Report of the Seventh Session of the IOTC Working Party on Temperate Tunas: Assessment Meeting

Shizuoka, Japan, 23–27 July 2019

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ACRONYMS

ALB	Albacore
ASAP	Age structured assessment program
ASPIC	A Stock-Production Model Incorporating Covariates
ASPM	Age-structured production model
B	Biomass (total)
BBDM	Bayesian biomass dynamics model
B_{MSY}	Biomass which produces MSY
BSPM	Bayesian State-Space Production Model
CMM	Conservation and Management Measure (of the IOTC; Resolutions and Recommendations)
CPCs	Contracting parties and cooperating non-contracting parties
CPUE	Catch per unit of effort
current	Current period/time, i.e. $F_{current}$ means fishing mortality for the current assessment year.
EEZ	Exclusive Economic Zone
F	Fishing mortality; F_{2011} is the fishing mortality estimated in the year 2011
F_{MSY}	Fishing mortality at MSY
HBF	Hooks between floats
HCR	Harvest control rule
IO	Indian Ocean
IOTC	Indian Ocean Tuna Commission
LL	Longline
LRP	Limit reference point
M	Natural mortality
MPF	Meeting participation fund
MSE	Management strategy evaluation
MSY	Maximum sustainable yield
n.a.	Not applicable
PS	Purse-seine
SC	Scientific Committee of the IOTC
SB	Spawning biomass (sometimes expressed as SSB)
SB_{MSY}	Spawning stock biomass which produces MSY
SS3	Stock Synthesis III
SST	Sea surface temperature
TAC	Total allowable catch
TRP	Target reference point
VB	Von Bertalanffy (growth)
WPTmT	Working Party on Temperate Tunas of the IOTC

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 7th Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Temperate Tunas: Assessment Meeting (WPTmT07(AS)) was held in Shizuoka , Japan, from 23 to 27 July 2019. A total of 23 participants (29 in 2016) attended the Session.

The WPTmT **RECALLED** the recommendations contained in the Working Party on Temperate Tunas: Data Preparatory Meeting (WPTmT07(DP)) Report.

The following are a subset of the complete recommendations from the WPTmT07(AS) to the Scientific Committee, which are provided at Appendix VI.

Revision of the WPTmT Program of Work

WPTmT07.01 (para 83) The WPTmT **RECOMMENDED** that the SC consider and endorse the WPTmT Program of Work (2020–24), as provided at Appendix V.

Date and place of the 8th and 9th Sessions of the WPTmT

WPTmT07.02 (para 89) The WPTmT **RECOMMENDED** that a data preparatory meeting (DP) and stock assessment meeting (AS) be held in the same year, with the data preparatory meeting being held between April and June and the assessment meeting in August or September. This would facilitate the provision of CPUE series using data from the previous year to the data preparatory meeting, while ensuring catch data for the previous year, which is due to be submitted to the IOTC Secretariat by the end of June each year, is available for use in the stock assessments. The exact dates and meeting locations will be confirmed and communicated by the IOTC Secretariat to the SC for its consideration.

i. WPTmT08(DP): Host to be decided. Meeting to be held between April and June 2022 (TBC).

ii. WPTmT08(AS): Host to be decided. Meeting to be held between August and September 2022 (TBC).

Review of the draft, and adoption of the Report of the 7th Session of the WPTmT

WPTmT07.03 (para 90) The WPTmT **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPTmT07, provided in Appendix VI, as well as the management advice provided in the draft resource stock status summary for albacore (Appendix IV).

Stock status table

A summary of the stock status for temperate tunas under the IOTC mandate is provided in Table 1, Appendix IV.

1. Opening of the meeting

1. The 7th Session of the Indian Ocean Tuna Commission's (IOTC) Working Party on Temperate Tunas (WPTmT07(AS)) was held in Shizuoka, Japan, from 23 to 26 July 2019. A total of 23 participants (29 in 2016) attended the Session. The list of participants is provided at Appendix I. The meeting was opened by the Chairperson, Dr Jiangfeng Zhu (China), who welcomed participants to Shizuoka, Japan.

2. Adoption of the Agenda and arrangements for the Session

2. The WPTmT **ADOPTED** the Agenda provided at Appendix II. The documents presented to the WPTmT07 (AS) are listed in Appendix III.

3. Update of any new data available at the Secretariat for albacore tuna since the data preparatory meeting

3. The WPTmT **NOTED** the main discussion points and recommendations arising from the report of the WPTmT Data Preparatory meeting (IOTC-2019-WPTmT07(DP)-R), held in Kuala Lumpur in January 2019.

4. The WPTmT **NOTED** the relatively minor updates to the IOTC datasets since the WPTmT Data Preparatory meeting and that the latest data available for the stock assessment of albacore tuna includes catches up to 2017.

5. The WPTmT further **NOTED** that, since the WPTmT Data Preparatory meeting in early-2019, the IOTC Secretariat has commissioned a number of projects that focus on long-standing issues with the quality and availability of data for the stock assessment of albacore tuna. Specifically:

    i. Review of potential inconsistencies in the longline size frequency data, and the implications for the stock assessment of IOTC species, including tropical tunas and albacore tuna.

    ii. A scoping study that outlines options for improving the biological parameters used in IOTC stock assessments of albacore tuna; in addition a benefits component involving sensitivity analysis to consider how much the assessment reliability might be improved by estimating the biological parameters.

The WPTmT **NOTED** that both projects are scheduled to complete in late-2019 and **REQUESTED** an update be provided at the next WPTmT meeting.

4. Review of new information on the status of albacore tuna

4.1 Review new information on albacore biology, stock structure, fisheries and associated environmental data since the data preparatory meeting

6. The WPTmT **NOTED** paper IOTC–2019–WPTmT07–04 which provided a scoping study on improving biological knowledge of albacore tuna in the Indian Ocean including the following abstract provided by the authors:

"The biological parameters incorporated in the 2019 Indian Ocean albacore stock assessment models are derived from limited biological studies from the Indian Ocean or are assumed to be equivalent values from studies conducted in other oceans. Here we present the preliminary results of a feasibility study into improving the biological understanding of albacore in the Indian Ocean. We explore the sensitivity of the 2019 stock assessment to variation in biological parameters, undertake power analyses on key biological parameters to determine sampling needs, and outline the biological and sampling considerations to develop a sampling design. The sensitivity of the stock assessment results to alternative biological parameters was investigated within the framework of the preliminary 2019 Indian Ocean stock assessment model. The estimates of stock status were most strongly influenced by the changes related to the assumptions of growth. Preliminary simulation modelling was carried out to assess sample size requirements for growth analyses by bootstrap resampling of the south Pacific Ocean albacore dataset. Nine growth models were fitted to each resampled dataset and the best fitting model (lowest AIC) was used to predict size for fish aged 4 and 10 located at longitude 200°E. The ability of the models to characterize the relationship between growth parameters and longitude improved with increasing sample size, but evidence for such a relationship was reliably identified even in the lower range of sample sizes. Additional analyses are planned to explore sample size requirements for reproductive parameters, including female gonad index, spawning frequency and batch fecundity. To assess

the occurrence of spatial and temporal patterns in biological parameters reported elsewhere (e.g. south Pacific Ocean), we recommend that sampling cover the full geographic range of albacore in the IO, with good representation across months, over at least two years. Sampling of several distant water fishing nation longline fleets via observers will be crucial for ensuring a regular and broad geographical and temporal spread of samples, and for ensuring that catch information is available for sampled fish. Sampling several local longline fleets will be important for increasing sample sizes, as well as for increasing the likelihood of sampling small fish in specific geographical areas." – see Paper for the full abstract.

7. The WPTmT **NOTED** that this initiative will require substantial collaboration between IOTC CPCs in order to be successful. WPTmT participants were encouraged to facilitate their nations participation in the activities recommended in the scoping study final report, which will be presented to the Scientific Committee in 2019.

8. The WPTmT **NOTED** that the activities recommended in the scoping study were not intended to create additional work for observers. The scoping study provides advice on how samples can be collected and stored while only requiring a minimal additional effort on behalf of the observers.

9. The WPTmT **ENCOURAGED** national scientists to liaise with the consultants to address any issues or uncertainties they may have regarding the sampling.

Albacore tuna landing at fishing ports in Thailand between 2016 and 2018

10. The WPTmT **NOTED** paper IOTC–2019–WPTmT07(AS)–18 which provided information on Albacore tuna (*Thunnus alalunga*) landing at fishing ports in Thailand between 2016 and 2018 including the following abstract provided by the authors:

"Thailand is one of world's largest exporters of tuna products. However, the required raw materials for tuna processing in the country were imported. Albacore tuna is important species in the tuna supply chain in Thailand for white meat tuna products. This paper presents the updated information on albacore tuna caught from the Indian Ocean unloaded by foreign vessels at fishing ports in Thailand between 2016 and 2018." – see Paper for the full abstract.

11. The WPTmT **THANKED** the authors for this valuable contribution and encouraged Thailand to continue to provide this information.

12. The WPTmT **NOTED** the relatively small catches of albacore tuna unloaded by foreign vessels in Thailand (i.e., >20 t per annum), which have fallen to less than 5 t per annum in recent years, possibly due to the enforcement of PSM to combat IUU fishing.

4.2 Updated Nominal and standardised CPUE indices

Mauritius – catches of albacore tuna

13. The WPTmT **NOTED** paper IOTC–2019–WPTmT07(AS)–05 which provides a review of the catches of albacore tuna by local and licensed foreign longliners and transhipment of albacore in Mauritius, including the following abstract provided by the authors:

"*This paper focuses on the catches of albacore tuna made by the local and foreign licensed longliners and the transshipment of albacore over the last five years. Majority of the foreign licensed longliners comes from the Asian countries namely Taiwan Province of China, Indonesia, Korea, People's Republic of China and Malaysia. In 2018, one hundred and ninety nine fishing licences were issued to the foreign tuna longliners. The catches increased from 5 686 tons in 2014 to 10 079 tons in 2018 while the percentage of albacore in the total catch varied between 37.6% and 49.1%. The highest percentage, 49.1% was recorded in 2015. Majority of the catch that is 87% is attributed to the Taiwan, Province of China fleet.*" *- see paper for full abstract*.

14. The WPTmT **NOTED** the importance of catches transhipped through Port Louis, Mauritius, which in the last five years (2014 to 2018) accounted for around 49,800 t of tuna and tuna-like species per annum (of which albacore tuna accounted for 45% of catches transhipped, or ≈22,500 t). The WPTmT **STRESSED** the importance of conducting biological data collection initiatives in Mauritius, particularly for length frequency information.

15. The WPTmT **SUGGESTED** that the authors provide more information on fleet/fishing operations in the future as this information is crucial for CPUE standardisation which could be carried out for the Mauritian fleet.

Malaysian Tuna Longliners catch and effort

16. The WPTmT **NOTED** paper IOTC–2019–WPTmT07(AS)–06 which summarises the status of catch and effort for albacore tuna by Malaysian Tuna Longliners in the Indian Ocean, including the following abstract provided by the authors:

    "*Malaysia tuna fisheries began with tropical tuna fishing in 2005 to 2011 before shifted to albacore tuna fishing in 2012. Currently, a total of 19 Malaysia tuna longline fishing vessels and 1 carrier are operated in the Indian Ocean. The Malaysia tuna longliners fishing activities covered the area from 10oS in the north to 39oS and longitude from 40oE to 70oE. This paper describes the detail on fishing characteristics of Malaysia tuna longliners, which emphasize on catch and CPUE trends for albacore tuna in southwest of Indian Ocean from 2013 to 2017. All the data described in this paper was based on the data extracted from fishing logbooks which were sent by vessel's owner to Department of Fisheries Malaysia. In 2017, the total catch of albacore increased significantly by 17% to 1, 607 tons from 1,330 tons in 2016. Catches of albacore tuna by Malaysia tuna fishing vessels ranged from 2.74- 281.69 tons with average of 93.79 + 66.07 tons. The average monthly catches for 5 years showed that there were two peaks seasons for albacore fishing; from May- August and October – January*".

17. The WPTmT **NOTED** the increase in catches of albacore by Malaysian longliners since 2010 onwards, which appears to be a combination of a change in targeting (from tropical tunas to temperate tunas), as well as a recent increase in the number of longline vessels.

