Report of the 24th Session of the IOTC Working Party on Tropical Tunas, Data Preparatory Meeting

Virtual Meeting, 30 May – 03 June 2022

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BIBLIOGRAPHIC ENTRY
IOTC–WPTT24(DP) 2022. Report of the 24th Session of the IOTC Working Party on Tropical Tunas, Data Preparatory Meeting. Online, 30-May – 03 June 2022. *IOTC–2022–WPTT24(DP)–R[E]: 37 pp.*

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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.
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
FOB	Floating Object (or Fish aggregating devices FADs)
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 24th Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Tropical Tunas (WPTT), Data Preparatory Meeting was held online using the Zoom online platform from 30 May - 03 June May 2022. The meeting was opened by the Chairperson, Dr Gorka Merino (EU, Spain) who welcomed participants and Vice-Chair, Dr M. Shiham Adam (IPNLF). A total of 67 participants attended the Session (cf. 80 in 2021, 62 in 2020 and 68 in 2019). The list of participants is provided at Appendix I.

1. Opening of the Meeting

1. The 24th Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Tropical Tunas (WPTT), Data Preparatory Meeting was held online using the Zoom online platform from 30 May - 03 June May 2022. The meeting was opened by the Chairperson, Dr Gorka Merino (EU, Spain) who welcomed participants and Vice-Chair, Dr M. Shiham Adam (IPNLF). A total of 67 participants attended the Session (cf. 80 in 2021, 62 in 2020 and 68 in 2019). The list of participants is provided at Appendix I.

2. Adoption of the Agenda and Arrangements for the Session

2. The WPTT **ADOPTED** the Agenda provided in Appendix II. The documents presented to the WPTT24(DP) are listed in Appendix III.

3. The IOTC Process: Outcomes, Updates and Progress

3.1 Outcomes of the 24th Session of the Scientific Committee

3. The WPTT **NOTED** paper IOTC–2022–WPTT24(DP)–03 on the Outcomes of the 24th Session of the Scientific Committee.

4. The WPTT **NOTED** that in 2021, the SC made a number of observations in relation to the WPTT23 report (noting that updates on Recommendations of the SC24 are dealt with under Agenda item 3.4 below). Those observations are provided in the document and have not been reproduced here as they are extensive.

5. The WPTT **DISCUSSED** whether the WGFAD should remain under the WPTT or whether it should report to the Commission directly. The WPTT **NOTED** that the Commission had stated that the recently formed WGEMS should stay a scientific Working Group, but it was pointed out that the discussions under the past WGFAD were of a more political and policy-based nature. As such the WPTT **SUGGESTED** that the SC review this issue and make a recommendation to the Commission on the future of the WGFAD. Should the nature of the WGFAD change, the TORs should likewise be updated.

3.2 Outcomes of the 25th Session of the Commission (IOTC Secretariat)

6. The WPTT(DP) **NOTED** paper IOTC–2022–WPTT24(DP)–04 on Outcomes of the 25th Session of the Commission.

7. **NOTING** that the Commission also made a number of general comments and requests on the recommendations made by the Scientific Committee in 2020, which have relevance for the WPTT (details as follows: paragraph numbers refer to the report of the Commission (IOTC–2021–S25–R), the WPTT **AGREED** that any advice to the Commission would be provided in the relevant sections of this report, below.

On the status of tropical and temperate tunas

- *(Para. 18) The Commission **NOTED** that the current status of tropical and temperate tunas is as follows (full details are provided in Appendix 5):*

Bigeye tuna   *In 2019 a new stock assessment was carried out for bigeye tuna in the IOTC area of competence to update the stock status undertaken in 2016. On the weight-of-evidence available in 2019, the bigeye tuna stock is determined to be not overfished but subject to overfishing.*
Yellowfin tuna

No new stock assessment was carried out for yellowfin tuna in 2020, thus, stock status is determined on the basis of the 2018 assessment and other information presented in 2020. On the weight-of-evidence available in 2018, 2019 and 2020, the yellowfin tuna stock is determined to remain overfished and subject to overfishing.
Skipjack tuna *A new stock assessment was carried out for skipjack tuna in 2020 using Stock Synthesis with data up to 2019. The outcome of the 2020 stock assessment model does not differ substantially from the previous assessment (2017) despite the large catches recorded in the period 2018-2019, which exceeded the catch limits established in 2017 for this period. On the weight-of-evidence available in 2020, the skipjack tuna stock is determined to be: (i) above the adopted biomass target reference point; (ii) not overfished ($SB_{2019}>SB_{40\%SB0}$); (iii) with fishing mortality below the adopted target fishing mortality, and; (iv) not subject to overfishing ($E_{2019}<E_{40\%SB0}$)*

8. The WPTT also **NOTED** that although the S26 meeting had taken place prior to the WPTT(DP) meeting, the report (including its discussion of the new Yellowfin Assessment in 2021) was not yet adopted. As such the outcomes from that meeting could not be considered by the WPTT at this stage.

3.3 Review of Conservation and Management Measures relevant to tropical tuna (IOTC Secretariat)

9. The WPTT **NOTED** paper IOTC–2022–WPTT24(DP)–05 containing a Review of Conservation and Management Measures relevant to tropical tuna. The aim of this document was to encourage participants at the WPTT24(DP) to review the existing CMMs relevant to tropical tunas.

3.4 Progress made on the recommendations of WPTT23 (IOTC Secretariat)

10. The WPTT **NOTED** paper IOTC–2022–WPTT24(DP)–06 on the Progress made on the recommendations of WPTT23. The WPTT **AGREED** to consider and revise as necessary, its previous recommendations, and for these to be combined with any new recommendations arising from the WPTT24(DP), noting that these will be provided to the SC for its endorsement.

4. Review of the Data Available at the Secretariat for Tropical Tuna Species

11. The WPTT **NOTED** papers IOTC–2022–WPTT24(DP)–07–TROPICALS and IOTC–2022–WPTT24(DP)–07–BET which provide a review of the statistical data and fishery trends for tropical tunas and bigeye tuna (respectively) as received by the IOTC Secretariat for the period 1950–2020. The paper covers data on nominal catches, catch and effort, size-frequency and observations at sea performed by scientific observers, and provides a range of fishery indicators, including (estimated) average weight and catch and effort trends for fisheries catching bigeye tuna in the IOTC area of competence.

12. The WPTT **NOTED** that while catch trends of all 16 IOTC species remained stable at around 1,800,000 t in the last five years, catches of all tropical tuna combined are instead showing a decrease of 8.6%, from 1,150,000 t reported in 2018 to 1,050,000 t in 2020.

13. In particular, the WPTT **NOTED** how this decrease is mostly due to the reduction of catches of skipjack tuna, with bigeye and yellowfin tuna remaining stable at around the same levels as 2018.

14. Additionally, the WPTT **NOTED** that the contribution of artisanal fisheries (i.e., fisheries operated by vessels of less than 24 m in length overall, and exclusively fishing in the EEZ of the flag state) to catches of IOTC and tropical species has increased in 2020 due to factors that include, among others, further developments of line fisheries (artisanal in nature, and mostly using handline, troll line and coastal longline as gears) as well as the consequences of the CoViD-19 pandemic on industrial fisheries operated by distant-water fishing nations.

15. The WPTT **ACKNOWLEDGED** how the increase in relative contribution of artisanal fisheries to total catch levels has also affected bigeye tuna, with around 30% of its catch volumes accounted for by coastal fisheries in 2020.

16. The WPTT also **NOTED** the difference in trends of bigeye tuna catches reported by industrial purse seine fisheries compared to all other fisheries (both industrial and artisanal) with the former in a contracting phase, as opposed to the latter which are now increasing back to levels comparable to 2016 after an initial phase of decreasing catches.

17. The WPTT **ACKNOWLEDGED** that the fraction of bigeye tuna caught on FOB-associated schools versus the total of purse seine catches (all fishing modes combined) oscillates between 80% and 95% during the last five years, and **NOTED** how the French component of the European Union purse seine fleet is now reporting captures on FOB-associated schools to percentages comparable to all other EU and assimilated fleets.

18. The WPTT **NOTED** a large peak in catches of bigeye tuna reported in 2012 by all deep-freezing industrial longline fisheries combined, and **CONFIRMED** that this was due to increases in catch levels reported by several fleets, in particular those from Taiwan,China, Seychelles, China, and Japan.

19. The WPTT also **ACKNOWLEDGED** that a relevant contribution to the marked increase in catches from longline fisheries in 2012 originates from the (estimated) *not elsewhere reported* component of these fisheries and **NOTED** how this was particularly relevant in years between 1995 and 2010, before the implementation of Port State Measures contributed to its decrease.

20. Furthermore, the WPTT **NOTED** that this exceptional recent peak in catches from longline fisheries was eventually followed by a steady decline that continued until 2018.

21. The WPTT **NOTED** the reporting quality (and the level of re-estimation) of the three main datasets available to the IOTC Secretariat, and **ACKNOWLEDGED** that notwithstanding improvements in recent years, bigeye tuna size-frequency data are still largely incomplete or inaccurate, and particularly those associated to artisanal fisheries.

22. For this reason, the WPTT **CONFIRMED** that it would not be possible to attempt an accurate estimation of the fraction of juvenile bigeye tuna caught by some of the most important artisanal fisheries operating in the Indian Ocean, such as those from Indonesia which account for around 10% of total bigeye catches in recent years.

23. The WPTT **NOTED** that due to the effects of the CoViD-19 pandemic, industrial purse seine size-frequency data for the statistical year 2020 for EU and assimilated fleets are particularly low in numbers, and **ACKNOWLEDGED** that data from EU,Spain has been collected but not yet provided to the IOTC Secretariat due to administrative issues.

24. The WPTT **ACKNOWLEDGED** that size-frequency data of bigeye tuna recorded in logbooks from the deep-freezing longline fleet of Taiwan,China present similar issues as those already identified for yellowfin tuna (i.e., tendency to measure larger fish, differences in average weight compared to the available catch-and-effort data for the same strata).

25. Therefore, the WPTT **SUGGESTED** that all logbook data from the Taiwanese deep-freezing longline fleet are excluded from the input data, and that only observer data from the same fleet are considered for stock assessment purposes.

26. The WPTT also **NOTED** the differences in size distribution of bigeye tuna reported through logbook and observer data for the deep-freezing longline fisheries of Japan, and **ACKNOWLEDGED** that these could be due to observers being deployed on vessels specifically targeting southern bluefin tuna, as opposed to data from logbooks that originate from vessels operating in other areas and targeting tropical species.

27. The WPTT **NOTED** that the use of size-frequency histograms based on raw samples aggregated over time and space may be misleading when comparing the size composition between fleets or data sources (e.g., logbook vs. observer) and **REQUESTED** the Secretariat adopt a standardization procedure for representing and comparing size-frequency distributions.

28. **RECALLING** the discussions initiated during the 21st session of the Working Party on Tropical Tunas (2019) and specifically related to the detected peak in bigeye tuna catches reported by the purse seiners of EU,Spain for 2018, the WPTT **NOTED** how annual catches from this same fishery for 2019 and 2020 have roughly returned to the 2017 levels of around 13,000 t (i.e., around 50% of the catches reported for 2018).

