The Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean

Eighteenth Regular Session of the Scientific Committee

Electronic Meeting
10–18 August 2022

SUMMARY REPORT

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Scientific Committee
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EXECUTIVE SUMMARY

AGENDA ITEM 1 — OPENING OF THE MEETING

1. The Eighteenth Regular Session of the Scientific Committee of the Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean (SC18) took place for seven days during 10–18 August 2022 as an electronic meeting in response to the continuing global coronavirus disease (COVID-19) pandemic. The electronic meeting was chaired by Dr Tuikolongahau Halafihi (Tonga).

2. The following WCPFC Members, Cooperating Non-members and Participating Territories (CCMs) attended SC18: Australia, Canada, China, Cook Islands, European Union (EU), Federated States of Micronesia (FSM), Fiji, Indonesia, Japan, Kiribati, Republic of Korea, Republic of Marshall Islands (RMI), Nauru, New Zealand, Niue, Palau, Papua New Guinea (PNG), Philippines, Samoa, Solomon Islands, Chinese Taipei, Tonga, Tuvalu, United States of America (USA), Vanuatu, American Samoa, French Polynesia, New Caledonia, Tokelau, Ecuador, Nicaragua, Panama, Thailand and Vietnam.

3. Observers from the following inter-governmental organizations attended SC18: Agreement for the Conservation of Albatross and Petrels (ACAP), Inter-American Tropical Tuna Commission (IATTC), Pacific Community (SPC), Pacific Islands Forum Fisheries Agency (FFA), Parties to the Nauru Agreement (PNA), Secretariat of the Pacific Regional Environment Programme (SPREP), and The World Bank.

4. Observers from the following non-governmental organizations attended SC18: American Tunaboat Association (ATA), Australian National Centre for Ocean Resources and Security (ANCORS), Birdlife International, Conservation International (CI), International Seafood Sustainability Foundation (ISSF), Marine Stewardship Council, Pew Charitable Trust (Pew), Sustainable Fisheries Partnership (SFP) Foundation, The Ocean Foundation, World Tuna Purse Seine Organisation (WTPO) and the World Wide Fund for Nature (WWF).

5. The conveners and their assigned theme sessions were:

Themes	Conveners
Data and Statistics (ST)	Valerie Post (USA)
Stock Assessment (SA)	Keith Bigelow (USA) and Hidetada Kiyofuji (Japan)
Management Issues (MI)	Robert Campbell (Australia)
Ecosystem and Bycatch Mitigation (EB)	Yonat Swimmer (USA)

AGENDA ITEM 2 — DATA AND STATISTICS THEME

6. The Data and Statistics (ST) theme was convened by V. Post (USA).

2.1 Data gaps of the Commission

2.1.1 Data gaps

7. P. Williams (SPC) presented SC18-ST-WP-01 (*Scientific data available to the Western and Central Pacific Fisheries Commission*).

Recommendations

8. **SC18 recommended WCPFC support a project to improve the coverage and quality of purse seine processor data.**

9. **SC18 recommended the inclusion of tables of the operational level catch and effort data fields for longline, purse seine and pole-and-line gears, as a guideline and without the column of "binding" and adding the title of "Annex 2, guidelines for data submission of operational level catch and effort data fields for fisheries", as an additional ANNEX of the "Scientific Data to be Provided to the Commission", with an additional paragraph under Section 3. Operational level catch and effort data as follows:**

> **"Annex 2 provides tables of the guidelines of operational level catch and effort data fields for longline, purse seine and pole-and-line gears in order to clarify and assist members in understanding the requirements of each data field and thereby facilitate the submission of data to the WCPFC."**

10. **Noting the inconsistency in the data reporting requirements between the Scientific Data to be Provided by the Commission (SciData), and other WCPFC reporting obligations (e.g., in CMMs), and the need to improve the data available for stock assessments, SC18 recommended that the Scientific Services Provider undertake a review of the minimum data reporting requirements and report to SC19 in 2023. SC18 requested CCMs to submit proposals for additional or amended data field, with associated justification, before 30th March 2023. For example, the proposal for including FAD minimum data fields recorded by vessel operators in the SciData which was presented to SC18 should be forwarded to SC19 for consideration.**

2.2 Other commercial fisheries for bigeye, yellowfin and skipjack tuna

11. F. Satria (Indonesia) presented SC18-ST-WP-02 (*An update on the options for a baseline of the "large-fish" Handline fishery fishing in Indonesia's EEZ (IEEZ) with vessels >30GT for the WCPFC Tropical Tuna Measure*).

Recommendation

12. **SC18 noted the information provided by Indonesia related to options for a baseline of the "large-fish" handline fishery fishing in Indonesia's EEZ. SC18 observed the decision on this fishery's baseline is a policy decision, and that it did not believe it appropriate to provide any recommendations on a baseline, but recommended the Commission consider the information provided in the relevant SC18 papers and the comments in the SC18 Online Discussion Forum (ODF)[1] on the topic in its decisions making.**

[1] https://forum.wcpfc.int/c/sc-18/23

AGENDA ITEM 3 — STOCK ASSESSMENT THEME

13. The stock assessment (SA) theme was convened by K. Bigelow (USA) and H. Kiyofuji (Japan).

3.1 WCPO Tunas

3.1.1 Skipjack tuna (*Katsuwonus pelamis*)

3.1.1.1 Review of 2022 skipjack tuna stock assessment

14. J. Scutt Phillips (SPC) presented SC18-SA-WP-04 **(***Quantifying Rates of Mixing in Tagged, WCPO Skipjack Tuna*), and C. Castillo-Jordán (SPC) presented SC18-SA-WP-01 **(***Stock assessment of skipjack tuna in the western and central Pacific Ocean*).

15. **SC18 agreed to accept the 2022 skipjack stock assessment and uncertainty grid, and to use equal weighting for formulating management advice.**

16. **SC18 agreed on several recommendations, which are included after management advice.**

3.1.1.2 Provision of scientific information

a. Status and trends

17. **SC18 noted that the total catch in 2021 was 1,547,945t, a 10% decrease from 2020 and a 14% decrease from the 2016-2020 average. Purse seine catch in 2021 (1,254,022t) was a 11% decrease from 2020 and a 13% decrease from the 2016-2020 average. Pole and line catch (97,908t) was a 39% decrease from 2020 and a 37% decrease from the 2016-2020 average catch. Catch by other gears totalled 192,182t and was a 25% increase from 2020 and 5% decrease from the average catch in 2016-2020.**

18. **SC18 adopted the 2022 assessment and a structural uncertainty grid was used to develop management advice which included axes for tag mixing (three options), growth (two options) and steepness (three options), resulting in 18 models (Table SKJ-01). All models within the grid were equally weighted. The assessment grid of models estimated that the overall median recent spawning depletion ($SB_{recent}/SB_{F=0}$) is 0.51 (80^{th} percentile 0.43-0.64), which is close to the interim target reference point (TRP) of 0.50 (CMM 2021-01). No grid models were below the limit reference point (LRP) of 0.20 $SB_{F=0}$. The median of F_{recent}/F_{MSY} was 0.32 (80^{th} percentile 0.18-0.45) (Table SKJ-02). The 2022 stock assessment of skipjack tuna for the WCPO, indicated that according to WCPFC reference points the stock is not overfished, nor undergoing overfishing.**

19. **Catches of skipjack tuna in the WCPO have increased from approximately 250,000 metric tonnes in the late 1970s to a peak catch of approximately 2,000,000 metric tonnes in 2019; catches have dropped from 2019 to 2021 (Figure SKJ-02). Catches are dominated by purse seine fisheries in equatorial regions 6, 7, and 8, and purse seine and other gears in region 5 (Figure SKJ-03). Catches are dominated by pole-and-line in the northern regions 1–4 and continue to be low compared to those in the equatorial regions (Figures SKJ-03 and SKJ-04). The spawning potential and total biomass, while showing variability over time, do not show sustained long-term declining trends (Figures SKJ-05 and SKJ-08). In contrast, the trajectory of spawning potential depletion ($SB/SB_{F=0}$) shows a long-term trend towards a more depleted status (Figure SKJ-09). The spawning potential depletion**

trajectory was largely driven by the model estimates of increased levels of unfished spawning potential over time which are in turn driven by the model estimates of increasing recruitment over time (Figure SKJ-05). The model estimated increased recruitment over time to account for the increased catches in the face of a relatively stable biomass that is partly informed by several long-term stable CPUE indices of abundance (i.e., pole-and-line fishery indices) within the assessment. However, it is noted that spawning potential, recruitment and total biomass are estimated to have declined since around 2010 (Figure SKJ-05).

20. **Fishing mortality continues to increase over time for the adult and juvenile components of the stock, with fishing mortality being consistently higher for adults (Figure SKJ-06).**

21. **Fishery impact analyses show that the purse seine fisheries continue to dominate the impact in the equatorial regions 6, 7, and 8, with similar impacts by the 'associated' and 'unassociated' components, except for region 8 where 'associated' fishing appears to have more impact (Figure SKJ-07). Fishery impacts in region 5 are dominated by purse seine and other gears, and in regions 1-4, by pole-and-line, but with increasing impact of purse seine over time (Figure SKJ-07).**

22. **The influences of the structural uncertainty grid axes on key management quantities are shown in Figure SKJ-10. Tag mixing assumptions that applied longer tag mixing periods, and the externally estimated growth curve, resulted in more optimistic estimates of spawning potential depletion and spawning potential and lower fishing mortality.**

23. **Majuro and Kobe plots summarising stock status for the 18 models in the structural uncertainty grid are included for the 'latest' (2021, Figure SKJ-11) and 'recent' periods (2018-2021, Figure SKJ-12). These plots show that the stock status estimates across the 18 models are all within the zones indicating that the stock is not overfished nor undergoing overfishing.**

24. **The assessment provided a range of diagnostic analyses derived from the diagnostic model that indicated conflict between tag and CPUE data and instability in the convergence minima. Despite this, the model showed low retrospective bias and the important spawning potential depletion management quantities were robust to the differences in model convergence. However, as noted by several CCMs, data conflicts and the instability in model convergence minima require follow-up work and should be improved.**

Table SKJ-01. Structural uncertainty grid for the 2022 WCPO skipjack tuna stock assessment. Bold values indicate settings for the diagnostic case.

