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REFERENCE DOCUMENT FOR THE REVIEW OF CMM 2017-01 AND DEVELOPMENT OF HARVEST STRATEGIES UNDER CMM 2014-06 (Bigeye, Yellowfin, and Skipjack Tuna)

WCPFC15-2018-11
6 November 2018

Paper prepared by the Secretariat

A. INTRODUCTION

1. The purpose of this paper is to provide a quick reference guide to the recommendations of the Scientific Committee (SC) and the Technical and Compliance Committee (TCC) of relevance to the discussions in support of the review of CMM 2017-01. This paper includes stock status and management advice for each species, review of the effectiveness of bigeye measure through projections, recommendations on target reference points for bigeye and yellowfin tuna, management issues related with the use of FADs, and the progress of developing management strategy evaluation for skipjack tuna stock.

B. SCIENTIFIC COMMITTEE RECOMMENDATIONS

2. Brief descriptions on stock status and management advice from SC14 on bigeye, yellowfin and skipjack tuna are listed below. Full recommendations from SC12 to SC14 on each of the three species are annexed as Attachments to this document.

BIGEYE TUNA (*Paragraphs 158 – 184, 499, SC14 Summary Report*)

Stock status and management advice (*see* **Attachment 1** *for the details*)

3. SC14 noted that the preliminary estimate of total catch of WCPO bigeye tuna for 2017 was 126,929 mt, a 17% decrease from 2016 and a 19% decrease from the average 2012-2016. Longline catch in 2017 (58,164 mt) was an 8% decrease from 2016 and a 19% decrease from the 2012-2016 average. Purse seine catch in 2017 (56,194 mt) was a 12% decrease from 2016 and a 13% decrease from the 2012-2016 average. Pole and line catch (1,411 mt) was a 65% decrease from 2016 and a 70% decrease from the average 2012-2016 catch. Catch by other gear (11,160 mt) was a 48% decrease from 2016 and 28% decrease from the average catch in 2012-2016.

4. Based on the uncertainty grid adopted by SC14, the WCPO bigeye tuna spawning biomass is above the biomass LRP and recent F is very likely below F_{MSY}. The stock is not experiencing overfishing (94% probability $F<F_{MSY}$) and it is not in an overfished condition (0% probability $SB/SB_{F=0}<LRP$).

5. SC14 noted that levels of fishing mortality and depletion differ among regions, and that fishery impact was higher in the tropical region (Regions 3, 4, 7 and 8 in the stock assessment model), with particularly high fishing mortality on juvenile bigeye tuna in these regions. SC14 therefore recommends that WCPFC15 could continue to consider measures to reduce fishing mortality from fisheries that take juveniles, with the goal to increase bigeye fishery yields and reduce any further impacts on the spawning biomass for this stock in the tropical regions.

Research recommendations (*Paragraphs 183 – 184, SC14 Summary Report*)

6. SC14 noted that the acceptance of the updated new growth model for BET raises a number of issues in relation to patterns of growth and stock structure of BET across the Pacific Ocean and recommended that the following research issues need to be addressed:

1) Two different growth models separated at 150˚W effectively means that Pacific BET should be assessed as a two-stock resource between the WCPO and EPO. However, catch information indicates that the fishing grounds near 150˚W are a core area of BET catch, thus influencing the assessments of both the WCPFC and IATTC. Also, tagging information suggests movement of BET between the WCPO and EPO. Therefore, the appropriateness off delineating the two stocks at 150˚W needs to be investigated.
2) The updated new growth analysis suggests area variant growth across the Pacific. While the level of variation is seen to be relatively small within the WCPO (and possibly within the margins of observation error), there is a suggestion of substantial change in growth around the boundary between the WCPO and the EPO (c.f. Figure 14 in SC14-SA-WP-01). The reasons for this suggested change in growth remains unknown, but SC14 noted the utility of collecting more information from the regions either side of this boundary to inform a greater understanding of possible changes in growth around this area. While the incorporation of area-variant growth within the assessment model would also help explore this issue, SC14 noted the difficulty of this task.
3) SC11 concluded that the stock status of WCPO BET from the Pan-Pacific assessment and the WCPO-only assessment were similar when the growth models were similar in the EPO and WCPO. This conclusion needs to be revisited in light of the different growth between EPO and WCPO by adopting the new growth.

7. The following additional research activities were also recommended by SC14 in order to improve the understanding of the age and growth of BET across the Pacific:

1) A WCPO growth model based on size composition and tagging data, as well as the use of additional modeling approaches (e.g., length-conditional), should also be evaluated.
2) Collaboration with the IATTC to analyze bigeye growth from otolith and tagging data collected across the entire Pacific, to better characterize the apparent regional difference in growth between the WCPO and EPO, and possible environmental determinants of such differences.
3) Analyzing the same otoliths by different laboratories, to build confidence in ageing estimates and to estimate ageing error.
4) Continued development of a high-confidence tagging dataset for growth analysis, with particular focus on larger bigeye tuna and events with reliable measurements at release. Such data would assist with the validation of the age estimates of large bigeye in the WCPO, and could potentially be incorporated directly into the assessment model as an additional data set. However, a reliable measurement of both length at release and recapture are necessary to accurately estimate incremental growth.

5) Collect otoliths of very small bigeye that are captured by the Indonesian, Vietnamese, and Philippines domestic fisheries in region 7 and estimate age through daily ring counts to aid in the estimation of the size at age-1 qtr^{-1} parameter (L1) within the assessment model.

Review the effectiveness of CMM 2017-01 (*Paragraphs 409 and 180 – 182, SC14 Summary Report*)

Effectiveness of the CMM through projections (Paragraphs 494 and 180 – 182, SC14 Summary Report):

8. As requested in the Harvest Strategy Work Plan, as updated by WCPFC14, SC14 reviewed information on the likely outcomes of the revised tropical tuna measure (CMM 2017-01) in relation to bigeye tuna (SC14-MI-WP-08a; detailed analysis of the projections of BET is provided in Section 4.1.1.2 of the report, including the following three paragraphs). SC14 noted that outcomes are strongly influenced by the assumed future recruitment levels and the time period of the projections. SC14 recommended that the working paper be forwarded to WCPFC15. SC14 noted that projection analyses such as those detailed in the working paper should be presented in conjunction with the stock assessment results in future SC meetings.

(Section 4.1.1.2)

9. SC14 noted that according to CMM 2017-01 bigeye tuna $SB/SB_{F=0}$ is to be maintained above the 2012-2015 level ($SB_{recent}/SB_{F=0}$ = 0.36; Table BET-3) pending the agreement on a TRP. SC14 also noted that the projection results based on scenarios estimating CMM 2017-01 indicated a high level of uncertainty on the levels of spawning stock biomass relative to the LRP and the objective of CMM 2017-01 in 2045. Under the scenario assuming long-term average recruitment continues into the future there was a high risk (18-32%) of breaching the LRPs and a zero probability of achieving the objective of CMM 2017-01, while under the scenario which assumes higher more recent recruitments continues into the future there was a low risk (0-5%) of breaching the LRPs and a 100% probability of achieving the objective of CMM 2017-01.

10. However, SC14 also noted that the projections assume that longline catches would be maintained regardless of the decrease in biomass. This may result in unlikely high levels of effort. Therefore, the catch estimates under the long term recruitment scenario, especially in the longer term projections, are more uncertain.

11. Based on these results, SC14 recommends that WCPFC15 takes note of the results of the projections in relation to achieving CMM-2017-01 and as a precautionary approach that the fishing mortality on bigeye tuna stock should not be increased from the recent average (2011-2014) level to maintain spawning biomass at or above the 2012-2015 average, until the Commission can articulate the management objectives and agree on an appropriate TRP for bigeye, although one CCM considers that SC14 could provide more options for the commission to consider.

Management issues related to FADs (Paragraphs 507 – 508 and 520 – 521, SC14 Summary Report)

12. SC14 reviewed information on analyses of the PNA's fish aggregating device (FAD) tracking program (SC14-MI-WP-09). SC14 expressed strong support for this type of research and its continuation, noting that the PNA FAD tracking program is providing information and insight that is adding substantial value to the scientific understanding of WCPO fisheries. However, SC14 noted the ongoing practice of fleets not providing full data (estimates indicate that 60–70% of buoy transmissions are not forwarded to the PNA via practices such as geo-fencing) which substantially undermines the scientific value of the information and prevents the SC from being able to provide comprehensive advice to the Commission on FAD dynamics, economics and management. SC14 also expressed concern about the estimated high rate

(5%) of beaching events in tracked FADs, with the vast majority of these being in PNA countries, together with the estimated high rate of 'lost' FADs (up to 27%).

13. SC14 recommends that WCPFC15 note the importance of FAD marking and monitoring programs to better identify and follow individual FADs. To address the marine pollution issue, reduce the risk to coastal communities, reefs, and fish stocks SC14 recommends the use of biodegradable FADs, non-entangling, non-entrapping, and environmentally-friendly FAD designs, better measures for FAD control and retrieval, and fewer FAD deployments. SC14 also recommends that the Secretariat ensure this working paper is made available to inform the deliberations of the FAD Management IWG meeting to be held in October 2018 and that WCPFC15 take note of the concerns expressed above and support appropriate measures.

14. SC14 reviewed information on the estimation of the number of drifting Fish Aggregating Device (FAD) deployments and active FADs per vessel over the period 2011-2018 (SC14-MI-WP-10), noting that purse seine fishing on drifting FADs accounts for about 40% of the purse seine tuna catch in the WCPO. SC14 noted the limitations of the different sources of data used in the analysis but expressed strong support for and the utility of this research. Preliminary estimates of FAD deployments ranged between 30,700–56,900 in 2016 and 44,700–64,900 in 2017 (using combined fishery and PNA FAD tracking data). SC14 also noted that based upon the information provided in the paper, the present per vessel limit of 350 active FADs (at any one time) in the WCPO likely does not constrain or reduce the number of FADs in the water, given that the average vessel at the moment is estimated to have around 117 FADs in the water at any time (assuming the average life of an active FAD is 6 months). However, pointing to the uncertainty of the number of FADs deployed in the WCPO, the identified deficiencies in FAD tracking data, and the differences of the number of active FADs between estimates and the actual operations, some CCMs suggested that the SC continues to provide the further analysis on active FAD number with the additional available data such as improving the FAD data fields to be reported by observers and/or vessel operators.

15. SC14 recommends that the Secretariat ensure this working paper is made available to inform the deliberations of the FAD Management IWG meeting to be held in October 2018. SC14 also recommends that the FAD Management IWG and WCPFC15 take into consideration the concerns expressed above and determine a more appropriate limit that (i) helps reduce the amount of marine debris, synthetic pollution and beaching events generated by FAD deployment, and (ii) helps to avoid any economic impacts on the purse seine fishery through reduced CPUE. SC14 also recommends that additional work on these issues be supported, noting that improved data collection in both the observer and logbook records would also assist this research.

Target reference points for bigeye and yellowfin tuna (*Paragraphs 398, SC14 Summary Report*)

16. SC14 reviewed information on what would be the minimum setting for a candidate spawning-biomass-depletion-based TRP (or maximum fishing-mortality-based TRP) for yellowfin tuna that avoids breaching the LRP with a specified level of probability under the current uncertainty framework (SC14-MI-WP-01). While SC14 noted that the main biological consideration for a TRP is that it should be sufficiently above the LRP, SC14 also noted that the choice of a TRP can be based on a combination of biological, ecological and socioeconomic considerations. In this regard consideration in future of other economic and social objectives for yellowfin tuna in the selection of candidate TRPs would be welcome. Several CCMs also viewed management objectives and TRPs as economic decisions, and that in the context of a multi-species and multi-gear fishery they cannot be taken on a species by species basis in isolation. SC14 recommended that the analyses be repeated for bigeye tuna taking account of the updated 2018 bigeye stock assessment, and with both 'recent' and 'long term' recruitment assumptions. SC14 recommends that WCPFC15 take note of these results in consideration of management objectives upon

which any candidate TRPs for yellowfin tuna and bigeye tuna should be based, and in so doing clarify the management objectives for these species (including the selection of risk levels) so that the additional work identified above can be undertaken.