29. The WPTT **ACKNOWLEDGED** that, notwithstanding the re-estimation procedure of tropical tuna species composition discussed at its 21st session (IOTC-2019-WPTT21) as well as at the 15th session of the Working Party on Data Collection and Statistics (IOTC-2019-WPDCS15), all information presented in this paper and currently used for the preparation of the stock assessment input files is still referring to the species composition and catch levels originally reported by EU,Spain for 2018.

30. The WPTT **NOTED** that the issue has been raised at the last IOTC Compliance Committee during which the EU proposed to include the Secretariat in the review of the analysis of the fisheries and sampling data for that year.

31. The WPTT **DISCUSSED** the different options for estimating the Spanish purse seine catch of bigeye tuna in 2018 for input to the 2022 stock assessment model and **AGREED** on applying the spatio-temporal re-estimation procedure proposed at the WPDCS in 2019 (IOTC-2019-WPDCS15-10_Rev2) based on the proxying scenario number four as recommended by the WPDCS (IOTC-2019-WPDCS15), that uses catch and effort data from Seychelles 2018, EU.France 2018, EU.Spain 2017 and nominal catches from EU.Spain 2017 (in this order) to re-estimate the monthly species composition of spatialized EU.Spain catches reported as 1x1 degrees grids in 2018. This procedure will be applied to re-estimate Spanish purse seine catch for the 2022 stock assessment model unless further clarifications are provided by the Spanish and EU administrations.

32. The WPTT **NOTED** that this approach differs from the T3 procedure usually applied to the EU and assimilated purse seine fleets, that estimates catch levels and species composition through a substitution scheme and data sourced from larger, irregular statistical areas on a quarterly basis.

33. At the same time, the WPTT **ACKNOWLEDGED** that the proposed re-estimation procedure is based on public data available to the IOTC Secretariat and **NOTED** how, in light of its implementation details, this is expected to yield a species composition that is indeed an averaged version of data originally computed through T3.

34. The WPTT **NOTED** that scientists from EU.Spain confirmed the similarities in species composition between the proposed procedure and the results of applying the T3 process to re-estimate EU.Spain catches for 2018.

35. The WPTT also **RECALLED** how the estimation procedure introduced in 2019 by EU,Spain to produce their official data for 2018 is instead based on sampling at the landing site and on other information not originally provided as input to the T3 process, hence the detected discontinuity with previous years.

36. **RECALLING** that, until 2017 included, species composition for EU,Spain FOB-associated PS catches was estimated using the T3 process in agreement with all other EU and assimilated fleets, the WPTT **REQUESTED** EU,Spain to clarify if the same approach was also adopted during 2019 and 2020, which show comparable species compositions to 2017 and previous years.

37. **RECALLING** how IOTC Res. 15/02 already requests that (para. 4a) "(...) *documents describing the extrapolation procedures (including raising factors corresponding to the logbook coverage) shall*

also be submitted routinely" and that the IOTC Secretariat is currently working on standardizing the format for the provision of this information (IOTC-2021-WPDCS17-27), the WPTT reiterated the **REQUESTED** that EU,Spain provide a document with details on the re-estimation procedures adopted for 2018 and following years at the next session of the WPTT in October 2022, further **NOTING** that all CPCs should provide similar information for their different fisheries as part of the regular data submissions.

5. New Information on Biology, Ecology, Fisheries and Environmental Data Relating to Tropical Tunas

5.1 Review new Information on the biology, stock structure, their fisheries and associated environmental data for bigeye tuna

38. The WPTT **NOTED** paper IOTC-2022-WPTT24(DP)-08 on an Updated outline of climate and oceanic conditions to March 2022 for the Indian Ocean, with perspectives on climate change effects on fish catch potential in Maldives and in three coastal upwelling systems, including the following abstract written by the authors:

> *"The updated descriptors of ocean status indicate that the Indian Ocean Dipole has been in a neutral phase since 2020, with dominant normal conditions in sea surface temperature. The Dipole is predicted to enter a negative phase in May 2022 until the end of the year, potentially causing thermocline shoaling in the West IO and deepening in the East IO. The thermocline fluctuated in opposite ways between East and West IO. Shallow thermocline conditions took place in the Central IO from March to October 2021, shifting to the West IO in the first quarter of 2022. A strong positive dipole in 2019 boosted (depleted) the plankton production in the East IO (West IO). In 2021, there was higher chlorophyll concentration than normal in the East (+12%) and in the West IO (+8%), and values around the average in the ISSG (+3%) and the Mozambique Channel (-2%)."* – see document for full abstract.

39. The WPTT **CONGRATULATED** the author for the work which provides insight into the major oceanographic features of the Indian Ocean with a focus on the period 2019-2022, including monthly maps of anomalies of sea surface temperature, 20° isotherm depths, and sea surface chlorophyll as well as possible climate change potential impacts on tropical tuna catches in various regions.

40. The WPTT **NOTED** the major influence that large-scale environmental features may have on marine productivity and vertical structure of the ocean, and the need to disentangle the effects of abundance and catchability in the CPUE standardisation process.

41. The WPTT **NOTED** that IOTC has adopted Resolution 22/01 on Climate Change and **QUESTIONED** the author how this resolution could be practically implemented. The WPTT **NOTED** that there are several oceanographic indicators that can be used to identify and monitor the impacts of climate change on stock abundance, distribution, and recruitment that can inform fishery management advice.

42. Among those indicators, the WPTT **DISCUSSED** candidate indicators to inform how better accounting for Climate Change within the management advice through Climate Change indicators and other environmental indices, including but not limited to:

   - Chlorophyll abundance with a certain time lag could be used to inform productivity and recruitment.
   - The Indian Ocean Dipole, a more integrated variable of various oceanographic characteristics, can inform abundance, however, this indicator shows marked regional differences with different effect between the western and eastern Indian Ocean.

- Other oceanographic features, such as thermocline depth, sea surface temperature, upwelling could also inform the CPUE standarization.
- And more general models to predict tuna distribution in different climate change scenarios could also inform potential changes on tuna availability by region.

43. The WPTT **NOTED** paper IOTC-2022-WPTT24(DP)-09 on a preliminary report on Estimates of fecundity, age at maturity, sex ratios, spawning season, and spawning fraction for yellowfin tuna, including the following abstract written by the authors:

    "This paper describes preliminary work to estimate reproductive parameters for yellowfin tuna (Thunnus albacares) in the Indian Ocean as part of the 'GERUNDIO' project. [...] A total of 1145 yellowfin tuna were sampled in the project (476 females and 669 males). The individuals were collected in 2020-2021 predominantly from purse seine fisheries unloading at canneries in the western Indian Ocean. Histological sections were prepared for 212 ovary samples (i.e., females only), which were read by project partners using an agreed classification system after receiving training at an online workshop in July 2021. Additional ovaries collected in the current project will be processed soon to update the current analysis. Data from an additional 921 yellowfin tuna (476 females and 445 males) were obtained from previous projects (EMOTION database, see Bodin et al. 2018), which included histological data from 388 females classified using a similar classification scheme to that agreed in the project. The individuals were collected between 2009-2019 and were also predominantly from the western Indian Ocean." – see document for full abstract

44. The WPTT **NOTED** paper IOTC-2022-WPTT24(DP)-10 on a preliminary report on Estimates of fecundity, age at maturity, sex ratios, spawning season, and spawning fraction for skipjack tuna, including the following abstract written by the authors:

    "This paper describes preliminary work to estimate reproductive parameters for skipjack tuna (Katsuwonus pelamis) in the Indian Ocean as part of the 'GERUNDIO' project. [...] A total of 635 skipjack tuna were sampled in the GERUNDIO project (296 females and 339 males). The individuals were collected in 2020-2021 predominantly from purse seine fisheries unloading at canneries in the western Indian Ocean. Histological sections were prepared from a subset of 84 ovary samples, which were read using an agreed classification system. Additional ovaries collected in the project will be processed soon to update the current analysis. Data from an additional 1,151 skipjack tuna (862 females and 649 males) were obtained from previous projects (EMOTION database, see Bodin et al. 2018), which included histological data from 756 females classified using a similar classification scheme to that agreed in the GERUNDIO project. The individuals were collected from 2009-2019 and were also predominantly from the western Indian Ocean." – see document for full abstract.

45. The WPTT **CONGRATULATED** the authors for the work on the reproductive biology of yellowfin and skipjack tunas and **NOTED** that the authors standardized the analysis protocols between institutes and recovered some samples from past projects to combine them all in a single database.

46. The WPTT **NOTED** the lack of samples in the eastern Indian Ocean as well as low sample size in some seasons. The WPTT **ENCOURAGED** the authors to continue the sampling so as to present an updated document with more samples covering all seasons and the whole Indian Ocean area. The authors **INFORMED** the WPTT that a biological sampling program is currently in place that they will be able to collect more samples.

47. The WPTT **NOTED** that JAPAN has recently been involved in the GERUNDIO project to collaborate on the sampling operations at sea so as to complement the sampling and better balance the sampling design.

48.The WPTT **NOTED** that the estimates of maturity for skipjack tuna were consistent with previous analyses while there were major differences for yellowfin tuna between the samples collected as part of the GERUNDIO project only (i.e., 84.2 cm fork length) and all the samples combined (~101.7 cm fork length). The WPTT **NOTED** that the authors are in the process of checking the analysed slices and conduct complementary analyses to understand the reasons for these discrepancies.

49.The WPTT **NOTED** that the relative batch fecundity for skipjack tuna appears to be higher at intermediate sizes (~45 cm fork length) than at larger sizes while no pattern with size was found for yellowfin tuna, i.e., no increased maternal investment in offspring for this species in terms of quantity of eggs produced per female.

50.The WPTT **NOTED** that raw estimates of reproductive parameters can be biased by sampling stratification, e.g., sampling aggregations of spawning individuals during the spawning season could bias the maturity ogive to smaller sizes. Therefore, the WPTT **ENCOURAGED** the authors to use a statistical model to adjust for the effects of covariates such as location and month/season on reproductive parameters (i.e., maturity, fecundity, etc.) in order to get estimates at population level, as required for the stock assessment (e.g., Farley et al. 2014).

51.The WPTT **NOTED** that there was a major difference in the length-weight relationship fitted to the data of skipjack tuna and the one available from the IOTC Secretariat (IOTC-2022-WPTT24(DP)-DATA13), **NOTING further** that all data collected as per the GERUNDIO project are publicly available and could be used to check for the observed differences and eventually complement the data available at the Secretariat so as to update the reference IOTC relationships and be included in the IOTC biological catalogue.

52.The WPTT **NOTED** that the sex-ratio between GERUNDIO project and when and when samples from other projects are used are different, with GERUNDIO sex-ratio better approximating to the tuna observed sex-ratios by length. Thus, the WPTT **REQUESTED** the authors to check and review sex-ratio information when more samples are available.

53.The WPTT **NOTED** that innovative administrative approaches should be explored to ensure the contribution of the CPCs in the collection of data. The WPTT **DISCUSSED** the possibility to develop an IOTC regional biological sampling program for growth and reproductive studies where each IOTC CPC could contribute with a minimum number of biological samples to the regional biological sampling pool. This coordinated biological sampling effort would allow covering spatially/regionally different areas to obtain population level growth and reproductive parameters. Although the WPTT **RECOGNISED** the challenges and difficulties, the WPTT **REQUESTED** that the development of a coordinated biological sampling program is discussed and considered at the next WPDCS and SC and that the WPTT/WPDCS develop a sampling strategy, and minimum samples by CPCs, needed to obtain population and regional/seasonal specific growth and reproductive parameters. The WPTT **NOTED** that the WCPFC Tuna Tissue Bank could be an example to follow, and start with, as an inventory of the biological samples available in IOTC.