Axis	Levels	Option 1	Option 2	Option 3
Tag mixing	3	T1, D=0.1 (longer period)	**T2,** D=0.2 (intermediate)	T3, D=0.3 (shorter)
Growth	2	**G1,** Internally estimated (Dirichlet-multinomial)	G2, Externally estimated (otolith and tagging data)	
Steepness	3	0.65	**0.8**	0.95

Table SKJ-02. Summary of reference points over the 18 individual models in the structural uncertainty grid.

	Mean	Median	Min	10%ile	90%ile	Max	Diagnostic model
C_{latest}	1530209	1530208	1530207	1530207	1530212	1530212	1530207
F_{MSY}	0.23	0.23	0.18	0.19	0.27	0.28	0.24
fmult	3.61	3.18	1.88	2.22	5.54	8.08	2.86
F_{recent}/F_{MSY}	0.32	0.32	0.12	0.18	0.45	0.53	0.35
MSY	2933489	2648400	2046000	2167840	4777200	4868000	2416000
SB_0	7958888	7204500	5317000	5611000	12842000	14390000	5686000
$SB_{F=0}$	8073171	7616930	5953338	6156944	12310363	12744728	6147339
SB_{latest}/SB_0	0.48	0.48	0.37	0.41	0.56	0.60	0.48
$SB_{latest}/SB_{F=0}$	0.47	0.46	0.35	0.38	0.60	0.61	0.44
SB_{latest}/SB_{MSY}	2.82	2.68	1.65	1.95	3.81	4.62	2.54
SB_{MSY}	1419366	1335000	806300	870530	1984600	2925000	1073000
SB_{MSY}/SB_0	0.18	0.18	0.13	0.13	0.22	0.22	0.19
$SB_{MSY}/SB_{F=0}$	0.17	0.17	0.11	0.13	0.22	0.23	0.17
$SB_{recent}/SB_{F=0}$	0.52	0.51	0.41	0.43	0.64	0.66	0.50
SB_{recent}/SB_{MSY}	3.12	2.98	1.92	2.20	4.22	4.97	2.88
$Y_{Frecent}$	1896888	1892400	1621600	1683880	2116000	2282800	1762400
$(SB_{recent}/SB_{F=0})/(SB_{2012}/SB_{F=0})$	0.84	0.85	0.82	0.82	0.86	0.87	0.85

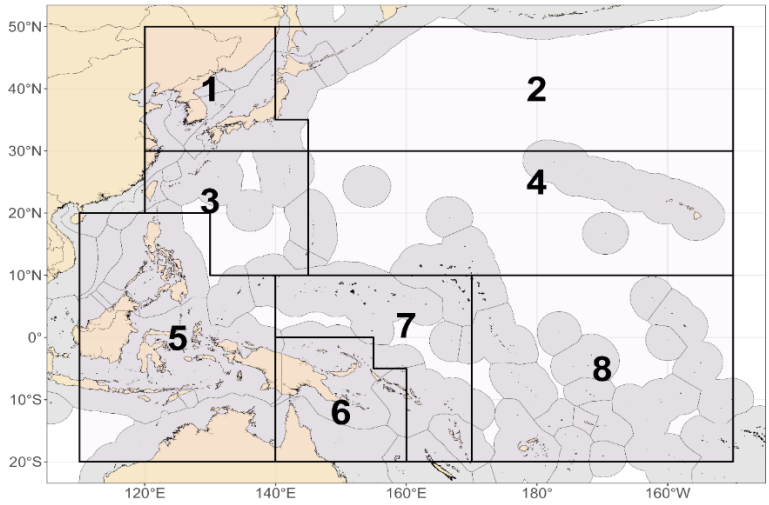

Figure SKJ-01. The geographical area covered by the stock assessment and the boundaries of the eight model regions used for 2022 WCPO skipjack assessment.

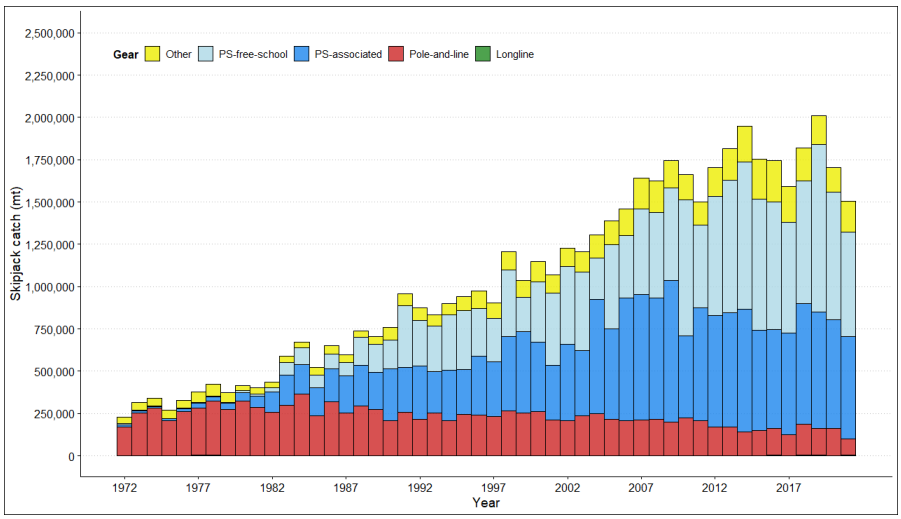

Figure SKJ-02. Annual catches of skipjack by gear type in the WCPO area covered by the assessment.

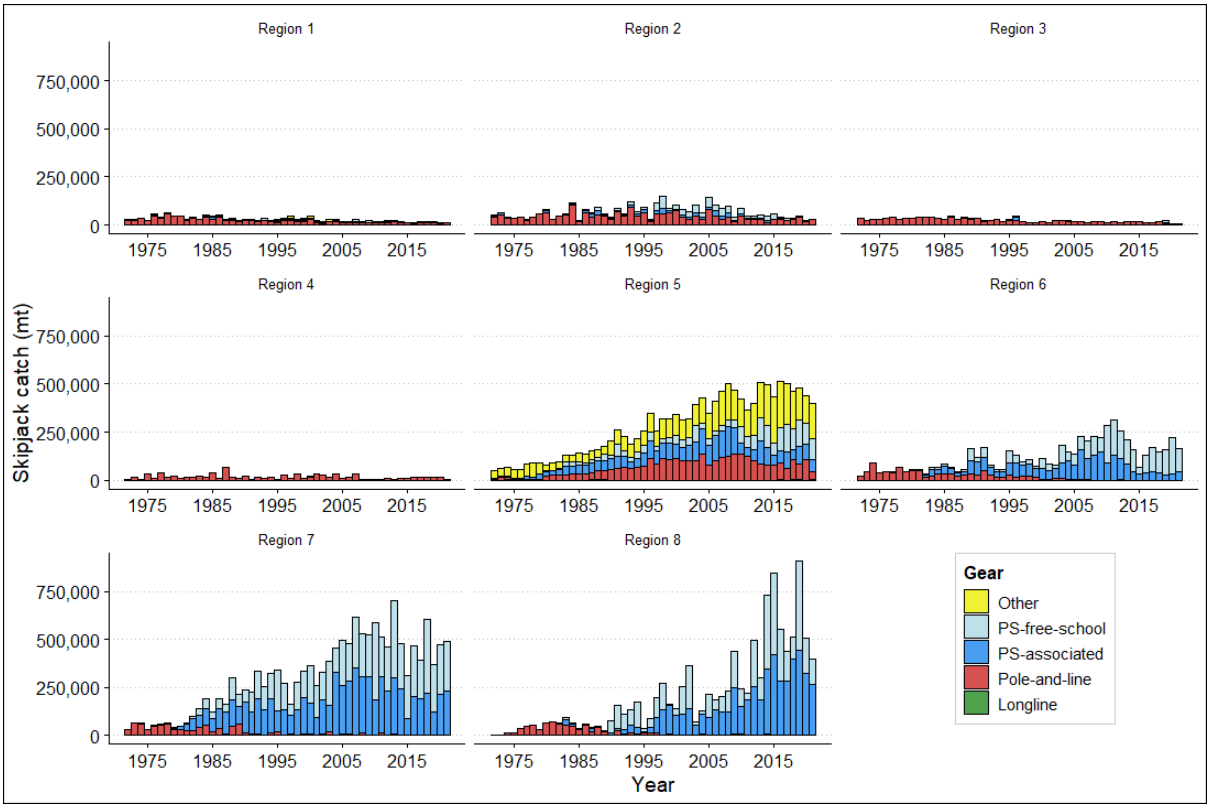

Figure SKJ-03. Annual catches of skipjack by gear type for each of the eight model regions.