Indonesian – Catch-per-unit-effort (CPUE)

18. The WPTmT **NOTED** paper IOTC–2019–WPTmT07(AS)–07 which provided a standardised CPUE series for albacore based on Indonesian longline catch and effort statistics from 2006 to 2018, including the following abstract provided by the authors:

    "*Albacore (Thunnus alalunga) is the third dominant catch of Indonesian tuna longline fishery operating in the eastern Indian Ocean. The percentage production of albacore catch was reaching up 6% of the total catch of tuna groups in Indonesia. This study aims to examine a relative abundance indices using standardized catch per unit of effort (CPUE) of longliner based on albacore tuna. This information will give a valuable input and information to support stock assessment particularly in the regional basis. In this study, we use Generalized Linear Model (GLM) with Tweedie distribution to standardize the CPUE and to estimate relative abundance indices based on the Indonesian longline dataset time series. Data were collected from January 2006 to December 2018 (2,811 data sets) by conducting direct onboard observation on tuna longline vessels operating in the Indian Ocean. The result show that year, area, hooks between floats significantly influenced the nominal CPUE of albacore. CPUE standardization of ALB in the periods of 2006 to 2014 was tend to be stable and increase from year to year but in 2015 to 2018 the CPUE standardization tend to be unstable and fluctuate due to changes in fishing patterns and changes in the area of onboard observer program.*"

19. The WPTmT **NOTED** the standardisation was based on scientific observer data covering 2006 to 2018. The WPTmT further **NOTED** that there is a potential to develop a longer time series using commercial logbook data available from 1979. However the logbook data require extensive processing before they can be used for the analysis.

20. The WPTmT **NOTED** the standardisation has included year, season, area, and hooks between floats as explanatory variables, and a Tweedie model was used to accommodate zero catches.

21. The WPTmT **NOTED** that the distribution of catch rates were modelled on a relatively coarse spatial scale (within and outside EEZ). The WPTmT suggested that it would be more appropriate to use a finer spatial scale (e.g. 5x5 longitude latitude grid)

22. The WPTmT **NOTED** that the very large variability in the standardised index since 2014 is unlikely to have reflected changes in abundance given that the fishery is mostly based on large/adult fish. The fluctuations may have been related to poor and inconsistent observer coverage in some years. The WPTmT suggested that it may be useful to check whether the observed pattern is related to environmental/oceanographic factors (e.g. Indian Ocean Dipole indices)

China – Catch-per-unit-effort (CPUE)

23. The WPTmT **NOTED** paper IOTC–2019–WPTmT07(AS)–08 which provided a preliminary standardised CPUE series based on logbook data from the Chinese longline fishery, including the following abstract provided by the authors:

 "*Based on logbook data from the Chinese longline fishery, this study conducted a preliminary analysis of fishery and CPUE standardization for the Indian Ocean albacore (Thunnus alalunga). The temporal and spatial variations of fishing effort, albacore catch and individuals' mean weight were examined from 2014 to 2018. According to the basic setting used in the existing joint CPUE standardization and stock assessment for albacore in 2016 WPTmT, this study estimated the standardized CPUE of albacore in year-quarter scale. This is a good beginning to derive albacore CPUE from the logbook of Chinese longline fishery. More effort will be spent in the future for further exploring the Chinese albacore fishery data.*"

24. The WPTmT **NOTED** that the standardisation was based on commercial logbook data from 2014 to 2018. The data before 2014 was not used due to potential quality issues. The WPTmT further **NOTED** that outliers were excluded from the analysis based on the plotting of catch effort distribution and a more robust data grooming procedure will be developed for further analysis.

25. The WPTmT **NOTED** that the index was developed for the whole Indian Ocean. The WPTmT suggested given that the population size structure of albacore tuna is different amongst regions (i.e. more small fish in the southern regions) it would be better for the analysis to be applied to individual regions (R1–R4) so that the standardised CPUE can index the appropriate population component.

26. The WPTmT **NOTED** that the SST was modelled as a linear effect and suggested that a more flexible functional form (e.g. a polynomial or cubic spline) is probably more appropriate.

27. The WPTmT suggested more diagnostic plots such as those showing species composition, effort distribution could help better understand the data.

Taiwan,China – Catch-per-unit-of-effort (CPUE)

28. The WPTmT **NOTED** paper IOTC–2019–WPTmT07(AS)–09 which provided a standardised CPUE for albacore based on Taiwan,China longline catch and effort statistics from 1980 to 2014 with simultaneous nominal portion from observer data, including the following abstract provided by the authors:

 "*The cluster analysis was adopted to explore the targeting of fishing operations. In addition, the CPUE standardizations were conducted using generalized linear model and generalized linear mixed model for examining the influence of treating the vessel ID as fixed and random effects on the CPUE standardizations*."

29. The WPTmT **NOTED** that the species composition used in the cluster analysis may be misleading if there are changes in reporting overtime (e.g. the increase of shark target cluster in more recent years may be due to improved reporting).

30. The WPTmT **NOTED** that in each region, only the main clusters associated with the species of interest were retained in the standardisation except in area 2 where all clusters were included as there is little albacore catches since 2010 in that region. The WPTmT further suggested that the delta-lognormal model may be better for accounting for the trend in the zero catches.

31. The WPTmT **NOTED** that the Taiwanese fleet has developed an oil fish target fishery in the southwest region since the mid-2000s. The cluster analysis performed reasonably well in identifying the oil fish targeted effort despite that the oil fish had been reported together in the 'others' species category until around 2010.

Taiwan,China; Japan; Rep. of Korea – joint Catch-per-unit-of-effort (CPUE)

32. The WPTmT **NOTED** paper IOTC–2019–WPTmT07(AS)–10- which provided a joint standardised CPUE for albacore based on Taiwan,China; Japan; Rep. of Korea longline catch and effort operational data from 1952 to 2018, including the following abstract provided by the authors:

 "In May and June 2018 and January 2019 a collaborative study was conducted between national scientists with expertise in Japanese, Korean, Seychelles, and Taiwanese longline fleets, an independent scientist, and an IOTC scientist. The meetings addressed Terms of Reference covering several important issues related to yellowfin

and albacore tuna CPUE indices in the Indian Ocean. The study was funded by the Indian Ocean Tuna Commission (IOTC)." – see Paper for the full abstract

33. The WPTmT **ACKNOWLEDGED** the analysis presented, the excellent progress of the workshop carried out in 2019 toward attaining reliable abundance indices for albacore tuna.

34. Bearing in mind that the main objective of the analysis/clustering is to integrate all the data in a joint CPUE, the WPTmT **NOTED** that it would be worthwhile to explore separate standardisation models by cluster as well as by fleet to examine whether there are different trends among clusters/fleets. The WPTmT **SUGGESTED** inclusion of interactions between cluster/fleet in the joint standardization to explore the effect of temporal trends in clusters/fleets.

35. The WPTmT **NOTED** that the updated analysis has refined the criteria used for sub-setting data for the standardisations in each region, which involves the selection of vessels if they had fished for sufficient quarters (the actual thresholds used depends on the amount of data available in the analysis). The Area weighting was used to reduce bias due to shift in effort and also to reduce influence from stratum with a very small number of sets.

36. The WPTmT **NOTED** that the analysis has omitted Japan data after 2005 in region 4 as the large increase of albacore catches per set since 2005 remains unexplained. The WPTmT discussed potential reasons for the increase in albacore catch rate, such as changes in fishing/reporting behaviour of vessels targeting southern bluefin tuna. The WPTmT **AGREED** that this requires further investigation.

37. The WPTmT **NOTED** that there is a strong seasonal pattern in the influence of vessel and cluster effects on the standardised indices, which probably reflects the seasonal trend in the presence of vessels as they move in and out of a fishery during the year with associated changes in targeting behaviour.

CPUE discussion summary

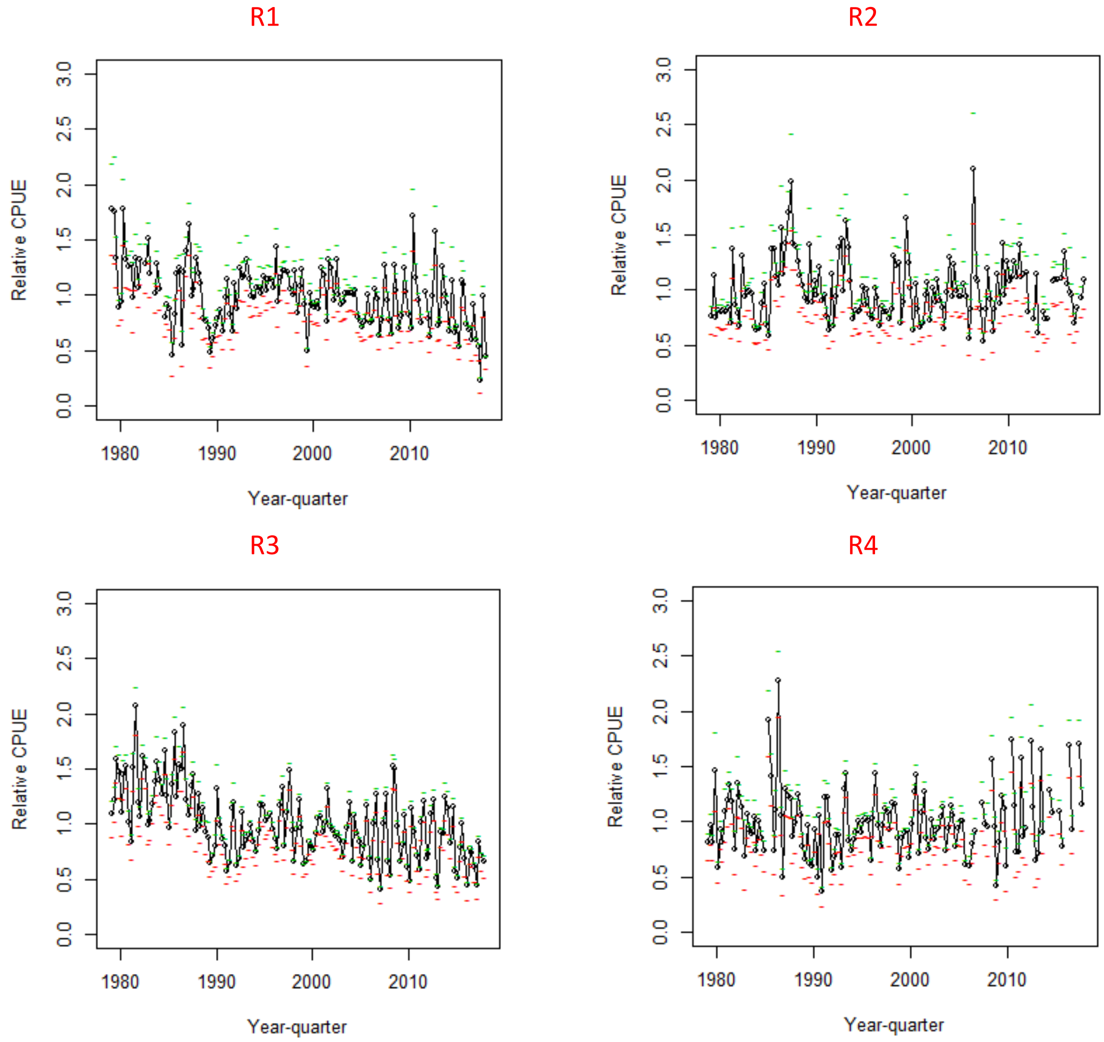
38. The WPTmT **AGREED** that there is a merit in using operational data from the main fleets (Japan, Taiwan,China and Rep. of Korea) together in a joint CPUE standardization with a unified procedure to define common areas, select targeting strategies, and incorporating vessel effects. The WPTmT further **NOTED** that combining observations across fleets in a single analysis provides a time series with better spatial and temporal coverage.

39. The WPTmT **NOTED** that the Japanese CPUE data has some unresolved issues in the south for the most recent years, especially since 2006 (possibly relating to changes from southern Bluefin tuna targeting to albacore tuna targeting) which gives less confidence in the Japanese data in the joint CPUE analysis from that period onwards. This is particularly true for the southeast Japanese CPUE index from 2005 onwards, since the importance of the Japanese fleet activity was minor in other areas. Therefore the WPTmT **AGREED** to exclude the recent Japanese southeast data from the Joint CPUE standardisations.