6. Review of New Information on the Status of Tropical Tunas

6.1 Review of fishery dynamics by fleet

54.The WPTT **NOTED** paper IOTC-2022-WPTT24(DP)-11 on Tropical tuna fisheries of Pakistan-status and trends, including the following abstract provided by the authors:

> *"Annual landings of tropical tuna in Pakistan have increased by 8.04 % in 2021 as compared to landings of 2020. During 2021, yellowfin tuna (Thunnus albacares) contributed 5,598 m. tons whereas landings of skipjack tuna (Katsuwonus pelamis) during 2021 were recorded to be 810 m. tons. The increase in the landings of yellowfin and skipjack tunas during 2021 over 2020 were 7.26 % and 13.76 % respectively. As compared, landings of neritic tuna have shown a decrease of 22.77 % during the same period. Increase in the landings of tropical*

tuna is attributed to operation of tuna longliners in offshore waters during August to December 2021. Decrease in landings of neritic tuna during same period is on account of partial closure of small scale fishing operations along Balochistan coast during September to December because of protest of fishermen on account of poaching of shrimp trawlers in waters of Balochistan. Overall annual tuna landings of Pakistan have shown a decrease of 15.80 % during 2021 as compared to year 2020."

55. The WPTT **THANKED** the authors for the paper and **NOTED** that no bigeye tuna has been estimated to be caught in Pakistani gillnet fisheries in 2021 while the catches of skipjack and yellowfin tuna increased by about 8% and the catches of neritic species decreased by more than 20% when compared to 2020.

56. The WPTT **NOTED** that a component of the Pakistani gillnet fishing fleet based in Karachi has moved in 2020 to the fishing port of Gwadar, located close to the Iranian border, to get lower fuel prices and access the Iranian market of tropical tuna.

57. The WPTT **NOTED** that many fishing vessels stopped their fishing operations in 2021 following a partial closure of the small-scale fishing operations along the Balochistan coast, further **NOTING** that some vessels shifted fishing gear from gillnet to trawl, which changed the target species to mackerel, barracudas, and particularly dolphinfish, which are in demand in European and South African markets.

58. **NOTING** that nominal catch data from Pakistan were submitted way past the deadline in 2021 (data for the year 2020) due to administrative issues, the WPTT **REQUESTED** Pakistan to make the most to submit the 2021 data prior to the deadline (30th of June 2022) as per IOTC Resolution 15/02.

59. **RECALLING** that no geo-referenced catch and effort data has been submitted by Pakistan to the IOTC Seretariat since 1991, the WPTT **REQUESTED** Pakistan to make efforts to compile and submit catch and effort data for their gillnet fisheries as per IOTC Resolution 15/02.

7. Nominal and Standardized CPUE Indices

60. The WPTT **NOTED** paper IOTC-2022-WPTT24(DP)-12 on European purse seiners CPUE standardization of Big Eye tuna caught under dFADs, including the following abstract provided by the authors:

"*Abundance index for Big Eye tuna (BET) in the Indian Ocean was derived from the European purse seiner CPUEs series (2010-2021) for fishing operations made on drifting FADs (Fishing aggregating Devices). By classifying sets to non-followed dFADs (i.e., dFADs randomly encounter for which the purse seiner has no previous information) and followed-dFADs (dFADs from which purse seiner has previous information and therefore it is not randomly encounter) we take into account the difference between them. The VAST methodology was used to standardized the BET CPUE. A GLMM approach has been also applied to compare the outputs when using an alternative modelling approach.*"

61. The WPTT **THANKED** the authors for the study which constitutes a first application of the VAST (Vector autoregressive spatio-temporal model) method to purse seine CPUE data in order to provide information on abundance trends in small bigeye tuna and complement longline CPUE indices.

62. The WPTT **NOTED** that there were some differences between the nominal and standardized values of CPUE but that the standardisation process based on VAST did not result in any real change in terms of tendency, further **NOTING** that there was almost no difference in the CPUE outputs between the VAST and standard GLMM approach.

63. The WPTT **QUERIED** why the large common trends observed in the VAST influence plots were not reflected in the result between the nominal and standardized indices and **REQUESTED** the authors to explore the reasons for that.

64. The WPTT **ENCOURAGED** the authors to use the vessel effects as fixed and not random in the model to assess the impact on the results.

65. The WPTT **QUERIED** about some possible technological changes (e.g., new equipment) which might have affected the efficiency of purse seine fisheries in recent decades and may not be captured in the model. In particular, the WPTT **NOTED** that small bigeye tunas may occur deeper than other tuna species associated under drifting floating objects and that deepening of the purse seines might result in increasing catchability for that species. However, the WPTT **NOTED** that the time series considered in the study starts in 2010 and that no change in the gear is thought to have occurred in purse seines design and structure since 2010.

66. The WPTT **NOTED** that the study does not account for the time of the day while the species composition of purse seine catch has been shown to vary over the course of the day in the Pacific Ocean, which could bias the estimates if the timing of the sets has changed over the years. The WPTT **NOTED** that most fishing sets on floating objects may occur in the early morning but **ENCOURAGED** the authors to look at the timing of the fishing operations over the years as well at the proportion of each species in the sets as a function of the time of the day to assess whether time should be included as an additional covariate in the statistical models.

67. The WPTT **NOTED** that the VAST modelling approach assumes a random distribution of the fish for raising the data while the number of dFADs may affect the distribution and local abundance of the tunas associated with the drifting floating objects (e.g., Sempo et al. 2013), and that this may question the applicability of the approach to the specific case of FAD fisheries.

68. The WPTT **NOTED** paper IOTC-2022-WPTT24(DP)-13 on Associative-behavior abundance index (ABBI) for Bigeye tuna in the Western Indian Ocean obtained from echosounder buoys data, including the following abstract provided by the authors:

> "*This paper presents the estimates of bigeye tuna (Thunnus obesus) abundance assessed from the associative behavior-based abundance index (ABBI). Taking advantage of the associative behavior of species around floating objects (FOBs) and acoustic data collected by echosounder buoys used in the tropical tuna purse seine fishery, the ABBI approach index allows for direct and effort-independent abundance estimates of tropical tuna species. Its implementation in the western Indian Ocean on small bigeye tuna (individual less than 10 kg) has shown a decline in abundance of this species since 2018, relative to the reference levels of 2013.*"

69. The WPTT **CONGRATULATED** the authors for the work which aims to provide a fishery-independent perspective on the biomass of small bigeye tuna based on a model of associative dynamics at drifting floating objects and a combination of data sets (i.e., species composition of the purse seine catch, acoustic-based indices of abundance, acoustic tagging information, number of floating objects at sea, and total catch per fishing set on floating objects).

70. The WPTT **NOTED** that the fraction of floating objects occupied by bigeye tuna showed a marked decreasing trend over recent years while the overall estimate of biomass remained fairly stable between 2013 and 2019 as there are other components of abundance (i.e., aggregation size and number of floating objects) that are accounted for in the model.

71. The WPTT **NOTED** that the values of absolute biomass estimated in the five 10x10 grid squares of the western Indian Ocean considered in the study appear to be small (500-2,000 t) and sensitive to the values of the average continuous absence time (CAT) parameter (i.e., time spent between two

FOB associations), **AGREEING** that the ABBI provides a relative index of recruitment for bigeye tuna in that sub-region of the stock area.

72. The WPTT **ENCOURAGED** the authors to compare the trends with the abundance index derived from purse seine commercial catch rates (IOTC-2022-WPTT24(DP)-12) as well as the relevant subregion longline index (but accounting for the time lag associated with the different age classes represented by both indices) and with the model outputs of the bigeye tuna stock assessment.

73. The WPTT **NOTED** paper IOTC-2022-WPTT24(DP)-14 on Standardization of bigeye tuna CPUE by Japanese longline fishery in the Indian Ocean, including the following abstract provided by the authors:

   "Standardization of bigeye tuna CPUE by Japanese longline fishery in the Indian Ocean was conducted using the Generalized Linear Model (GLM) with lognormal error structure. Cluster analysis was conducted before standardization, and cluster number was used for main effect as well as year, quarter, vessel ID and five degree latitude/longitude block. Area definition is the same as that for 2019 IOTC bigeye tuna stock assessment. CPUEs show decreasing trend from early 1980s to late 2000s, and then CPUEs show increasing trend. The trend of CPUE was usually similar to that in the previous study."

74. The WPTT **NOTED** that the indices of abundance estimated in 2022 showed major differences with the time series estimated in 2019, likely due to a change in aggregation of the catch and a different clustering method. The WPTT **ENCOURAGED** the authors to investigate the factors involved to better understand these differences.

75. The WPTT **NOTED** that the distribution of model residuals for region 2 in particular was not centered, i.e., it showed some departure from normality, and **ENCOURAGED** the authors to explore the reasons for this bias which may affect the standardisation process.

76. **NOTING** that the CPUE time series considered in 2022 includes data between 1975 and 1979 following the rescue and availability of the vessel's identifier for that period, the WPTT **RECALLED** that there is a major "jump" in the CPUE signal prior to 1980 which could explain some of the differences observed between the previous (2019) and new (2022) time series of standardized CPUEs.

77. The WPTT **NOTED** paper IOTC-2022-WPTT24(DP)-15 on the Joint CPUE indices for the bigeye tuna in the Indian Ocean based on Japanese, Korean and Taiwanese longline fisheries data up to 2022, including the following abstract provided by the authors:

   "Joint CPUE standardization was conducted for the Indian Ocean bigeye tuna based on Japanese, Korean and Taiwanese longline fisheries data up to 2020 to provide the WPTT with information on provisional abundance indices for use in the coming stock assessment for this stock. The intention was to produce combined indices by increasing the spatial and temporal coverage of fishery data. Due to the limitation of remote data access, an approach adopted among the three counties for the previous analyses of tropical tunas for IOTC and ICCAT was used to share only aggregated data. As an underlying analysis, a clustering approach was applied to account for the inter-annual changes of the target in each fishery in each region. For this purpose, a hierarchical clustering method with "fastcluster" was used, and the outputs of the finalized cluster were then used to assign the cluster label on fishery target to each catch-effort data. For standardizing the catch-per-unit-effort data, the conventional linear models and delta-lognormal linear models were employed for the shared aggregated data of monthly and 1° grid resolution in each region. Basically, the trend of CPUE was similar to that for the previous stock assessment. The models were diagnosed by the standard residual plots and influence analyses."

78. The WPTT **THANKED** all the authors involved in the collaborative study which has been shown to be instrumental to derive the abundance indices used as inputs for the assessment of the status of bigeye tuna. The WPTT strongly **ENCOURAGED** the resumption of the in-person collaborative CPUE workshops and **NOTED** that they may be held when the conditions regarding safety are met, and travel restrictions lifted.

79. The WPTT **NOTED** that the regional scaling estimates were not made due to late data availability and time constraints but that the analysis could be conducted prior to the assessment meeting planned for October 2022. The WPTT further **NOTED** that the VAST approach could be developed and applied to the CPUE data after inclusion of the 2021 data and that the model outputs could provide better scaling factors than derived from the current approach.