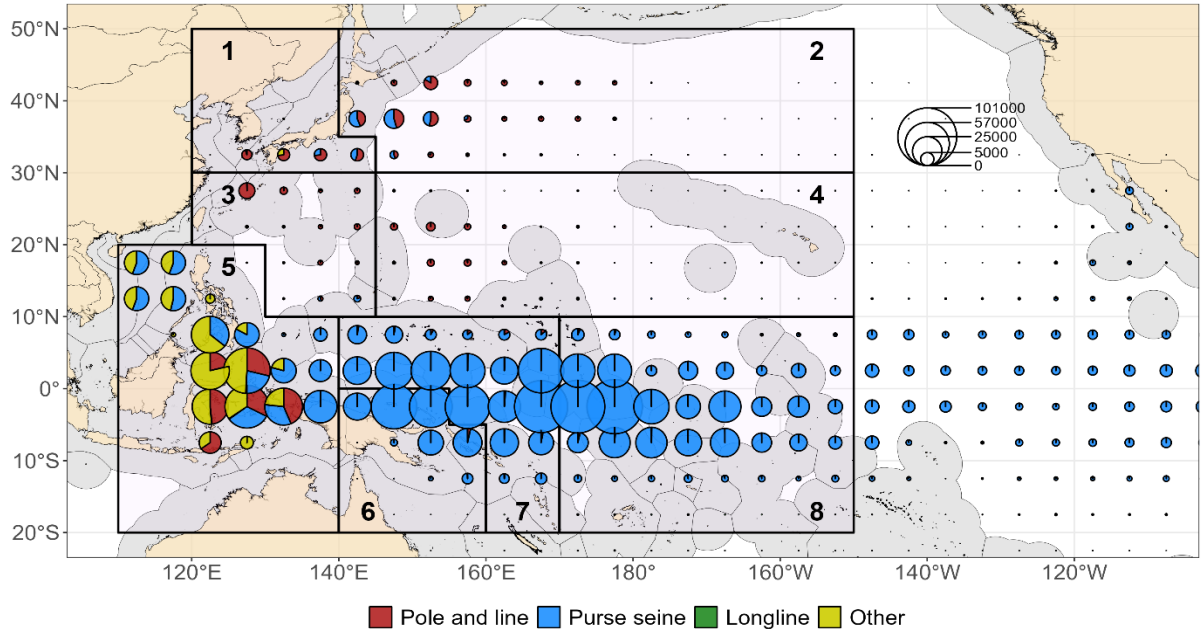

Figure SKJ-04. Distribution and magnitude of skipjack catches (mt) by gear type summed over the last 10 years (2012-2021) for 5 x 5 degree cells.

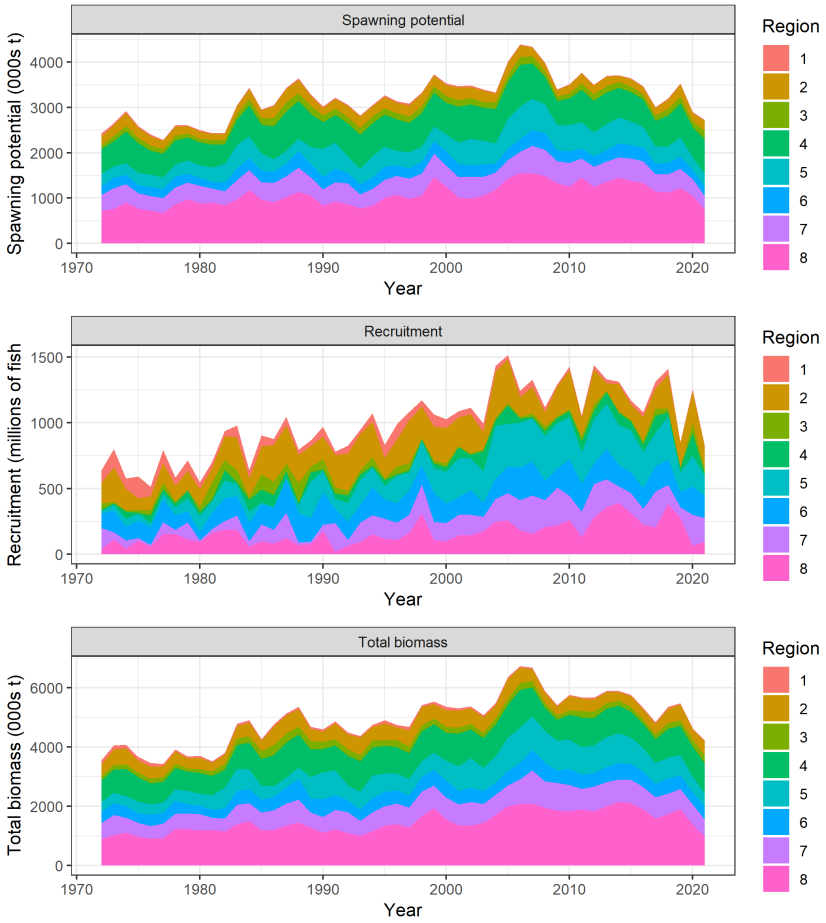

Figure SKJ-05. Estimated average quarterly recruitment, spawning potential and total biomass by model region from 1972-2021 for the 2022 skipjack diagnostic model, showing the relative proportions among regions.

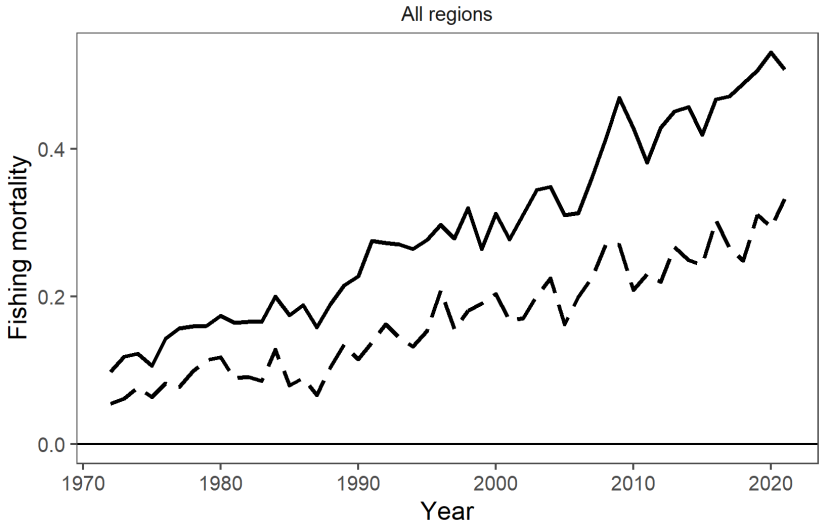

Figure SKJ-06. Estimated average quarterly adult (solid line) and juvenile (dashed line) fishing mortality for the diagnostic model from 1972-2021.

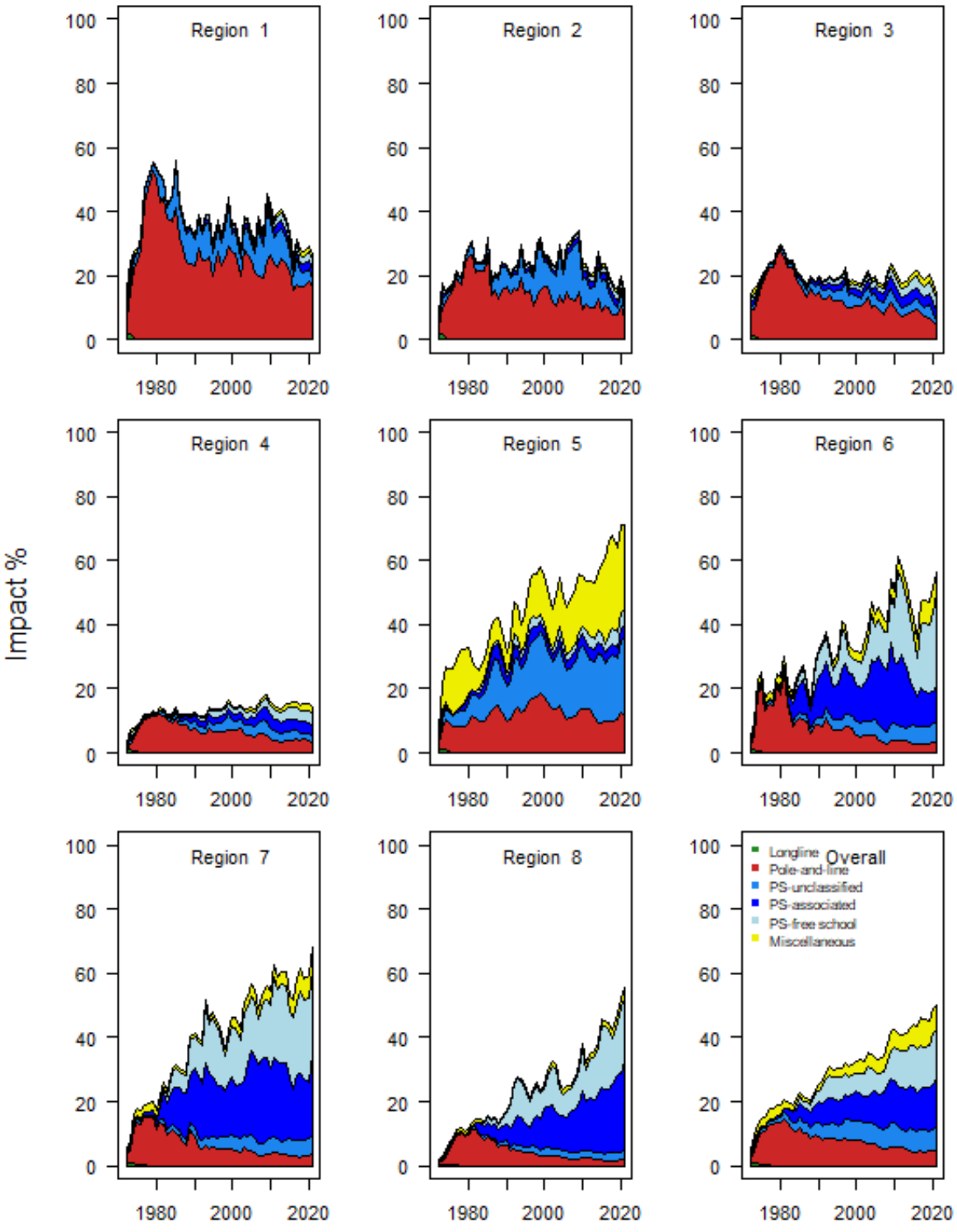

Figure SKJ-07. Estimates of reduction in spawning potential due to fishing (Fishery Impact = 1–$SB_{latest}/SB_{F=0}$) by region, and over all regions (lower right panel), attributed to various fishery groups for the diagnostic model.

