4	2	50	0.976	0.929
LL-DWater	Q4	2	0	0.982	0.926
LL-DWater	Q4	3	100	0.970	0.934
LL-DWater	Q4	3	50	0.979	0.928
LL-DWater	Q4	3	0	0.987	0.922
PS-LS	Q1	1	100	0.973	0.932
PS-LS	Q1	1	50	1.010	0.897
PS-LS	Q1	1	0	1.059	0.856
PS-LS	Q1	2	100	0.977	0.929
PS-LS	Q1	2	50	1.048	0.863
PS-LS	Q1	2	0	1.114	0.806
PS-LS	Q1	3	100	0.981	0.927
PS-LS	Q1	3	50	1.085	0.832
PS-LS	Q1	3	0	1.209	0.731
PS-LS	Q2	1	100	0.971	0.933
PS-LS	Q2	1	50	0.990	0.915
PS-LS	Q2	1	0	1.009	0.898
PS-LS	Q2	2	100	0.972	0.932
PS-LS	Q2	2	50	1.009	0.897
PS-LS	Q2	2	0	1.047	0.858
PS-LS	Q2	3	100	0.973	0.932
PS-LS	Q2	3	50	1.029	0.879
PS-LS	Q2	3	0	1.082	0.833
PS-LS	Q3	1	100	0.970	0.934
PS-LS	Q3	1	50	1.003	0.902
PS-LS	Q3	1	0	1.035	0.873
PS-LS	Q3	2	100	0.969	0.934
PS-LS	Q3	2	50	1.034	0.873
PS-LS	Q3	2	0	1.106	0.813
PS-LS	Q3	3	100	0.968	0.935
PS-LS	Q3	3	50	1.065	0.846
PS-LS	Q3	3	0	1.153	0.773
PS-LS	Q4	1	100	0.968	0.935
PS-LS	Q4	1	50	0.999	0.905

Closed fleet	Closed season	No. months closed	Reallocation (%)	B/Bmsy	F/Fmsy
PS-LS	Q4	1	0	1.029	0.878
PS-LS	Q4	2	100	0.965	0.938
PS-LS	Q4	2	50	1.026	0.879
PS-LS	Q4	2	0	1.084	0.827
PS-LS	Q4	3	100	0.961	0.940
PS-LS	Q4	3	50	1.053	0.854
PS-LS	Q4	3	0	1.115	0.832
LS-FS	Q1	1	100	1.014	0.886
LS-FS	Q1	1	50	1.029	0.875
LS-FS	Q1	1	0	1.059	0.856
LS-FS	Q1	2	100	1.055	0.843
LS-FS	Q1	2	50	1.085	0.824
LS-FS	Q1	2	0	1.114	0.806
LS-FS	Q1	3	100	1.098	0.797
LS-FS	Q1	3	50	1.139	0.777
LS-FS	Q1	3	0	1.209	0.731
LS-FS	Q2	1	100	0.993	0.909
LS-FS	Q2	1	50	1.001	0.903
LS-FS	Q2	1	0	1.009	0.898
LS-FS	Q2	2	100	1.014	0.886
LS-FS	Q2	2	50	1.030	0.875
LS-FS	Q2	2	0	1.047	0.858
LS-FS	Q2	3	100	1.045	0.858
LS-FS	Q2	3	50	1.059	0.848
LS-FS	Q2	3	0	1.082	0.833
LS-FS	Q3	1	100	1.007	0.893
LS-FS	Q3	1	50	1.021	0.883
LS-FS	Q3	1	0	1.035	0.873
LS-FS	Q3	2	100	1.043	0.855
LS-FS	Q3	2	50	1.069	0.837
LS-FS	Q3	2	0	1.106	0.813
LS-FS	Q3	3	100	1.078	0.818
LS-FS	Q3	3	50	1.116	0.795
LS-FS	Q3	3	0	1.153	0.773
LS-FS	Q4	1	100	1.004	0.896
LS-FS	Q4	1	50	1.016	0.887
LS-FS	Q4	1	0	1.029	0.878
LS-FS	Q4	2	100	1.036	0.860
LS-FS	Q4	2	50	1.060	0.844
LS-FS	Q4	2	0	1.084	0.827
LS-FS	Q4	3	100	1.068	0.827
LS-FS	Q4	3	50	1.114	0.774

Closed fleet	Closed season	No. months closed	Reallocation (%)	B/Bmsy	F/Fmsy
LS-FS	Q4	3	0	1.115	0.832
Others	Q1	1	100	0.972	0.933
Others	Q1	1	50	0.977	0.918
Others	Q1	1	0	0.985	0.900
Others	Q1	2	100	0.974	0.932
Others	Q1	2	50	0.984	0.904
Others	Q1	2	0	0.996	0.877
Others	Q1	3	100	0.973	0.931
Others	Q1	3	50	0.992	0.889
Others	Q1	3	0	1.010	0.852
Others	Q2	1	100	0.971	0.933
Others	Q2	1	50	0.978	0.917
Others	Q2	1	0	0.984	0.902
Others	Q2	2	100	0.971	0.933
Others	Q2	2	50	0.985	0.902
Others	Q2	2	0	1.056	0.827
Others	Q2	3	100	0.973	0.931
Others	Q2	3	50	0.992	0.887
Others	Q2	3	0	1.013	0.844
Others	Q3	1	100	0.971	0.934
Others	Q3	1	50	0.977	0.920
Others	Q3	1	0	0.982	0.908
Others	Q3	2	100	0.971	0.933
Others	Q3	2	50	0.982	0.907
Others	Q3	2	0	0.993	0.884
Others	Q3	3	100	0.971	0.933
Others	Q3	3	50	0.987	0.895
Others	Q3	3	0	1.005	0.860
Others	Q4	1	100	0.970	0.934
Others	Q4	1	50	0.975	0.924
Others	Q4	1	0	0.980	0.910
Others	Q4	2	100	0.970	0.933
Others	Q4	2	50	0.981	0.909
Others	Q4	2	0	0.987	0.896
Others	Q4	3	100	0.970	0.933
Others	Q4	3	50	0.983	0.905
Others	Q4	3	0	0.994	0.880
Troll	Q1	1	100	0.971	0.933
Troll	Q1	1	50	0.979	0.924
Troll	Q1	1	0	0.986	0.915
Troll	Q1	2	100	0.972	0.933
Troll	Q1	2	50	0.987	0.915