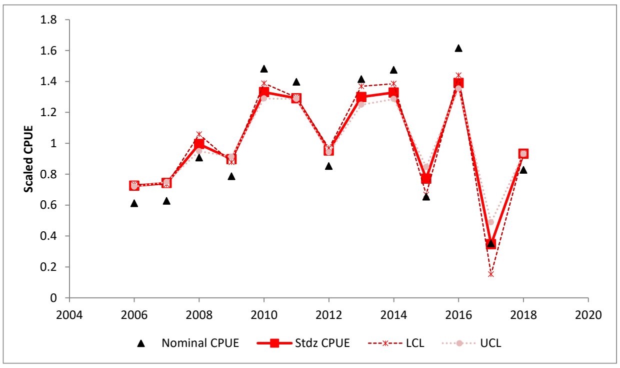
40. The WPTmT **NOTED** the CPUE series available for assessment purposes, listed below (**Fig.1** & **Table 1**):
    - Joint Taiwan, China; Japan, Rep. of Korea CPUE (1954-1979, and 1979-2017).
    - Indonesia (2006–2018):
    - China (2014–2018):
    - Taiwan,China (1979–2018):

    The WPTmT **AGREED** that the joint series (southwest and northwest area; Fig.1a) should be used in the final stock assessment models for management advice purposes, for the reasons discussed above.

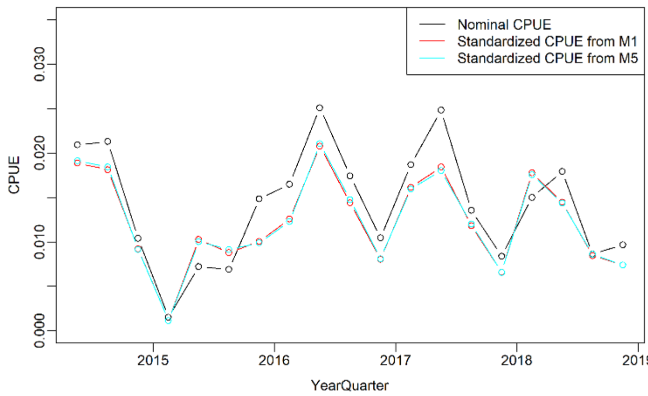
a)


R1
R2
R3
R4
Relative CPUE
Year-quarter
0.0
0.5
1.0
1.5
2.0
2.5
3.0
1980
1990
2000
2010

b)


Scaled CPUE
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2004
2006
2008
2010
2012
2014
2016
2018
2020
Nominal CPUE
Stdz CPUE
LCL
UCL

c)


Nominal CPUE
Standardized CPUE from M1
Standardized CPUE from M5
CPUE
0.000
0.010
0.020
0.030
2015
2016
2017
2018
2019
YearQuarter

d)

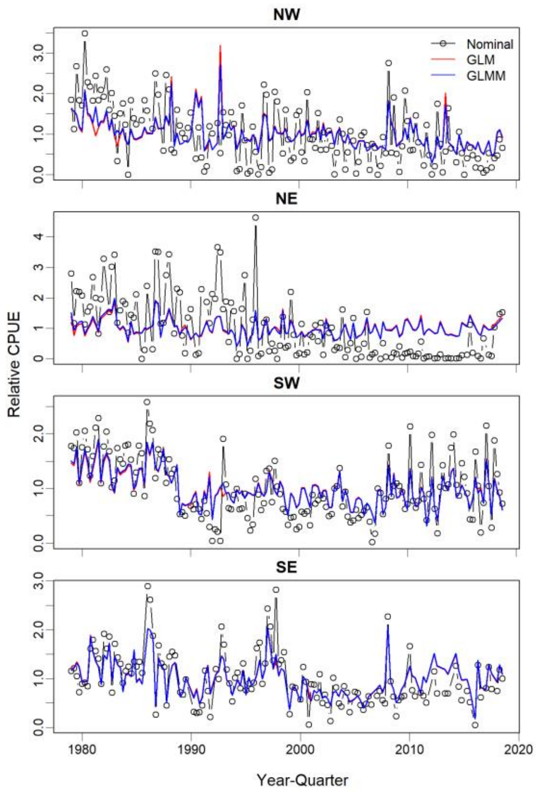


Fig.1. Comparison of the CPUE series for longline fleets fishing for albacore in the IOTC area of competence (R1=Northwest, R2=Northeast, R3=Southwest, R4=Southeast):

a) Joint CPUE (1979-2017);
b) Indonesian CPUE (EEZ and high seas)
c) Chinese CPUE (Areas: R1,R3,R4);
d) Taiwanese CPUE (Areas: R1,R2,R3,R4).
Series have been rescaled relative to their respective means (time period varies according to each CPUE).

Table 1. Summary of CPUE series used by the albacore assessment models. Regions refer to final model options presented below.

	BSSPM (Doc# 14_Rev1)	**SSPM (Doc# 13)**	**ASPIC (Doc# 15)**	**SCAA (Doc #17_Rev1)**	**SS3 (Doc# 11_Rev1)**
CPUE series	LL: Joint CPUE (R3 + R4 or R3)	LL: Joint CPUE (R1 orR3)	LL: Joint CPUE (R3)	LL: Joint CPUE (R1 and R2 and R3+R4)	LL: Joint CPUE: R1 or R3
CPUE period	1979–2017	1979–2017	1979-2017	1954-2017	1979–2017

4.3 Stock assessments

41. The WPTmT **NOTED** that a range of quantitative modelling methods as detailed below (BSSPM, SSPM, ASPIC, SCAA, and SS3) were applied to the assessment of albacore in 2019, ranging from the ASPIC surplus production model to the age and sex-structured SS3 analysis. The different assessments were presented to the WPTmT in documents IOTC–2019–WPTmT07(AS)–11, 12, 13, 14, and 15. Each model is summarised in the sections below.

Summary of stock assessment models in 2019: albacore

42. The WPTmT **NOTED** Table 2 which provides an overview of the key features of each of the stock assessments presented in 2019 (5 model types).

Table 2. Summary of final stock assessment model features as applied to the Indian Ocean albacore resource in 2019.

Model feature	BSSPM (Doc# 14_Rev1)	SSPM (Doc# 13)	ASPIC (Doc #15)	SCAA (Doc #17_Rev1)	SS3 (Doc# 11_Rev1)
Software availability	Original	Original	NMFS toolbox	Nishida & Rademeyer	NMFS toolbox
Population spatial structure / areas	1	1	1	1	1
Number CPUE Series	1	1	1	3	2 (combined logsheet);
Uses Catch-at-length/age	No	No	No	Yes	Yes
Age-structured	No	No	No	Yes	Yes
Sex-structured	No	No	No	No	Yes
Number of Fleets	1	1	1	8	11
Stochastic Recruitment	Yes (process error)	Yes (process error)	No	Yes	Yes

43. The WPTmT **RECALLED** the value in undertaking a number of different modelling approaches to facilitate comparison across model structure and results, and **AGREED** that more complex models such as integrated age-structured population models, which are capable of more detailed representation of complicated population and fishery dynamics, and integrate several sources of data and biological research, cannot be considered at the same level as simpler production models.

A Stock-Production Model Incorporating Covariates (ASPIC)

44. The WPTmT **NOTED** paper IOTC–2019–WPTmT07(AS)–15 which provided a stock assessment for albacore in the Indian Ocean using A Stock-Production Model Incorporating Covariates (ASPIC), including the following abstract provided by the authors:

"An assessment for the Indian Ocean stock of albacore was conducted based on ASPIC. A time series of catch (1950-2017 or 1979-2017) and that of standardized CPUE (longline 'joint') were used for the analysis. Convergence and reasonable results were obtained for the scenarios which assumed 1%/yr increase of catchability, and was regarded as reference case. According to the reference case, the stock status was estimated to be in the green zone of Kobe plot. Kobe II (risk assessments) indicated that the risk of B and F exceeding MSY level is lower than 50% if future catch is up to 10% higher than current level. The results for the scenarios without increase of catchability were more optimistic."

45. The WPTmT **NOTED** the key assessment results for A Stock-Production Model Incorporating Covariates (ASPIC) as shown below (**Tables 4** & **5**; **Fig.2**).

Table 4. Albacore: Key management quantities from the ASPIC assessment, for the Indian Ocean.

Management Quantity	Indian Ocean
2017 catch estimate	38,713
Mean catch from 2013–2017	36,235
MSY (1000 t) (80% CI)	38.7 (35.0–41.1)
Data period used in assessment	1950–2017
FMSY (80% CI)	0.32
BMSY (1000 t) (80% CI)	120 (67–252)
F2017/FMSY (80% CI)	0.70 (0.60–0.84)
B2017/BMSY (80% CI)	1.57 (1.28–1.42)
SB2017/SBMSY	n.a.
B2017/B1950 (80% CI)	0.51

n.a. not available

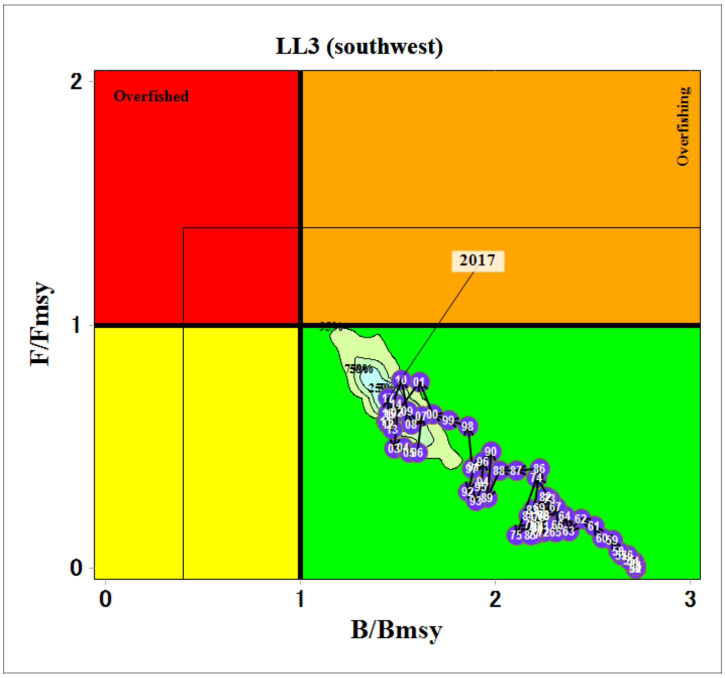


Fig. 2. Albacore: ASPIC aggregated Indian Ocean assessment Kobe plot (base case scenario during the WPTmT07 meeting).

46. The WPTmT **NOTED** that scenarios with no increase of catchability produced results that were too optimistic, and that scenarios with a 1%/year increase of catchability seemed to be more realistic, and therefore scenarios with a 1%/yr increase of catchability, with CPUE in the whole area and the 1950-2017 assessment period (Run 3) were chosen as the base model in the initial analyses. Finally, to harmonize with the SS3 base model, an additional scenario with longline CPUE in the southwest area (with no increase of catchability) was run and chosen.

47. The WPTmT **NOTED** the ASPIC model was unable to take into account changes in selectivity over time, which indirectly affects the estimates of stock productivity and MSY.

48. The WPTmT **NOTED** that no process error was included in the model, and suggested the author explore options for incorporating process error in future models and its effect on stock uncertainty.

Statistical-Catch-At-Age (SCAA)

49. The WPTmT **NOTED** paper IOTC–2019–WPTmT07(AS)–17_Rev1 which provided a stock assessment for albacore in the Indian Ocean using Statistical-Catch-At-Age (SCAA), including the following abstract provided by the authors:

"We preliminary attempted stock assessments for albacore tuna (Thunnus alalunga) in the Indian Ocean using Statistical-Catch-At-Age (SCAA) with 64 years data (1954-2017) including joint CPUE (Japan, Korea and Taiwan) in 4 regions. Very preliminary results show that the stock status (2017) is in the yellow zone of the Kobe plot (SSB/SSBmsy=0.65 and F/Fmsy=0.73). As this is very preliminary with very limited grid search for uncertainties thus the results should not be used for management advices"

50. The WPTmT **NOTED** the development of a Statistical-Catch-at-Size model and the future work planned on model development, sensitivities and diagnostics. In particular, under the current model configuration, SigmaR is a fixed parameter. Developments are planned to use integrated likelihood methods to estimate SigmaR in future model configurations.