YELLOWFIN TUNA (*SC14: Paragraphs 193 – 198; SC13: Paragraphs 265 – 279*)

Stock status and management advice (*see* **Attachment 2** *for details of scientific information from SC13*)

17. SC14 noted that the total yellowfin catch in 2017 was a record 670,890 mt, a 4% increase from 2016 and a 12% increase from the average 2012-2016.

18. Purse seine catch in 2017 (472,279 mt) was a 22% increase from 2016 and a 33% increase from the 2012-2016 average. Longline catch in 2017 (83,399 mt) was a 6% decrease from 2016 and a 9% decrease from the 2012-2016 average. Pole and line catch (12,219 mt) was a 48% decrease from 2016 and a 56% decrease from the average 2012-2016 catch. Catch by other gear (102,993 mt) was a 28% decrease from 2016 and 17% decrease from the average catch in 2012-2016.

19. SC14 noted that under recent fishery conditions, the yellowfin stock was initially projected to increase as recent estimated relatively high recruitments support adult stock biomass, then decline slightly. Median F_{2019}/F_{MSY} = 0.63; median $SB_{2019}/SB_{F=0}$ = 0.37; median SB_{2019}/SB_{MSY} = 1.51. Risk that SB_{2019} < LRP = 6%.

20. SC14 noted that no stock assessment was conducted for WCPO yellowfin tuna in 2018. Therefore, the stock status description from SC13 is still current, and the advice from SC13 should be maintained to achieve the objectives set in CMM 2017-01, pending a new assessment or other new information.

Research recommendations

21. SC14 reviewed the work on age and growth of yellowfin tuna presented in SC14-SA-WP-13 and noted that the final results of this projected will be presented to SC15. SC14 encouraged analysis of the same otoliths by different laboratories, to build confidence in ageing estimates through inter laboratory daily-annual age workshop.

SKIPJACK TUNA (*Paragraphs 209 – 215, SC14 Summary Report*)

Stock status and management advice (*see* **Attachment 3** *for details of scientific information from SC12*)

22. SC14 noted that the total catch in 2017 was 1,624,162 mt, a 9% decrease from 2016 and comparable to the average from 2012-2016.

23. Purse seine catch in 2017 (1,280,311 mt) was a 7% decrease from 2016 and a 12% decrease from the 2012-2016 average. Pole and line catch (123,132 mt) was a 21% decrease from 2016 and a 23% decrease from the average 2012-2016 catch. Catch by other gear (218,175 mt) was a 13% decrease from 2016 and 1% decrease from the average catch in 2012-2016.

24. SC14 noted that under recent fishery conditions (2017 catch level for longline and other fisheries and effort level for purse seine), the skipjack stock was initially projected to decrease for a short period as recent relatively high recruitments move out of the stock. Median F_{2019}/F_{MSY} = 0.47; median $SB_{2019}/SB_{F=0}$

= 0.45; median SB_{2019}/SB_{MSY} = 1.67. In the longer term, assuming long term average recruitment, modest increases in the stock were projected.

25. SC14 noted that no stock assessment has been conducted since SC12. Therefore, the advice from SC12 should be maintained to achieve the objectives set in CMM 2017-01, pending a new assessment or other new information.

Research Recommendations

26. SC14 discussed a proposal for an alternative regional structure to be considered in the next skipjack stock assessment (SC14-SA-WP-04) and recommended that the pre-assessment workshop consider how this proposal might be included in the next assessment.

27. SC14 supports an ongoing tagging program for skipjack tuna to ensure a reliable indicator of skipjack tuna abundance in the stock assessment.

28. SC14 recommended that the Scientific Services Provider continue research on standardizing purse seine CPUE for use in the assessment.

Management Strategy Evaluation *(Paragraphs 454 – 458, SC14 Summary Report)*

29. SC14 reviewed several papers related to ongoing work which is being undertaken by the Scientific Services Provider as specified in the Harvest Strategy Work Plan as updated by WCPFC14 (Attachment L in the WCPFC14 Summary Report). It noted that the MSE evaluation framework is constructed from two main components, an operating model (OM) and a management procedure (MP).

30. First, SC14 reviewed information on the process of developing and parameterising an OM for the dynamics of the skipjack stock in the WCPO and the fishing fleets that exploit them (SC14-MI-WP-03). In particular, it reviewed and provided feedback on the sources of uncertainty (such as implementation error) that should be included to ensure that the OM covers all important sources of uncertainty, against which the performance of a MP should be evaluated. Several CCMs also expressed a view that the OMs being developed should allow the impacts on other species to be considered. SC14 noted that in the past the Scientific Services Provider have used some models to look at the impacts of CMMs on more than one species and such an approach, effectively running species-specific but similarly structured OMs in parallel, may be applicable in this case as part of future developments. SC14 also noted that the selection and refinement of OMs and other components of the MSE process will involve an extended iterative and consultative process and requested that the Scientific Services Provider incorporate the specific feedback of CCMs into future iterations.

31. Second, SC14 reviewed information and provided clarification and feedback on the development and use of a range of performance indicators for evaluating the relative performance of a set of demonstration management procedures (SC14-MI-WP-04), in particular the list of 11 indicators (**Attachment 4**) identified for inclusion for the Tropical Purse Seine Fisheries from Attachment M in WCPFC13 Summary Report. Methods for comparing and synthesizing the relative performance of management procedures using the performance indicators (PI) were also reviewed. SC14 noted that several performance indicators that cannot be quantified in the OM can be moved to the monitoring strategy, though it expressed support for the retention of performance indicator PI-5 (to maximize SIDS revenue from resource rents) and recommended that further work be undertaken to identify options to better evaluate this objective. For PI-10 (avoid adverse impacts on small scale fisheries) several CCMs advocated that the estimation of MSY for the tropical tunas can be used as a proxy to assess downstream effects from the purse seine fishery and recommended that further work be undertaken. Some CCMs also

supported the retention of PI-11 because of the multi-species nature of this fishery. SC14 also noted that the use of a smaller number of performance indicators will aid in comparing the relative performance of candidate management procedures. SC14 also agreed that, i) the distribution of the indicator values, not just a measure of the central tendency, should be considered, ii) that the time periods over which the indicators are calculated should be based on an appropriate number of management cycles, based on the life history of the stock, and iii) that the further development of potential indicators and how they are presented is an ongoing process and will benefit from the engagement with other stakeholder groups.

32. Third, SC14 reviewed information on the key decisions that i) regional fishery managers and stakeholders, and ii) scientists (through the Scientific Committee) will need to consider under the work plan for adoption of harvest strategies for tuna stocks and fisheries in the WCPO (SC14-MI-WP-05). In noting the useful summary provided by this paper of the roles that each group plays in moving the harvest strategy workplan forward, SC14 also noted that discussion and negotiations would be required on a number of issues and that certain issues would need to be undertaken by both managers and scientists together.

33. SC14 requested that revised versions of the above working papers be forwarded to WCPFC15 taking into account the suggestions to clarify, revise and update as appropriate, aspects of these papers. SC14 recommends that WCPFC15 note the progress on the development of the MSE being undertaken under the Harvest Strategy Work Plan and provide the necessary elements being requested from the Commission to further progress this work against the scheduled time-lines noted in this work-plan.

C. TECHNICAL AND COMPLIANCE COMMITTEE RECOMMENDATIONS

34. [Provisional CMR report and Executive Summary] TCC14 recommended that WCPFC15 review and revise, as appropriate, the following obligations, noting that more information related to these recommendations is contained in the Provisional CMR:

c. the equivalent of paragraphs 14, 16, 18 and 22 of CMM 2016-01 in CMM 2017-01;
d. CMM 2016-01, and subsequent versions, in relation to charters.

(TCC14 draft summary report, para 98)

Attachment 1

WCPO BIGEYE TUNA (*Paragraphs 158 – 184, SC14 Summary Report*)

Provision of scientific information

a. Stock status and trends

1. The median values of relative recent (2012-2015) spawning biomass depletion ($SB_{recent}/ SB_{F=0}$) and relative recent (2011-2014) fishing mortality (F_{recent}/F_{MSY}) over the uncertainty grid of 36 models (Table BET-1) were used to define stock status. The values of the upper 90th and lower 10th percentiles of the empirical distributions of relative spawning biomass and relative fishing mortality from the uncertainty grid were used to characterize the probable range of stock status.

2. A description of the updated structural sensitivity grid used to characterize uncertainty in the assessment is set out in Table BET-1. Time series of total annual catch by fishing gear over the full assessment period is shown in Figure BET-1. Estimated trends in spawning biomass depletion for the 36 models in the structural uncertainty grid is shown in Figure BET-2, and juvenile and adult fishing mortality rates from the diagnostic case model is show in BET-3. Figure BET-4 displays Majuro plots summarising the results for each of the models in the structural uncertainty grid. Figures BET-5 show Kobe plots summarising the results for each of the models in the structural uncertainty grid. Table BET-2 provides a summary of reference points over the 36 models in the structural uncertainty grid.

3. SC14 agreed to use the "updated new growth" model to describe the stock status of bigeye tuna because SC14 considered it to be the best available scientific information. By removing results using the old growth model, the stock status becomes considerably more optimistic. However, SC14 also notes that questions remain regarding the "updated new growth" model.

4. Therefore, SC14 acknowledges that further study is warranted related to the new growth model, in particular as to the cause of the difference of growth between EPO and WCPO. An inter-laboratory ageing workshop is planned for late 2018 to review ageing approaches in the WCPO and EPO and to resolve differences, if they exist.

5. In addition, SC14 acknowledges that further study is warranted to refine the tagging dataset in the WCPO to assist validating age estimates of bigeye in the WCPO. SC14 further notes that adopting the updated new growth curve generates new broader questions related to the bigeye tuna stock assessment and agreed that several aspects need to be investigated further to inform future assessments.

Table BET-1. Description of the updated structural sensitivity grid used to characterize uncertainty in the assessment.

Axis	Levels	Option
Steepness	3	0.65, 0.80, 0.95
Growth	1	'Updated new growth'
Tagging over-dispersion	2	Default level (1), fixed (moderate) level
Size frequency weighting	3	Sample sizes divided by 10, 20, 50
Regional structure	2	10°N regions, 20°N regions

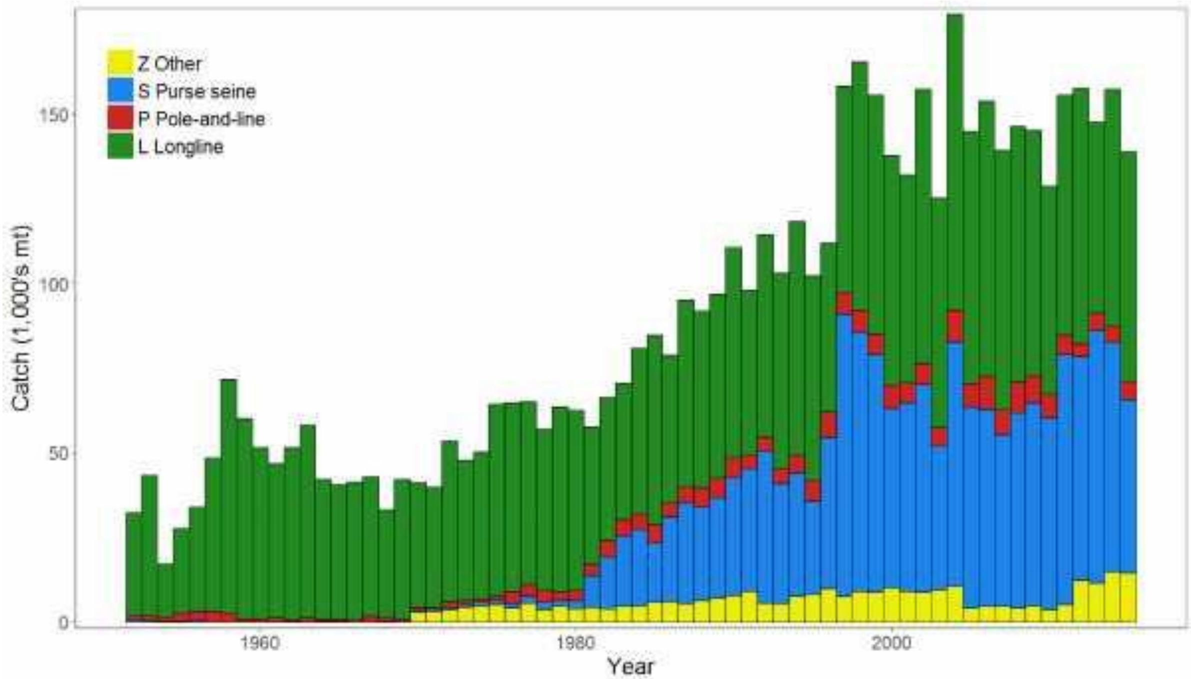


Figure BET-1. Time series of total annual catch (1000's mt) by fishing gear over the full assessment period.