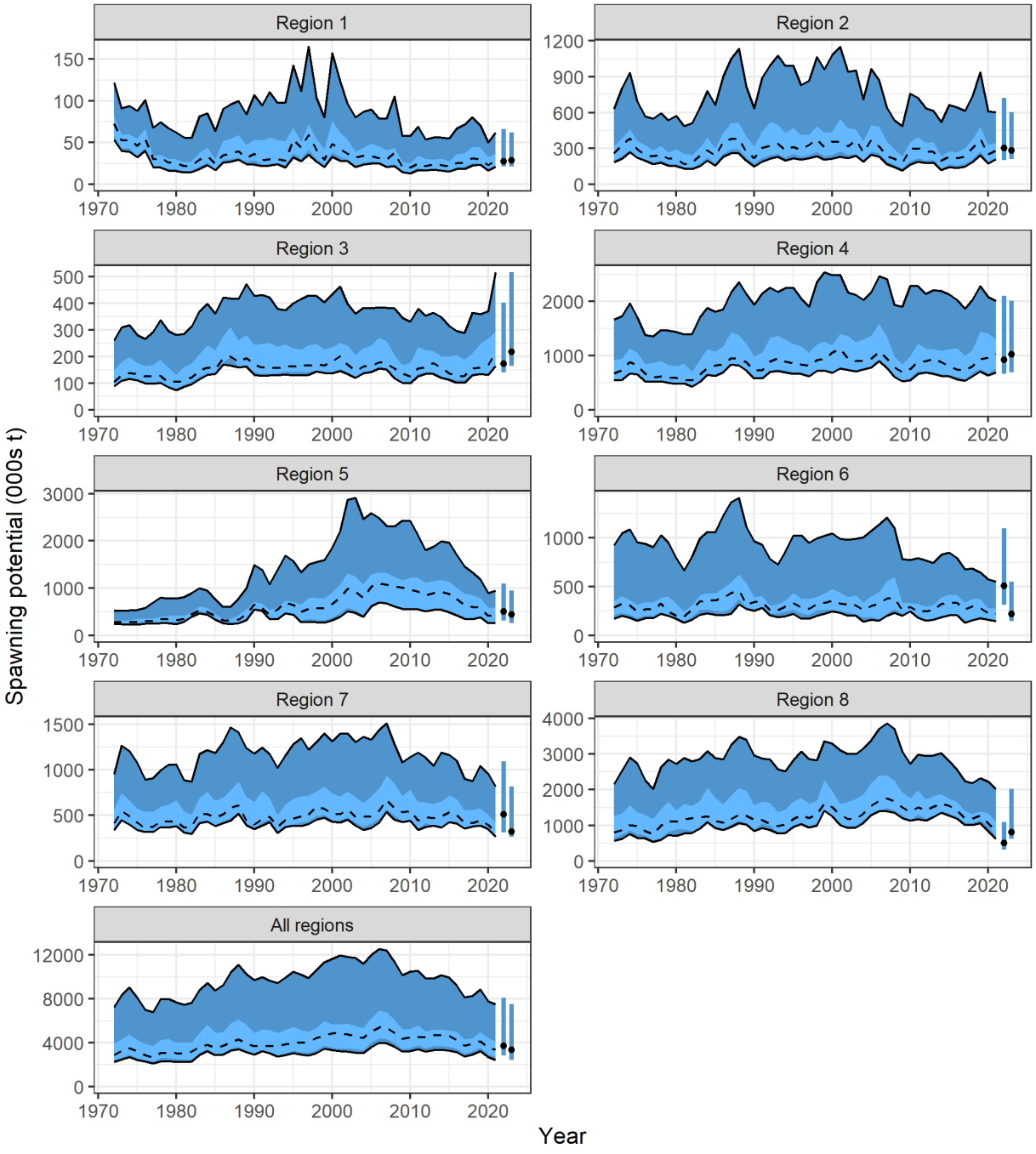

Figure SKJ-08. Trajectories of spawning potential (SB) across all models in the structural uncertainty grid over the period 1972-2021. The dashed line represents the median. The lighter band shows the 50th percentile, and the dark band shows the 80th percentile of the model estimates. The bars at the right of each ribbon indicate the median (black dots) and 80th percentile range for (left bar) SB_{recent} and (right bar) SB_{latest}.

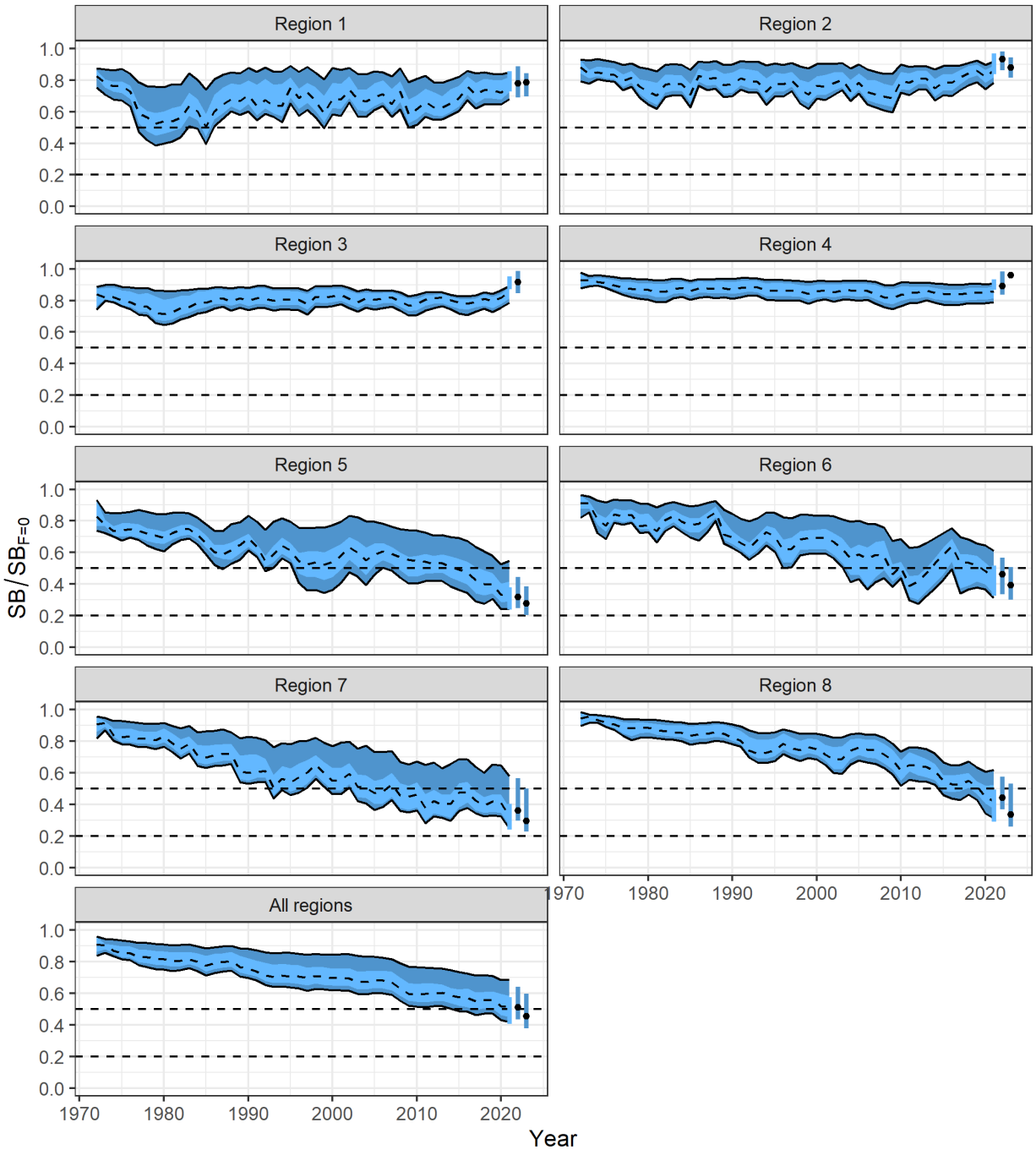

Figure SKJ-09. Trajectories of spawning potential depletion across all models in the structural uncertainty grid over the period 1972-2021. The dashed line represents the median. The lighter band shows the 50th percentile, and the dark band shows the 80th percentile of the model estimates. The bars at the right of each ribbon indicate the median (black dots) and 80th percentile range for (left bar) $SB_{recent}/SB_{F=0}$ and (right bar) $SB_{latest}/SB_{F=0}$.