80. The WPTT **NOTED** that although the nominal CPUE time series between Taiwan,China and Japan showed different signals and trends in region R2 over the decade 2010-2020, i.e., increasing for Japan and decreasing for Taiwan,China, the trends became consistent following the standardisation process.

7.1 Input data required for the adopted BET Management Procedure

81. The WPTT **NOTED** the adoption of an Indian Ocean bigeye tuna management procedure (MP) at the 20th Session of the Commission and that details of the management procedure are described in IOTC-2022-TCMP05-07.

82. The WPTT **NOTED** the need to clearly specify the data inputs required to run the bigeye tuna MP in 2022, which include a time series of bigeye tuna catch and a standardised spatially aggregated CPUE series. The WPTT **REQUESTED** that the MP developers work intersessionally with the Secretariat, the SC Chair, and relevant Working Party Chairs to document the full specification of data inputs for the MP and report these to the WPM in 2022.

8. BIGEYE STOCK ASSESSMENT

8.1 Discussion on bigeye assessment models to be developed and their specifications

83. The WPTT **NOTED** the presentation that summaries the structure and configuration of the bigeye tuna assessment model. The WPTT NOTED that only longline CPUE indices were available and included in the 2019 assessment, and that the newly developed purse seine index and echosounder buoys index will be explored and potentially included within the preliminary model grid in the new assessment, for further review by WPTT in November.

84. The WPTT **DISCUSSED** how the time period for recruitment deviates is determined. Recruitment deviations are generally estimated for years in which data for informing recruitment strength (e.g., size composition data) are available, and deviates for regional recruitment distribution are estimated for the period when regional abundance trends diverge. The WPTT **NOTED** that it is important to explore alternative options to prevent the model from being over parameterized.

85. The WPTT **NOTED** the model adopted a 4-region spatial structure in which the western tropical region (R1) is divided into north (R1N) and south (R1S). This stratification is intended to account for potentially incomplete tag mixing, as indicated by significant reduction of tag dispersion and recovery rates along latitude bands. As such, the assumption that the tagged fish are well mixed with the population on the relevant spatial scale is more likely to be met.

86. The WPTT **NOTED** that the spatially structured model estimates fish movement between regions, but model data are generally less informative about movement rates – all tags are released in one region and the CPUE and size composition provide only indirect information. The WPTT **NOTED** that it is important for evaluating if the assessment results are sensitive to alternative movement scenarios.

87. The WPTT **NOTED** the plan to apply a Statistical-Catch-At-Size (SCAS) model as a reference to Stock Synthesis. The SCAS model is based on catch-at-size and will use the same length composition dataset prepared for the Stock Synthesis model. The difference between SCAS and Stock Synthesis is that SCAS is the season aggregated (annual basis) model without explicit spatial structures.

8.2 Identification of data inputs for the different assessment models and advice framework

88. The WPTT **NOTED** paper IOTC-2022-WPTT24(DP)-16 on Assessing the impact of the growth on estimates of fishing mortality for the Indian Ocean bigeye tuna, with the following abstract provided by the authors:

"In 2021, a new growth estimate for bigeye tuna in the Indian Ocean was derived based on otolith aging studies. The new growth estimates represent a size-at-age that is significantly larger than the growth currently used for bigeye tuna stock assessment. This is expected to have a significant impact on the assessment results if included in the model. This report aims to assess the potential impact of the new growth on the estimates of fishing mortality for bigeye tuna by performing an analysis of length composition data based on the assumption that the length distribution is primarily determined by fish growth and mortality. Assuming that growth and natural mortality are known, the analytical method estimates fishing mortality rates and selectivity parameters from the longline length freqeuncy dataset (assuming each length abundance is a steady distribution). The performance of the estimator was validated using simulated data. The analysis shows that longline length frequency data suggest that estimates of annual fishing mortality for new growth are 2–3 times higher than the current growth estimates for bigeye tuna."

89. The WPTT **NOTED** this analysis is independent of the stock assessment and aims to understand the potential impact of change of growth curve on the estimation of fishing mortality from. The analysis was based on the assumption that size distribution is primarily determined by mortality and growth. The WPTT **NOTED** the results may not be comparable to analysis from other data sources (such as tag data), or the stock assessment model using a range of datasets. The WPTT **NOTED** the analysis highlighted that the size composition data can have a significant effect on the estimation of the scale of the population, and as such it is important to make appropriate decisions on the modelling of size data in the assessment (e.g., assumptions on selectivity, effective sample size, etc.).

90. The WPTT **NOTED** this new growth was estimated from the otolith aging study from the Gerundio Project. The method uses both daily and annual aging and has been validated by a number of methods. The old growth curve was largely based on the IOTTP tag recapture data (some otolith data was used to estimate the initial size at age). The WPTT **NOTED** that additional analyses showed that the tagging data contained several cohorts which may have different growth rates which were not well explained in the integrated modelling. It was suggested that the new otolith aging study provides better growth estimates for the bigeye tuna, although the sample size was small (n≈100). The WPTT **NOTED** additional otolith samples can be used to further validate and update the new growth estimates.

91. The WPTT **NOTED** paper IOTC-2022-WPTT24(DP)-17 on Proposed natural mortality ogives for the Indian Ocean bigeye tuna stock assessment, with the following abstract provided by the authors:

"Natural mortality (M) is a very influential parameter in fish stock assessments but is also difficult to estimate. Various sources of information have been used to support M estimates in different species, including the age structure of the population, the maximum observed age, tagging data, and inferences from related species. Two of the main components to estimate are the mean value of M, and its possible variation among population subgroups (e.g., sexes and age classes). In 2021, an analysis of potential approaches for modelling natural mortality was initiated for yellowfin tuna (Hoyle, 2021a). After comments by the

IOTC Working Party on Tropical Tunas, additional analysis has been requested. The aim of this work is to compare approaches for defining appropriate levels of M for inclusion in stock assessments of Indian Ocean bigeye and yellowfin tuna."

92. The WPTT **NOTED** the alternative estimates of M-at-age use the Then et al. (2015) or Hamel and Cope (in Review) to estimate the M for adult based on maximum age (Amax), and the M for juvenile are estimated using the Lorenzen method. The WPTT **NOTED** that there are several variations in the implementation of the Lorenzen approach, and the estimate is based on the formula used for the Atlantic bigeye tuna assessment with minor revisions.

93. The WPTT **NOTED** the maximum age is estimated from samples collected from the exploited population. It was suggested collaboration with fishing companies will help gain access to large/old fish to improve the representative of samples. The WPTT **NOTED** that the exploited population of fish may tend to grow faster, which can lead to bias in Amax. Ideally the Amax should be estimated from a relatively unexploited population to represent the average age for the oldest fish from the fish population.

94. The WPTT **NOTED** that in a heavily exploited population Amax might underestimate the average longevity and as such sensitivity analysis of alternative Amax is useful. The WPTT **NOTED** that assessments may or may not be sensitive to the choice of Amax depending on other model configurations.

95. The WPTT **NOTED** the Amax may vary between oceans due to the effect of different oceanic and environmental conditions which may affect the longevity of the fish, but this is difficult to verify due to that there is not enough data.

96. The WPTT **NOTED** that when M-at-age is calculated using the growth function (e.g., Lorenzen method), It is important to ensure the consistency of the growth function and M in the assessment.

97. The WPTT **NOTED** paper IOTC-2022-WPTT24(DP)-18 on preliminary estimates of sex ratio, spawning season, batch fecundity and length at maturity for Indian Ocean bigeye tuna, with the following abstract provided by the authors:

"This paper describes preliminary work to estimate reproductive parameters for bigeye tuna (Thunnus obesus) in the Indian Ocean as part of the 'GERUNDIO' project1. The 2019 stock assessment for bigeye tuna in the Indian Ocean (IOTC) indicated that the stock is not considered to be overfished but is subject to overfishing (Fu et al. 2019; IOTC 2021). The assessment model used a maturity ogive equivalent to that used by Shono et al. (2009), for which length at 50% maturity was 110.9 cm fork length (FL) and full maturity was around 125 cm FL. The source of this maturity ogive is unclear. The aim of the current project was to produce updated estimates of key biological reproductive parameters for bigeye tuna in the Indian Ocean, including information on length at maturity."

98. The WPTT **NOTED** that the shape of the preliminary maturity obtained in this study is very different to the ogive currently used in the stock assessment although the estimates of length at 50% maturity are similar (112.7 cm versus 110.9 cm FL). The proportion mature at length does not reach 100% as expected in the larger length classes and requires further investigation.

8.3 Other indicators

99. The WPTT **NOTED** paper IOTC–2022–WPTT24(DP)-INF02 and paper IOTC–2022–WPTT24(DP)-INF03 on Indicators of stock status for skipjack tuna in the Indian Ocean.

100. The WPTT **NOTED** the usefulness of developing fishery indicators for monitoring the stock status and suggested that the following indicators be considered: total catch, average weight/size of the catch; fishing effort, nominal CPUE, and area where fishing are active.

9. OTHER MATTERS

9.1 Use of model diagnostics in the WPTT

101. The WPTT **NOTED** the paper IOTC-2022-WPTT24(DP)-19 on the analysis of recruitment deviates of tropical tuna stock including the following abstract provided by the authors:

"Fishery stock assessment consists of fitting fish biology and fisheries information into population dynamics' equations. Stock assessments are subject to uncertainty, and it is a common practice to characterize this using alternative hypotheses and assumptions within an ensemble of models to develop scientific advice for fisheries management. In this context, there is a need to assign levels of plausibility to each of the combinations of factors that ultimately reflect the uncertainty on different biological and fishery processes. In this study, we describe and apply a method to identify trends in process error in each combination of hypotheses of tropical tuna stock assessments. Our results demonstrate that the assessments of tropical tunas contain trends in process error that are overlooked, and we describe their implications for fisheries management." – see document for full abstract.

102. The WPTT congratulated the authors for the extremely comprehensive and excellent work. The WPTT **NOTED** that the stock assessment is not an automated process, and it is important to understand the underlying mechanism behind different model components and how they interact with each other. The WPTT **AGREED** that the synthetization of stock assessments across different species and across different oceans can provide valuable insights to the common problems encountered in the tropical tuna stock assessment.

103. The WPTT **NOTED** that the trend in the recruitment deviates is usually considered to be unaccounted process errors or model misspecifications. These process errors are typically not consistent with the data generation process, and thus may undermine the predictive ability of the model.

104. The WPTT also **NOTED** there are other factors that may also explain trends in recruitment deviates, including occurrence of strong or weak cohorts, or regime shift. In some oceans, better data (e.g., Purse seine data on juveniles) can improve estimation on cohort strength, which has been shown to be likely real in some cases. However, the WPTT **NOTED** that the analysis primarily concerned with the linear trend in the recruitment deviates and is not affected by the periodic trends in the data.

105. The WPTT **NOTED** that climate change can significantly impact oceanographic conditions and life history traits and can alter the spawning response of the fish population under severe depletion. Therefore, it is important to understand the biological processes that can cause changes in recruitment patterns.

106. The WPTT **NOTED** the experiment with simulated data in the analysis is an efficient way to diagnosing model-specification. The simulation approach assumes that true parameters are known, and as such is very efficient to identify and isolate factors that can drive trends in recruitment. However, the WPTT **NOTED** that in real world applications, there will be a higher degree of data conflict which can lead to trends in recruitment that are often difficult to interpret.