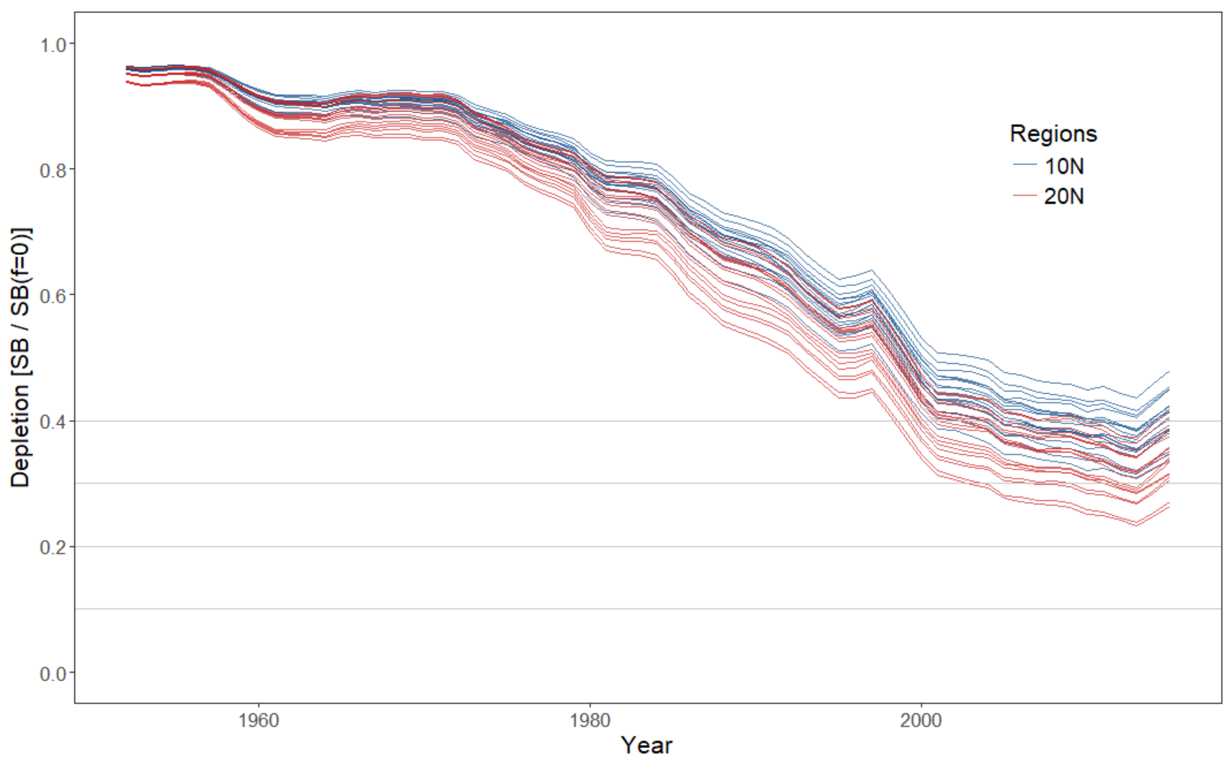


Figure BET-2. Plot showing the trajectories of spawning biomass depletion for the 36 model runs included in the structural uncertainty grid. The colours depict the models in the grid with the 10°N and 20°N spatial structures.

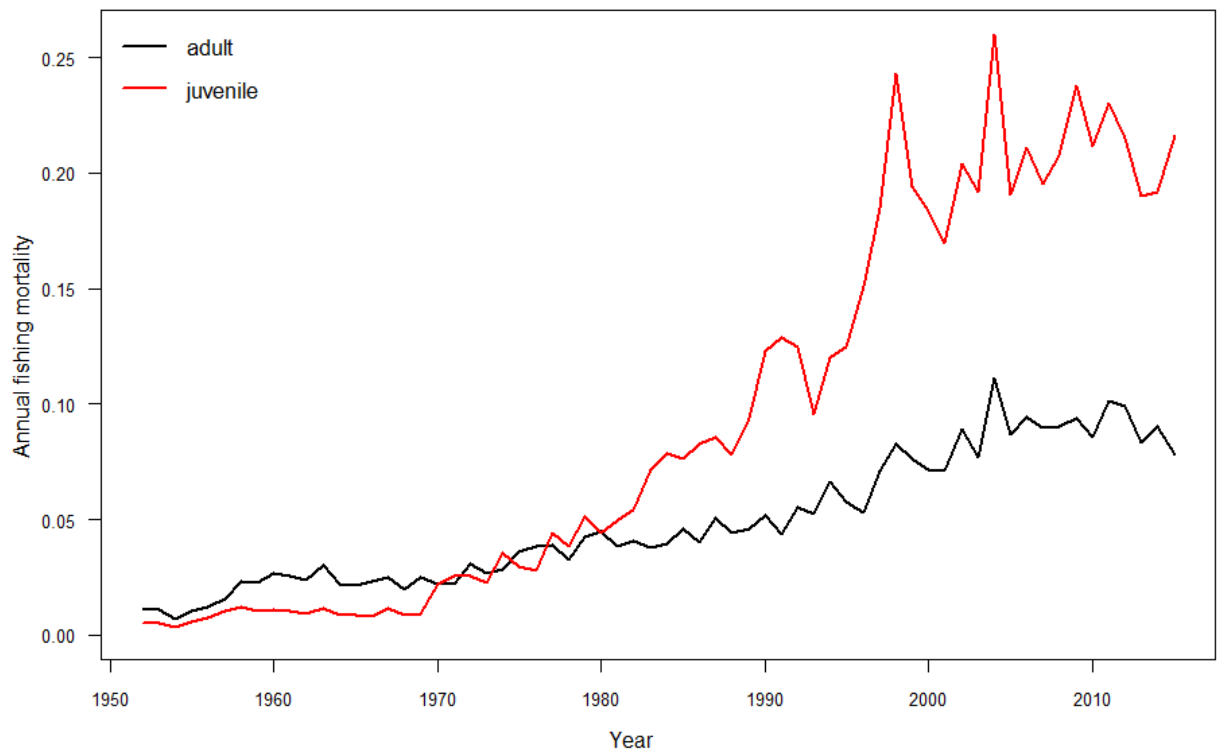
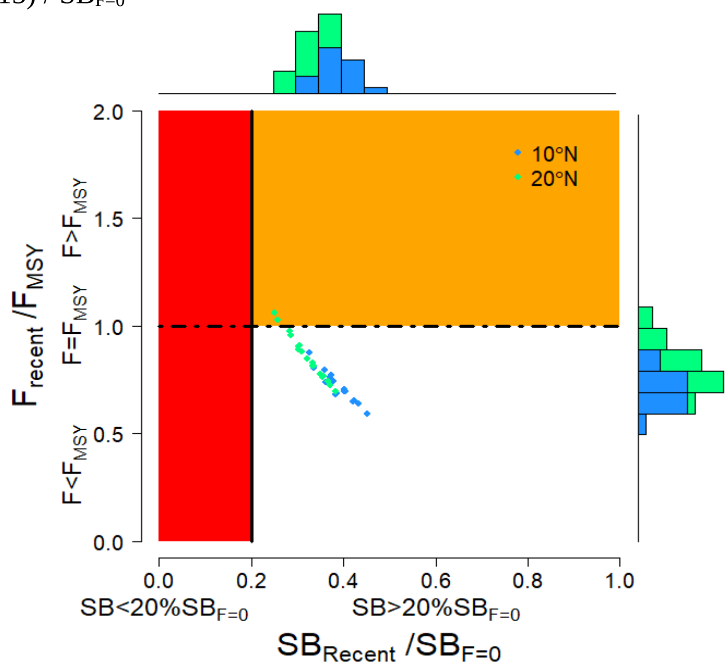


Figure BET-3. Estimated annual average juvenile and adult fishing mortality for the diagnostic case model.

SB_{recent} (2012-2015) / $SB_{F=0}$



SB_{latest} (2015) / $SB_{F=0}$

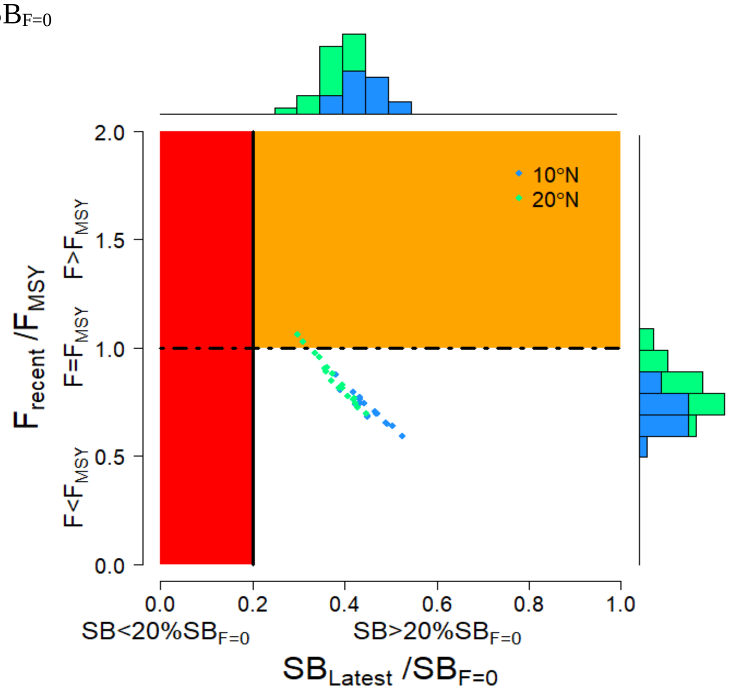
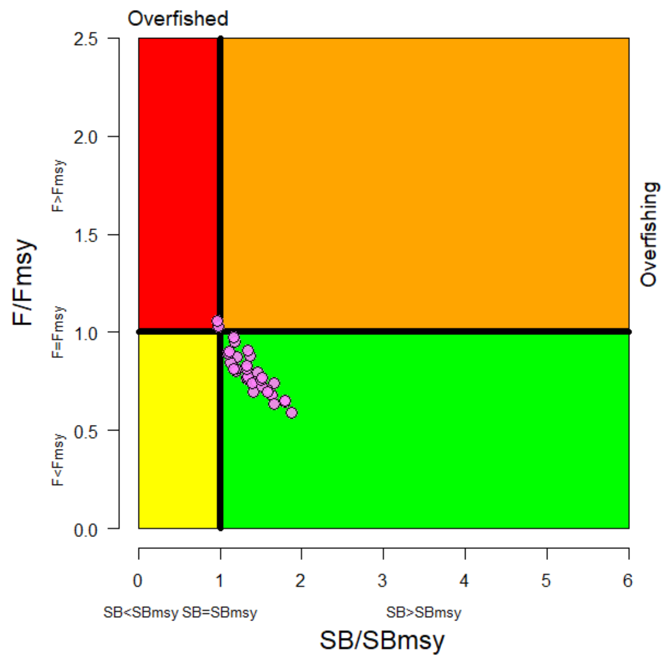


Figure BET-4. Majuro plot summarising the results for each of the models in the structural uncertainty grid. The plots represent estimates of stock status in terms of spawning biomass depletion and fishing mortality. The red zone represents spawning biomass levels lower than the agreed limit reference point, which is marked with the solid black line. The orange region is for fishing mortality greater than F_{MSY} (F_{MSY} is marked with the black dashed line). In the upper panel, the points represent $SB_{recent}/SB_{F=0}$, where SB_{recent} is the mean SB over 2012-2015. In the lower panel, the points represent $SB_{latest}/SB_{F=0}$, where SB_{latest} is from 2015. In both panels the colors depict the models in the grid with the 10°N and 20°N regional structures.