Bayesian State-Space Surplus Production Model (BSSPM)

51. The WPTmT **NOTED** paper IOTC–2019–WPTmT07–14_rev1 which analysed population dynamics of Indian Ocean albacore (*Thunnus alalunga*) using Bayesian State-Space Surplus Production Model (***BSSPM***) including the following abstract provided by the authors:

"A Bayesian state-space production model with the Pella and Tomlinson function was developed to assess the stock status of albacore tuna (Thunnus alalunga) in the Indian Ocean. The catch data used span from 1950 to 2017, and the joint standardized CPUEs of longline fleets were used as the abundance indices. As a result, for the base case which used CPUE of R34 with the initial year of 1950 and no increase in catchability, the median estimates of carrying capacity (K), maximum sustainable yield (MSY), BMSY, and FMSY were 290,003 ton, 93,933 ton, 128,890 ton and 0.748/year, respectively. And the ratios of B2017/BMSY, and F2017/FMSY for the base case were respectively estimated as 1.589, and 0.259, which indicate that the stock is not overfished and not subject to overfishing. However, in sensitivity analyses, the scenarios using CPUE of R3 showed that the stock is overfished and not subject to overfishing."

52. The WPTmT **NOTED** the development of the Bayesian State-Space Surplus Production model (***BSSPM***) and the future work planned on model development including further investigation of the inclusion of process error which in this preliminary model, resulted in better model fits.

53. The WPTmT **NOTED** that the model estimated a large depletion in the B/BMSY ratio at the beginning of the timeseries but an overall low F/Fmsy ratio.

54. The WPTmT **NOTED** that the density of standard deviation for the observation error of the CPUE (sigma_cpue) was likely due to a combination of process error and observation error, which are difficult to discriminate.

State-space production models - ML and Bayesian approaches (SSPM)

55. The WPTmT **NOTED** paper IOTC–2019–WPTmT07(AS)–13 which provided a stock assessment for albacore in the Indian Ocean by a State-Space Production Model (**SSPM**), including the following abstract provided by the authors:

"Population dynamics for the Indian Ocean albacore tuna was inferred using state-space ageaggregated surplus production models. For the estimation, both the maximum likelihood (ML) method with a Laplace approximation and Bayesian methods with several MCMC sampling approaches were employed. A total of 12 scenarios were assumed for the state-space models as combinations of [two different surplus production functions: Fox and Pella-Tomlinson][two different assumptions for initial depletion: start at 1950 with the assumption of B1950=K and start at 1979 with B1979 = D1979*K < K] *[Assumed extents of sampling CV for CPUE=0, 10% and 20%, in addition to an unknown additional model error]. Furthermore, non-state-space models were run for comparison purposes. In both the ML and Bayesian estimation methods, key parameters in the production function were not well estimated under the Pella-Tomlinson model because of unidentifiability between shape and intrinsic growth rate. As a result, mainly to highlight the impact of presence/absence of process errors (for the comparison of the results in this paper to the ASPIC paper) and to draw attention to the influence of the assumed CV in the CPUE in the estimation process, the results of the Fox production model are shown. These results showed that when estimating the initial depletion level in 1979, the presence/absence of process errors displayed a difference in the population trajectory. Furthermore, the assumed extent of the CV of the CPUE influenced trajectory to some extent, which implied a risk in subjectivity for such assumptions. Regarding the stock status, the results also suggested that the albacore tuna population had not been overfished and had not been subjected to overfishing. One of the main intentions behind the*

submission of this paper, with a focus on state-space production models, is to compare full assessment results which might be agreed upon in the Working Party with those driven by these simplified models, as is done in this paper. Such simplified models can be used for underlying stock assessment models within model-based management procedures, and therefore it is worth confirming whether there is a consistency between these approaches."

56. The WPTmT **NOTED** the increased flexibility of the state-space model relative to the ASPIC model due to the inclusion of process error, and its effect on biomass estimations.

57. The WPTmT **NOTED** that key parameters in the production function were not well estimated under the Pella-Tomlinson model because of unidentifiability between shape and intrinsic growth rate in both the ML and Bayesian estimation methods.

58. The WPTmT **NOTED** the potential to use hindcasting procedures to assess the predictive power of models in certain instances. The WPTmT further **NOTED** that the production model was unable to predict recent declines in CPUE in LL3 using this method.

59. The WPTmT **SUGGESTED** the authors examine temporal trace of process error over time to look for autocorrelation effects.

60. The WPTmT **NOTED** the difficulties in comparing different modelling approaches, particularly in that production models provides estimates of total biomass, and thus differ to structured models such as SS3 which estimate spawning biomass (and thus precluding comparisons of (B2017/Bmsy and F2017/Fmsy) ratios between models).

Table 9. Albacore: Key management quantities from the **SSPM** assessment for the Indian Ocean albacore tuna combining results from two models which incorporated LL1 and LL3 CPUE respectively.

Management Quantity	**Indian Ocean**
2017 catch estimate	38,713
Mean catch from 2013–2017	36,235
MSY (1000 t) (95% CI)	40.76 (33.18–54.10)
Data period used in assessment	1950–2017
F_{MSY} (95% CI)	0.42 (0.24–0.72)
B_{MSY} (1000 t) (95% CI)	97.37 (59.07–163.89
F_{2017}/F_{MSY} (95% CI)	0.75 (0.49–1.07)
B_{2017}/B_{MSY} (95% CI)	1.26 (1.06-1.50)
SB_{2017}/SB_{MSY}	n.a.
B_{2017}/B_{1980} (95% CI)	n.a.
SB_{2017}/SB_{1980}	n.a.
$B_{2017}/B_{1980,\ F=0}$	0.46 (0.39–0.55)
$SB_{2017}/SB_{1980,\ F=0}$	n.a.

n.a. not available

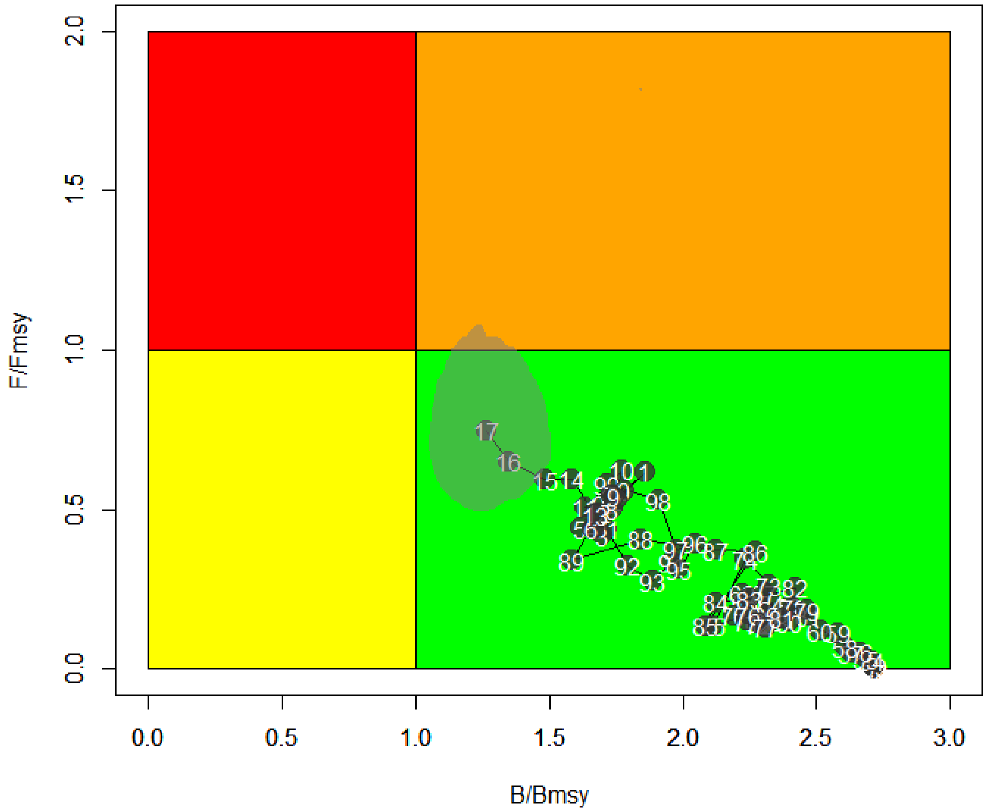


Fig.5. Albacore: **SSPM** aggregated Indian Ocean assessment Kobe plot. The results are from combining results from two models which incorporated LL1 and LL3 CPUE respectively (IOTC–2019–WPTmT07(AS)–13).

Stock Synthesis III (SS3)

61. The WPTmT **NOTED** paper IOTC–2019–WPTmT07(AS)–11 Rev_1 which provided a stock assessment for albacore in the Indian Ocean by Stock Synthesis III (SS3) model, including the following abstract provided by the author:

"This report presents the preliminary results of the 2019 stock assessment modelling of Indian Ocean albacore tuna using Stock Synthesis (Version 3.30.12). The assessment results will be finalised at the WPTmT7 meeting. The model included catch data from 1952 to 2017. A wide range of model options were investigated during the model development phase. The final model options were configured with a single model region, although fisheries were defined by dividing the Indian Ocean into four regions. The CPUE indices derived for main longline fishery in the southwest region were incorporated as the primary abundance indices in the assessment model.

The current assessment has highlighted a considerable conflict between key sources of data included in the model (longline CPUE indices and length composition data). The estimates of stock status are, in part, influenced by the selection of the primary abundance index (LL3) and the relative weighting assigned to the individual data sets within the model. Consequently, the current stock status is considered to be uncertain as indicated by the relatively broad range of estimates from the range of model sensitivities (SB2017/SBMSY 0.887 -1.764) and the uncertainty associated with individual model estimates of stock status. Correspondingly, estimates of current levels of fishing mortality (F2017/FMSY 0.80-1.68) are also uncertain, although almost all model options indicate fishing mortality rates are either approaching or have exceeded the reference level, indicating the overfishing is likely to be occurring.

The MSY based reference points correspond to a low overall level of stock size relative to unexploited conditions (SBMSY approximately 20% SB0). The recent level of catch (2013-2017 average of 35,737 t) is about the middle of the range of estimates of MSY for the stock (MSY 30,000-38,000 t).

Stock projections were conducted to evaluate the impact of current (2017) level of catch. The projections are not intended to provide a reliable prediction of future stock status due to the simplifying assumptions of equilibrium recruitment (from SRR), constant catch and unconstrained fishing mortality. Instead, the projections provide an indication of relative trends in stock biomass under different catch assumptions. For the reference model option, the stock was projected to decline below SBMSY over the next 10 years"

62. The WPTmT **NOTED** the key results for the preliminary SS3 models and thanked the author for the very thorough work. Based on the results of the preliminary model outlined in the paper, The WPTmT **NOTED** the following with respect to the modelling approach presented at the meeting:

i. There are some noticeable changes in spatial distribution of Longline catches compared to the previous assessment data set, with historical catch shifted to equatorial regions (LL1 and LL2) from southern fisheries (LL3 and LL4). This may relate to changes or revisions in the catch estimation/allocation procedure used by the IOTC Secretariat.

ii. In addition to the combined CPUE indices from JPN, TWN, KOR, the 2019 assessment also included the CPUE indices and size frequency data from Taiwanese drift net fishery fleet in the 1980s and 1990s (presumably representing the juvenile population). However the large variation in the Drift net indices is more likely to have reflected the recruitment variability rather than abundance.

iii. Taiwanese LL logsheet size data after 2003 were not used in the assessment. Following the recommendation from the data preparatory meeting, model runs were conducted with and without the pre-2003 Taiwanese LL data. As excluding the early data will greatly reduce the availability and coverage of the size frequency data, the reference case has included the early TWN size data. The results are not influential as the size data were down weighted in the model. It is expected further recommendations will be made regarding the TWN data following the completion of the LL size data review project. All models have included the observer data (available for more recent years).

iv. The LL size data were restricted to the core areas such that the size data (and selectivity) are more consistent with fishery catch and CPUE indices. Restriction to core areas removed JPN LL size data from NE region, which were comprised of mostly larger fish.

v. The growth parameters are sex specific and are based on the new estimates from Farley et al (2019) using samples from west Indian Ocean. The new growth function has a lower Linf than 2016 growth function (North Pacific ALB Chen et al 2012).

vi. Models did not explicitly account for the seasonality in the CPUE indices. Exploratory runs incorporating seasonal movement or catchability yielded similar results. There are some seasonality in the size frequency data but they are not consistent over time.

vii. The model starts in 1952 assuming an unfished equilibrium state and included vessel based LL CPUE index from 1979 (the CPUE indices in the early years were not considered to be proportional to abundance). Starting the model in later years was not considered as a viable option as there is little information to estimate the initial F.

viii. The spatial structure of the model was explored thoroughly. In general, the multi-region model configurations (including 4-region and 2-region model) requires the temporal variations in regional recruitment (or movement) to be estimated in order to account for the differential trend in regional LL CPUE indices. But it was considered that there was very limited information included in model to reliably estimate regional dynamics (recruitment and movement).

ix. The preferred single region configuration cannot adequately accommodate the differential trends in the regional CPUE indices. The single-region reference model included only the CPUE indices from region 3 (LL3) which was considered to be a more reliable index of stock abundance compared to LL1, LL2, LL4. The following factors were noted:

- Region 3 has relatively larger biomass compared to other regions (as indicated in the regional scaling factor analysis) and is more likely to be representative of the overall abundance.