107. The WPTT **NOTED** the P-value used in the statistical test for the significance of recruitment trend used a threshold value of 0.1, and suggested that the value of 0.05 be used based on common practice. The WPTT further **NOTED** that the degree of the trend (slope) is more likely to indicate possible model-misspecification errors.

108. The WPTT **NOTED** that the analysis of deviation trends is a very useful addition to the pool of diagnostic tools for detecting model specification errors and evaluates and validates candidate models.

109. The WPTT **NOTED** that when recruitment deviations show an increasing trend, these can compensate for the loss of biomass in periods of increased catch beyond the surplus production. In these cases, variation in recruitment is not a random process, but rather takes the function of a compensatory, systematic driver in productivity.

110. The WPTT **NOTED** that models with trends in recruitment deviates can amplify the uncertainty on the projections used to develop management advice from stock assessment models.

111. The WPTT **SUGGESTED** that more work be done to take advantage of this approach. The WPTT also **NOTED** that there was ongoing collaboration between RFMOs on model weighting and this analysis can helped improve defining weighting criteria

9.2 External review of the yellowfin stock assessment (IOTC Secretariat)

112. The WPTT **NOTED** that the draft Terms of Reference (APPENDIX 6C, IOTC–2021–SC24–R[E]_Rev1) for the yellowfin tuna stock assessment peer review has been approved by the commission. The WPTT also **NOTED** the update on the progress related to key activities leading to the Peer Review. The WPTT further **NOTED** the review workshop is tentatively arranged to be in February 2023 with dates and location to be finalized within the next few weeks after consultations with the assessment team.

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

113. The WPTT **NOTED** that physical meetings are once again beginning to take place and that the 2022 sessions of the Commission and Scientific Committee have been/will be held using a hybrid approach. The Secretariat welcomed any offers by CPCs to host the future meetings of the WPTT in 2023 and 2024. These details will be further discussed during the WPTT assessment meeting later in 2022.

9.4 Review of the draft, and adoption of the Report of the 24th Session of the WPTT(DP) (Chair)

114. The meeting was officially closed on the 2nd of June (a day earlier than scheduled). The report of the 24th Session of the Working Party on Tropical Tunas Data Preparatory Meeting (IOTC–2022–WPTT24(DP)–R) was **ADOPTED** by correspondence.

Appendix I
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Appendix II
Agenda for the 24th Working Party on Tropical Tunas, Data Preparatory Meeting

Date: 30 May - 03 June 2022

Location: Online

Platform: Microsoft Teams

Time: 12:00 – 16:00 daily (Seychelles time)

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

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

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

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

    3.1. Outcomes of the 24th Session of the Scientific Committee (IOTC Secretariat)

    3.2. Outcomes of the 25th Session of the Commission (IOTC Secretariat)

    3.3. Review of Conservation and Management Measures relevant to tropical tunas (IOTC Secretariat)

    3.4. Progress on the recommendations of WPTT23 (IOTC Secretariat)

4. **REVIEW OF THE DATA AVAILABLE AT THE SECRETARIAT FOR TROPICAL TUNA SPECIES** (IOTC Secretariat)

5. **NEW INFORMATION ON BIOLOGY, ECOLOGY, FISHERIES AND ENVIRONMENAL DATA RELATING TO YELLOWFIN TUNAS** (Chair)

    5.1. Review new information on the biology, stock structure, their fisheries and associated environmental data for bigeye tuna: Catch and effort; Observer data; Catch at size; Catch at age; Biological indicators, including age-growth curves and age–length keys

6. **REVIEW OF NEW INFORMATION ON THE STATUS OF TROPICAL TUNAS** (Chair)

    6.1. Review of fishery dynamics by fleet (CPCs)
    6.2. Nominal and standardised CPUE indices
    6.3. Other abundance indices
    6.4. Input data required for BET Management Procedure

7. **BIGEYE STOCK ASSESSMENT** (Chair)

    7.1. Discussion on bigeye assessment models to be developed and their specifications
    7.2. Identification of data inputs for the different assessment models and advice framework
    7.3. Fishery indicators

8. **OTHER MATTERS** (Chair)

    8.1. Use of models diagnostics in the WPTT

    8.2. External review of the yellowfin stock assessment

9. REVIEW OF THE DRAFT, AND ADOPTION OF THE REPORT OF THE 24th SESSION OF THE WORKING PARTY ON TROPICAL TUNAS (DATA PREPARATORY) (Chair)

Appendix III
List of Documents for the 24th Working Party on Tropical Tunas, Data Preparatory Meeting

Document	Title
IOTC–2022–WPTT24(DP)–01a	Draft: Agenda of the 24th Working Party on Tropical Tunas (DP)
IOTC–2022–WPTT24(DP)-01b	Draft: Annotated agenda of the 24th Working Party on Tropical Tunas (DP)
IOTC–2022–WPTT24(DP)-02	Draft: List of documents for the 24th Working Party on Tropical Tunas (DP)
IOTC–2022–WPTT24(DP)-03	Outcomes of the 24th Session of the Scientific Committee (IOTC Secretariat)
IOTC–2022–WPTT24(DP)–04	Outcomes of the 25th Session of the Commission (IOTC Secretariat)
IOTC–2022–WPTT24(DP)-05	Review of Conservation and Management Measures relevant to tropical tuna (IOTC Secretariat)
IOTC–2022–WPTT24(DP)-06	Progress made on the recommendations of WPTT23 (IOTC Secretariat)
IOTC–2022–WPTT24(DP)–07 – BET IOTC–2022–WPTT24(DP)–07 – TROPICALS	Review of bigeye tuna statistical data (IOTC Secretariat) Overview of Indian Ocean tropical tuna fisheries
IOTC–2022–WPTT24(DP)–08	Updated outline of climate and oceanic conditions to March 2022 for the Indian Ocean, with perspectives on climate change effects on fish catch potential in Maldives and in three coastal upwelling systems (Marsac F)
IOTC–2022–WPTT24(DP)–09	A preliminary report on Estimates of fecundity, age at maturity, sex ratios, spawning season, and spawning fraction for yellowfin tuna to be provided to the Working Party on Tropical Tunas (Zudaire I, Artetxe-Arrate I, Farley J, Murua H, Kukul D, Vidot A, Abdul Razzaque S, Ahusan M, Romanov E, Eveson P, Clear N, Luque P, Fraile I, Bodin N, Chassot E, Govinden R, Ebrahim A, Shahid U, Marsac F and Merino G)
IOTC–2022–WPTT24(DP)–10	A preliminary report on Estimates of fecundity, age at maturity, sex ratios, spawning season, and spawning fraction for skipjack tuna to be provided to the Working Party on Tropical Tunas. (Zudaire I, Artetxe-Arrate I, Farley J, Murua H, Kukul D, Vidot A, Abdul Razzaque S, Ahusan M, Romanov E, Eveson P, Clear N, Luque P, Fraile I, Bodin N, Chassot E, Govinden R, Ebrahim A, Shahid U, Marsac F and Merino G)
IOTC–2022–WPTT24(DP)-11	Tropical tuna fisheries of Pakistan-status and trends (Moazzam M)

IOTC–2022–WPTT24(DP)–12	European purse seiners CPUE standardization of Big Eye tuna caught under dFADs (Akia S, Guery L, Grande M, Kaplan D, Baéz J.C, Ramos M. L, Uranga J, Abascal F, Santiago J, Merino G and Gaertner D)
IOTC–2022–WPTT24(DP)–13	Associative-behavior abundance index (ABBI) for Bigeye tuna in the Western Indian Ocean obtained from echosouder buoys data (Baidai Y, Dagorn L, Gaertner D, Deneubourg J-L, Duparc A, Floch L, and Capello M.)
IOTC–2022–WPTT24(DP)–14	Standardization of bigeye tuna CPUE by Japanese longline fishery in the Indian Ocean (Matsumoto T)
IOTC–2022–WPTT24(DP)–15	Joint CPUE indices for the bigeye tuna in the Indian Ocean based on Japanese, Korean and Taiwanese longline fisheries data up to 2020 (Kitakado T, Wang S-P, Matsumoto T, Lee SI, Tsai W-P, Satoh K, Yokoi H, Okamoto K, Lee MK, Lim J-H, Kwon Y, Su N-J, Chang S-T and Chang F-C)
IOTC–2022–WPTT24(DP)–16	Assessing the impact of the growth on estimates of fishing mortality for the Indian Ocean bigeye tuna (Fu D)
IOTC–2022–WPTT24(DP)–17	Proposed natural mortality ogives for the Indian Ocean bigeye tuna stock assessment (Hoyle S)
IOTC–2022–WPTT24(DP)–18	A preliminary report on Estimates of fecundity, age at maturity, sex ratios, spawning season, and spawning fraction for bigeye tuna to be provided to the Working Party on Tropical Tunas. (Zudaire I, Artetxe-Arrate I, Farley J, Murua H, Kukul D, Vidot A, Abdul Razzaque S, Ahusan M, Romanov E, Eveson P, Clear N, Luque P, Fraile I, Bodin N, Chassot E, Govinden R, Ebrahim A, Shahid U, Marsac F and Merino G)
IOTC–2022–WPTT24(DP)–19	Analysis of recruitment deviates of tropical tuna stock assessments (Merino, G., A. Urtizberea, D. Fu, H. Winker, M. Cardinale, M.V. Lauretta, H. Murua, T. Kitakado, H. Arrizabalagaa, R. Scott, G. Pilling, C. Minte-Vera, H. Xui, A. Laborda, M. Erauskin-Extraminiana, A. Uriarte, J. Santiago)
Information documents	
IOTC–2022–WPTT24(DP)-INF01	Consideration on the period of the most recent catch to be used for the projections (Nishida T and Matsumoto T)
IOTC–2022–WPTT24(DP)-INF02	Indicators of stock status for skipjack tuna in the Indian Ocean (de Bruyn P and Murua H)
IOTC–2022–WPTT24(DP)-INF03	Indicators of stock status for skipjack tuna in the Indian Ocean (Merino G, Murua H, Arrizabalaga H and Santiago J)
IOTC–2022–WPTT24(DP)-INF04	Review of Indian Ocean skipjack tuna statistical data (IOTC Secretariat)
IOTC–2022–WPTT24(DP)-INF05	Review of Indian Ocean yellowfin tuna statistical data (IOTC Secretariat)

IOTC-2022-WPTT24(DP)-INF06	CPUE standardization of bigeye tuna caught by Korean tuna longline fishery in the Indian Ocean, 1979-2020 (Lee SI, Lee KM, Kwon Y and Lim J)

Appendix IV
Main Statistics For Bigeye Tuna

(Extracts from IOTC–2022–WPTT24(DP)–07_Rev1)

Trends in nominal catches

Nominal catches of bigeye tuna show an increasing trend over the last seven decades ranging between 7,000 and 136,000 t from the mid-1950s to the mid-2000s, with some variability between years (**Fig. A1**). Catches dropped considerably from the late-2000s, reaching an annual average of 96,000 t during the 2010s, i.e., around 30% less than what caught on average during the previous decade. Longliners and purse seiners are the main fisheries comprising more than 90% of the catches between the 1950s and 2000s, and more than 80% in the last decade.