SB$_{recent}$ (2012-2015) / SB$_{MSY}$



SB$_{latest}$ (2015) / SB$_{MSY}$

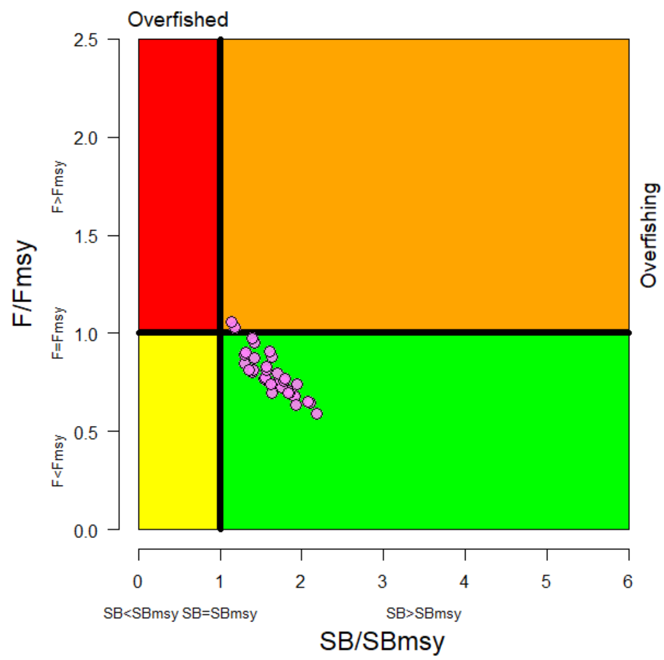


Figure BET-5. Kobe plot summarising the results for each of the models in the structural uncertainty grid. In the upper panel, the points represent *SBrecent/SBMSY*, where *SBrecent* is the mean *SB* over 2012-2015. In the lower panel, the points represent SB_{latest}/SB_{MSY}, where SB_{latest} is from 2015.

Table BET-2. Summary of reference points over the 36 models in the structural uncertainty grid. Note that *SBrecent/SBF=0* is calculated where *SBrecent* is the mean *SB* over 2012-2015 at the request of the Scientific Committee.

	Mean	Median	Min	10%	90%	Max
C_{latest}	152,148	151,846	148,888	148,936	154,971	155,577
YF_{recent}	154,180	153,220	133,120	141,140	170,720	172,280
f_{mult}	1.291	1.301	0.946	1.075	1.499	1.690
F_{MSY}	0.050	0.049	0.044	0.045	0.054	0.056
MSY	158,551	159,020	133,520	143,040	173,880	180,120
F_{recent}/F_{MSY}	0.789	0.768	0.592	0.667	0.931	1.058
SB_0	1,674,833	1,675,500	1,261,000	1,415,500	1,941,000	2,085,000
$SB_{F=0}$	1,841,609	1,858,775	1,509,007	1,632,014	2,043,108	2,139,644
SB_{MSY}	471,956	476,050	340,700	386,600	577,400	614,200
SB_{MSY}/SB_0	0.281	0.280	0.260	0.262	0.300	0.302
$SB_{MSY}/SB_{F=0}$	0.255	0.255	0.226	0.235	0.280	0.287
SB_{latest}/SB_0	0.456	0.456	0.346	0.392	0.523	0.568
$SB_{latest}/SB_{F=0}$	0.414	0.420	0.298	0.351	0.480	0.526
SB_{latest}/SB_{MSY}	1.633	1.624	1.146	1.306	1.933	2.187
$SB_{recent}/SB_{F=0}$	0.353	0.358	0.251	0.295	0.412	0.452
SB_{recent}/SB_{MSY}	1.394	1.377	0.963	1.117	1.659	1.879

6. SC14 noted that there has been a long-term decrease in spawning biomass from the 1950s to the present for bigeye tuna and that this is consistent with previous assessments.

7. SC14 also noted that the central tendency of relative recent (2012-2015) spawning biomass depletion was median ($SB_{recent}/SB_{F=0}$) = 0.36 with a range of 0.30 to 0.41 (80% probability interval).

8. SC14 further noted that there was 0% probability (0 out of 36 models) that the recent spawning biomass had breached the adopted LRP.

9. SC14 noted that there has been a long-term increase in fishing mortality for both juvenile and adult bigeye tuna (Figure BET-3), consistent with previous assessments.

10. SC14 also noted that the central tendency of relative recent fishing mortality was median (F_{recent}/F_{MSY}) = 0.77 with an 80% probability interval of 0.67 to 0.93.

11. SC14 further noted that there was a roughly 6% probability (2 out of 36 models) that the recent fishing mortality was above F_{MSY}.

12. SC14 also noted that, regardless of the choice of uncertainty grid, the assessment results show that the stock has been continuously declining for about 60 years since the late 1950's, except for the recent small increase.

13. SC14 also noted the continued relatively higher levels of depletion in the equatorial and western Pacific (specifically Regions 3, 4, 7 and 8) and the associated higher levels of impact, especially on juvenile bigeye tuna, in these regions due to the associated purse-seine fisheries and the 'other' fisheries within the western Pacific (as shown in Figures 46 and 47 of SC13-SA-WP-03).

14. Table BET-3 summarises the median values of $SB/SB_{F=0}$ and F/F_{MSY} achieved in the long term, along with the potential risk of breaching the limit reference point (LRP) and exceeding F_{MSY}, under each of the future fishing and recruitment combinations. Figure BET-6 presents the corresponding distributions of long term $SB/SB_{F=0}$ and Figure BET-7 those for F/F_{MSY}.

15. Potential outcomes under the 2013-15 average and CMM scenario conditions were strongly influenced by the assumed future recruitment levels.

16. Under the assumption that recent positive recruitments will continue into the future, spawning biomass relative to unfished levels is predicted to increase from recent levels under all examined future scenarios by 0-18% ($SB_{2045}/SB_{F=0}$ ranges from 0.36 to 0.42; Table BET-3, Figure BET-6). While future uncertainty in stock status increases due to stochastic future recruitment levels, the risk of future spawning biomass falling below the LRP falls to between 0 and 5%, due to the improved overall stock size. Fishing mortality falls slightly under both the status quo and optimistic scenarios, assuming recent recruitment. However, fishing mortality increases under the pessimistic scenario, but remains below F_{MSY} (30% risk of $F > F_{MSY}$ Table BET-3, Figure BET-7).

17. Under the assumption that less positive long-term recruitments are experienced in the future, spawning biomass relative to unfished levels will decline under all scenarios ($SB_{2045}/SB_{F=0}$ ranges from 0.25 to 0.30). The risk of spawning biomass falling below the LRP increases to between 17 and 32% (Table BET-3). In all fishing scenarios, fishing mortality increases relative to recent levels (by 109-138%) and is well above F_{MSY}. Risk of fishing mortality exceeding F_{MSY} ranges from 93 to 98%.

18. It should be noted that even under assumption of long term recruitment levels, the risk of exceeding the LRP in the short term ranges between 2% and 7% (2020) and 12 and 26% (2025), with only the pessimistic scenario exceeding the 20% level of risk in 2025. (Table BET-4 and Figure BET-8)

Table BET-3. Including '2013-2015 average levels'
Median values of reference point levels (adopted limit reference point (LRP) of 20% $SB_{F=0}$; F_{MSY}) and risk[1] of breaching reference points from the 2018 bigeye stock assessment incorporating updated new growth information, and in 2045 under the three future harvest scenarios (2013-2015 average fishing levels, optimistic, and pessimistic) and alternative recruitment hypotheses. 'Updated new growth' runs only.

Scenario		Scalars relative to 2013-2015		Median $SB_{2045}/SB_{F=0}$	Median $SB_{2045}/SB_{F=0}$ v $SB_{2012-15}/SB_{F=0}$	Median $F_{2041-2044}/F_{MSY}$	Median $F_{2041-2044}/F_{MSY}$ v $F_{2011-14}/F_{MSY}$	Risk	
Recruitment	**Fishing level**	**Purse seine**	**Long line**					**SB_{2045} < LRP**	**$F>F_{MSY}$**
Bigeye assessment ('recent' levels)				0.36	-	0.77	-	0%	6%
Recent	2013-2015 average	1	1	0.42	1.18	0.73	0.95	0%	11%
	Optimistic	1.11	0.98	0.41	1.15	0.75	0.98	0%	13%
	Pessimistic	1.12	1.35	0.36	1.00	0.89	1.15	5%	30%
Long-term	2013-2015 average	1	1	0.30	0.84	1.60	2.09	17%	93%
	Optimistic	1.11	0.98	0.29	0.82	1.64	2.13	18%	94%
	Pessimistic	1.12	1.35	0.25	0.70	1.84	2.38	32%	98%

[1] note risk within the stock assessment is calculated as the (weighted) number of models falling below the LRP (X / 36 models). Risk under a projection scenario is the number of projections across the grid that fall below the LRP (X / 3600 (36 models x 100 projections).

Table BET-4. Median values of $SB/SB_{F=0}$ and associated risk of breaching the adopted limit reference point (LRP) of 20% SBF=0 in 2020, 2025 and 2045 under the three future harvest scenarios (2013-2015 average fishing levels, optimistic, and pessimistic) and alternative recruitment hypotheses. 'Updated new growth' runs only.