- ➢ LL 3 CPUE indices are based on one of the main target LL fisheries and there is lower variability in CPUE indices over time. The trends in LL3 CPUE is similar to LL4 up until recent years. The decline in LL3 CPUE (in 1987 and 1993) is broadly consistent with peak in DN catch (from 1986 to 1991) and the overall (declining) trend in LL3 CPUE indices is consistent with overall (increasing) trend in total catch. Corresponding LF data are more consistent over time.
- ➢There are considerable uncertainty in the LL4 CPUE indices: Japanese data after 2005 have been excluded from the standardisations due to unsolved issues in potential changes in targeting or catchability; the large increase in LL 4 CPUE is probably due to the undue influence from data in the eastern part of the region (less biomass) which has different trend to the western part of the region (more biomass), and thus the LL 4 CPUE is likely to be biased.
- ➢ The differential trend in the LL3 CPUE which index the juvenile abundance, and LL1 CPUE which index adult abundance cannot be easily resolved assuming the one-region population structure. Sensitivity runs were conducted to examine the inclusion of indices from LL1 and LL4.

x. SigmaR was fixed at 0.3 in the reference model. The value was based on estimated recruitment deviations from initial runs. The WPTmT discussed various practice of choosing sigmaR and as a general rule sigmaR should not be greater than variability in estimated recruitment deviations. However, SigmaR is likely to be underestimated if there is lack of information in the data. Based on the discussions, the WPTmT **AGREED** to increase sigmaR to 0.6 for the reference model.

xi. For the reference model, LL1 and LL2 fisheries shared the same selectivity, and so did the LL3 and LL4. There appears to be no evidence to support that longline fishery in region 1 and 2 operated differently (and/or region 3 and 4). The shared selectivity is considered to be a more parsimonious parameterisation.

xii. The WPTmT discussed the feasibility of allowing time varying selectivity. The WPTmT **NOTED** that there was a general consensus that length data was of poor quality – they provided information on the overall fishing selectivity, but was unable to inform the changes of selectivity overtime.

xiii. The profile likelihood diagnostics revealed that the Purse seine size data is the only observational data that has provided information on the upper bound of the population scaling parameter R0 (or B0). This is perhaps due to that the decline in the mean length of the PS LF relative to Linf was interpreted by the model as fishing mortality. However the decline was not observed in the LL LF data and changes in the fishing operations or sampling procedure can also cause the decline in mean LF over time.

63. Based on the above discussions the WPTmT **SUGGESTED** sixteen additional model runs corresponding to combinations of the following model configurations :
    i. Alternative regional CPUE indices to be incorporated (LL3, LL1, LL3+LL1, LL3+LL4)
    ii. Alternative weighting on the PS size data (ESS 5 Lambda 1, ESS 5 Lambda 0)
    iii. Alternative weighting on the LL size data (ESS 5 Lambda 1, ESS 5 Lambda 0.05)

    The above model runs are based on configurations of the reference model in the document (i.e. one region structure) except that sigmaR will be set to be 0.6

64. The WPTmT **NOTED** the following results with respect to the additional analysis:
    i. There are conflicts between LL3 CPUE indices and LF data in the southern area (LL3 and LL4).
    ii. Reducing weight on the LL3 and LL4 LF data results in a shift in the selectivity to improve fits to LL3 and LL4 CPUE.
    iii. The PS LF data are still influential in determining stock status when LL LF data are removed.
    iv. Conflict between LL1 CPUE and LL3 CPUE not resolved but separate model fits to LL1 and LL3 CPUE yield similar estimates of stock status when LL LF data are substantially down weighted.

65. The WPTmT **AGREED** that the substantial influence from the PSLF data in determining abundance and the conflicts between the LL 3 CPUE indices and LF data creates uncertainty in the assessment. The WPTmT suggested that the models with both sets of length composition data down-weighted be included as alternative scenarios. The WPTmT proposed the four final model configuration options.

i. Model 1 - CPUE-Northwest, LL and PS LF included
ii. Model 2 - CPUE-Southwest, LL and PS LF included
iii. Model 3 - CPUE-Northwest, LL and PS LF excluded (selectivity fixed at values from initial fit)
iv. Model 4 - CPUE-Southwest, LL and PS LF excluded (selectivity fixed at values from initial fit)

66. The WPTmT **NOTED** that Model 4 results were significantly different from Models 1 – 3. This was due to the fact that the selectivity of the southwestern LL fishery doesn't include the large/old component of the population. The CPUE does not therefore monitor that component of the stock. As there is a lack of information in the size frequencies to inform the model of the upper range of the biomass levels, the results from this model are highly uncertain. This model was therefore excluded from the management advice. The combined estimates of stock status derived from the remaining 3 models are therefore effectively more weighted by the northwest CPUE.

67. The WPTmT **REQUESTED** that future stock status estimates incorporate a wider range of uncertainty, including additional natural mortality options and steepness values. Due to a lack of time during the assessment meeting, this was not possible.

68. The WPTmT **NOTED** the key assessment results for the Stock Synthesis III model (SS3) as shown below (**Tables 10** & **11**; **Fig. 6**).

69. The WPTmT **NOTED** the selectivity has changed over time particularly in recent time where a shift has been to target smaller fish, which is influential on the definition of FMSY. Therefore the WPTmT **REQUESTED** a KOBE plot based on a time varying FMSY and BMSY be provided.

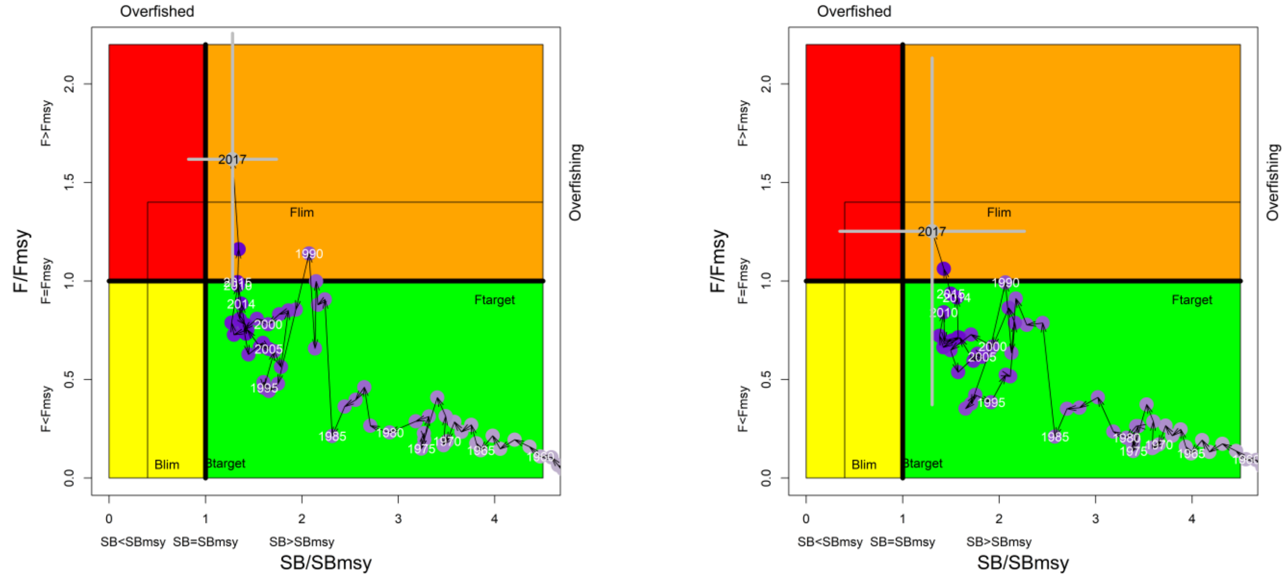
70. The WPTmT **NOTED** the recruitment in the terminal years of the assessment model are estimated to be well below average levels and this is projected to cause the stock to decline considerably over the short term. However, these recruitment estimates are poorly determined. Therefore the WPTmT **NOTED** the results of the K2SM (Table 11) and cautioned that the short term projections are more influenced by the recent low recruitment levels, whereas the long term projections are more determined by the assumptions of average recruitment levels over the longer term period.

Table 10. Albacore: Key management quantities from the SS3 assessment, for the Indian Ocean. Values are based on the median of the combined outputs of 3 model options: Models 1, 2 and 3

Management Quantity	Indian Ocean
2017 catch estimate	38,168
Mean catch from 2013–2017	35,737
MSY (1000 t) (95% CI)	35.7 (27.3-44.4)
Data period used in assessment	1950–2017
F_{MSY} (95% CI)	0.213 (0.195-0.237)
SB_{MSY} (1000 t) (95% CI)	23.2 (17.6-29.2)
F_{2017}/F_{MSY} (95% CI)	1.346 (0.588-2.171)
B_{2017}/B_{MSY} (95% CI)	n.a.
SB_{2017}/SB_{MSY} (95% CI)	1.281 (0.574-2.071)
B_{2017}/B_{1950} (95% CI)	0.333 (-)
SB_{2017}/SB_{1950} (95% CI)	0.262 (–)
$B_{2017}/B_{1950,\ F=0}$	n.a.
SB_{2017}/SB2017$_{,\ F=0}$	0.272

n.a. not available
* For SS3 SB is defined as mature female biomass.

(i) Model 1 (iii) Model 3



(ii) Model 2

(iv) Model 4

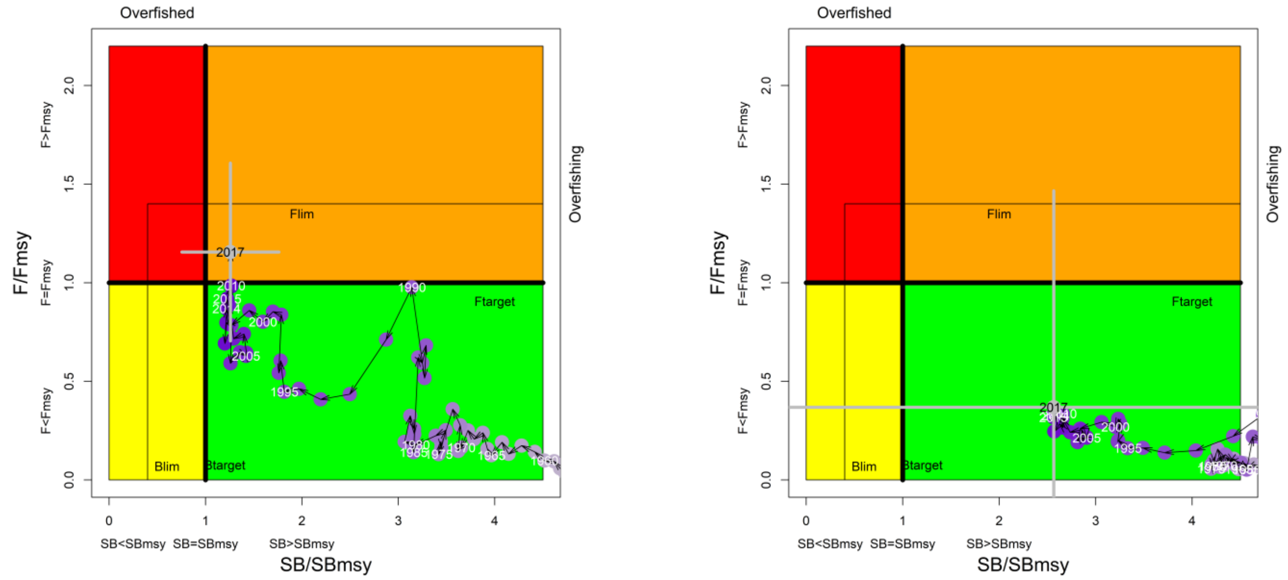


Fig. 6. Albacore: SS3 Indian Ocean assessment Kobe plot for the four model options: (i) Model 1 (ii) Model 2 (iii) Model 3 (iv) Model 4. Blue circles indicate the trajectory of the point estimates for the SB ratio and F ratio for each year 1950–2017 (the grey lines represent the 95 percentiles of the 2017 estimate). Target (Ftarg and SBtarg) and limit (Flim and SBlim) reference points are shown.