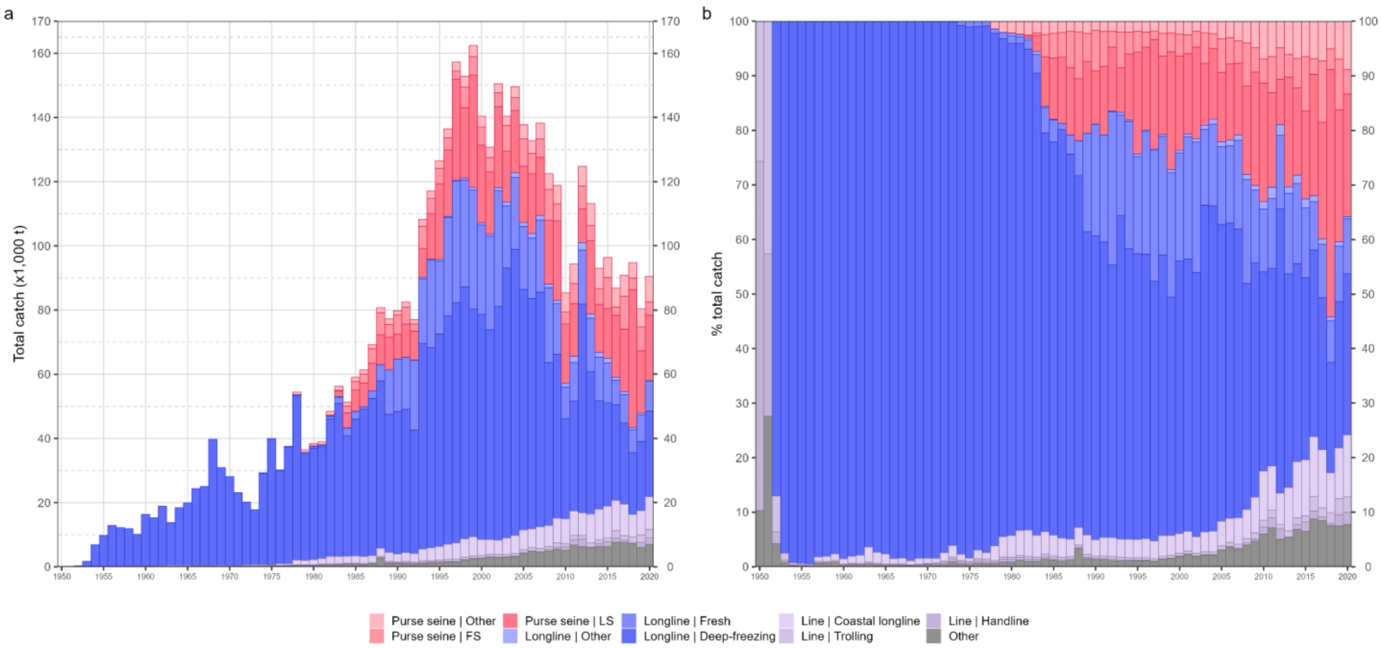

Fig. A1. Annual time series of cumulative nominal absolute (a) and relative (b) catches (t) of bigeye tuna by fishery for the period 1950-2020. LS = schools associated with floating objects; FS = free-swimming schools. Data source: raised time-area catches

Main fishery features

Bigeye tuna is mainly caught by longline and purse seine fisheries from different fleets operating all over the Indian Ocean. Between 2016 and 2020, purse seine fisheries (all fishing modes combined) caught annually more than 36,000 t of bigeye tuna, contributing to around 41% of the total nominal catches. During the same period, industrial longline fisheries represented the second main contributor of bigeye tuna catches, with about 33,000 t caught annually. Between 2016 and 2020, line fisheries represented around 14% of the recent catches with more than 10,000 t caught annually.

Catch trends by fishery group in the same period (2016-2020) show opposite behaviors between longline and purse seiner fisheries, with relatively stable trends in catches from lines as well as from vessels using all other gears (**Fig. A2**).

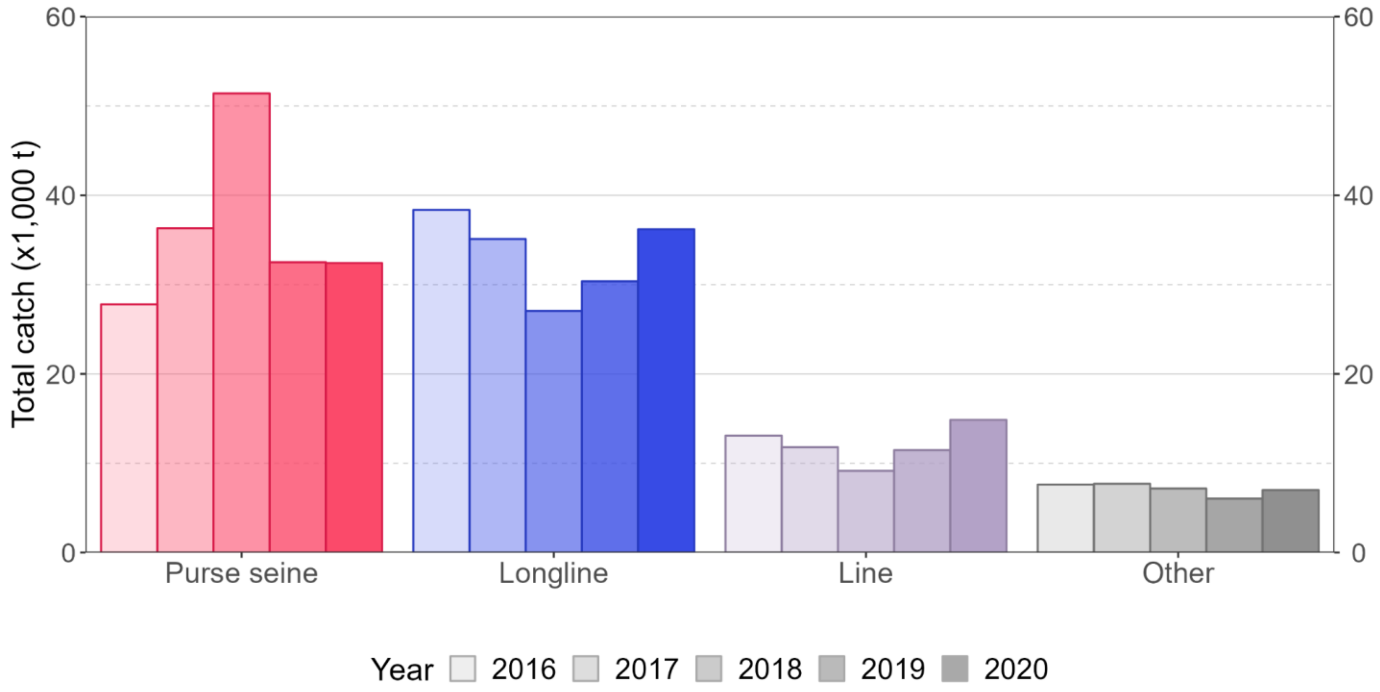

Fig. A2. Annual catch (t) trends of bigeye tuna by fishery group between 2016 and 2020. Data source: [best scientific estimate of nominal catches]

Uncertainties in nominal catch data

The quality of the nominal catches of bigeye tuna reported to the IOTC Secretariat shows major variability over the years (**Fig. A3**). The quality is mostly driven by the contribution of industrial fisheries to the total catches and showed a major declining trend from the 1970s to the 1990s when a substantial part of the catch had to be estimated for non-reporting (NEI) and Indonesian longline fleets (Herrera 2002). The situation improved throughout the 2000s although some estimation was still performed for NEI, Indonesian, and Indian longline fleets. The reporting quality has shown an increasing trend since the early 2010s due to increased reporting of nominal catch data for some artisanal fleets and implementation of Port State Measures which progressively reduced the extent of illegal, unreported, and unregulated (IUU) fisheries in the Indian Ocean (**Fig. A3**).

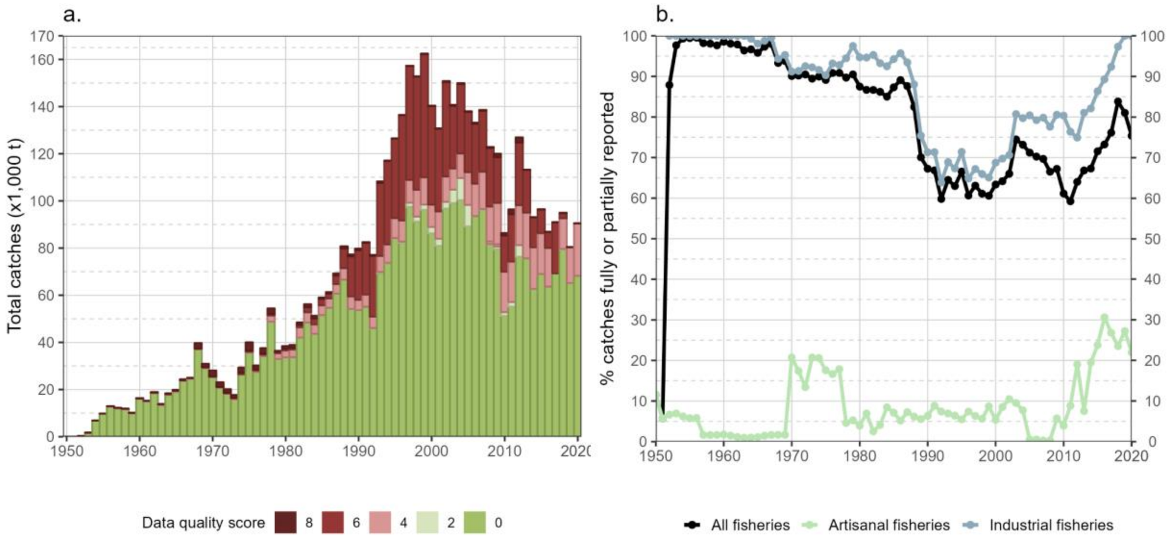

Fig. A3. Annual nominal catches (t) of bigeye tuna estimated by quality score (barplot) and percentage of nominal catch fully/partially reported to the IOTC Secretariat (lines with dots) for all fisheries (a) and by type of fishery (b), in the period 1950-2020

Some issues in reporting have been identified over the last decade for some artisanal fleets, including troll lines from Madagascar, small-scale purse seine and handline fisheries from Mozambique, as well as for the fresh longline fishery of Tanzania which operated between 2011 and 2014. Furthermore, catches of Indonesian artisanal fisheries have been annually re-estimated since the early 2010s based on fixed species compositions that depend on each fishing gear and were derived from samples mostly collected in the 2000s (Moreno et al. 2012). In 2020, the percentage of bigeye tuna catch fully or partially reported to the Secretariat was 75%.

Discard levels

The total amount of bigeye tuna discarded at sea remains unknown for most fisheries and time periods despite the obligation to report these data as per IOTC Res. 15/02. Furthermore, and except for very specific situations (i.e., the fish caught is considered unfit for human consumption or there is insufficient storage capacity following the final set of a trip), all tropical tunas caught with purse seine have to be retained onboard since 2018 (IOTC Res. 19/05).