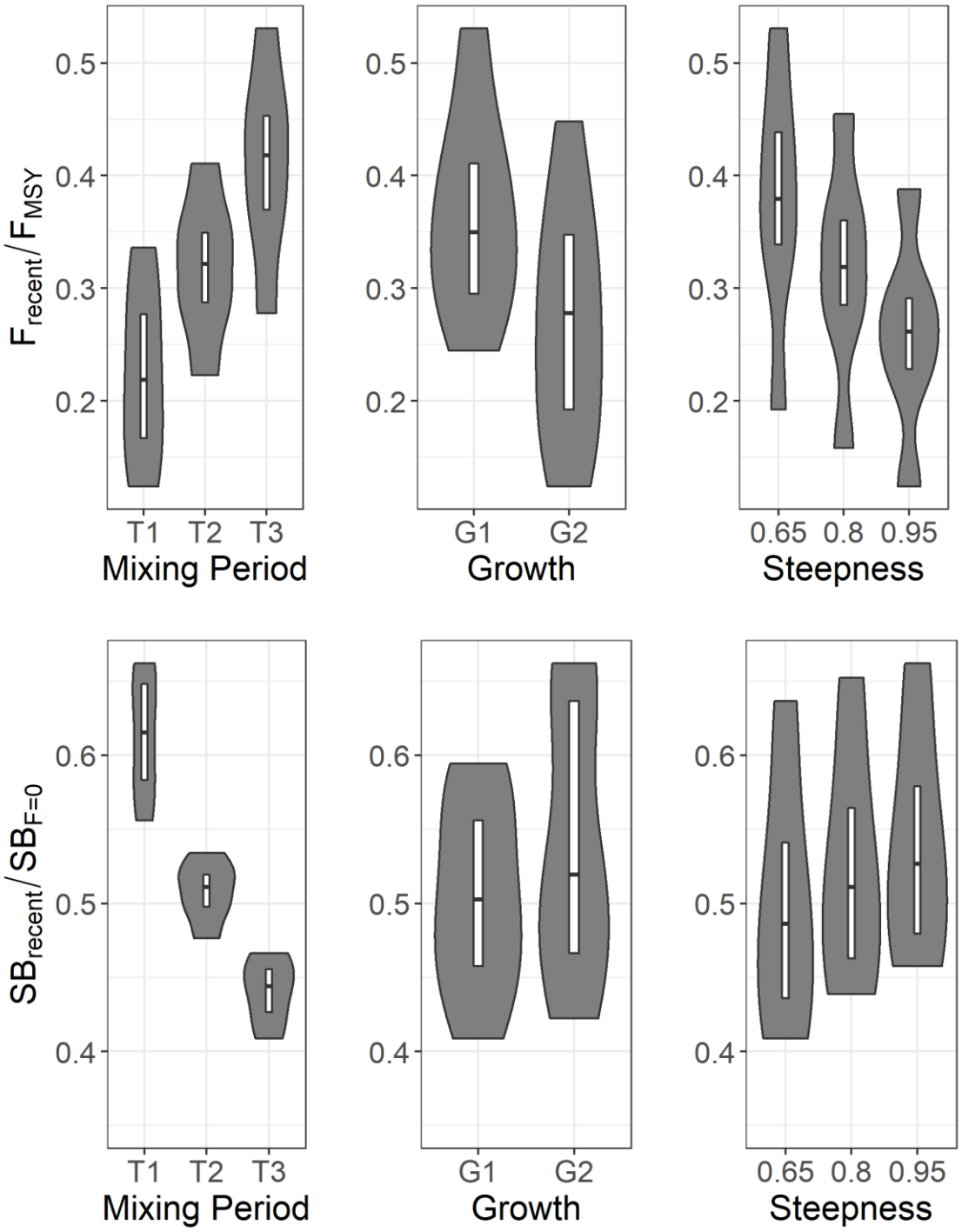

Figure SKJ-10. Box and violin plots summarizing (Top) the estimated F_{recent}/F_{MSY} and (Bottom) $SB_{recent}/SB_{F=0}$ for each of the models in the structural uncertainty grid grouped by uncertainty axes (growth, tag mixing and steepness). The line in the white box is the median of the estimates, while the box shows the 50th percentile. The shaded area shows the probability distribution (or density) of the estimates of all models of the structural uncertainty grid.

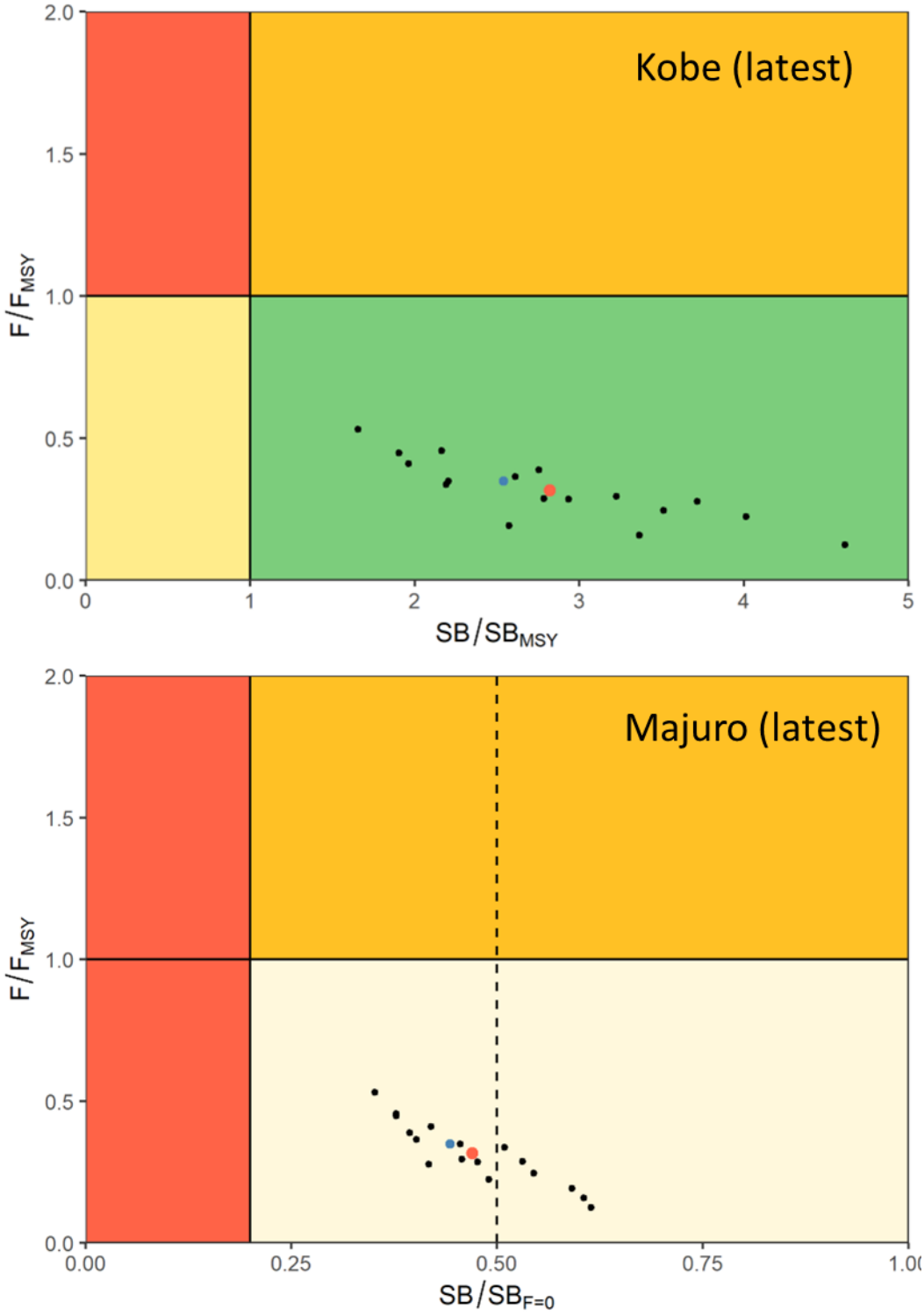

Figure SKJ-11. Kobe (top) and Majuro (bottom) plots summarising the results for each of the models in the structural uncertainty grid for the 'latest' (2021) period. The vertical dotted line on the Majuro plot is included to indicate the interim TRP of $0.50SB_{F=0}$ for the WCPFC-CA skipjack stock as specified in CMM 2021-01. The blue point is the diagnostic model, and the red point is the median.