Table 11. Albacore: SS3 aggregated Indian Ocean assessment Kobe II Strategy Matrix based on the model options (i) Model 1 (ii) Model 2 (iii) Model 3 . Probability (percentage) of violating the MSY-based target (top) and limit (bottom) reference points for constant catch projections (2017 catch level, ± 10%, ± 20%, ± 30% ± 40%) projected for 3 and 10 years.

Reference point and projection timeframe	**Alternative catch projections (relative to the catch level for 2017) and probability (%) of violating MSY-based target reference points ($SB_{targ} = SB_{MSY}$; $F_{targ} = F_{MSY}$)**								
	60% (22,901)	70% (26,718)	80% (30,534)	90% (34,351)	100% (38,168)	110% (41,985)	120% (45,802)	130% (49,618)	140% (53,435)
$SB_{2020} < SB_{MSY}$	0.614	0.678	0.715	0.769	0.818	0.828	0.87	0.883	0.898
$F_{2020} > F_{MSY}$	0.074	0.224	0.4	0.556	0.654	0.731	0.766	0.788	0.782
$SB_{2027} < SB_{MSY}$	0.176	0.307	0.456	0.572	0.713	0.823	0.898	1	1
$F_{2027} > F_{MSY}$	0.002	0.085	0.287	0.473	0.718	0.878	1	1	1
Reference point and projection timeframe	**Alternative catch projections (relative to the catch level for 2017) and probability (%) of violating MSY-based target reference points ($SB_{targ} = SB_{MSY}$; $F_{targ} = F_{MSY}$)**								
	60% (22,901)	70% (26,718)	80% (30,534)	90% (34,351)	100% (38,168)	110% (41,985)	120% (45,802)	130% (49,618)	140% (53,435)
$SB_{2020} < SB_{Lim}$	0.039	0.065	0.084	0.124	0.161	0.19	0.253	0.314	0.373
$F_{2020} > F_{Lim}$	0.003	0.037	0.129	0.277	0.414	0.537	0.629	0.696	0.712
$SB_{2027} < SB_{Lim}$	0.059	0.12	0.22	0.325	0.462	0.648	0.749	1	1
$F_{2027} > F_{Lim}$	0	0.006	0.127	0.309	0.622	0.843	1	1	1

4.4 Selection of Stock Status indicators

71. The WPTmT **NOTED** the following with respect to the various modelling approaches used in 2019:
    i. The Joint CPUE standardisation was based on a unified, well documented procedure which has been evolving overtime. it is currently considered as the best practice in standardising the operational level data from the main longline fleets (i.e. Japanese, Taiwanese, and Korean fleets). Combining observations across fleets in a single analysis also provides a time series with better spatial and temporal coverage.
    ii. The WPTmT discussed extensively, the reliability and representativeness of the Joint CPUE indices. The CPUE in the southwest area are mostly likely to represent the abundance of albacore tuna at the time, as the indices were based on a main target fishery with more consistent fishing operations. The southwest area also represents a significant proportion of the albacore biomass in the Indian Ocean
    iii. Conversely, the CPUE in the southeast area is more likely to be problematic: the Japanese CPUE seems to demonstrate very strong targeting shifts away from albacore (i.e., during the 1960s) and back towards albacore in recent years since 2006 (e.g., as a consequence of piracy in the western Indian Ocean, reduced or increased TAC for southern bluefin tuna, and increases in the commercial value for albacore). Similar trends are seen in the Rep. of Korea CPUE series. In addition, the standardization has not adequately accounted for the differential trend between the eastern and western part of region 4, and thus the large increase in CPUE from the eastern part of the region (which has less biomass) is likely to bias the overall indices.
    iv. It was agreed that all the stock assessment modelling approaches use the joint standardized CPUE for southwest area as well as northwest region.

72. The WPTmT **NOTED** the value of comparing different modelling approaches. The structured models are capable of a more detailed representation of complicated population and fishing processes, and integrate a diverse range of observational data that cannot be easily considered in the simple production models. However, there are a number of uncertainties in the basic albacore biology (e.g. growth rates, M, stock recruitment relationship), and it is difficult to represent all of these uncertainties. In contrast, the production models often provide robust

estimates regardless of uncertainties in basic biological characteristics. However, production models in general cannot represent some important dynamics which often yielded biased estimates of quantities (e.g. recruitment variability, fishing selectivity etc).

73. The WPTmT **NOTED** some recent progress in production model development. For example JABBA-Select is able to incorporate biological parameters and fishing selectivity and distinguishes between exploitable biomass (used to fit indices given fishery selectivity) and spawning biomass (used to predict surplus production). The WPTmT encourage CPC scientists to explore the utility of JABBA-Select in assessing the albacore stock via production models.

74. The WPTmT **NOTED** a thorough and in-depth analysis of SS3 was presented with a complete set of diagnostics, in comparison to other stock assessments for which some key diagnostics were not provided. Therefore, the WPTmT **AGREED** that albacore stock status should be determined by the results of the SS3 stock assessments undertaken in 2019 and that the results of the other models should be presented for informative purpose supporting the results of the SS3.

4.5 Update on Management Strategy Evaluation Progress (OM formulation)

75. The WPTmT **NOTED** paper IOTC-2019-WTmT07(AS)-16 had been withdrawn by the authors, however, document IOTC-2019-TCMP03-09_Rev1 which was presented to the Technical Committee on Management Procedures (TCMP) was summarised and presented. This document provided an update on the recent development and current status of the work on Management Strategy Evaluation for Indian Ocean albacore being conducted under the remit of the Working Party on Methods, and included the following abstract by the authors:

> "*An evaluation of Management Procedures (MPs) for Indian Ocean albacore tuna is being carried out. The analysis attempts to simulation-test a full MP, consisting on data collection, an specified mechanism to evaluate stock status and/or trends, and a decision rule. The base case Operating Model (OM) for albacore is being developed by the Working Party on Methods (WPM) with input from the Working Party on Temperate Tuna (WPTmT). The current base case is likely to be updated following the new stock assessment for this stock to be carried out by WPTmT in July 2019. This will update the OM to the start of 2018 without the current extension from the 2014 stock status estimates. Two types of MPs are being evaluated and presented here. They mainly differ in the method used to assess stock status: trends in the main CPUE series, or a surplus production stock assessment. Both depend on the availability of an index of abundance generated in a similar manner to what is currently being used by WPTmT for the albacore stock assessment. One of them also requires good estimates of total catches from all fleets.*" *– see Paper for the full abstract.*

76. The WPTmT **RECALLED** that the MSE process consists of the following components, of which the focus of the WPM is to develop OMs (item 3), and then condition them:
    1. Specification and prioritization of management objectives
    2. Translation of the management objectives to performance measures and risk indicators
    3. Construction of Operating Models (OMs)
    4. Proposition of management procedures (MPs) or harvest control rules (HCRs)
    5. Implementation of simulation trials
    6. Comparison of performance for various procedures
    7. Advice of MPs or HCRs which meet management objectives.

77. The WPTmT **NOTED** the discussion on the extent to which the current OMs are appropriate in light of the new assessment result. The WPTmT further **NOTED** that the main drivers of the differences in the model results are the standardized CPUE series used in assessments as well as the new growth curve, which may have implications not only for OMs but also for the Management Procedures, which are partly CPUE-based.

78. The WPTmT **DISCUSSED** if the current OMs are appropriate in light of the new assessment results. Preliminary examination indicates that although biomass and F ratios are within the 90% confidence intervals of the OM outputs, the absolute biomass values from the 4 SS3 models are not, and therefore reconditioning of the OM is required. The WPTmT **AGREED** that this will be further discussed and guided intersessionally by the Chair/vice-Chair of the WPTmT, the Chair/vice-Chair of the WPM and the key assessment modellers with support by the secretariat. These deliberations should be reported back to the next WPM and SC.

4.6 Development of technical advice on the status of the albacore tuna stock

79. The WPTmT **ADOPTED** the management advice developed for albacore as provided in the draft Executive Summary and **REQUESTED** that the IOTC Secretariat update the draft stock status summary for albacore with the latest 2018 catch data:
    - Albacore (*Thunnus alalunga*) – Appendix IV

5. RESEARCH RECOMMENDATIONS AND PRIORITIES

5.1 Revision of the WPTmT Program of Work

80. The WPTmT **NOTED** paper IOTC–2019–WPTmT07(AS)–08 which provided an opportunity to consider and revise the Program of Work for 2020–24 to align with the requests and directives from the Commission and Scientific Committee.

81. The WPTmT **RECALLED** that the SC, at its 16th Session, requested that all Working Parties provide their work plans with items prioritised based on the requests of the Commission or the SC. (SC16. para. 194). Similarly, at the 18th Session of the Commission, the Scientific Committee was requested to provide its Program of Work on a multi-year basis, with project priorities clearly identified. In doing so, the SC should consider the immediate and longer term needs of the Commission.

82. The WPTmT **NOTED** the range of research projects on albacore currently underway, or in development, and reminded participants to ensure that the projects described are included in their National Reports to the SC, which are due in early November 2019.

83. The WPTmT **RECOMMENDED** that the SC consider and endorse the WPTmT Program of Work (2020–24), as provided at Appendix V.

5.2 Development of priorities for an Invited Expert at the next WPTmT meeting

84. The WPTmT **NOTED** with thanks the contributions of Drs Simon Hoyle and Bradley Moore, IOTC consultants, who presented the results of the CPUE standardization and draft scoping study for albacore sampling, respectively. The WPTmT also **NOTED** the critical work carried out by Mr. Adam Langley, IOTC Consultant, who conducted the SS3 assessment.

85. The WPTmT **AGREED** to the following core areas of expertise and priority areas for contribution that need to be enhanced for the next meeting of the WPTmT, should an Invited Expert be necessary:
    i. Expertise: experience with CPUE analysis and standardisation for albacore.
    ii. Expertise: stock assessment experience, particularly with fully integrated models.

6. OTHER BUSINESS

6.1 Election of a Chairperson and Vice-Chairperson of the WPTmT for the Next Biennium

86. The WPTmT **CONSIDERED** candidates for the position of Chairperson and Vice-Chairperson of the WPTmT for the next *biennium*. Dr. Jiangfeng Zhu was nominated and re-elected as Chairperson of the WPTmT for the next *biennium*, while Dr Toshihide Kitakado was re-elected as Vice-Chairperson of the WPTmT.

6.2 Date and place of the 8th and 9th Sessions of the WPTmT

87. The WPTmT participants were unanimous in thanking Japan for hosting the 7th Session of the WPTmT and **COMMENDED** the Japanese Far Sea Fisheries Research Institute on the warm welcome, the excellent facilities and assistance provided to the IOTC Secretariat in the organisation and running of the Session.

88. Following a discussion on who would host the 8th and 9th Sessions of the WPTmT, the WPTmT **AGREED** that the IOTC Secretariat should liaise with CPCs to determine where it would be feasible to hold the next two meetings.

89. The WPTmT **RECOMMENDED** that a data preparatory meeting (DP) and stock assessment meeting (AS) be held in the same year, with the data preparatory meeting being held between April and June and the assessment meeting in August or September. This would facilitate the provision of CPUE series using data from the previous year to the data preparatory meeting, while ensuring catch data for the previous year, which is due to be

submitted to the IOTC Secretariat by the end of June each year, is available for use in the stock assessments. The exact dates and meeting locations will be confirmed and communicated by the IOTC Secretariat to the SC for its consideration.

i. WPTmT08(DP): Host to be decided. Meeting to be held between April and June 2022 (TBC).
ii. WPTmT08(AS): Host to be decided. Meeting to be held between August and September 2022 (TBC).

7. Review of the draft, and adoption of the Report of the 7th Session of the WPTmT(AS)

90. The WPTmT **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPTmT07(AS), provided at Appendix VI, as well as the management advice provided in the draft resource stock status summary for albacore (Appendix IV).

91. The report of the 7th Session of the Working Party on Temperate Tunas (*IOTC–2019–WPTmT07(AS)–R*) was **ADOPTED** on the 26 July 2019.