Closed fleet	Closed season	No. months closed	Reallocation (%)	B/Bmsy	F/Fmsy
Troll	Q1	2	0	1.001	0.895
Troll	Q1	3	100	0.973	0.932
Troll	Q1	3	50	0.995	0.905
Troll	Q1	3	0	1.019	0.873
Troll	Q2	1	100	0.971	0.933
Troll	Q2	1	50	0.987	0.915
Troll	Q2	1	0	0.984	0.916
Troll	Q2	2	100	0.971	0.934
Troll	Q2	2	50	0.984	0.917
Troll	Q2	2	0	0.996	0.901
Troll	Q2	3	100	0.971	0.933
Troll	Q2	3	50	0.990	0.909
Troll	Q2	3	0	1.011	0.884
Troll	Q3	1	100	0.970	0.934
Troll	Q3	1	50	0.979	0.922
Troll	Q3	1	0	0.990	0.907
Troll	Q3	2	100	0.970	0.934
Troll	Q3	2	50	0.988	0.909
Troll	Q3	2	0	1.004	0.887
Troll	Q3	3	100	0.970	0.934
Troll	Q3	3	50	0.996	0.897
Troll	Q3	3	0	1.021	0.864
Troll	Q4	1	100	0.970	0.934
Troll	Q4	1	50	0.977	0.925
Troll	Q4	1	0	0.985	0.915
Troll	Q4	2	100	0.970	0.934
Troll	Q4	2	50	0.984	0.916
Troll	Q4	2	0	0.998	0.898
Troll	Q4	3	100	0.969	0.935
Troll	Q4	3	50	0.991	0.907
Troll	Q4	3	0	1.012	0.881
All fleets	Q1	1	100	0.979	0.928
All fleets	Q1	1	50	1.081	0.832
All fleets	Q1	1	0	1.175	0.750
All fleets	Q1	2	100	0.993	0.916
All fleets	Q1	2	50	1.189	0.739
All fleets	Q1	2	0	1.392	0.584
All fleets	Q1	3	100	1.015	0.896
All fleets	Q1	3	50	1.305	0.648
All fleets	Q1	3	0	1.594	0.465
All fleets	Q2	1	100	0.977	0.926
All fleets	Q2	1	50	1.066	0.826

Closed fleet	Closed season	No. months closed	Reallocation (%)	B/Bmsy	F/Fmsy
All fleets	Q2	1	0	1.133	0.779
All fleets	Q2	2	100	0.985	0.918
All fleets	Q2	2	50	1.140	0.773
All fleets	Q2	2	0	1.293	0.650
All fleets	Q2	3	100	1.000	0.905
All fleets	Q2	3	50	1.226	0.704
All fleets	Q2	3	0	1.455	0.544
All fleets	Q3	1	100	0.969	0.934
All fleets	Q3	1	50	1.057	0.845
All fleets	Q3	1	0	1.140	0.766
All fleets	Q3	2	100	0.974	0.926
All fleets	Q3	2	50	1.152	0.757
All fleets	Q3	2	0	1.315	0.622
All fleets	Q3	3	100	0.980	0.917
All fleets	Q3	3	50	1.232	0.688
All fleets	Q3	3	0	1.483	0.509
All fleets	Q4	1	100	0.963	0.939
All fleets	Q4	1	50	1.065	0.843
All fleets	Q4	1	0	1.139	0.775
All fleets	Q4	2	100	0.961	0.935
All fleets	Q4	2	50	1.138	0.773
All fleets	Q4	2	0	1.312	0.636
All fleets	Q4	3	100	0.957	0.933
All fleets	Q4	3	50	1.220	0.705
All fleets	Q4	3	0	1.467	0.528

Bigeye tuna

Table 2: Bigeye tuna. Impacts of closure scenarios on the stock status by the end of a 10-year projection period. The TAC scenario did not implement any closure. PS-LS = FAD fishery. LS-FS = interaction between FAD and free school purse seine fisheries.

Closed fleet	Closed season	No. months closed	Reallocation (%)	B/Bmsy	F/Fmsy
TAC	-	-	-	0.943	0.941
Baitboat	Q1	1	100	0.943	0.941
Baitboat	Q1	1	50	0.944	0.939
Baitboat	Q1	1	0	0.946	0.937
Baitboat	Q1	2	100	0.943	0.941
Baitboat	Q1	2	50	0.946	0.937
Baitboat	Q1	2	0	0.948	0.933
Baitboat	Q1	3	100	0.944	0.941
Baitboat	Q1	3	50	0.947	0.935
Baitboat	Q1	3	0	0.951	0.928
Baitboat	Q2	1	100	0.944	0.941
Baitboat	Q2	1	50	0.957	0.918
Baitboat	Q2	1	0	0.971	0.897
Baitboat	Q2	2	100	0.944	0.940
Baitboat	Q2	2	50	0.972	0.896
Baitboat	Q2	2	0	0.998	0.856
Baitboat	Q2	3	100	0.945	0.939
Baitboat	Q2	3	50	0.986	0.874
Baitboat	Q2	3	0	1.027	0.817
Baitboat	Q3	1	100	0.943	0.942
Baitboat	Q3	1	50	0.955	0.921
Baitboat	Q3	1	0	0.968	0.901
Baitboat	Q3	2	100	0.942	0.942
Baitboat	Q3	2	50	0.967	0.901
Baitboat	Q3	2	0	0.992	0.863
Baitboat	Q3	3	100	0.942	0.942
Baitboat	Q3	3	50	0.980	0.881
Baitboat	Q3	3	0	1.018	0.827
Baitboat	Q4	1	100	0.941	0.943
Baitboat	Q4	1	50	0.961	0.910
Baitboat	Q4	1	0	0.982	0.878
Baitboat	Q4	2	100	0.938	0.945
Baitboat	Q4	2	50	0.979	0.880
Baitboat	Q4	2	0	1.020	0.822
Baitboat	Q4	3	100	0.935	0.947
Baitboat	Q4	3	50	0.997	0.850
Baitboat	Q4	3	0	1.059	0.771
PS-FSchool	Q1	1	100	0.944	0.941