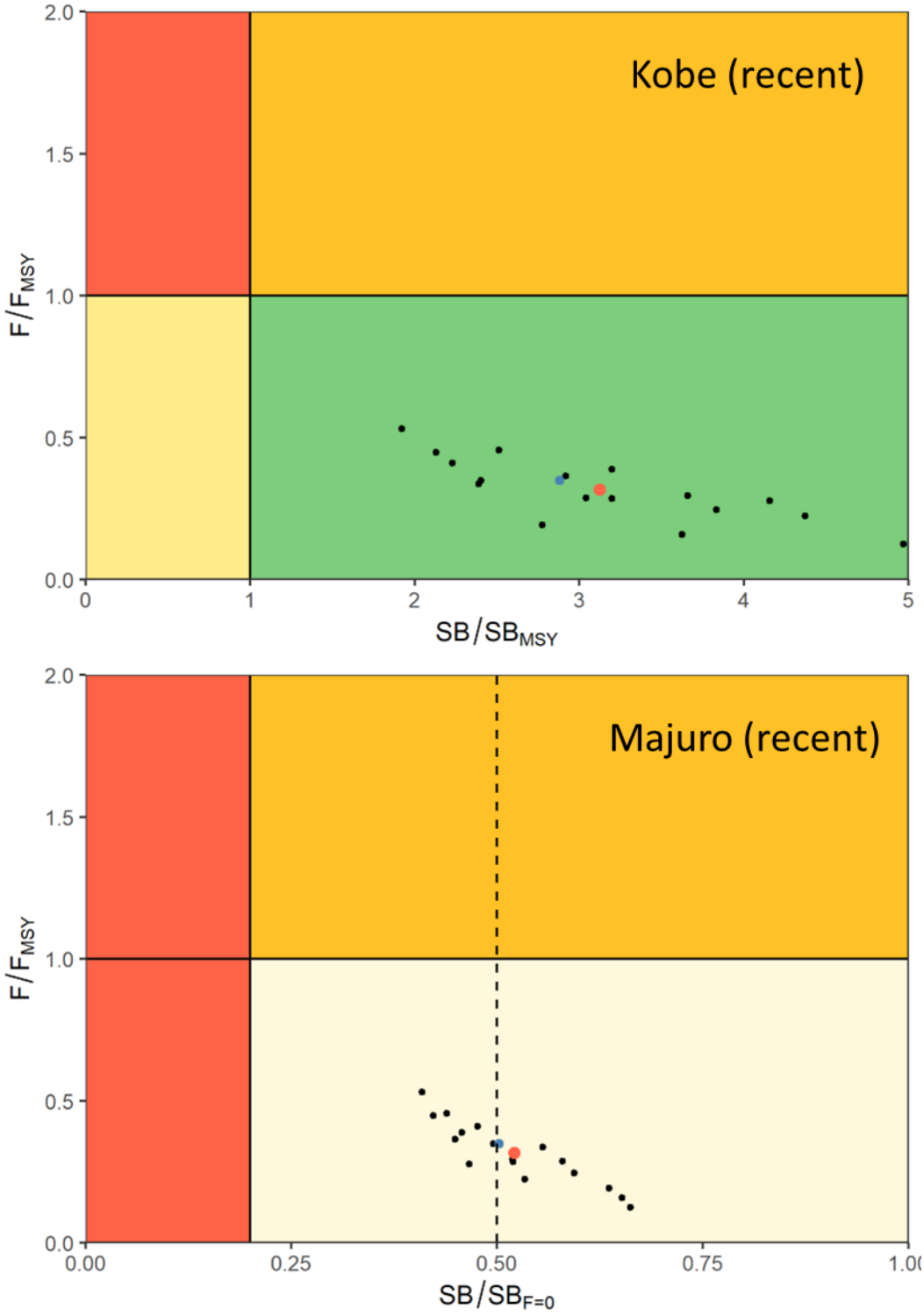

Figure SKJ-12. Kobe (top) and Majuro (bottom) plots summarising the results for each of the models in the structural uncertainty grid for the 'recent' (2018-2021) period. The vertical dotted line on the Majuro plot is included to indicate the interim TRP of 0.50$SB_{F=0}$ for the WCPFC-CA skipjack stock as specified in CMM 2021-01. The blue point is the diagnostic model, and the red point is the median.

25. **SC18 noted that the skipjack assessment continues to show that the stock is currently moderately exploited and the level of fishing mortality is sustainable.**

26. **SC18 noted that the stock was assessed to be above the adopted LRP and fished at rates below F_{MSY} with 100% probability. Therefore, the skipjack stock is not overfished, nor subject to overfishing. At the same time, it was also noted that fishing mortality is continuously increasing for both adult and juvenile stages while the estimated spawning potential has shown a declining trend since the mid to late 2000s, and spawning potential depletion reached a historically low level in recent years.**

27. **SC18 noted that levels of fishing mortality and depletion differ between regions, and that fishery impact was highest in the tropical region (Regions 5, 6, 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.**

b. Management advice and implications

(i) Management advice specific to skipjack

28. **SC18 did not achieve a consensus on the management advice for skipjack tuna in the WCPO.**

(ii) General recommendations for WCPFC stock assessments

29. **SC18 noted the challenge of fully reviewing the key inputs into WCPFC stock assessments and providing feedback within the time available. SC recommended that approaches that may address this issue be discussed at SC19 and recommended that the Scientific Services Provider develop a discussion paper to inform those discussions.**

Model diagnostics

30. **Model diagnostics serve an important function in the stock assessment process. They are integral to the development of a sensible assessment model, and are critical for reviewers to assess whether proposed models are suitable for the provision of management advice. This is especially true at the SC where reviewers have a short period of time to review assessments and obtain clarification from the Scientific Services Provider about areas of concern.**

31. **Key diagnostics are required for both the diagnostic case model and for models included in the structural uncertainty grid. In the case of 2022 WCPO skipjack SC18 thanked the assessment authors for updating the assessment report to include these diagnostics and note that the Shiny app[2] is a useful tool. However, SC18 also noted a lack of consistency in the level of available diagnostics between assessments of different species. In light of this, SC18 recommended that SC19 consider guidelines for WCPFC stock assessments defining:**

- **The minimum set of diagnostics that should be provided for each model being considered for management advice;**
- **Consideration of the importance and interpretation of alternative model diagnostics depending on how the assessment is used to provide management advice (i.e., single best model vs. ensembles and structural uncertainty grids);**
- **For key input analyses, such as the preparation of standardized indices of abundance, the**

[2] R Shiny app for exploring the diagnostics and outputs from the 2022 WCPO skipjack stock assessment is available at: https://ofp-sam.shinyapps.io/GridSKJ2022/

minimum set of diagnostics that should be included in the supporting working paper or information paper describing the analysis; and

- **Guidelines for the graphical presentation of diagnostics to ensure legibility.**

(iii) Research recommendations specific to the WCPO skipjack assessment

32. **SC18 identified a wide range of cross-cutting research recommendations for inclusion within the WCPFC tuna research plan for consideration, prioritisation and sequencing at SC19. SC18 noted the research recommendations made in SC18-SA-WP-01 (*Stock assessment of skipjack tuna in the western and central Pacific Ocean: 2022*) and suggested the following items for consideration as high-priority research areas:**

- **Hyperstability and effort creep in the CPUE indices, and incorporation of CPUE uncertainty in assessment results (i.e. inclusion as an axis in the structural uncertainty grid), including alternative model assumptions related to regional scaling**
- **Data conflicts that affect assessment outcomes, and approaches to resolving them.**
- **Review the model specification with the goal of conforming to the set of diagnostic criteria to determine whether an assessment model is suitable to provide management advice.**
- **Assumptions dealing with the parametrization of key model settings, such as the fishing effort regression used in the catch-conditioned approach to minimize their impact on estimates of stock status**
- **Tag mixing, including estimation using observed data, simulation, and simulation validation.**

33. **SC18 noted the terms of reference (TOR) for Project 18X2a and 18X2b (*Further development of ensemble model approaches for presenting stock assessment uncertainty*) and Project 18X4 (*Exploring evidence and mechanisms for a long-term increasing trend in recruitment of skipjack tuna in the equatorial Pacific and the development and modelling of defensible effort creep scenarios*) in SC18-GN-IP-07[3], which would address further issues of importance.**

34. **SC18 noted additional items that had relevance for both skipjack and wider WCPFC tuna stock assessments considered by the SC and ISC. These and additional items to consider where possible are further detailed below. Items also relevant to the upcoming WCPO yellowfin tuna peer review are denoted with an asterisk (*).**

i) Indices of abundance: *

- **Investigate a range of hypotheses which encompass the uncertainties in the spatial-temporal dynamics of the stock and the fishing effort.**
- **Refine effort creep scenarios for the Japanese pole-and-line fishery and equatorial purse seine fisheries.**
- **Develop alternative approaches for the interpolation of abundance into unfished areas when spatially averaging predictions to compute regional scalers. The use of preferential sampling models for standardizing CPUE data should be considered.**
- **Consider the biological limits to the spatiotemporal distribution of skipjack when making predictions of biomass in unfished areas with spatiotemporal models.**
- **Conduct analyses to incorporate additional process error in CPUE indices**
- **Evaluation of alternative sources of CPUE time series, such as FAD echo sounder buoys or additional indices for the purse seine fishery.**

[3] https://meetings.wcpfc.int/node/16222

ii) Data conflicts *

- **Likelihood profiles show conflict between data sources included in the model. The cause of these conflicts should be identified and methods to address them should be explored.**

iii) Trend in estimated recruitment:

- **Estimated WCPO skipjack recruitment steadily increased between 1975 and 2010. Possible explanations for this trend should be researched, including model misspecification. If the trend is related to model misspecification options to resolve it within the model should be presented, The SC noted the TOR for Project 18X4 (*Exploring evidence and mechanisms for a long-term increasing trend in recruitment of skipjack tuna in the equatorial Pacific and the development and modelling of defensible effort creep scenarios*) in SC18-GN-IP-07.**

iv) Recruitment distribution by region and season

- **Consider the thermal limits to the spatiotemporal distribution of skipjack recruitment within the model settings.**

v) Growth *

- **Model diagnostics for each growth curve indicate poor fit to some components of the size data. Given the potential for spatial and temporal growth variation which any assessment cannot represent, recommend approaches to modeling growth and fitting size data that are robust to the potential for bias due to systematic lack of fit.**
- **Support epigenetic aging for skipjack in the long-term while work progressing age validation and age estimation using otolith and spines should still be pursued.**

vi) Tag mixing *

- **Examine the utility of alternative approaches for including tagging data in the assessment, such as estimating movement and harvest rate parameters outside the assessment model and including them as priors.**
- **Review evidence for rates of tag mixing based on the tagging data included in the stock assessment.**
- **Consider the role of the Ikamoana simulation model in exploring scenarios of tag mixing, and the need for validation by comparing simulated and observed tag recovery patterns.**

vii) Tag reporting rates *

- **Identify approaches to prevent tag reporting rates being estimated on the boundary, as these indicate some form of model misspecification such as incomplete tag mixing or data conflicts.**

viii) Model structure enabling a converged solution *

- **Review the model structure as it relates to achieving a converged solution. This includes consideration of the spatial structure as well as confirming that estimated parameters are identifiable and well-determined. Consider the utility of such models for the provision of management advice, including evaluation of relevant CMMs.**

ix) Specification of the catch-conditioned model *

- **Estimation of the required fishing mortality spline regression parameters attracted a large penalty in the likelihood and modified population scale. The impact of parameterization on estimated quantities should be examined.**

x) Dirichlet-Multinomial set-up *

- **Review grouping assumptions when setting up the Dirichlet-Multinomial likelihood for size composition data, and identify if the model is sensitive to grouping assumptions.**

35. **SC18 recommended that SC19 consider the need for a review of the skipjack tuna stock assessment taking into account the outcomes of the 2023 yellowfin review.**

3.1.2 Pacific Bluefin Tuna *(Thunnus orientalis)*

3.1.2.1 Review of 2022 Pacific bluefin tuna stock assessment

36. H. Fukuda (Japan), the lead modeler for the ISC Pacific Bluefin tuna working group (PBFWG), presented SC18-SA-WP-05 **(***Stock assessment of Pacific bluefin tuna in the Pacific Ocean*).