Discarding of tropical tunas is thought to be small in coastal fisheries and negligible in baitboat fisheries (Miller et al. 2017). Besides, data collected by observers at sea have shown that the level of discarding of tropical tunas is low in the Indian Ocean purse seine fishery, and discarding mostly occurs in schools associated with floating objects (Amandè et al. 2012). Purse seine discards of bigeye tuna are mainly composed of fish smaller than 60 cm (~5.7 kg) although a few larger fish may be discarded when damaged. Estimates for the main component of the Indian Ocean purse seine fleet showed they amount to a few hundred tons annually (Ruiz et al. 2018).

Geo-referenced catches

Estimated geo-referenced catches show the spatial expansion and major changes that took place in the fisheries targeting bigeye tuna over the last decades (**Fig. A4**). As early as the 1950s, bigeye tuna was caught by large-scale longline fisheries across most of the Indian Ocean while coastal gillnet and line fisheries were active in the Arabian Sea and baitboats in the Maldives and off the south-western coast of India representing a small contribution to the bigeye tuna total catches.

Throughout the 1960s and 1970s, the longline fisheries expanded in the south-western part of the Indian Ocean, including in the Mozambique Channel. From the 1980s, the purse seine fishery developed in the western Indian Ocean, with most of the bigeye tuna caught by log-associated schools (**Fig. A4**).

During the 1990s and 2000s, the purse seine fishery increased its catches and expanded its fishing grounds in the western Indian Ocean while a large fresh longline and line fishery developed in the north-eastern Indian Ocean (**Fig. A4**).

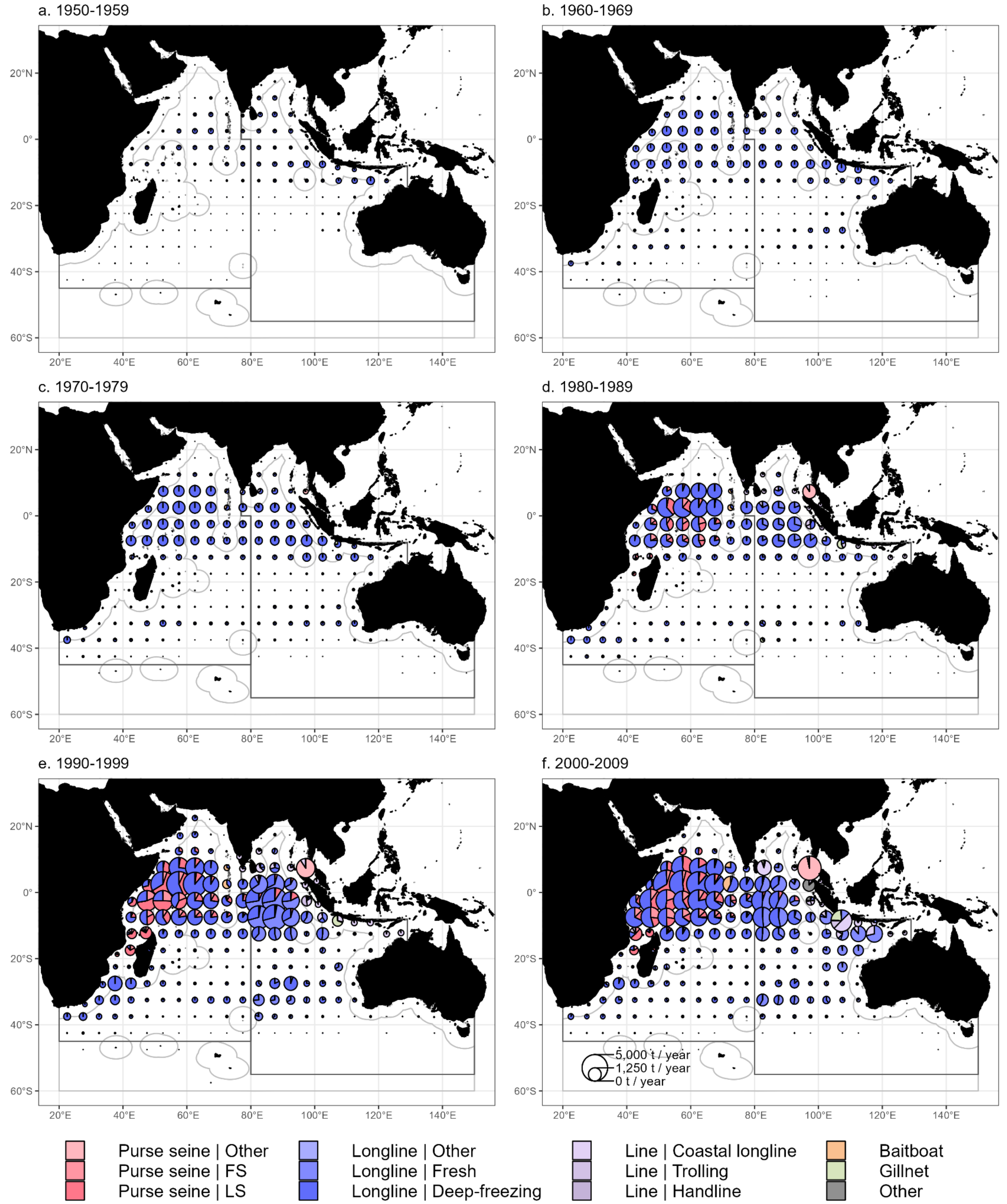

Fig. A4. Estimated mean annual time-area catches (t) of bigeye tuna by decade, 5x5 grid, and fishery. Data source: raised time-area catches

The overall annual distribution of bigeye tuna catches by fishery has changed little over the period 2016-2020 (**Fig. A5**). Indonesia appears to have developed an industrial purse seine fishery since 2018, which mainly operates in coastal areas of the eastern Indian Ocean with vessels of length overall (LOA) between 30 and 40 m. Baitboat fishing is essentially concentrated in the Maldives archipelago while line fisheries (handline, trolling and coastal longline) are widely used along the coasts of India, Sri Lanka, and Indonesia (**Fig. A5**).

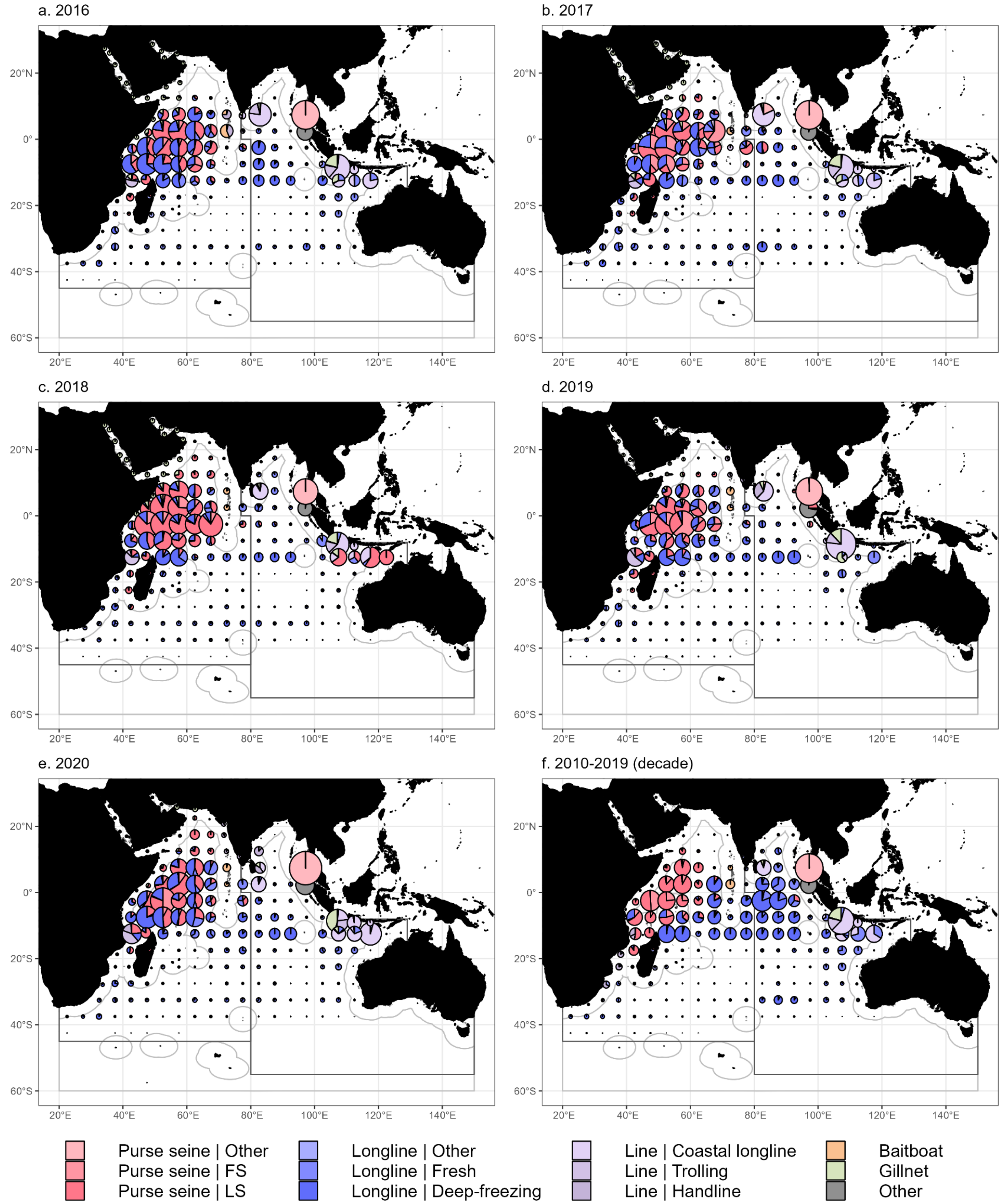

Fig. A5. Estimated mean annual time-area catches (t) of bigeye tuna by year / decade, 5x5 grid, and fishery. Data source: raised time-area catches

Uncertainties in catch and effort data

Catch and effort series are available for most industrial fisheries and some important artisanal fisheries. However, for many artisanal fisheries, these data are either not available or are considered to be of poor quality. Consequently, the trend in quality of the catch and effort data is driven to some extent by the relative contribution of artisanal fisheries to the total catches of bigeye tuna (**Fig. A6**).