Closed fleet	Closed season	No. months closed	Reallocation (%)	B/Bmsy	F/Fmsy
PS-FSchool	Q1	1	50	0.951	0.931
PS-FSchool	Q1	1	0	0.958	0.921
PS-FSchool	Q1	2	100	0.944	0.941
PS-FSchool	Q1	2	50	0.958	0.921
PS-FSchool	Q1	2	0	0.972	0.902
PS-FSchool	Q1	3	100	0.945	0.940
PS-FSchool	Q1	3	50	0.966	0.911
PS-FSchool	Q1	3	0	0.987	0.884
PS-FSchool	Q2	1	100	0.943	0.941
PS-FSchool	Q2	1	50	0.951	0.931
PS-FSchool	Q2	1	0	0.958	0.922
PS-FSchool	Q2	2	100	0.944	0.941
PS-FSchool	Q2	2	50	0.959	0.922
PS-FSchool	Q2	2	0	0.973	0.904
PS-FSchool	Q2	3	100	0.944	0.940
PS-FSchool	Q2	3	50	0.967	0.912
PS-FSchool	Q2	3	0	0.989	0.886
PS-FSchool	Q3	1	100	0.943	0.941
PS-FSchool	Q3	1	50	0.946	0.937
PS-FSchool	Q3	1	0	0.950	0.932
PS-FSchool	Q3	2	100	0.943	0.941
PS-FSchool	Q3	2	50	0.950	0.932
PS-FSchool	Q3	2	0	0.957	0.923
PS-FSchool	Q3	3	100	0.943	0.942
PS-FSchool	Q3	3	50	0.953	0.927
PS-FSchool	Q3	3	0	0.964	0.914
PS-FSchool	Q4	1	100	0.943	0.942
PS-FSchool	Q4	1	50	0.944	0.941
PS-FSchool	Q4	1	0	0.944	0.940
PS-FSchool	Q4	2	100	0.943	0.942
PS-FSchool	Q4	2	50	0.944	0.940
PS-FSchool	Q4	2	0	0.945	0.938
PS-FSchool	Q4	3	100	0.943	0.942
PS-FSchool	Q4	3	50	0.945	0.939
PS-FSchool	Q4	3	0	0.947	0.936
LL-FrTuna	Q1	1	100	0.943	0.941
LL-FrTuna	Q1	1	50	0.947	0.938
LL-FrTuna	Q1	1	0	0.951	0.935
LL-FrTuna	Q1	2	100	0.944	0.941
LL-FrTuna	Q1	2	50	0.951	0.935
LL-FrTuna	Q1	2	0	0.958	0.929
LL-FrTuna	Q1	3	100	0.944	0.941

Closed fleet	Closed season	No. months closed	Reallocation (%)	B/Bmsy	F/Fmsy
LL-FrTuna	Q1	3	50	0.955	0.932
LL-FrTuna	Q1	3	0	0.966	0.924
LL-FrTuna	Q2	1	100	0.943	0.941
LL-FrTuna	Q2	1	50	0.947	0.938
LL-FrTuna	Q2	1	0	0.950	0.936
LL-FrTuna	Q2	2	100	0.943	0.941
LL-FrTuna	Q2	2	50	0.951	0.935
LL-FrTuna	Q2	2	0	0.958	0.930
LL-FrTuna	Q2	3	100	0.943	0.941
LL-FrTuna	Q2	3	50	0.954	0.932
LL-FrTuna	Q2	3	0	0.965	0.924
LL-FrTuna	Q3	1	100	0.943	0.942
LL-FrTuna	Q3	1	50	0.946	0.939
LL-FrTuna	Q3	1	0	0.949	0.936
LL-FrTuna	Q3	2	100	0.943	0.942
LL-FrTuna	Q3	2	50	0.949	0.936
LL-FrTuna	Q3	2	0	0.956	0.931
LL-FrTuna	Q3	3	100	0.943	0.942
LL-FrTuna	Q3	3	50	0.953	0.934
LL-FrTuna	Q3	3	0	0.962	0.926
LL-FrTuna	Q4	1	100	0.943	0.942
LL-FrTuna	Q4	1	50	0.948	0.938
LL-FrTuna	Q4	1	0	0.952	0.934
LL-FrTuna	Q4	2	100	0.942	0.942
LL-FrTuna	Q4	2	50	0.952	0.934
LL-FrTuna	Q4	2	0	0.962	0.927
LL-FrTuna	Q4	3	100	0.942	0.943
LL-FrTuna	Q4	3	50	0.956	0.931
LL-FrTuna	Q4	3	0	0.971	0.920
Line	Q1	1	100	0.943	0.941
Line	Q1	1	50	0.948	0.938
Line	Q1	1	0	0.952	0.934
Line	Q1	2	100	0.944	0.941
Line	Q1	2	50	0.953	0.934
Line	Q1	2	0	0.961	0.927
Line	Q1	3	100	0.944	0.940
Line	Q1	3	50	0.958	0.930
Line	Q1	3	0	0.971	0.920
Line	Q2	1	100	0.943	0.941
Line	Q2	1	50	0.947	0.938
Line	Q2	1	0	0.951	0.935
Line	Q2	2	100	0.943	0.941