3.1.2.2 Provision of scientific information

a. Status and trends

37. **SC18 welcomed successful completion of an updated Pacific bluefin tuna (PBF) stock assessment and noted the following stock status and conservation information provided by ISC.**

PBF spawning stock biomass (SSB) has gradually increased in the last 10 years, and the rate of increase is accelerating. These biomass increases coincide with a decline in fishing mortality, particularly for fish aged 0 to 3, over the last decade. The latest (2020) SSB is estimated to be 10.2% of SSB_0.

1) No biomass-based limit or target reference points have been adopted for PBF, but the PBF stock is overfished relative to the potential biomass-based reference points ($20\%SSB_0$) adopted for other tuna species by the IATTC and WCPFC. On the other hand, SSB reached its initial rebuilding target ($SSB_{MED} = 6.3\%SSB_0$) in 2019, 5 years earlier than originally anticipated by the RFMOs.
2) No fishing mortality-based reference points have been adopted for PBF by the IATTC and WCPFC. The recent (2018-2020) $F_{\%SPR}$ is estimated to produce a fishing intensity of 30.7%SPR and is below the level corresponding to overfishing for many F-based reference points proposed for tuna species (Table PBF2), including SPR20%.

38. **SC18 noted that while the gradual improvement of the Pacific bluefin tuna stock is a step in the right direction, it must be remembered that the current spawning biomass of the stock is only 10.2% of the unfished level. This is well below the LRP of 20% adopted for the key tuna species in WCPFC and suggests the Pacific bluefin tuna stock remains overfished relative to the LRP of key tuna species.**

39. **SC18 noted some CCMs encourage a precautionary approach towards the management of Pacific bluefin tuna until such time as the second rebuilding target is met, especially as the stock assessment and projection results are based on certain assumptions, including those on future recruitment, that may not always be met.**

40. **SC18 supported the continued monitoring of recruitment and spawning stock biomass, and research on a recruitment index for the stock assessment given the uncertainty in future recruitment and the influence of recruitment on stock biomass, as well as the impact of changes in fishing operations due to management changes.**

b. Management advice and implications

41. **SC18 noted that the updated stock assessment presented at SC18 indicates that the stock is likely recovering as planned or possibly faster, which suggests that the measures incorporated in CMM 2021-02 appear to be working as intended.**

42. **SC18 recommended that the Commission exercise a precautionary approach, and noted that the PBF stock is still in a depleted state (10.2% of SSB_0) when it considers any revisions to the current CMM. Consideration of any increases to the catch limit needs to be weighted against reducing the probability of recovering to the second rebuilding target.**

43. **SC18 further welcomed ISC's effort on further investigation of structural uncertainty to incorporate it in future management advice.**

44. **SC18 noted the following management information from ISC:**

After the steady decline in SSB from 1996 to the historically low level in 2010, the PBF stock has started recovering, and recovery has been more rapid in recent years, consistent with the implementation of stringent management measures. The 2020 SSB was above the initial rebuilding target but remains below the second rebuilding target adopted by the WCPFC and IATTC. However, stock recovery is occurring at a faster rate than anticipated by managers when the Harvest Strategy to foster rebuilding (WCPFC HS 2017-02) was implemented in 2014. The fishing mortality ($F_{\%SPR}$) in 2018-2020 has been reduced to a level producing 30.7%SPR, the lowest observed in the time series. Based on these findings, the following information on the conservation of the Pacific bluefin tuna stock is provided:

1) The PBF stock is recovering from the historically low biomass in 2010 and has exceeded the initial rebuilding target ($SSB_{MED1952-2014}$) five years earlier than expected. The rate of recovery is increasing and under all projection scenarios evaluated, it is very likely the second rebuilding target ($20\%SSB_0$ with 60% probability) will be achieved (probabilities > 90%) by 2029 (Table PBF-3). The risk of SSB falling below the historical lowest observed SSB at least once in 10 years is negligible.
2) The projection results show that increases in catches are possible without affecting the attainment of the second rebuilding objective. Increases in catch should consider both the rebuilding rate and the distribution of catch between small and large fish.
3) The projection results assume that the CMMs are fully implemented and are based on certain biological and other assumptions. For example, these future projection results do not contain assumptions about discard mortality. Although the impact of discards on SSB is small compared to other fisheries, discards should be considered in future harvest scenarios.
4) Given the uncertainty in future recruitment and the influence of recruitment on stock biomass as well as the impact of changes in fishing operations due to the management, monitoring recruitment and SSB should continue and research on a recruitment index for the stock assessment should be pursued.
5) The results of projections from sensitivity models with lower productivity assumptions show that this conservation information is robust to uncertainty in stock productivity.

Table PBF-1. Total biomass, spawning stock biomass, recruitment, and spawning potential ratio of Pacific bluefin tuna (*Thunnus orientalis*) estimated by the base-case model, 1952-2020.

Year	Total Biomass (t)	Spawning Stock Biomass (t)	Recruitment (1,000 fish)	Spawning Potential Ratio	Depletion Ratio
1952	134,789	103,359	14,008	11.6%	16.1%
1953	136,421	97,912	20,617	12.9%	15.2%
1954	146,892	88,019	34,911	7.9%	13.7%
1955	156,701	75,353	13,343	11.4%	11.7%
1956	176,167	67,818	33,476	15.8%	10.5%
1957	193,973	77,053	11,635	10.8%	12.0%
1958	202,415	100,943	3,203	19.5%	15.7%
1959	209,868	136,650	7,709	23.9%	21.2%
1960	202,700	144,704	7,554	17.3%	22.5%
1961	194,047	156,534	23,235	3.4%	24.3%
1962	177,257	141,792	10,774	10.9%	22.0%
1963	166,291	120,933	27,842	6.6%	18.8%
1964	154,459	106,314	5,689	7.5%	16.5%
1965	142,916	93,572	10,955	3.0%	14.5%
1966	120,164	89,589	8,556	0.1%	13.9%
1967	105,483	83,751	10,951	1.1%	13.0%
1968	91,650	77,872	14,356	1.4%	12.1%
1969	80,731	64,561	6,450	8.6%	10.0%
1970	74,490	54,181	7,182	2.9%	8.4%
1971	66,467	47,017	12,407	1.3%	7.3%
1972	64,098	40,725	22,890	0.3%	6.3%
1973	62,899	35,510	11,251	5.6%	5.5%
1974	65,165	28,711	13,983	6.3%	4.5%
1975	65,978	26,420	11,223	8.9%	4.1%
1976	65,030	29,152	8,071	3.1%	4.5%
1977	74,864	35,066	25,589	3.7%	5.4%
1978	76,566	32,974	14,317	5.0%	5.1%
1979	73,608	27,866	12,876	8.2%	4.3%
1980	72,844	29,713	6,554	6.2%	4.6%
1981	57,749	27,591	13,360	0.3%	4.3%
1982	40,714	24,235	6,454	0.0%	3.8%
1983	33,472	14,773	10,090	6.0%	2.3%
1984	37,662	12,895	9,063	5.3%	2.0%
1985	39,805	12,957	9,654	2.7%	2.0%
1986	34,473	15,316	7,939	1.1%	2.4%
1987	32,080	14,105	5,980	8.2%	2.2%
1988	38,238	15,059	9,483	11.0%	2.3%
1989	42,074	14,888	4,291	14.6%	2.3%
1990	57,971	18,994	17,436	18.4%	3.0%
1991	69,431	25,290	10,617	9.8%	3.9%
1992	76,142	32,456	3,968	14.7%	5.0%
1993	83,395	43,890	4,430	16.8%	6.8%
1994	97,472	50,177	29,319	13.5%	7.8%
1995	93,999	62,246	16,012	5.2%	9.7%
1996	96,300	61,563	17,964	8.8%	9.6%
1997	90,121	56,179	11,082	6.0%	8.7%
1998	95,748	55,612	16,075	4.2%	8.6%
1999	91,805	51,374	22,755	3.4%	8.0%
2000	76,307	48,461	14,385	1.7%	7.5%
2001	77,426	46,059	17,302	9.5%	7.2%
2002	75,311	43,899	13,541	5.7%	6.8%
2003	67,904	43,152	7,157	2.3%	6.7%
2004	65,640	35,881	27,746	1.4%	5.6%
2005	55,074	29,159	15,118	0.7%	4.5%
2006	43,314	23,294	13,540	1.1%	3.6%
2007	42,659	18,424	22,227	0.5%	2.9%
2008	38,290	13,716	21,072	0.6%	2.1%
2009	33,985	10,195	8,277	1.2%	1.6%
2010	36,969	9,761	17,952	2.4%	1.5%
2011	38,817	11,183	13,526	4.9%	1.7%
2012	42,482	13,902	7,169	8.2%	2.2%
2013	52,764	16,313	13,169	5.7%	2.5%
2014	53,075	19,185	3,641	11.1%	3.0%
2015	59,220	23,640	8,653	12.5%	3.7%
2016	69,494	30,516	16,690	12.8%	4.7%
2017	82,681	32,538	10,895	21.9%	5.1%
2018	103,849	35,741	11,145	28.3%	5.6%
2019	129,972	45,173	11,843	28.8%	7.0%
2020	156,517	65,464	11,316	35.1%	10.2%
Median(1952-2020)	74,864	35,881	11,635	6.2%	5.6%
Average(1952-2020)	89,353	49,845	13,390	8.3%	7.7%

Table PBF-2. Ratios of the estimated fishing mortalities (Fs and 1-SPRs for 2002-04, 2011-13, 2016-18) relative to potential fishing mortality-based reference points, and terminal year SSB (t) for each reference period, and depletion ratios for the terminal year of the reference period for Pacific bluefin tuna (*Thunnus orientalis*) from the base-case model**.** F_{max}: Fishing mortality (F) that maximizes equilibrium yield per recruit (Y/R). $F_{0.1}$: F at which the slope of the Y/R curve is 10% of the value at its origin. F_{med}: F corresponding to the inverse of the median of the observed R/SSB ratio. $F_{x\%SPR}$: F that produces given % of the unfished spawning potential (biomass) under equilibrium condition.