Scenario		Scalars relative to 2013-2015		Median $SB_{2020}/SB_{F=0}$	Median $SB_{2025}/SB_{F=0}$	Median $SB_{2045}/SB_{F=0}$	Risk SB_{2020} < LRP	Risk SB_{2025} < LRP	Risk SB_{2045} < LRP
Recruitment	**Fishing level**	**Purse seine**	**Long line**						
Recent	2013-2015 average	1	1	0.42	0.41	0.42	0%	1%	0%
	Optimistic	1.11	0.98	0.41	0.40	0.41	0%	1%	0%
	Pessimistic	1.12	1.35	0.38	0.35	0.36	0%	4%	5%
Long-term	2013-2015 average	1	1	0.35	0.30	0.30	2%	12%	17%
	Optimistic	1.11	0.98	0.35	0.30	0.29	2%	13%	18%
	Pessimistic	1.12	1.35	0.32	0.26	0.25	7%	26%	32%

Recent recruitments   Long-term recruitment

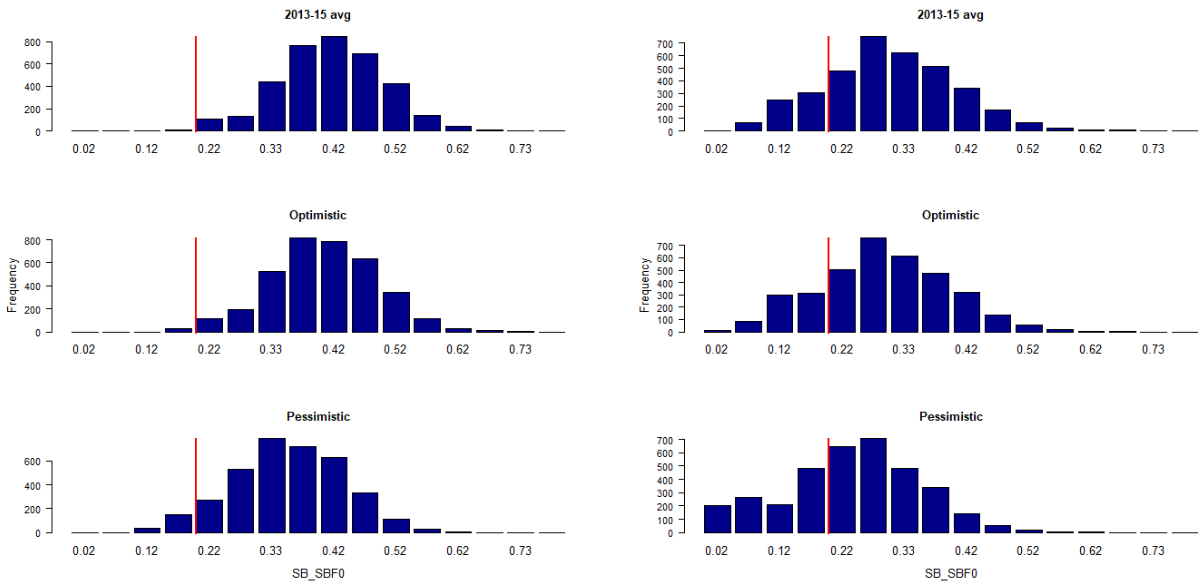


Figure BET-6. Distribution of $SB_{2045}/SB_{F=0}$ assuming recent and long term recruitment conditions (left and right columns, respectively), under the three future fishing scenarios: 2013-15 average (2013-15 average conditions, top row); optimistic conditions (middle row); and pessimistic conditions (bottom row). Projection results from ‘updated new growth’ models (3,600 projections) only where the red line indicates the LRP.

Recent recruitments   Long-term recruitment

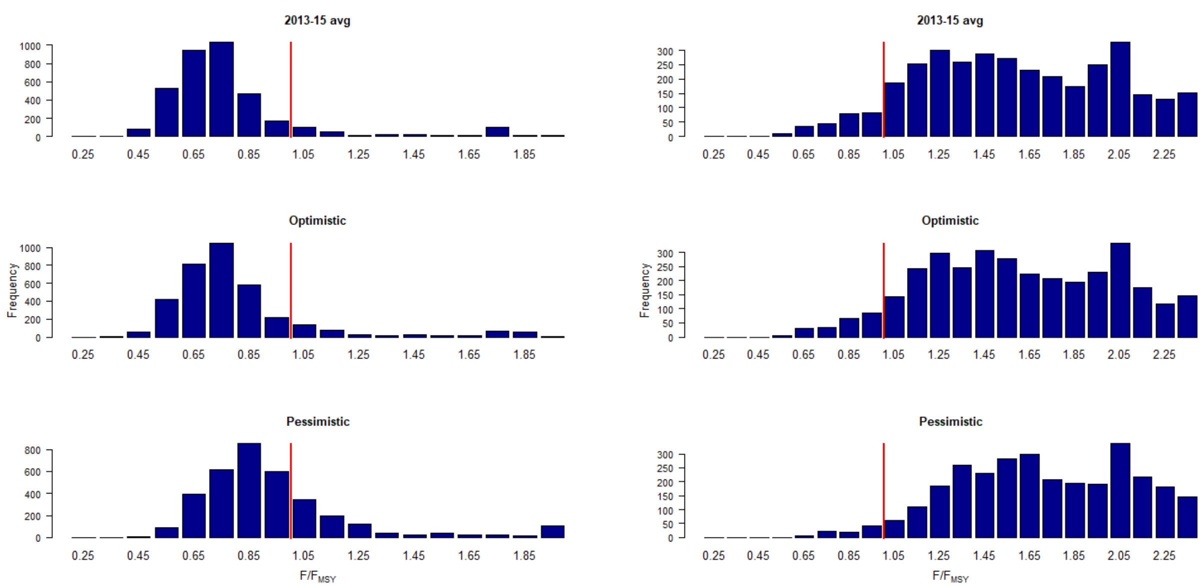
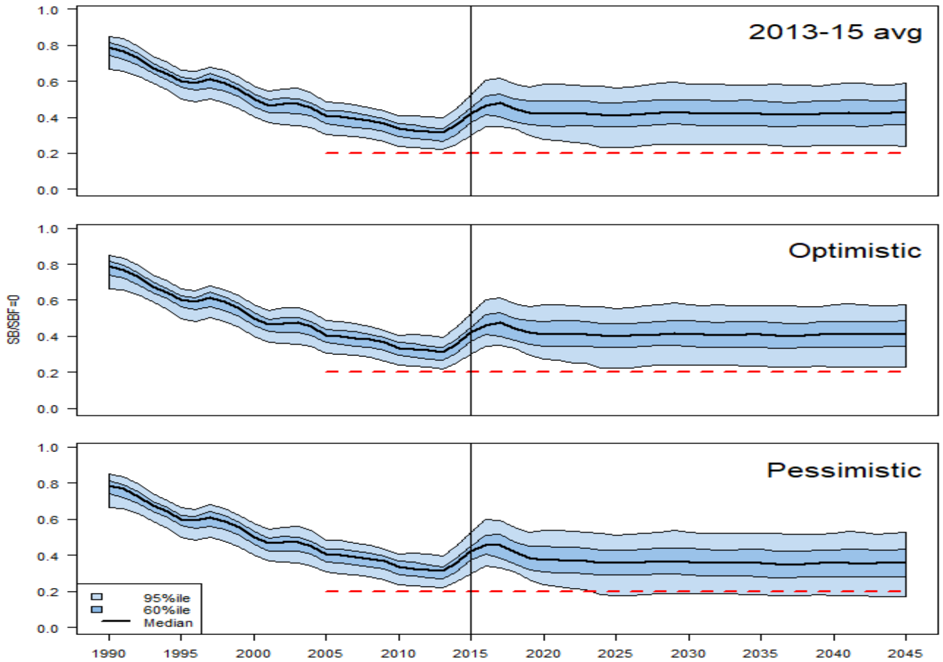


Figure BET-7. Distribution of F/F_{MSY} assuming recent and long term recruitment conditions (left and right columns, respectively), under the three future fishing scenarios: 2013-15 average (2013-15 average conditions, top row); optimistic conditions (middle row); and pessimistic conditions (bottom row). Projection results from ‘updated new growth’ models (3,600 projections) only.

Recent recruitments



Long-term recruitment

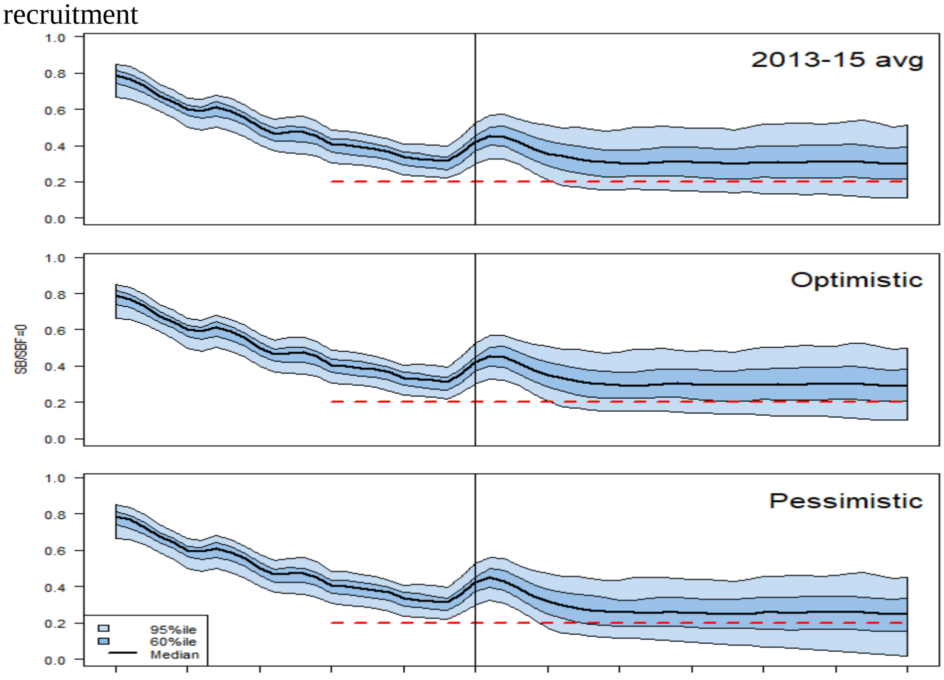


Figure BET-8. Time series of WCPO bigeye tuna spawning biomass ($SB/SB_{F=0}$) from the uncertainty grid of assessment model runs for the period 1990 to 2015 (the vertical line at 2015 represents the last year of the assessment), and stochastic projection results for the period 2016 to 2045 under the three future fishing scenarios ("2013-15 average", "Optimistic" and "Pessimistic"; rows). During the projection period (2016-2045) levels of recruitment variability are assumed to match those over the "recent" time period (2005-2014; left panel) or the time period used to estimate the stock-recruitment relationship (1962-2014; right panel). The red dashed line represents the agreed limit reference point.

b. Management advice and implications

19. SC14 noted that the preliminary estimate of total catch of WCPO bigeye tuna for 2017 was 126,929 mt, a 17% decrease from 2016 and a 19% decrease from the average 2012-2016. Longline catch in 2017 (58,164 mt) was an 8% decrease from 2016 and a 19% decrease from the 2012-2016 average. Purse seine catch in 2017 (56,194 mt) was a 12% decrease from 2016 and a 13% decrease from the 2012-2016 average. Pole and line catch (1,411 mt) was a 65% decrease from 2016 and a 70% decrease from the average 2012-2016 catch. Catch by other gear (11,160 mt) was a 48% decrease from 2016 and 28% decrease from the average catch in 2012-2016.

20. Based on the uncertainty grid adopted by SC14, the WCPO bigeye tuna spawning biomass is above the biomass LRP and recent F is very likely below F_{MSY}. The stock is not experiencing overfishing (94% probability $F<F_{MSY}$) and it is not in an overfished condition (0% probability $SB/SB_{F=0}<LRP$).

21. Although SC14 considers that the updated assessment is consistent with the previous assessment, SC14 also advises that the amount of uncertainty in the stock status results for the 2018 assessment update is lower than for the previous assessment due to the exclusion of old information on bigeye tuna growth.

22. SC14 noted that levels of fishing mortality and depletion differ among regions, and that fishery impact was higher in the tropical region (Regions 3, 4, 7 and 8 in the stock assessment model), with particularly high fishing mortality on juvenile bigeye tuna in these regions. SC14 therefore recommends that WCPFC15 could continue to consider measures to reduce fishing mortality from fisheries that take juveniles, with the goal to increase bigeye fishery yields and reduce any further impacts on the spawning biomass for this stock in the tropical regions.