Closed fleet	Closed season	No. months closed	Reallocation (%)	B/Bmsy	F/Fmsy
Line	Q2	2	50	0.952	0.935
Line	Q2	2	0	0.960	0.928
Line	Q2	3	100	0.943	0.941
Line	Q2	3	50	0.956	0.931
Line	Q2	3	0	0.968	0.922
Line	Q3	1	100	0.943	0.942
Line	Q3	1	50	0.949	0.937
Line	Q3	1	0	0.955	0.932
Line	Q3	2	100	0.943	0.942
Line	Q3	2	50	0.954	0.932
Line	Q3	2	0	0.966	0.924
Line	Q3	3	100	0.942	0.942
Line	Q3	3	50	0.960	0.928
Line	Q3	3	0	0.977	0.915
Line	Q4	1	100	0.943	0.942
Line	Q4	1	50	0.947	0.938
Line	Q4	1	0	0.951	0.935
Line	Q4	2	100	0.942	0.942
Line	Q4	2	50	0.951	0.935
Line	Q4	2	0	0.959	0.929
Line	Q4	3	100	0.942	0.942
Line	Q4	3	50	0.954	0.933
Line	Q4	3	0	0.967	0.923
LL-DWater	Q1	1	100	0.944	0.941
LL-DWater	Q1	1	50	0.953	0.933
LL-DWater	Q1	1	0	0.962	0.925
LL-DWater	Q1	2	100	0.945	0.940
LL-DWater	Q1	2	50	0.963	0.925
LL-DWater	Q1	2	0	0.980	0.910
LL-DWater	Q1	3	100	0.946	0.939
LL-DWater	Q1	3	50	0.973	0.917
LL-DWater	Q1	3	0	0.999	0.895
LL-DWater	Q2	1	100	0.943	0.941
LL-DWater	Q2	1	50	0.952	0.933
LL-DWater	Q2	1	0	0.962	0.925
LL-DWater	Q2	2	100	0.944	0.941
LL-DWater	Q2	2	50	0.962	0.925
LL-DWater	Q2	2	0	0.980	0.909
LL-DWater	Q2	3	100	0.944	0.941
LL-DWater	Q2	3	50	0.971	0.916
LL-DWater	Q2	3	0	0.998	0.894
LL-DWater	Q3	1	100	0.943	0.942

Closed fleet	Closed season	No. months closed	Reallocation (%)	B/Bmsy	F/Fmsy
LL-DWater	Q3	1	50	0.950	0.936
LL-DWater	Q3	1	0	0.957	0.930
LL-DWater	Q3	2	100	0.943	0.942
LL-DWater	Q3	2	50	0.957	0.930
LL-DWater	Q3	2	0	0.971	0.919
LL-DWater	Q3	3	100	0.942	0.942
LL-DWater	Q3	3	50	0.964	0.925
LL-DWater	Q3	3	0	0.986	0.908
LL-DWater	Q4	1	100	0.942	0.943
LL-DWater	Q4	1	50	0.959	0.928
LL-DWater	Q4	1	0	0.977	0.914
LL-DWater	Q4	2	100	0.940	0.944
LL-DWater	Q4	2	50	0.976	0.915
LL-DWater	Q4	2	0	1.011	0.889
LL-DWater	Q4	3	100	0.938	0.946
LL-DWater	Q4	3	50	0.992	0.902
LL-DWater	Q4	3	0	1.045	0.864
PS-LS	Q1	1	100	0.949	0.936
PS-LS	Q1	1	50	0.998	0.854
PS-LS	Q1	1	0	1.046	0.785
PS-LS	Q1	2	100	0.957	0.928
PS-LS	Q1	2	50	1.053	0.780
PS-LS	Q1	2	0	1.145	0.668
PS-LS	Q1	3	100	0.968	0.917
PS-LS	Q1	3	50	1.109	0.714
PS-LS	Q1	3	0	1.244	0.572
PS-LS	Q2	1	100	0.945	0.939
PS-LS	Q2	1	50	0.976	0.886
PS-LS	Q2	1	0	1.006	0.838
PS-LS	Q2	2	100	0.947	0.936
PS-LS	Q2	2	50	1.008	0.836
PS-LS	Q2	2	0	1.068	0.753
PS-LS	Q2	3	100	0.950	0.932
PS-LS	Q2	3	50	1.041	0.789
PS-LS	Q2	3	0	1.130	0.679
PS-LS	Q3	1	100	0.941	0.943
PS-LS	Q3	1	50	0.984	0.869
PS-LS	Q3	1	0	1.026	0.806
PS-LS	Q3	2	100	0.940	0.943
PS-LS	Q3	2	50	1.025	0.806
PS-LS	Q3	2	0	1.108	0.701
PS-LS	Q3	3	100	0.938	0.942

Closed fleet	Closed season	No. months closed	Reallocation (%)	B/Bmsy	F/Fmsy
PS-LS	Q3	3	50	1.067	0.749
PS-LS	Q3	3	0	1.190	0.612
PS-LS	Q4	1	100	0.938	0.946
PS-LS	Q4	1	50	0.975	0.881
PS-LS	Q4	1	0	1.010	0.825
PS-LS	Q4	2	100	0.932	0.951
PS-LS	Q4	2	50	1.006	0.828
PS-LS	Q4	2	0	1.076	0.733
PS-LS	Q4	3	100	0.925	0.956
PS-LS	Q4	3	50	1.037	0.779
PS-LS	Q4	3	0	1.143	0.654
LS-FS	Q1	1	100	1.005	0.826
LS-FS	Q1	1	50	1.026	0.804
LS-FS	Q1	1	0	1.046	0.785
LS-FS	Q1	2	100	1.064	0.733
LS-FS	Q1	2	50	1.105	0.698
LS-FS	Q1	2	0	1.145	0.668
LS-FS	Q1	3	100	1.122	0.653
LS-FS	Q1	3	50	1.184	0.609
LS-FS	Q1	3	0	1.244	0.572
LS-FS	Q2	1	100	0.981	0.866
LS-FS	Q2	1	50	0.993	0.852
LS-FS	Q2	1	0	1.006	0.838
LS-FS	Q2	2	100	1.017	0.802
LS-FS	Q2	2	50	1.043	0.776
LS-FS	Q2	2	0	1.068	0.753
LS-FS	Q2	3	100	1.054	0.743
LS-FS	Q2	3	50	1.092	0.709
LS-FS	Q2	3	0	1.130	0.679
LS-FS	Q3	1	100	0.992	0.843
LS-FS	Q3	1	50	1.009	0.824
LS-FS	Q3	1	0	1.026	0.806
LS-FS	Q3	2	100	1.039	0.762
LS-FS	Q3	2	50	1.074	0.730
LS-FS	Q3	2	0	1.108	0.701
LS-FS	Q3	3	100	1.085	0.690
LS-FS	Q3	3	50	1.138	0.648
LS-FS	Q3	3	0	1.190	0.612
LS-FS	Q4	1	100	0.982	0.859
LS-FS	Q4	1	50	0.996	0.841
LS-FS	Q4	1	0	1.010	0.825
LS-FS	Q4	2	100	1.019	0.789