APPENDIX I
LIST OF PARTICIPANTS

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APPENDIX II
AGENDA FOR THE 7TH WORKING PARTY ON TEMPERATE TUNAS (AS)

Date: 23 - 27 July 2019

Location: Shizuoka, Japan

Venue: National Research Institute of Far Seas Fisheries (NRIFSF)

Time: 09:00 – 17:00 daily

Chair: Dr Jiangfeng Zhu (People's Republic of China); **Vice-Chair:** Dr Toshihide Kitakado (Japan)

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 ALBACORE TUNA SPECIES SINCE THE DATA PREPARATORY MEETING (**IOTC Secretariat**)**

4. **ALBACORE STOCK ASSESSMENT** (Chair)
   - 4.1 Review new information on albacore biology, stock structure, fisheries and associated environmental data since the data preparatory meeting (all)
   - 4.2 Updated nominal and standardised CPUE indices
   - 4.3 Stock assessments
     - Stock Synthesis (SS3)
     - Statistical-Catch-At-Age (SCAA)
     - State-space Production Model
     - Bayesian Surplus Production model
     - ASPIC
   - 4.4 Selection of Stock Status indicators for albacore
   - 4.5 Update on Management Strategy Evaluation Progress (OM formulation)
   - 4.6 Development of management advice for albacore tuna (all)
   - 4.7 Update of albacore tuna Executive Summary for the consideration of the Scientific Committee (all)

5. **WPTmT PROGRAM OF WORK**
   - 5.1 Revision of the WPTmT Program of Work (2019–2023)
   - 5.2 Development of priorities for an Invited Expert at the next WPTmT meeting

6. **OTHER BUSINESS**
   - 6.1 Election of a Chairperson and a Vice-Chairperson for the next biennium (IOTC Secretariat)
   - 6.2 Date and place of the 8th and 9th Sessions of the WPTmT (Chair and IOTC Secretariat)

7. Review of the draft, and adoption of the Report of the 7th Session of the WPTmT(AS) (Chair)

APPENDIX III
LIST OF DOCUMENTS

Document	Title
IOTC–2019–WPTmT07(AS)–01a_Rev1	Draft Agenda of the 7th Working Party on Temperate Tunas
IOTC–2019–WPTmT07(AS)–01b_Rev2	Draft Annotated agenda of the 7th Working Party on Temperate Tunas
IOTC–2019–WPTmT07(AS)–02_Rev2	Draft List of documents
IOTC–2019–WPTmT07(AS)–03	Revision of the WPTmT Program of Work (2020–2024) (IOTC Secretariat)
IOTC–2019–WPTmT07(AS)–04	Improving biological knowledge of albacore tuna, *Thunnus alalunga*, in the Indian Ocean: a scoping study. (Moore B, Langley A, Farley J and Hoyle S)
IOTC–2019–WPTmT07(AS)–05_Rev1	A review of the catches of albacore tuna by local and licensed foreign longliners and transshipment of albacore in Mauritius. (Shung C L and Sheikmamode A)
IOTC–2019–WPTmT07(AS)–06	Status of catch and effort for albacore tuna by Malaysian Tuna Longliners in the Indian Ocean (2013- 2017). (Faizal E M, Halim N H A, Jamon S & Jamaludin N A)
IOTC–2019–WPTmT07(AS)–07	Standardizing CPUE of Albacore Tuna (*Thunnus alalonga* Bonnaterre, 1788) on Tuna Longline Fishery in Eastern Indian Ocean. (Rochman F, Setyadjie B and Fahmi Z)
IOTC–2019–WPTmT07(AS)–08	Preliminary analysis of the Chinese albacore fishery and CPUE standardization in the Indian Ocean. (Ma Q et al.)
IOTC–2019–WPTmT07(AS)–09	CPUE standardization of albacore caught by Taiwanese longline fishery in the Indian Ocean. (Wang S-P)
IOTC–2019–WPTmT07(AS)–10	Collaborative study of albacore tuna CPUE from multiple Indian Ocean longline fleets in 2019. (Hoyle S D, Fu D, Kim D-N, Lee S-I, Matsumoto T, Satoh K, Wang S-P, and Kitakado T)
IOTC–2019–WPTmT07(AS)–11	Stock assessment of albacore tuna in the Indian Ocean using Stock Synthesis for 2019. (Langley A)
IOTC–2019–WPTmT07(AS)–13	Estimation of population dynamics for the Indian Ocean albacore using state-space production models. (Kitakado T et al.)
IOTC–2019–WPTmT07(AS)–14_Rev1	Stock assessment of albacore tuna in the Indian Ocean using Bayesian Surplus Production model. (Lee S-I, Kitakado T, Kim D-N)
IOTC–2019–WPTmT07(AS)–15	Stock and risk assessments of albacore in the Indian Ocean based on ASPIC. (Matsumoto T)
IOTC–2019–WPTmT07(AS)–17_Rev1	Preliminary stock assessments of albacore (Thunnus alalunga) in the Indian Ocean using Statistical-Catch-At-Age (SCAA). (Nishida T and Kitakado T)
IOTC–2019–WPTmT07(AS)–18	Albacore tuna (Thunnus alalunga) landing at fishing ports in Thailand between 2016 and 2018. (Chumchuen W, and Songphatkaew J)
INFO Papers	
IOTC-2019-TCMP03-09_Rev1	Indian Ocean Albacore Tuna Management Procedures Evaluation: Status Report. (Mosquiera I)
IOTC–2019–WPTmT07(AS)–INF02	Allometric curve for the Indian Ocean albacore. (Kitakado T. Fiorellato F. and de Bruyn P)

APPENDIX IV
DRAFT RESOURCE STOCK STATUS SUMMARY – ALBACORE

Draft: Status of the Indian Ocean albacore (ALB: *Thunnus alalunga*) resource

TABLE 1. Albacore: Status of albacore (*Thunnus alalunga*) in the Indian Ocean.

Area[1]	Indicators – 2019 assessment		2019 stock status[3] determination
Indian Ocean		SS3	
	Catch 2017[2]:	38,713 t	
	Average catch 2013–2017:	36,235 t	
	MSY (1000 t) (95% CI):	35.7 (27.3–44.4)	
	F_{MSY} (95% CI):	0.21 (0.195-0.237)	
	SB_{MSY} (1000 t) (95% CI):	23.2 (17.6–29.2)	
	F_{2017}/F_{MSY} (95% CI):	1.346 (0.588–2.171)	
	SB_{2017}/SB_{MSY} (95% CI):	1.281 (0.574–2.071)	
	SB_{2017}/SB_{1950} (95% CI):	0.262 (-)	

[1] Boundaries for the Indian Ocean stock assessment are defined as the IOTC area of competence.
[2] Proportion of catch estimated or partially estimated by IOTC Secretariat for 2017: 17%
[3] The stock status refers to the most recent years' data used in the last assessment conducted in 2019.

Colour key	Stock overfished(SB_{year}/SB_{MSY}< 1)	Stock not overfished (SB_{year}/SB_{MSY}≥ 1)
Stock subject to overfishing(F_{year}/F_{MSY}> 1)		
Stock not subject to overfishing (F_{year}/F_{MSY}≤ 1)		

INDIAN OCEAN STOCK – MANAGEMENT ADVICE

Stock status. A new stock assessment was carried out for albacore in 2019 to update the assessment undertaken in 2016. The stock assessment was carried out using Stock Synthesis III (SS3), a fully integrated model that is currently also used to provide scientific advice for the three tropical tunas stocks in the Indian Ocean. The model used in 2019 is based on the model developed in 2016 with a series of revisions that were noted during the WPTmT data preparatory meeting held in January 2019. There are some noticeable changes in spatial distribution of Longline catches compared to the previous assessment data set, with historical catch shifted to equatorial regions (LL1 and LL2) from southern fisheries (LL3 and LL4). This is due to revisions in the historical catch data carried out since the last assessment.

The current assessment has utilised CPUE series that are significantly different from the last assessment. In particular a revised approach to the analysis of the joint LL CPUE series was conducted and the resulting indices were included in the SS3 model. The final set of model options included alternative models using the northwest and southwest CPUE indices. Both sets of indices show a considerable decline from 1979 to current. The two sets of indices effectively monitor different components of the albacore stock. The CPUE in the southwest area (LL3) is mostly likely to represent the abundance of albacore tuna at the time, as the indices were primarily based on a main target fishery with more consistent fishing operations. The southwest area also represents a significant proportion of the albacore biomass in the Indian Ocean. The LL1 CPUE indices largely represent bycatch of the tropical tuna fisheries. The assessment results were sensitive to the influence of the length composition data sets in the models. There is concern regarding the information content of these data. Consequently, the final set of model options included alternative treatments of these data including down-weighting or excluding these data.

Trends in the CPUE series suggest that the longline vulnerable biomass has declined to around 45 - 50% of the levels observed in 1980–82. Prior to 1980 there was 20 years of moderate fishing, after which total catches of albacore tuna in the Indian Ocean have more than doubled in subsequent years (**Fig. 1**). Catches have also increased substantially since 2007 for some fleets (i.e., Indonesian and Taiwan,China longline fisheries), although there is substantial uncertainty regarding the reliability of the catch estimates. Catches in 2017 were marginally above the MSY level of the SS3 model. Fishing mortality represented as F_{2017}/F_{MSY} is 1.346 (0.588–2.171). Biomass is estimated to be above the SB_{MSY} level (1.281 (0.574–2.071)) from the SS3 model (**Table 1**, **Fig. 2**). These changes in stock status since the previous assessment are possibly due to decreases in the CPUE in recent years, while catches have remained relatively stable. Also, there has been a large redistribution of catch to the southern regions which impacts on small fish (and therefore influences the computation of FMSY). In addition, the latest assessment uses a revised growth curve which also impacts FMSY. Thus, the stock status in relation to the Commission's B_{MSY} and F_{MSY} target reference points indicates that the stock is **not overfished** but is **subject to overfishing** (**Table 1**).

Outlook. Maintaining or increasing effort in the core albacore fishing grounds is likely to result in further decline in the albacore tuna biomass, productivity and CPUE. The impacts of piracy in the western Indian Ocean resulted in the displacement of a substantial portion of longline fishing effort into the traditional albacore fishing areas in the southern and eastern Indian Ocean. However, in recent years the effort distribution in the Indian Ocean has been rather dynamic. Projections indicate that under current catch assumptions, the biomass will continue to decline as recent recruitment levels are estimated to be low. The recruitment in the terminal years of the assessment model are estimated to be well below average levels and this is projected to cause the stock to decline considerably over the short term. However, these recruitment estimates are poorly determined. Therefore it is cautioned that the short term projections are more influenced by the recent low recruitment levels, whereas the long term projections are more determined by the assumptions of average recruitment levels over the longer term period.

Management advice. Although considerable uncertainty remains in the SS3 assessment conducted in 2019, particularly due to the conflicts in key data inputs, a precautionary approach to the management of albacore tuna should be applied. The K2SM indicates that catch reductions are required in order to prevent the biomass from declining to below MSY levels in the short term, due to the low recent recruitment levels. Although there is considerable uncertainty in the projections, current catches are exceeding the estimated MSY level (35,700 t; **Table 2**).

The following should be noted:

- The primary sources of data that drive the assessment, total catches, CPUE and length data, are highly uncertain and should be developed further as a priority.
- The catch estimates for 2017 (38,713t) are above the current estimated MSY levels (**Table 1**).
- A Kobe 2 Strategy matrix was calculated to quantify the risk of different future catch scenarios, using the projections from the SS3 model (**Table 2**).
- Provisional reference points: noting that the Commission in 2015 adopted Resolution 15/10 *On interim target and limit reference points and a decision framework*, the following should be noted:
    - **Fishing mortality**: Current fishing mortality is considered to be above the provisional target reference point of F_{MSY}, but below the provisional limit reference point of $1.4*F_{MSY}$ (**Fig. 2**).
    - **Biomass**: Current spawning biomass is considered to be above the target reference point of SB_{MSY}, and therefore above the limit reference point of $0.4*SB_{MSY}$ (**Fig. 2**).
- **Main fishing gear (average catches 2013–17)**: Albacore tuna are currently caught almost exclusively using drifting longliners, with the remaining catches recorded using purse seines and other gears. Catches from the longline fisheries are split between deep-freezing longliners and fresh-tuna longliners (Fig. 1).
- **Main fleets (average catches 2013–17)**: The majority of albacore catches are attributed to vessels flagged to distant water fishing nations (i.e., Taiwan,China and Japan), followed by coastal countries such as Indonesia and Malaysia.