23. SC14 noted that according to CMM 2017-01 bigeye tuna $SB/SB_{F=0}$ is to be maintained above the 2012-2015 level ($SB_{recent}/SB_{F=0}$ = 0.36; Table BET-3) pending the agreement on a TRP. SC14 also noted that the projection results based on scenarios estimating CMM 2017-01 indicated a high level of uncertainty on the levels of spawning stock biomass relative to the LRP and the objective of CMM 2017-01 in 2045. Under the scenario assuming long-term average recruitment continues into the future there was a high risk (18-32%) of breaching the LRPs and a zero probability of achieving the objective of CMM 2017-01, while under the scenario which assumes higher more recent recruitments continues into the future there was a low risk (0-5%) of breaching the LRPs and a 100% probability of achieving the objective of CMM 2017-01.

24. However, SC14 also noted that the projections assume that longline catches would be maintained regardless of the decrease in biomass. This may result in unlikely high levels of effort. Therefore, the catch estimates under the long term recruitment scenario, especially in the longer term projections, are more uncertain.

25. Based on these results, SC14 recommends that WCPFC15 takes note of the results of the projections in relation achieving CMM 2017-01 and as a precautionary approach that the fishing mortality on bigeye tuna stock should not be increased from the recent average (2011-2014) level to maintain spawning biomass at or above the 2012-2015 average, until the Commission can articulate the management objectives and agree on an appropriate TRP for bigeye, although one CCM considers that SC14 could provide more options for the commission to consider.

c. Research Recommendations

26. SC14 noted that the acceptance of the updated new growth model for BET raises a number of issues in relation to patterns of growth and stock structure of BET across the Pacific Ocean and recommended that the following research issues need to be addressed:

4) Two different growth models separated at 150˚W effectively means that Pacific BET should be assessed as a two-stock resource between the WCPO and EPO. However, catch information indicates that the fishing grounds near 150˚W are a core area of BET catch, thus influencing the assessments of both the WCPFC and IATTC. Also, tagging information suggests movement of BET between the WCPO and EPO. Therefore, the appropriateness off delineating the two stocks at 150˚W needs to be investigated.
5) The updated new growth analysis suggests area variant growth across the Pacific. While the level of variation is seen to be relatively small within the WCPO (and possibly within the margins of observation error), there is a suggestion of substantial change in growth around the boundary between the WCPO and the EPO (c.f. Figure 14 in SC14-SA-WP-01). The reasons for this suggested change in growth remains unknown, but SC14 noted the utility of collecting more information from the regions either side of this boundary to inform a greater understanding of possible changes in growth around this area. While the incorporation of area-variant growth within the assessment model would also help explore this issue, SC14 noted the difficulty of this task.
6) SC11 concluded that the stock status of WCPO BET from the Pan-Pacific assessment and the WCPO-only assessment were similar when the growth models were similar in the EPO and WCPO. This conclusion needs to be revisited in light of the different growth between EPO and WCPO by adopting the new growth.

27. The following additional research activities were also recommended by SC14 in order to improve the understanding of the age and growth of BET across the Pacific:

6) A WCPO growth model based on size composition and tagging data, as well as the use of additional modeling approaches (e.g., length-conditional), should also be evaluated.
7) Collaboration with the IATTC to analyze bigeye growth from otolith and tagging data collected across the entire Pacific, to better characterize the apparent regional difference in growth between the WCPO and EPO, and possible environmental determinants of such differences.
8) Analyzing the same otoliths by different laboratories, to build confidence in ageing estimates and to estimate ageing error.
9) Continued development of a high-confidence tagging dataset for growth analysis, with particular focus on larger bigeye tuna and events with reliable measurements at release. Such data would assist with the validation of the age estimates of large bigeye in the WCPO, and could potentially be incorporated directly into the assessment model as an additional data set. However, a reliable measurement of both length at release and recapture are necessary to accurately estimate incremental growth.
10) Collect otoliths of very small bigeye that are captured by the Indonesian, Vietnamese, and Philippines domestic fisheries in region 7 and estimate age through daily ring counts to aid in the estimation of the size at age-1 qtr^{-1} parameter (L1) within the assessment model.

Attachment 2

WCPO YELLOWFIN TUNA (*Paragraphs 265 – 279, SC13 Summary Report*)

Provision of scientific information

1. SC13 noted that preliminary total yellowfin tuna catch in 2016 (651,575 mt) was a 12% increase over 2015 and a 14% increase over 2011-2015. Longline catch (91,635 mt) was 10% lower than in 2015 and 1% lower than the 2011-2015 average. Pole and line catch (23,074 mt) was 36% lower than in 2015 and 25% lower than 2011-2015 average. Purse seine catch (394,756 mt) was 29% higher than in 2015, and 17% higher than 2011-2015 average. Catches from other gears (142,110 mt) were 2% higher than in 2015 and 26% higher than the 2011-2015 average. (see SC13-SA-WP-02).

2. SC13 endorsed the 2017 WCPO yellowfin tuna stock assessment as the most advanced and comprehensive assessment yet conducted for this species.

3. SC13 also endorsed the use of the assessment model uncertainty grid to characterize stock status and management advice and implications.

4. SC13 reached consensus on the weighting of assessment models in the uncertainty grid for yellowfin tuna. The consensus weighting considered all options within five axes of uncertainty for steepness, tagging dispersion, tag mixing, size frequency (with two levels), and regional structure to be equally likely. The resulting uncertainty grid was used to characterize stock status, to summarize reference points as provided in the assessment document SC13-SA-WP-06, and to calculate the probability of breaching the adopted spawning biomass limit reference point ($0.2*SB_{F=0}$) and the probability of F_{recent} being greater than F_{MSY}.

a. Status and trends

5. The median values of relative recent spawning biomass (2012-2015) ($SB_{recent}/SB_{F=0}$) and relative recent fishing mortality (F_{recent}/F_{MSY}) over the uncertainty grid were used to measure the central tendency of stock status. The values of the upper 90th and lower 10th percentiles of the empirical distributions of relative spawning biomass and relative fishing mortality from the uncertainty grid were used to characterize the probable range of stock status.

6. Descriptions of the updated structural sensitivity grid used to characterize uncertainty in the assessment are provided in Table YFT-1. Catch trend data is presented in Figure YFT-1. Estimated annual average recruitment, biomass, fishing mortality and depletion are shown in Figures YFT-2 – YFT-5. Majuro plots summarizing the results for each of the models in the structural uncertainty grid retained for management advice are represented in Figures YFT-6 and YFT-7. Figure YFT-8 and YFT-9 present Kobe plots summarizing the results for each of the models in the structural uncertainty grid. Figure YFT-10 provides estimated time-series (or "dynamic") Majuro and Kobe plots from the yellowfin 'diagnostic case' model run. Figure YFT-11 shows estimates of reduction in spawning potential due to fishing by region, and over all regions attributed to various fishery groups (gear-types) for the diagnostic case model. Table YFT-2 provides a summary of reference points over the 48 models in the structural uncertainty grid (based on the SC decision to include size frequency weighting levels 20 and 50 only).

Table YFT-1: Description of the updated structural sensitivity grid used to characterize uncertainty in the assessment

Axis	Levels	Option
Steepness	3	0.65, 0.80, 0.95
Tagging overdispersion	2	Default level (1), fixed (moderate) level
Tag mixing	2	1 or 2 quarters
Size frequency weighting	3	Sample sizes divided by 10, 20, 50
Regional structure	2	2017 regions, 2014 regions

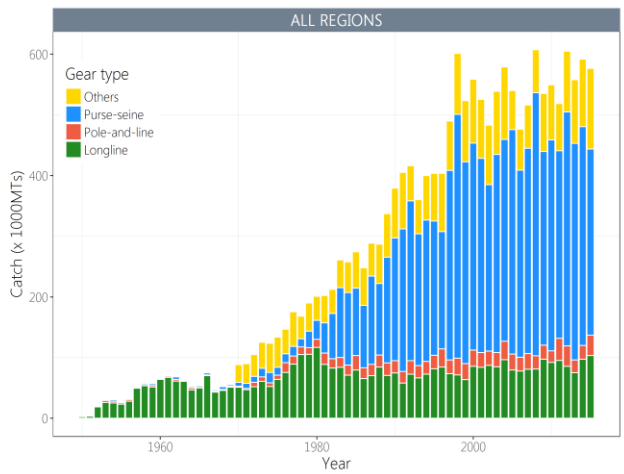


Figure YFT-1. Time series of total annual catch (1000's mt) by fishing gear for the diagnostic case model over the full assessment period.

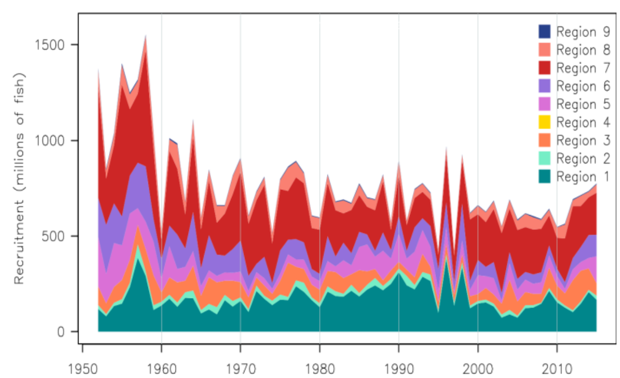


Figure YFT-2. Estimated annual average recruitment by model region for the diagnostic case model, showing the relative sizes among regions.

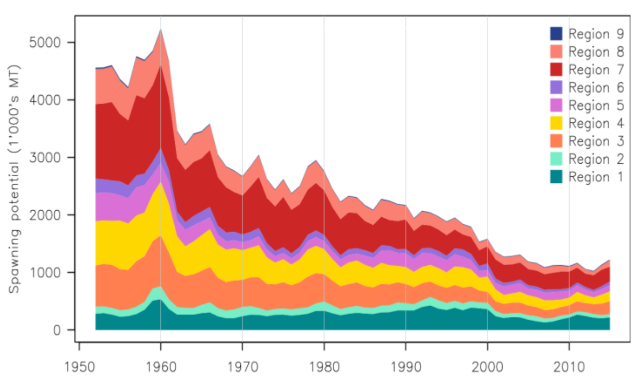


Figure YFT-3. Estimated annual average spawning potential by model region for the diagnostic case model, showing the relative sizes among regions.

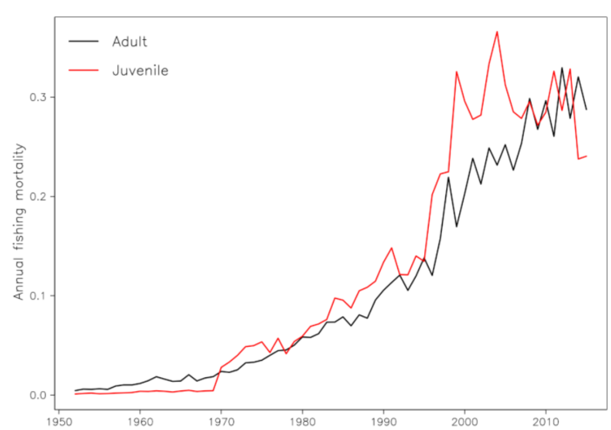


Figure YFT-4. Estimated annual average juvenile and adult fishing mortality for the diagnostic case model.