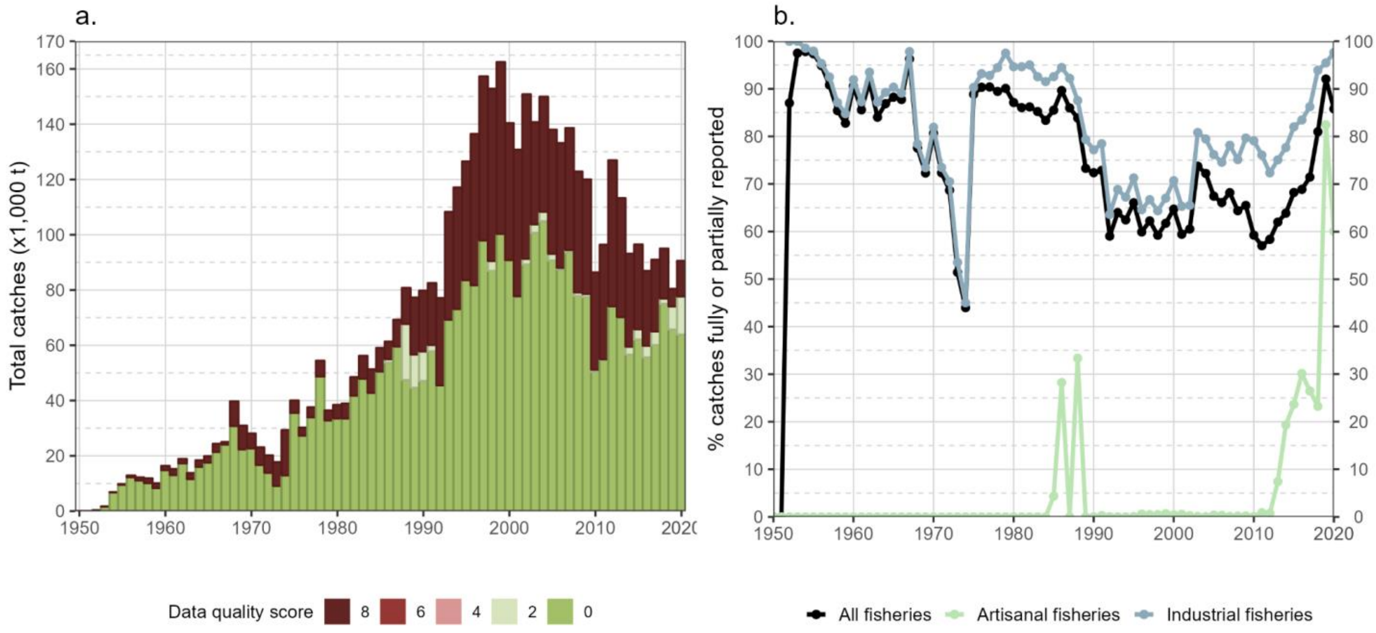

Fig. A6. Annual nominal catches (t) of bigeye tuna estimated by quality score (barplot) and percentage of geo-referenced catches reported to the IOTC Secretariat in agreement with the requirements of Res. 15/02 (lines with dots) for all fisheries (a) and by type of fishery (b), in the period 1950-2020

The main issues identified in the past concern:

- the fresh-tuna longline fishery of Taiwan,China, for which data have only been available since 2007;
- purse seine and fresh-tuna longline fisheries of Indonesia, with data only available from 2018 onward (although logbook coverage is thought to be low);
- the purse seine fisheries of I.R. Iran (until 2004) for which data are either incomplete or lacking;
- the longline fisheries of Sri Lanka (since 2014), described by poor quality effort data;
- some coastal fisheries using hand and/or troll lines for which no data (or incomplete data) have been reported to the Secretariat, in particular: Comoros (until 2018), Indonesia (2018 and 2020), Mauritius (since 2011 but without data from 2013 to 2015), and France,Reunion (until 2012).

Temporal trends in estimated average weights

Considering the limitations in the original data and in the process that produces this estimation, it shall be noted that the average weights calculated for the longline fisheries of Japan and Taiwan,China are relatively stable and fluctuate at around 40-60 kg (**Fig. A7**). The FOB-associated component of all Indian Ocean purse seine fisheries shows a relative stable trend since the mid-1980s, with an estimated average weight of 3.7 kg in 2020 which is very close to the estimated average for all fisheries combined, which in 2020 was estimated at 4.1 kg.

In fact, the overall estimated trend in average weights shows a clear decreasing pattern, driven in recent years by the analogous behavior of average weights estimated for the FOB-associated component of the purse seine fisheries, which is the fishery accounting for the majority of catches for the species in the same period (**Fig. A7**).

Trends in average weight for all other fisheries (baitboat, gillnet and all other gears) are more difficult to assess due to the inherently artisanal nature of several of them, which in turn implies a lower number of available samples which are often of lower quality compared to those provided by industrial fleets (recorded through logbooks or collected by scientific observers, in several cases).

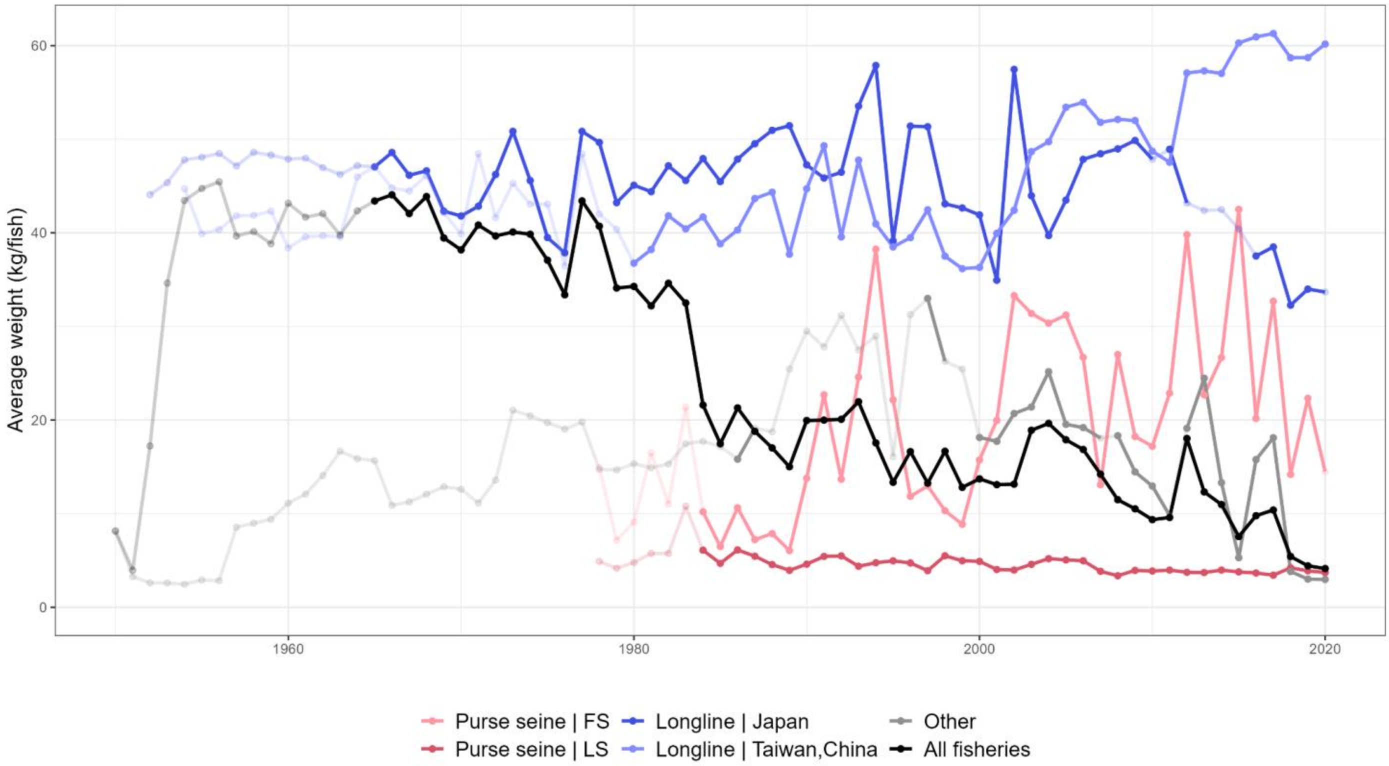

Fig. A7. Combined estimated bigeye tuna average weight (kg/fish) in the catch by fishery and year. Semi-transparent points correspond to years for which the original size samples cover strata with reported catches (by year and fishery) lower than 50 t. LS = schools associated with floating objects; FS = free-swimming schools. Longline | Japan = includes data from longliners flagged by Japan, Rep. of Korea and Thailand; Longline | Taiwan = includes data from longliners flagged by Taiwan,China and all other flags not otherwise mentioned. Data source: raised time-area catches

Uncertainties in size-frequency data

The overall quality – as measured by the percentage of nominal catches with size data of quality scores between 0-2 – of size data available for bigeye tuna in IOTC databases is poor, particularly for artisanal fisheries. Almost no size data are available prior to the 1980s and the fraction of data of acceptable quality averages around 51% since 1984 (ranging between 32% and 86%) with a marked increase in quality from about 45% in 2011 to around 86% in 2019 (**Fig. A8**).

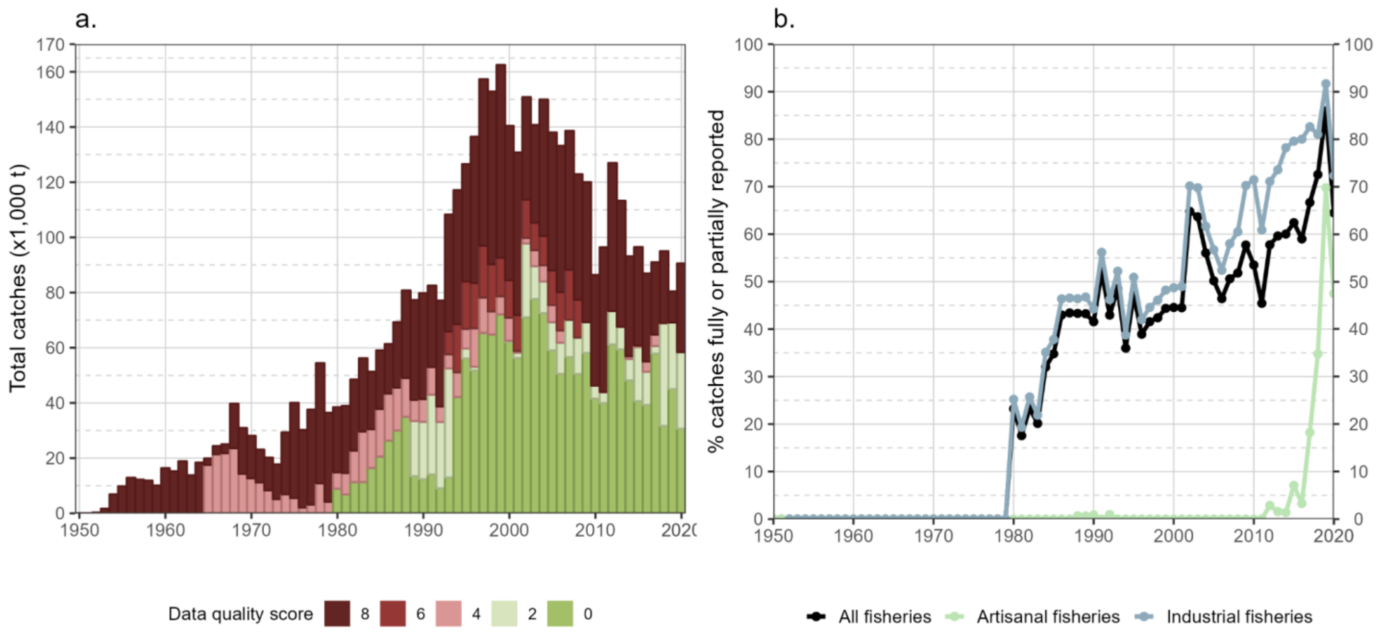

Fig. A8. Annual nominal catches (t) of bigeye tuna estimated by quality score (barplot) and percentage of geo-referenced size-frequency data reported to the IOTC Secretariat in agreement with the requirements of Res. 15/02 (lines with dots) for all fisheries (a) and by type of fishery (b), in the period 1950–2020