Closed fleet	Closed season	No. months closed	Reallocation (%)	B/Bmsy	F/Fmsy
LS-FS	Q4	2	50	1.048	0.759
LS-FS	Q4	2	0	1.076	0.733
LS-FS	Q4	3	100	1.056	0.726
LS-FS	Q4	3	50	1.100	0.687
LS-FS	Q4	3	0	1.143	0.654
Others	Q1	1	100	0.944	0.941
Others	Q1	1	50	0.951	0.933
Others	Q1	1	0	0.959	0.925
Others	Q1	2	100	0.944	0.940
Others	Q1	2	50	0.960	0.924
Others	Q1	2	0	0.975	0.909
Others	Q1	3	100	0.945	0.940
Others	Q1	3	50	0.968	0.916
Others	Q1	3	0	0.991	0.893
Others	Q2	1	100	0.943	0.941
Others	Q2	1	50	0.946	0.937
Others	Q2	1	0	0.949	0.933
Others	Q2	2	100	0.943	0.941
Others	Q2	2	50	0.949	0.933
Others	Q2	2	0	0.956	0.925
Others	Q2	3	100	0.943	0.941
Others	Q2	3	50	0.953	0.929
Others	Q2	3	0	0.962	0.917
Others	Q3	1	100	0.943	0.942
Others	Q3	1	50	0.948	0.935
Others	Q3	1	0	0.954	0.929
Others	Q3	2	100	0.943	0.942
Others	Q3	2	50	0.954	0.929
Others	Q3	2	0	0.965	0.917
Others	Q3	3	100	0.943	0.942
Others	Q3	3	50	0.959	0.922
Others	Q3	3	0	0.976	0.904
Others	Q4	1	100	0.943	0.942
Others	Q4	1	50	0.947	0.936
Others	Q4	1	0	0.951	0.931
Others	Q4	2	100	0.942	0.942
Others	Q4	2	50	0.950	0.931
Others	Q4	2	0	0.959	0.920
Others	Q4	3	100	0.942	0.943
Others	Q4	3	50	0.954	0.926
Others	Q4	3	0	0.967	0.910
All fleets	Q1	1	100	0.952	0.934

Closed fleet	Closed season	No. months closed	Reallocation (%)	B/Bmsy	F/Fmsy
All fleets	Q1	1	50	1.033	0.824
All fleets	Q1	1	0	1.113	0.736
All fleets	Q1	2	100	0.963	0.924
All fleets	Q1	2	50	1.122	0.731
All fleets	Q1	2	0	1.276	0.596
All fleets	Q1	3	100	0.978	0.910
All fleets	Q1	3	50	1.213	0.651
All fleets	Q1	3	0	1.437	0.486
All fleets	Q2	1	100	0.946	0.938
All fleets	Q2	1	50	1.018	0.841
All fleets	Q2	1	0	1.088	0.760
All fleets	Q2	2	100	0.950	0.933
All fleets	Q2	2	50	1.092	0.758
All fleets	Q2	2	0	1.229	0.630
All fleets	Q2	3	100	0.956	0.926
All fleets	Q2	3	50	1.167	0.685
All fleets	Q2	3	0	1.369	0.526
All fleets	Q3	1	100	0.940	0.943
All fleets	Q3	1	50	1.021	0.831
All fleets	Q3	1	0	1.100	0.741
All fleets	Q3	2	100	0.938	0.944
All fleets	Q3	2	50	1.098	0.741
All fleets	Q3	2	0	1.252	0.600
All fleets	Q3	3	100	0.935	0.943
All fleets	Q3	3	50	1.175	0.663
All fleets	Q3	3	0	1.403	0.488
All fleets	Q4	1	100	0.933	0.950
All fleets	Q4	1	50	1.021	0.831
All fleets	Q4	1	0	1.108	0.736
All fleets	Q4	2	100	0.922	0.960
All fleets	Q4	2	50	1.098	0.741
All fleets	Q4	2	0	1.268	0.592
All fleets	Q4	3	100	0.906	0.972
All fleets	Q4	3	50	1.176	0.662
All fleets	Q4	3	0	1.428	0.479
All fleets	Qall	3	0	1.549	0.411

Skipjack tuna

Table 3: Skipjack tuna. Impacts of closure scenarios on the stock status by the end of a 10-year projection period. The TAC scenario did not implement any closure. PS-LS = FAD fishery. LS-FS = interaction between FAD and free school purse seine fisheries.