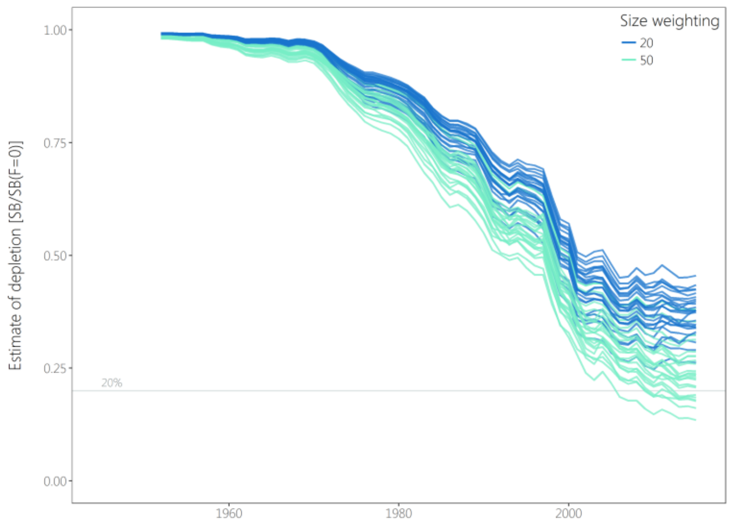


Figure YFT-5: Plot showing the trajectories of fishing depletion (of spawning potential) for the 48 model runs retained for the structural uncertainty grid used for management advice. The colours depict the models in the grid with the size composition weighting using divisors of 20 and 50.

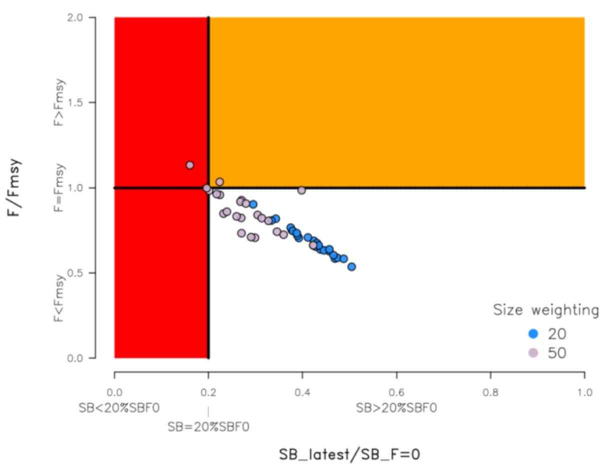


Figure YFT-6. Majuro plot summarising the results for each of the models in the structural uncertainty grid retained for management advice. The plots represent estimates of stock status in terms of spawning potential depletion and fishing mortality. The red zone represents spawning potential levels lower than the agreed limit reference point which is marked with the solid black line. The orange region is for fishing mortality greater than F_{MSY} (F_{MSY} is marked with the black horizontal line). The points represent $SB_{latest}/SB_{F=0}$, and the colours depict the models in the grid with the size composition weighting using divisors of 20 and 50.

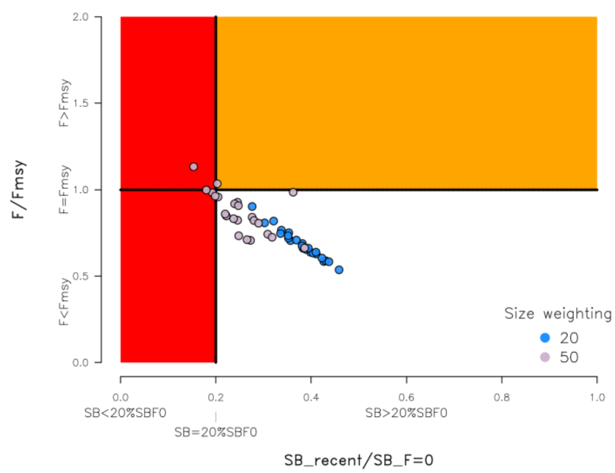


Figure YFT-7: Majuro plot summarising the results for each of the models in the structural uncertainty grid retained for management advice. The plots represent estimates of stock status in terms of spawning potential depletion and fishing mortality. The red zone represents spawning potential levels lower than the agreed limit reference point which is marked with the solid black line. The orange region is for fishing mortality greater than F_{MSY} (F_{MSY} is marked with the black horizontal line). The points represent $SB_{recent}/SB_{F=0}$, and the colours depict the models in the grid with the size composition weighting using divisors of 20 and 50.

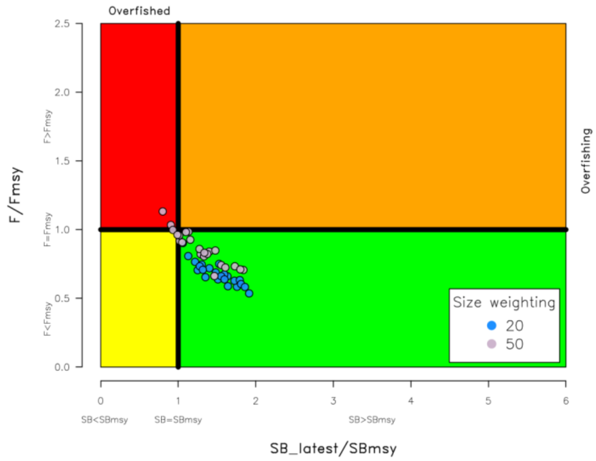


Figure YFT-8. Kobe plot summarising the results for each of the models in the structural uncertainty grid. The points represent SB_{latest}/SB_{MSY}, the colours depict the models in the grid with the size composition weighting using divisors of 20 and 50.

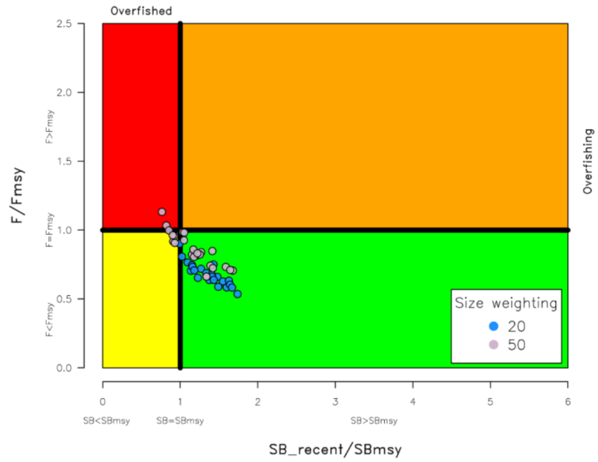


Figure YFT-9. Kobe plot summarising the results for each of the models in the structural uncertainty grid. The points represent $SB_{\mathit{recent}}/SB_{MSY}$, the colours depict the models in the grid with the size composition weighting using divisors of 20 and 50.

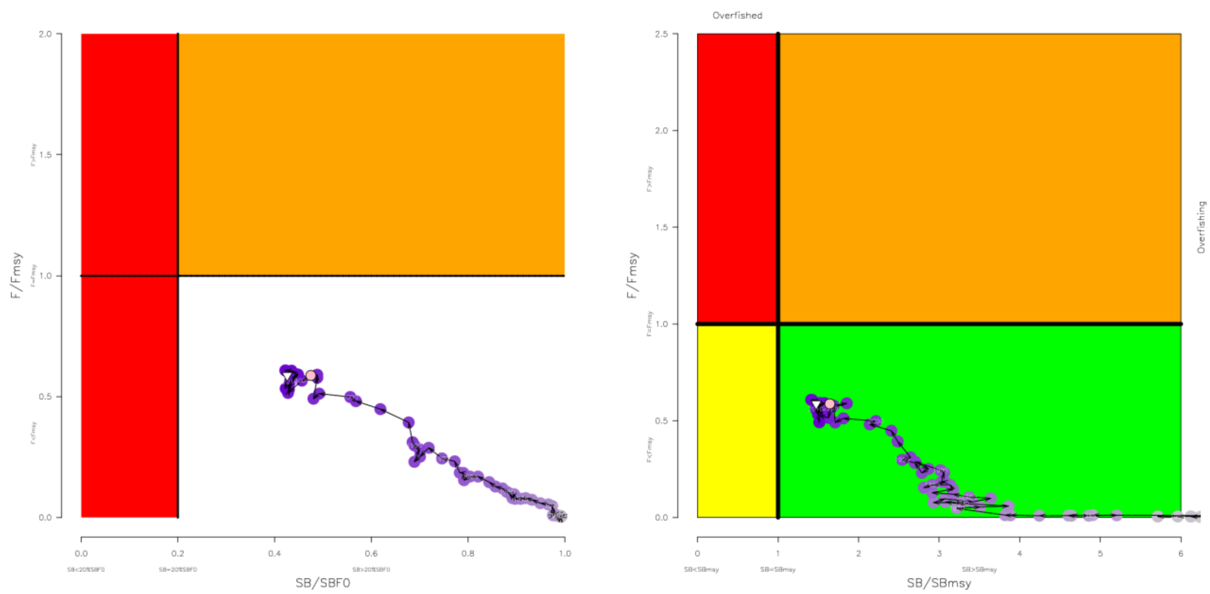


Figure YFT-10. Estimated time-series (or “dynamic”) Majuro and Kobe plots from the yellowfin ‘diagnostic case’ model run.

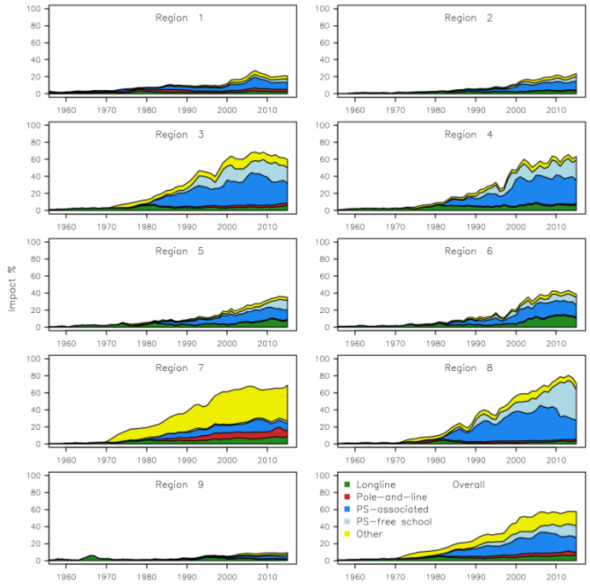


Figure YFT-11. Estimates of reduction in spawning potential due to fishing by region, and over all regions (lower right panel), attributed to various fishery groups (gear-types) for the diagnostic case model.

Table YFT-2. Summary of reference points over the 48 models in the structural uncertainty grid retained for management advice using divisors of 20 and 50 for the weighting on the size composition data. Note that $SB_{recent}/SB_{F=0}$ is calculated where SB_{recent} is the mean SB over 2012-2015 instead of 2011-2014 (used in the stock assessment report), at the request of the Scientific Committee.

	Mean	**Median**	**Min**	**10%**	**90%**	**Max**
C_{latest}	611,982	612,592	606,762	607,517	614,237	614,801
MSY	670,658	670,800	539,200	601,480	735,280	795,200
$Y_{Frecent}$	646,075	643,400	534,400	586,120	717,880	739,600
F_{mult}	1.34	1.36	0.88	1.03	1.61	1.86
F_{MSY}	0.12	0.12	0.07	0.10	0.14	0.16
F_{recent}/F_{MSY}	0.77	0.74	0.54	0.62	0.97	1.13
SB_{MSY}	544,762	581,400	186,800	253,320	786,260	946,800
SB_0	2,199,750	2,290,000	1,197,000	1,366,600	2,784,500	3,256,000
SB_{MSY}/SB_0	0.24	0.24	0.15	0.18	0.28	0.34
$SB_{F=0}$	2,083,477	2,178,220	1,193,336	1,351,946	2,643,390	2,845,244
$SB_{MSY}/SB_{F=0}$	0.25	0.26	0.16	0.19	0.30	0.35
SB_{latest}/SB_0	0.33	0.34	0.18	0.23	0.42	0.45
$SB_{latest}/SB_{F=0}$	0.35	0.37	0.16	0.22	0.46	0.50
SB_{latest}/SB_{MSY}	1.40	1.39	0.80	1.02	1.80	1.91
$SB_{recent}/SB_{F=0}$	0.32	0.33	0.15	0.20	0.41	0.46
SB_{recent}/SB_{MSY}	1.40	1.41	0.81	1.05	1.71	1.93

7. SC13 noted that the central tendency of relative recent spawning biomass was median $(SB_{recent}/SB_{F=0})$ = 0.33 with a probable range of 0.20 to 0.41 (80% probable range), and there was a roughly 8% probability (4 out of 48 models) that the recent spawning biomass had breached the adopted LRP with $Prob((SB_{recent}/SB_{F=0})<0.2) = 0.08$. The median estimate (0.33) is below that estimated from the 2014 assessment grid $((SB_{current}/SB_{F=0}) = 0.41$, see SC10-SA-WP-04), noting the differences in grid uncertainty axes used in that assessment.