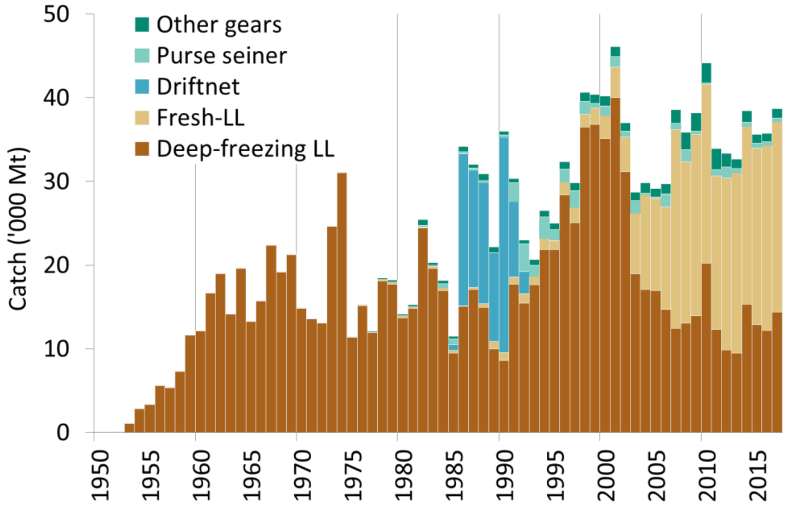
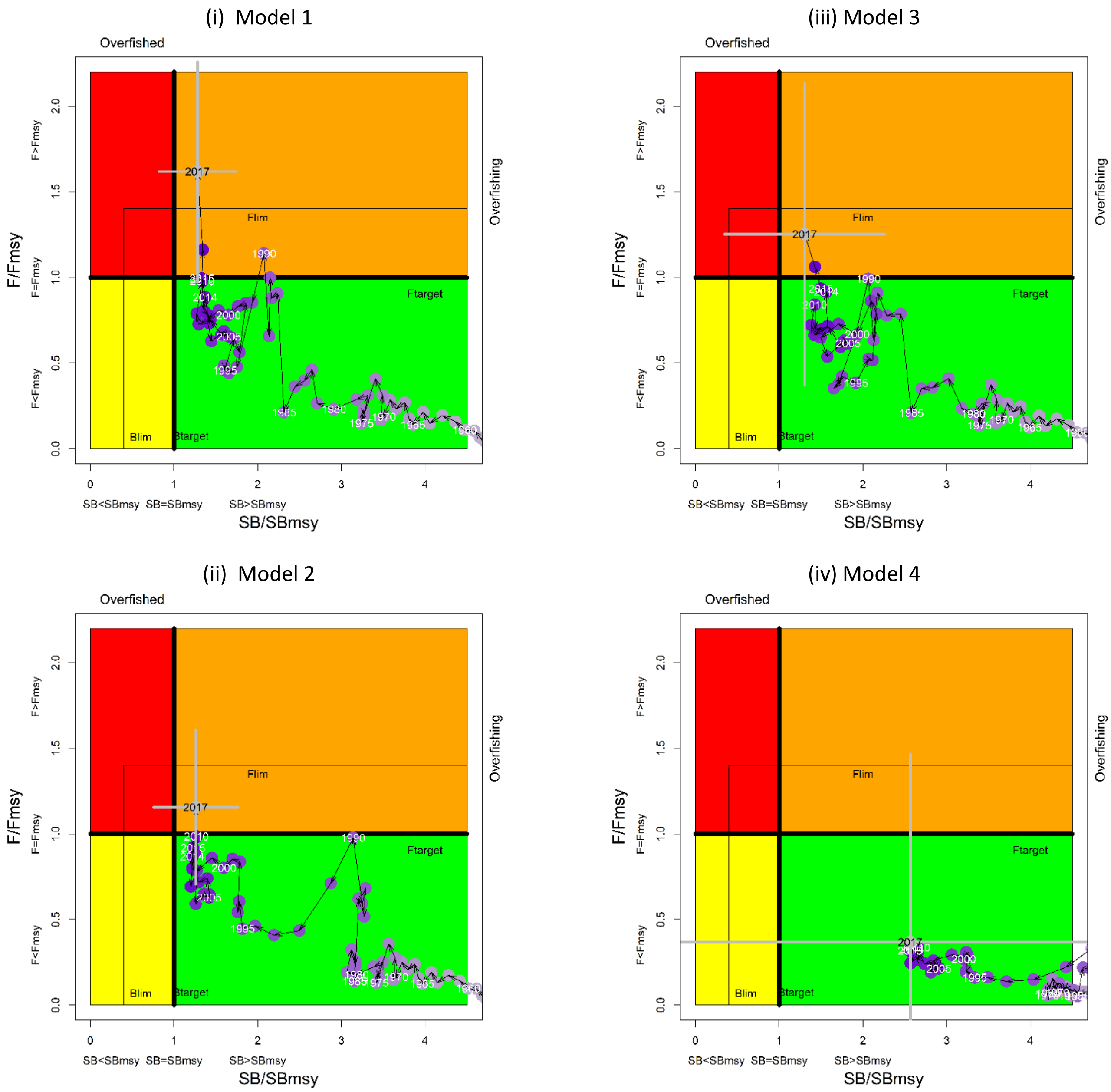


Fig. 1. Albacore: Catches of albacore by gear (1950-2017)[1].



[1] **Definition of fisheries**: Driftnet (**DN; Taiwan,China**); Freezing-longline (**LL**); Fresh-tuna longline (**FLL**); Purse seine (**PS**); Other gears nei (**OT**).

Fig. 2. Albacore: SS3 Indian Ocean assessment Kobe plot for the four model options: (i) Model 1 (ii) Model 2 (iii) Model 3 (iv) Model 4. Blue circles indicate the trajectory of the point estimates for the SB ratio and F ratio for each year 1950–2017 (the grey lines represent the 95 percentiles of the 2017 estimate). Target (Ftarg and SBtarg) and limit (Flim and SBlim) reference points are shown.

Table 2. Albacore: SS3 aggregated Indian Ocean assessment Kobe II Strategy Matrix based on the model options (i) Model 1 (ii) Model 2 (iii) Model 3 . Probability (percentage) of violating the MSY-based target (top) and limit (bottom) reference points for constant catch projections (2017 catch level, ± 10%, ± 20%, ± 30% ± 40%) projected for 3 and 10 years.

Reference point and projection timeframe	**Alternative catch projections (relative to the catch level for 2017) and probability (%) of violating MSY-based target reference points ($SB_{targ} = SB_{MSY}$; $F_{targ} = F_{MSY}$)**								
	60% (22,901)	70% (26,718)	80% (30,534)	90% (34,351)	100% (38,168)	110% (41,985)	120% (45,802)	130% (49,618)	140% (53,435)
$SB_{2020} < SB_{MSY}$	0.614	0.678	0.715	0.769	0.818	0.828	0.87	0.883	0.898
$F_{2020} > F_{MSY}$	0.074	0.224	0.4	0.556	0.654	0.731	0.766	0.788	0.782
$SB_{2027} < SB_{MSY}$	0.176	0.307	0.456	0.572	0.713	0.823	0.898	1	1
$F_{2027} > F_{MSY}$	0.002	0.085	0.287	0.473	0.718	0.878	1	1	1

Reference point and projection timeframe	**Alternative catch projections (relative to the catch level for 2017) and probability (%) of violating MSY-based target reference points ($SB_{targ} = SB_{MSY}$; $F_{targ} = F_{MSY}$)**								
	60% (22,901)	70% (26,718)	80% (30,534)	90% (34,351)	100% (38,168)	110% (41,985)	120% (45,802)	130% (49,618)	140% (53,435)
$SB_{2020} < SB_{Lim}$	0.039	0.065	0.084	0.124	0.161	0.19	0.253	0.314	0.373
$F_{2020} > F_{Lim}$	0.003	0.037	0.129	0.277	0.414	0.537	0.629	0.696	0.712
$SB_{2027} < SB_{Lim}$	0.059	0.12	0.22	0.325	0.462	0.648	0.749	1	1
$F_{2027} > F_{Lim}$	0	0.006	0.127	0.309	0.622	0.843	1	1	1

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APPENDIX V
WORKING PARTY ON TEMPERATE TUNAS PROGRAM OF WORK (2020–2024)

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 albacore in the Indian Ocean;
- **Table 2**: Stock assessment schedule.

Table 1. Priority topics for obtaining the information necessary to develop stock status indicators for albacore in the Indian Ocean (2020–2024)

Topic	Sub-topic and project	Priority	Est. budget and/or potential source	Timing				
				2020	2021	2022	2023	2024
1. Stock structure (connectivity and diversity)	1.1 Genetic research to determine the connectivity of albacore throughout its distribution and the effective population size.	Low (5)	1.3 m Euro: European Union					
2. Biological information (parameters for stock assessment)	2.1 Biological research (collaborative research to improve understanding of spatio-temporal patterns in age and growth and reproductive parameters)	High (1)	TBD					
	2.1.1 Age and growth studies: Uncertainty about the growth curve is a primary source of uncertainty in the stock assessment. A preliminary growth curve was developed in 2019, but there is substantial work to be done to ensure that growth curves include data from smaller size classes, and that spatio-temporal patterns in growth are quantified for use in the stock assessment. Collaborative sampling programs, involving a combination of observer- and port-based sampling, are required to ensure that adequate samples are collected.		TBD					

		2..1.2 Quantitative biological studies are necessary for albacore throughout its range to determine spatio-temporal patterns in key reproductive parameters including sex ratio; female length- and age-at-maturity; spawning location, periodicity and frequency; batch fecundity at length and age; spawning fraction and overall reproductive potential, to inform future stock assessments.		TBD					
3	CPUE standardisation	3.1 Continue the development of standardized CPUE series for each albacore fishery for the Indian Ocean, with the aim of developing appropriate CPUE series for stock assessment purposes.	High (2)	CPUE Workshop (TBD)					
		3.1.1 Spatio-temporal structure and target changes need to be considered carefully, as fish density and targeting practices can vary in ways that affect CPUE indices. Developments may include changes to fishery spatial structure, new approaches for area weighting, time-area interactions in the model, and/or indices using VAST.		CPCs directly					
4	Size frequency data	5.1 Further investigate the size information provided by CPCs in order to better understand the stock dynamics and inputs into the assessment models. This is particularly necessary for the purse seine data.	High (3)	TBD					
5	Management strategy evaluation	6.1 Continue to collaborate with the WPM on input to the Management Strategy Evaluation (MSE) process.	High (4)	TBD					

Table 2. Assessment schedule for the IOTC Working Party on Temperate tuna 2020-2024.

Working Party on Temperate Tunas					
Species	**2020**	**2021**	**2022**	**2023**	**2024**
Albacore	–		Data preparatory Meeting (4 days) (April/May/June) Stock assessment meeting (5 days) (August/September)	–	–

APPENDIX VI
CONSOLIDATED RECOMMENDATIONS OF THE 7TH SESSION OF THE WORKING PARTY ON TEMPERATE TUNAS : ASSESSMENT MEETING

The WPTmT **RECALLED** the recommendations contained in the Working Party on Temperate Tunas: Data Preparatory Meeting (WPTmT07(DP)) Report.

Revision of the WPTmT Program of Work

WPTmT07.01 (Para 83) The WPTmT **RECOMMENDED** that the SC consider and endorse the WPTmT Program of Work (2020–24), as provided at Appendix V.

Date and place of the 8th and 9th Sessions of the WPTmT

WPTmT07.02 (para 89) The WPTmT **RECOMMENDED** that a data preparatory meeting (DP) and stock assessment meeting (AS) be held in the same year, with the data preparatory meeting being held between April and June and the assessment meeting in August or September. This would facilitate the provision of CPUE series using data from the previous year to the data preparatory meeting, while ensuring catch data for the previous year, which is due to be submitted to the IOTC Secretariat by the end of June each year, is available for use in the stock assessments. The exact dates and meeting locations will be confirmed and communicated by the IOTC Secretariat to the SC for its consideration.

i. WPTmT08(DP): Host to be decided. Meeting to be held between April and June 2022 (TBC).

ii. WPTmT08(AS): Host to be decided. Meeting to be held between August and September 2022 (TBC).

Review of the draft, and adoption of the Report of the 7th Session of the WPTmT

WPTmT07.03 (para 90) The WPTmT **RECOMMENDED** that the Scientific Committee consider the consolidated set of recommendations arising from WPTmT07, provided in Appendix VI, as well as the management advice provided in the draft resource stock status summary for albacore (Appendix IV).