Closed fleet	Closed season	No. months closed	Reallocation (%)	B/Bmsy	F/Fmsy
TAC	-	-	-	1.289	0.809
PS-FSchool	Q1	1	100	1.286	0.810
PS-FSchool	Q1	1	50	1.295	0.804
PS-FSchool	Q1	1	0	1.303	0.797
PS-FSchool	Q1	2	100	1.283	0.812
PS-FSchool	Q1	2	50	1.300	0.799
PS-FSchool	Q1	2	0	1.317	0.786
PS-FSchool	Q1	3	100	1.279	0.815
PS-FSchool	Q1	3	50	1.306	0.795
PS-FSchool	Q1	3	0	1.331	0.775
PS-FSchool	Q2	1	100	1.288	0.809
PS-FSchool	Q2	1	50	1.294	0.804
PS-FSchool	Q2	1	0	1.301	0.799
PS-FSchool	Q2	2	100	1.287	0.809
PS-FSchool	Q2	2	50	1.300	0.799
PS-FSchool	Q2	2	0	1.313	0.790
PS-FSchool	Q2	3	100	1.287	0.809
PS-FSchool	Q2	3	50	1.306	0.795
PS-FSchool	Q2	3	0	1.325	0.780
PS-FSchool	Q3	1	100	1.289	0.808
PS-FSchool	Q3	1	50	1.290	0.807
PS-FSchool	Q3	1	0	1.292	0.806
PS-FSchool	Q3	2	100	1.289	0.808
PS-FSchool	Q3	2	50	1.292	0.806
PS-FSchool	Q3	2	0	1.294	0.804
PS-FSchool	Q3	3	100	1.289	0.808
PS-FSchool	Q3	3	50	1.293	0.805
PS-FSchool	Q3	3	0	1.297	0.802
PS-FSchool	Q4	1	100	1.290	0.808
PS-FSchool	Q4	1	50	1.293	0.805
PS-FSchool	Q4	1	0	1.297	0.803
PS-FSchool	Q4	2	100	1.291	0.807
PS-FSchool	Q4	2	50	1.298	0.802
PS-FSchool	Q4	2	0	1.304	0.797
PS-FSchool	Q4	3	100	1.293	0.806
PS-FSchool	Q4	3	50	1.303	0.799
PS-FSchool	Q4	3	0	1.312	0.791
Gillnet	Q1	1	100	1.278	0.816

Closed fleet	Closed season	No. months closed	Reallocation (%)	B/Bmsy	F/Fmsy
Gillnet	Q1	1	50	1.310	0.791
Gillnet	Q1	1	0	1.341	0.768
Gillnet	Q1	2	100	1.266	0.825
Gillnet	Q1	2	50	1.330	0.776
Gillnet	Q1	2	0	1.391	0.733
Gillnet	Q1	3	100	1.250	0.837
Gillnet	Q1	3	50	1.349	0.762
Gillnet	Q1	3	0	1.442	0.700
Gillnet	Q2	1	100	1.286	0.810
Gillnet	Q2	1	50	1.309	0.792
Gillnet	Q2	1	0	1.331	0.776
Gillnet	Q2	2	100	1.284	0.812
Gillnet	Q2	2	50	1.329	0.777
Gillnet	Q2	2	0	1.372	0.746
Gillnet	Q2	3	100	1.280	0.814
Gillnet	Q2	3	50	1.348	0.762
Gillnet	Q2	3	0	1.414	0.718
Gillnet	Q3	1	100	1.292	0.806
Gillnet	Q3	1	50	1.322	0.783
Gillnet	Q3	1	0	1.351	0.762
Gillnet	Q3	2	100	1.295	0.804
Gillnet	Q3	2	50	1.355	0.759
Gillnet	Q3	2	0	1.412	0.720
Gillnet	Q3	3	100	1.300	0.800
Gillnet	Q3	3	50	1.388	0.736
Gillnet	Q3	3	0	1.471	0.682
Gillnet	Q4	1	100	1.299	0.801
Gillnet	Q4	1	50	1.330	0.778
Gillnet	Q4	1	0	1.360	0.757
Gillnet	Q4	2	100	1.312	0.793
Gillnet	Q4	2	50	1.371	0.750
Gillnet	Q4	2	0	1.428	0.711
Gillnet	Q4	3	100	1.327	0.783
Gillnet	Q4	3	50	1.414	0.722
Gillnet	Q4	3	0	1.496	0.670
Handline	Q1	1	100	1.285	0.810
Handline	Q1	1	50	1.298	0.800
Handline	Q1	1	0	1.311	0.790
Handline	Q1	2	100	1.281	0.812
Handline	Q1	2	50	1.307	0.792
Handline	Q1	2	0	1.334	0.773
Handline	Q1	3	100	1.275	0.814

Closed fleet	Closed season	No. months closed	Reallocation (%)	B/Bmsy	F/Fmsy
Handline	Q1	3	50	1.316	0.784
Handline	Q1	3	0	1.356	0.757
Handline	Q2	1	100	1.288	0.809
Handline	Q2	1	50	1.303	0.797
Handline	Q2	1	0	1.318	0.786
Handline	Q2	2	100	1.286	0.809
Handline	Q2	2	50	1.317	0.786
Handline	Q2	2	0	1.347	0.764
Handline	Q2	3	100	1.285	0.809
Handline	Q2	3	50	1.331	0.775
Handline	Q2	3	0	1.377	0.744
Handline	Q3	1	100	1.290	0.808
Handline	Q3	1	50	1.308	0.794
Handline	Q3	1	0	1.326	0.781
Handline	Q3	2	100	1.292	0.807
Handline	Q3	2	50	1.327	0.781
Handline	Q3	2	0	1.362	0.756
Handline	Q3	3	100	1.295	0.806
Handline	Q3	3	50	1.347	0.767
Handline	Q3	3	0	1.398	0.732
Handline	Q4	1	100	1.292	0.808
Handline	Q4	1	50	1.303	0.799
Handline	Q4	1	0	1.315	0.790
Handline	Q4	2	100	1.295	0.806
Handline	Q4	2	50	1.318	0.789
Handline	Q4	2	0	1.340	0.773
Handline	Q4	3	100	1.300	0.805
Handline	Q4	3	50	1.334	0.779
Handline	Q4	3	0	1.366	0.756
Line	Q1	1	100	1.279	0.814
Line	Q1	1	50	1.312	0.789
Line	Q1	1	0	1.345	0.765
Line	Q1	2	100	1.266	0.822
Line	Q1	2	50	1.334	0.771
Line	Q1	2	0	1.398	0.727
Line	Q1	3	100	1.251	0.831
Line	Q1	3	50	1.354	0.755
Line	Q1	3	0	1.451	0.693
Line	Q2	1	100	1.286	0.809
Line	Q2	1	50	1.318	0.786
Line	Q2	1	0	1.348	0.763
Line	Q2	2	100	1.282	0.811