8. SC13 noted that the central tendency of relative recent fishing mortality was median (F_{recent}/F_{MSY}) = 0.74 with an 80% probability interval of 0.62 to 0.97, and there was a roughly 4% probability (2 out of 48 models) that the recent fishing mortality was above F_{MSY} with Prob((F_{recent}/F_{MSY})>1) = 0.04. The median estimate (0.74) is also comparable to that estimated from the 2014 assessment grid ($F_{current}/F_{MSY}$ = 0.76, see SC10-SA-WP-04).

9. SC13 noted that the assessment results show that the stock has been continuously declining for about 50 years since the late 1960's.

10. SC13 also noted that levels of fishing mortality and depletion differ between regions, and that fishery impact was highest in the tropical region (Regions 3, 4, 7 and 8 in the stock assessment model), mainly due to the purse seine fisheries in the equatorial Pacific and the "other" fisheries within the Western Pacific (as shown in Figure 44 of SC13-SA-WP-06).

b. Management advice and implications

11. Based on the uncertainty grid adopted by SC13 the spawning biomass is highly likely above the biomass LRP and recent F is highly likely below F_{MSY}, and therefore noting the level of uncertainties in the current assessment is appears that the stock is not experiencing overfishing 96% probability) and it appears that the stock is not in an overfished condition (92% probability).

12. Based on the diagnostic case, both juvenile and adult fishing mortality show a steady increase since the 1970s. Adult fishing mortality has increased continuously over most of the time series, while juvenile fishing mortality has stabilized since the late 1990s at a level similar to that now estimated for adult yellowfin.

13. SC13 reiterates its previous advice from SC10 that WCPFC could consider measures to reduce fishing mortality from fisheries that take juveniles, with the goal to increase to maximum fishery yields and reduce any further impacts on the spawning potential for this stock in the tropical regions.

14. SC13 also reiterates its previous advice from SC10 that measures should be implemented to maintain current spawning biomass levels until the Commission can agree on an appropriate target reference point (TRP).

c. Research Recommendations

15. SC13 recognized that reviewing yellowfin growth through a study of yellowfin otoliths collected from the WCPO and incorporating this into future assessments should be encouraged.

Attachment 3

WCPO SKIPJACK TUNA from SC12 (*SC12 - Paras 301-321*)

Provision of scientific information

a. Stock status and trends

1. The SC12 was unable to reach consensus on the description of stock status based on the 2016 stock assessment. So majority and alternative views were provided for the stock status whereas SC12 provided agreed management advice.

> **Note**
> The Scientific Services Provider conducted additional sensitivity model runs to supplement the 2016 stock assessment. This paper is posted on the SC12 website (SC12-SA-WP-04a) on 28 November 2016, which can be considered at WCPFC13:
> http://www.wcpfc.int/system/files/SC12-SA-WP-04a%20%5BAdditional%20analysis%20to%20support%20SKJ%20assessment%5D.pdf

Majority view of stock status and trends

2. A majority of SC12 CCMs selected the reference case model as the base case to represent the stock status of skipjack tuna (column "Ref Case" in Table SKJ2). To characterize uncertainty, those CCMs chose the structural uncertainty grid. Summaries of important model quantities for these models are shown in Table SKJ2.

Table SKJ2: Estimates of management quantities for the selected stock assessment models. For the purpose of this assessment, "recent" is the average over the period 2011–2014 and "latest" is 2015. The column "Ref Case" shows summaries for the reference case and the remaining columns are the quantiles of the structural uncertainty grid, e.g. 5% and 50% are the 5% quantile and the median (50% quantile), respectively. Option 1 in the text recommends basing management advice on the reference case model and considering the uncertainty represented by the 5% and 95% quantile columns. Option 2 recommends basing management advice on the range of model runs in the structural uncertainty grid, as represented by the 5% and 95% quantile columns.

Quantity	Ref Case	50%	5%	25%	75%	95%
C_{latest}	1,679,528	1,679,444	1,678,646	1,679,170	1,679,497	1,679,592
MSY	1,891,600	1,875,600	1,618,060	1,785,400	1,976,700	2,199,880
$Y_{F_{recent}}$	1,594,800	1,607,000	1,486,660	1,533,200	1,755,200	1,808,860
f_{mult}	2.23	2.07	1.57	1.85	2.29	2.62
F_{MSY}	0.24	0.24	0.21	0.22	0.26	0.28
F_{recent}/F_{MSY}	0.45	0.48	0.38	0.44	0.54	0.64
SB_{MSY}	1,626,000	1,628,000	1,258,700	1,425,750	1,852,750	2,166,100
SB_0	6,764,000	6,359,500	5,214,050	5,853,750	7,095,250	8,340,450
$SB_{F=0}$	7,221,135	6,876,526	5,778,079	6,408,578	7,425,353	8,555,240
SB_{latest}/SB_0	0.62	0.55	0.43	0.49	0.59	0.71
$SB_{latest}/SB_{F=0}$	0.58	0.51	0.39	0.47	0.57	0.67
SB_{latest}/SB_{MSY}	2.56	2.15	1.6	1.81	2.43	3.08
$SB_{recent}/SB_{F=0}$	0.52	0.49	0.4	0.46	0.52	0.57

3. Dynamics of most model quantities are relatively consistent with the results of the 2014 stock assessment, although there has been a period of several subsequent years with high recruitments and increased spawning biomass.

4. Fishing mortality of all age-classes is estimated to have increased significantly since the beginning of industrial tuna fishing, but fishing mortality still remains below the level that would result in the MSY (F_{recent}/F_{MSY} = 0.45 for the reference case), and is estimated to have decreased moderately in the last several years. Across the reference case and the structural uncertainty grid F_{recent}/F_{MSY} varied between 0.38 (5% quantile) to 0.64 (95% quantile). This indicates that overfishing is not occurring for the WCPO skipjack tuna stock.

5. The estimated MSY of 1,891,600 mt is moderately higher than the 2014 estimate due to the adoption of an annual, rather than quarterly, stock-recruitment relationship. Recent catches are lower than, but approaching, this MSY value.

6. The latest (2015) estimate of spawning biomass is well above both the level that will support MSY (SBlatest/SBMSY = 2.56, for the reference case model) and the adopted LRP of 0.2 SBF=0 (SBlatest/SBF=0 = 0.58, for the reference case model), and SBlatest/SBF=0 was relatively close to the adopted interim target reference point (0.5 SBF=0) for all models explored in the assessment (structural uncertainty grid: median = 0.51, 5% and 95% quantiles = 0.39 and 0.67).

Alternative view of stock status and trends

7. China, Japan and Chinese Taipei considered it is not possible to select a base-case model from various sensitivity models in the 2016 assessment, given the advice from the Scientific Service Provider that a suite of the sensitivity models were plausible. Therefore, these members considered that it would be more appropriate to provide advice to WCPFC13 on skipjack stock status based on the range of uncertainty expressed by the alternative model runs in the sensitivity analysis rather than based on the single base case model (represented by the 5% and 95% quantiles of the structural sensitivity grid presented in Table SKJ2).

8. The estimated MSY of the WCPO skipjack stock ranges from 1,618,060 mt (5% quantile) to 2,199,880 mt (95% quantile) across the alternative skipjack stock assessment models represented in the sensitivity grid. These CCMs also noted that some alternative models indicate that the 2015 biomass is below the adopted TRP of 0.5SBF=0.

b. Management advice and implications

9. SC12 noted that the skipjack assessment continues to show that the stock is currently moderately exploited and fishing mortality level is sustainable. The recent catches are fluctuating around and some models also indicate that the stock is currently under the TRP.

10. SC12 noted that fishing is having a significant impact on stock size and can be expected to affect catch rates. The stock distribution is also influenced by changes in oceanographic conditions associated with El Niño and La Niña events, which impact on catch rates and stock size. Additional purse-seine effort will yield only modest gains in long-term skipjack tuna catches and may result in a corresponding increase in fishing mortality for bigeye and yellowfin tunas. The management of total effort in the WCPO should recognize this.

11. SC12 noted that skipjack spawning biomass is now around the adopted TRP and SC12 recommends that the Commission take action to keep the spawning biomass near the TRP and also advocates for the adoption of harvest control rules based on the information provided.

12. In order to maintain the quality of stock assessments for this important stock, SC12 recommends 1) continued work on developing an index of abundance based on purse seine data; 2) regular large scale tagging cruises and complementary tagging work continue to be undertaken in a way that provides the best possible data for stock assessment purposes.

13. SC12 also notes that the current method of calculating the TRP is based on the most recent 10 years of recruitment information. However, the information on spawning potential, SB_{2015}, which is used to evaluate current stock status relative to the TRP can change very rapidly for skipjack which mature at age 1 and this rapid maturation may provide an optimistic status evaluation when recruitment is estimated have an increasing trend but is estimated with substantial uncertainty, as is currently observed in the case of skipjack which does not have a fishery-independent index of recruitment strength.

14. There is ongoing concern by at least one CCM that high catches in the equatorial region may be causing a range contraction of WCPO skipjack tuna, thus reducing skipjack tuna availability to fisheries conducted at higher latitudes than the Pacific equatorial region. SC12 reiterates the advice of SC11 whereby there is no demonstrated statistical evidence for SKJ range contraction. As a result, SC12 recommends that ongoing research on range contraction of skipjack tuna be continued in the framework of Project 67.

Attachment 4

SC14 Summary Report, Table MSE-2. Summary of proposed performance indicators for the purse seine skipjack tuna fishery (WCPFC, 2017). The Calculated column notes whether or not the indicator can be calculated using the current operating models.

	Objective type	MOW4 objective	Performance indicator (WP14)	Calculated
1	Biological	Maintain SKJ (and YFT and BET) biomass at or above levels that provide fishery sustainability throughout their range.	Probability of $SB/SB_{F=0} > 0.2$ as determined from MSE.	Y
2	Economic	Maximise economic yield from the fishery	Predicted effort relative to *EMEY* (to take account of multi-species considerations, SKJ, BET and YFT may be calculated at the individual fishery level). *BMEY* and *FMEY* may also be considered at a single species level.	Y
3	Economic	Maximise economic yield from the fishery	Average expected catch (may also be calculated at the assessment region level)	Y
4	Economic	Maintain acceptable CPUE	Average deviation of predicted SKJ CPUE from reference period levels	Y
5	Economic	Maximise SIDS revenues from resource rents	Proxy: average value of SIDS / non-SIDS catch	N
6	Economic	Catch stability	Average annual variation in catch	Y
7	Economic	Stability and continuity of market supply	Effort variation relative to reference period level (may also be calculated at the assessment region level)	Y
8	Economic	Stability and continuity of market supply	Probability of and deviation from $SB/SB_{F=0} > 0.5$ (SKJ) in the short-, medium- and long-term as determined from MSE (may also be calculated at the assessment region level)	Y
9	Social	Food security in developing states (import replacement)	As a proxy: average proportion of CCMs catch to total catch for fisheries operating in specific regions	N
10	Social	Avoid adverse impacts on small scale fishers	• MSY of SKJ, BET, YFT • Possible information on other competing fisheries targeting SKJ (may also be calculated at the assessment region level) • Any additional information on other fisheries / species as possible	N
11	Ecosystem	Minimise bycatch	Number of FAD sets; Expected catch of other species	N