Closed fleet	Closed season	No. months closed	Reallocation (%)	B/Bmsy	F/Fmsy
Line	Q2	2	50	1.345	0.764
Line	Q2	2	0	1.406	0.724
Line	Q2	3	100	1.278	0.812
Line	Q2	3	50	1.373	0.744
Line	Q2	3	0	1.462	0.687
Line	Q3	1	100	1.291	0.807
Line	Q3	1	50	1.312	0.791
Line	Q3	1	0	1.333	0.776
Line	Q3	2	100	1.293	0.806
Line	Q3	2	50	1.335	0.774
Line	Q3	2	0	1.376	0.746
Line	Q3	3	100	1.297	0.804
Line	Q3	3	50	1.359	0.758
Line	Q3	3	0	1.419	0.717
Line	Q4	1	100	1.299	0.804
Line	Q4	1	50	1.331	0.779
Line	Q4	1	0	1.362	0.757
Line	Q4	2	100	1.311	0.798
Line	Q4	2	50	1.373	0.752
Line	Q4	2	0	1.433	0.712
Line	Q4	3	100	1.325	0.790
Line	Q4	3	50	1.417	0.725
Line	Q4	3	0	1.502	0.671
LL-DWater	Q1	1	100	1.289	0.809
LL-DWater	Q1	1	50	1.289	0.808
LL-DWater	Q1	1	0	1.290	0.808
LL-DWater	Q1	2	100	1.288	0.809
LL-DWater	Q1	2	50	1.289	0.808
LL-DWater	Q1	2	0	1.290	0.807
LL-DWater	Q1	3	100	1.288	0.809
LL-DWater	Q1	3	50	1.290	0.808
LL-DWater	Q1	3	0	1.291	0.807
LL-DWater	Q2	1	100	1.289	0.809
LL-DWater	Q2	1	50	1.289	0.808
LL-DWater	Q2	1	0	1.290	0.808
LL-DWater	Q2	2	100	1.289	0.809
LL-DWater	Q2	2	50	1.289	0.808
LL-DWater	Q2	2	0	1.290	0.807
LL-DWater	Q2	3	100	1.289	0.809
LL-DWater	Q2	3	50	1.290	0.808
LL-DWater	Q2	3	0	1.291	0.807
LL-DWater	Q3	1	100	1.289	0.809

Closed fleet	Closed season	No. months closed	Reallocation (%)	B/Bmsy	F/Fmsy
LL-DWater	Q3	1	50	1.289	0.808
LL-DWater	Q3	1	0	1.289	0.808
LL-DWater	Q3	2	100	1.289	0.809
LL-DWater	Q3	2	50	1.289	0.808
LL-DWater	Q3	2	0	1.289	0.808
LL-DWater	Q3	3	100	1.289	0.809
LL-DWater	Q3	3	50	1.289	0.808
LL-DWater	Q3	3	0	1.289	0.808
LL-DWater	Q4	1	100	1.289	0.808
LL-DWater	Q4	1	50	1.289	0.808
LL-DWater	Q4	1	0	1.289	0.808
LL-DWater	Q4	2	100	1.289	0.808
LL-DWater	Q4	2	50	1.289	0.808
LL-DWater	Q4	2	0	1.289	0.808
LL-DWater	Q4	3	100	1.289	0.808
LL-DWater	Q4	3	50	1.289	0.808
LL-DWater	Q4	3	0	1.290	0.808
PS-LS	Q1	1	100	1.259	0.825
PS-LS	Q1	1	50	1.361	0.750
PS-LS	Q1	1	0	1.458	0.687
PS-LS	Q1	2	100	1.223	0.847
PS-LS	Q1	2	50	1.427	0.701
PS-LS	Q1	2	0	1.611	0.598
PS-LS	Q1	3	100	1.178	0.876
PS-LS	Q1	3	50	1.488	0.658
PS-LS	Q1	3	0	1.758	0.525
PS-LS	Q2	1	100	1.284	0.809
PS-LS	Q2	1	50	1.341	0.766
PS-LS	Q2	1	0	1.397	0.728
PS-LS	Q2	2	100	1.279	0.810
PS-LS	Q2	2	50	1.392	0.729
PS-LS	Q2	2	0	1.498	0.663
PS-LS	Q2	3	100	1.272	0.810
PS-LS	Q2	3	50	1.442	0.693
PS-LS	Q2	3	0	1.597	0.606
PS-LS	Q3	1	100	1.298	0.802
PS-LS	Q3	1	50	1.400	0.730
PS-LS	Q3	1	0	1.496	0.669
PS-LS	Q3	2	100	1.310	0.795
PS-LS	Q3	2	50	1.506	0.665
PS-LS	Q3	2	0	1.684	0.570
PS-LS	Q3	3	100	1.324	0.786

Closed fleet	Closed season	No. months closed	Reallocation (%)	B/Bmsy	F/Fmsy
PS-LS	Q3	3	50	1.612	0.608
PS-LS	Q3	3	0	1.864	0.491
PS-LS	Q4	1	100	1.313	0.799
PS-LS	Q4	1	50	1.397	0.738
PS-LS	Q4	1	0	1.477	0.687
PS-LS	Q4	2	100	1.342	0.788
PS-LS	Q4	2	50	1.503	0.680
PS-LS	Q4	2	0	1.650	0.597
PS-LS	Q4	3	100	1.378	0.775
PS-LS	Q4	3	50	1.610	0.628
PS-LS	Q4	3	0	1.817	0.524
LS-FS	Q1	1	100	1.314	0.787
LS-FS	Q1	1	50	1.388	0.734
LS-FS	Q1	1	0	1.458	0.687
LS-FS	Q1	2	100	1.340	0.767
LS-FS	Q1	2	50	1.481	0.672
LS-FS	Q1	2	0	1.611	0.598
LS-FS	Q1	3	100	1.365	0.748
LS-FS	Q1	3	50	1.573	0.617
LS-FS	Q1	3	0	1.758	0.525
LS-FS	Q2	1	100	1.304	0.796
LS-FS	Q2	1	50	1.351	0.761
LS-FS	Q2	1	0	1.397	0.728
LS-FS	Q2	2	100	1.320	0.784
LS-FS	Q2	2	50	1.411	0.718
LS-FS	Q2	2	0	1.498	0.663
LS-FS	Q2	3	100	1.335	0.772
LS-FS	Q2	3	50	1.472	0.679
LS-FS	Q2	3	0	1.597	0.606
LS-FS	Q3	1	100	1.318	0.788
LS-FS	Q3	1	50	1.409	0.724
LS-FS	Q3	1	0	1.496	0.669
LS-FS	Q3	2	100	1.346	0.769
LS-FS	Q3	2	50	1.523	0.655
LS-FS	Q3	2	0	1.684	0.570
LS-FS	Q3	3	100	1.375	0.751
LS-FS	Q3	3	50	1.634	0.596
LS-FS	Q3	3	0	1.864	0.491
LS-FS	Q4	1	100	1.313	0.794
LS-FS	Q4	1	50	1.397	0.736
LS-FS	Q4	1	0	1.477	0.687
LS-FS	Q4	2	100	1.338	0.780

Closed fleet	Closed season	No. months closed	Reallocation (%)	B/Bmsy	F/Fmsy
LS-FS	Q4	2	50	1.500	0.677
LS-FS	Q4	2	0	1.650	0.597
LS-FS	Q4	3	100	1.363	0.767
LS-FS	Q4	3	50	1.601	0.624
LS-FS	Q4	3	0	1.817	0.524
Others	Q1	1	100	1.284	0.811
Others	Q1	1	50	1.301	0.798
Others	Q1	1	0	1.318	0.786
Others	Q1	2	100	1.278	0.814
Others	Q1	2	50	1.313	0.788
Others	Q1	2	0	1.346	0.764
Others	Q1	3	100	1.271	0.817
Others	Q1	3	50	1.324	0.778
Others	Q1	3	0	1.375	0.743
Others	Q2	1	100	1.287	0.809
Others	Q2	1	50	1.313	0.789
Others	Q2	1	0	1.338	0.771
Others	Q2	2	100	1.284	0.809
Others	Q2	2	50	1.336	0.771
Others	Q2	2	0	1.385	0.737
Others	Q2	3	100	1.282	0.809
Others	Q2	3	50	1.359	0.753
Others	Q2	3	0	1.433	0.706
Others	Q3	1	100	1.292	0.807
Others	Q3	1	50	1.326	0.782
Others	Q3	1	0	1.359	0.758
Others	Q3	2	100	1.296	0.805
Others	Q3	2	50	1.362	0.756
Others	Q3	2	0	1.426	0.714
Others	Q3	3	100	1.300	0.803
Others	Q3	3	50	1.400	0.732
Others	Q3	3	0	1.493	0.674
Others	Q4	1	100	1.302	0.803
Others	Q4	1	50	1.351	0.768
Others	Q4	1	0	1.398	0.735
Others	Q4	2	100	1.319	0.797
Others	Q4	2	50	1.412	0.731
Others	Q4	2	0	1.500	0.675
Others	Q4	3	100	1.339	0.790
Others	Q4	3	50	1.475	0.696
Others	Q4	3	0	1.600	0.623
All fleets	Q1	1	100	1.227	0.846

Closed fleet	Closed season	No. months closed	Reallocation (%)	B/Bmsy	F/Fmsy
All fleets	Q1	1	50	1.428	0.702
All fleets	Q1	1	0	1.608	0.601
All fleets	Q1	2	100	1.152	0.896
All fleets	Q1	2	50	1.548	0.624
All fleets	Q1	2	0	1.877	0.476
All fleets	Q1	3	100	1.055	0.971
All fleets	Q1	3	50	1.654	0.563
All fleets	Q1	3	0	2.125	0.385
All fleets	Q2	1	100	1.275	0.812
All fleets	Q2	1	50	1.429	0.704
All fleets	Q2	1	0	1.570	0.623
All fleets	Q2	2	100	1.260	0.815
All fleets	Q2	2	50	1.556	0.625
All fleets	Q2	2	0	1.812	0.505
All fleets	Q2	3	100	1.242	0.819
All fleets	Q2	3	50	1.676	0.559
All fleets	Q2	3	0	2.037	0.418
All fleets	Q3	1	100	1.308	0.797
All fleets	Q3	1	50	1.505	0.666
All fleets	Q3	1	0	1.682	0.572
All fleets	Q3	2	100	1.333	0.783
All fleets	Q3	2	50	1.702	0.565
All fleets	Q3	2	0	2.016	0.435
All fleets	Q3	3	100	1.365	0.765
All fleets	Q3	3	50	1.892	0.484
All fleets	Q3	3	0	2.326	0.338
All fleets	Q4	1	100	1.351	0.781
All fleets	Q4	1	50	1.549	0.653
All fleets	Q4	1	0	1.726	0.561
All fleets	Q4	2	100	1.425	0.752
All fleets	Q4	2	50	1.787	0.546
All fleets	Q4	2	0	2.097	0.422
All fleets	Q4	3	100	1.516	0.719
All fleets	Q4	3	50	2.023	0.463
All fleets	Q4	3	0	2.443	0.324
All fleets	Qall	3	0	2.316	0.340