Reference Period				(1-SPR)/(1/$SPR_{xx\%}$)				Estimated SSB for terminal year of each period (ton)	Depletion rate for terminal year of each period (%)
	Fmax	F0.1	Fmed	$SPR_{10\%}$	$SPR_{20\%}$	$SPR_{30\%}$	$SPR_{40\%}$		
2002-2004	1.96	2.89	1.16	1.08	1.21	1.38	1.61	35,881	5.6%
2011-2013	1.54	2.27	0.87	1.04	1.17	1.34	1.56	16,313	2.5%
2018-2020	0.75	1.14	0.33	0.77	0.87	0.99	1.15	65,464	10.2%

Table PBF-3. Future projection scenarios for Pacific bluefin tuna (*Thunnus orientalis*) and their probability of achieving various target levels by various time schedules based on the base-case model.

Harvesting scenarios					Peformance indicators						
Reference No	WCPO		EPO		The fishing year expected to achive the 2nd rebuilding target with >60% probability	Risk to breach SSB_{loss} at least once by 2030	Probability of achiving the 2nd rebuilding target at 10 years after achieving initial rebuilding target [2029]	Median SSB at 10 years after achieving initial rebuilding target [2029]	Median SSB at 2034	Fishery impact ratio of WPO fishery at 10 years after achieving the initial rebuilding target [2029]	Fishery impact ratio of EPO fishery at 10 years after achieving the initial rebuilding target [2029]
	Small	Large	Small	Large							
1	New CMM				2023	0%	98.8%	262,795	307,336	81.1%	18.9%
2	New CMM	500 tons increase on the New CMM	500 tons increase on the New CMM		2023	0%	98.2%	256,170	298,867	80.3%	19.7%
3	10% increase on the New CMM				2023	0%	96.9%	245,333	280,687	82.3%	17.7%
4	20% increase on the New CMM				2023	0%	94.0%	227,183	253,598	83.4%	16.6%
5	-580 tons	+853 tons	New CMM		2023	0%	99.3%	269,289	319,863	80.2%	19.8%
6	+30%	+30%	+190%		2023	0%	64.1%	154,417	150,121	75.5%	24.5%
7	New CMM	+130%	+190%		2029	0%	60.0%	147,931	157,963	75.2%	24.8%
8	+60%	+60%	+90%		2023	0%	61.3%	147,275	135,698	80.6%	19.4%
9	New CMM	+230%	+90%		2030	0%	58.6%	145,058	160,473	78.3%	21.7%
10	Old CMM (50% of 2002-04 average level)	Old CMM (2002-04 average level)	Old CMM		2023	0%	99.4%	272,845	320,885	82.1%	17.9%
11	0	0	0		2022	0%	100.0%	478,465	578,729	83.0%	17.0%

* The Reference number of Scenario is different from those given by the IATTC-WCPFC NC Joint WG meeting.
* Fishing mortality for scenario 1 is specified as average level of age-specific fishing mortality during 2002-2004, which is the reference years in the WCPFC. Higher levels of the fishing mortality are specified for other scenarios to fulfill their quota in those projections.
* The Japanese unilateral measure (transferring 250 mt of catch upper limit from that for small PBF to that for large PBF during 2020-2034) is reflected in the projections.

Table PBF-4. Expected yield for Pacific bluefin tuna (*Thunnus orientalis*) under various harvesting scenarios based on the base-case model.

Reference No	Harvesting scenarios						Future expected catch							
	Catch upper limit increments from status quo			Catch upper limit in the projection			2024				2034			
	WCPO		EPO	WCPO		EPO	WCPO		EPO		WCPO		EPO	
	Small	Large	Commercial	Small	Large	Commercial	Small	Large	Commercial	Sport	Small	Large	Commercial	Sport
1	New CMM			4,475	7,860	3,995	4,496	7,884	4,008	1,228	4,497	7,922	4,012	1,540
2	New CMM	500 tons increase on the New CMM	500 tons increase on the New CMM	4,475	8,360	4,495	4,496	8,366	4,506	1,216	4,496	8,419	4,510	1,513
3	10% increase on the New CMM			4,948	8,621	4,395	4,965	8,610	4,404	1,189	4,965	8,674	4,407	1,430
4	20% increase on the New CMM			5,420	9,382	4,794	5,434	9,307	4,801	1,150	5,435	9,413	4,802	1,318
5	-580 tons	+853 tons	New CMM	3,895	8,713	3,995	3,916	8,749	4,009	1,250	3,917	8,787	4,013	1,616
6	+30%	+30%	+190%	5,893	10,143	11,586	5,892	10,181	11,521	996	5,889	10,018	11,247	924
7	New CMM	+130%	+190%	4,475	17,752	11,586	4,492	17,733	11,552	1,012	4,491	17,144	11,486	1,079
8	+60%	+60%	+90%	7,310	12,425	7,591	7,240	12,502	7,594	979	7,211	12,073	7,512	841
9	New CMM	+230%	+90%	4,475	25,362	7,591	4,494	23,864	7,601	1,030	4,493	24,055	7,597	1,160
10	Old CMM (50% of 2002-04 average level)	Old CMM (2002-04 average level)	Old CMM	4,475	6,841	3,300	4,497	6,866	3,317	1,243	4,497	6,888	3,319	1,580
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* Catch limits for EPO commercial fisheries are applied for the catch of both small and large fish made by the fleets.

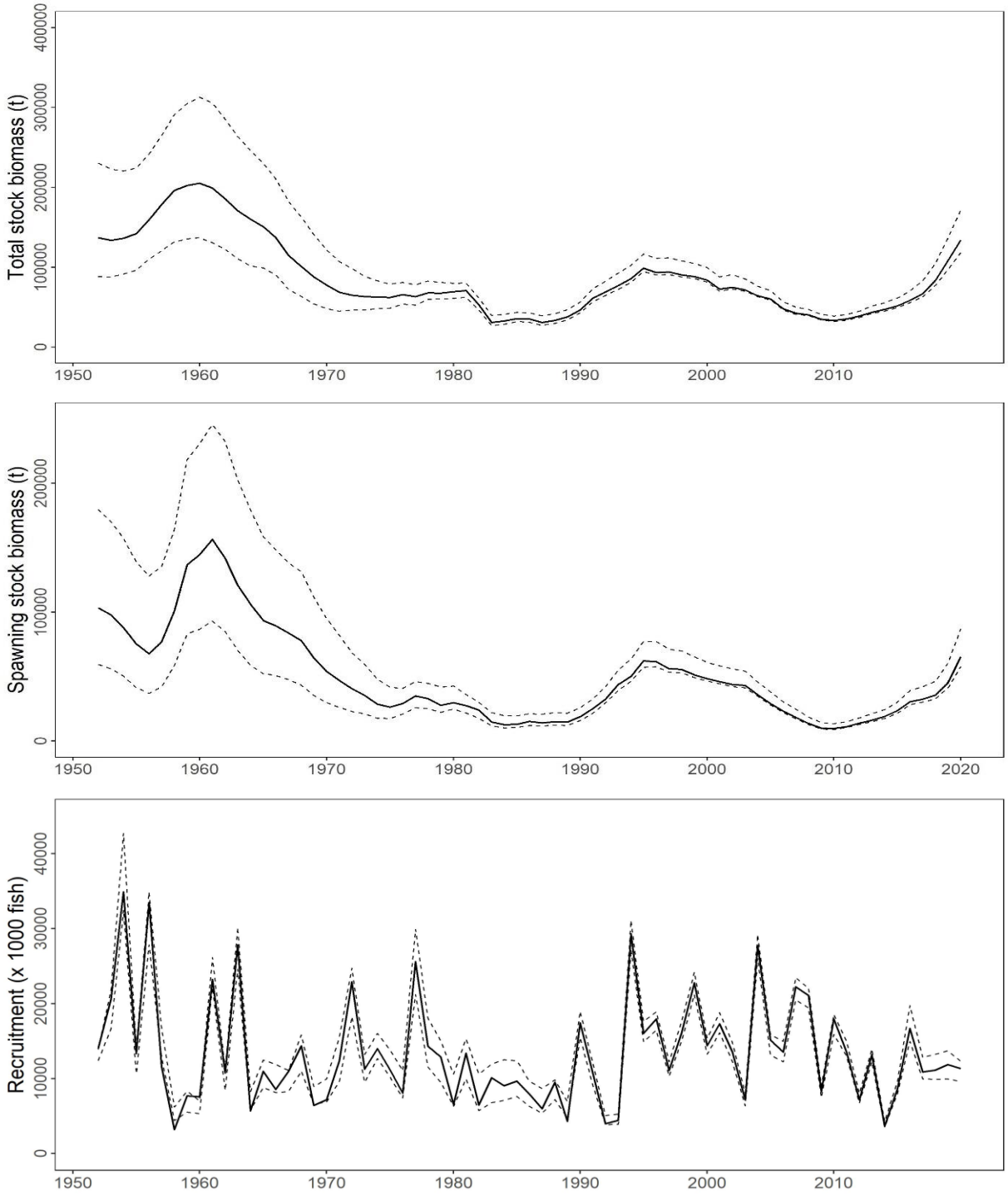

Figure PBF-1. Total stock biomass (top), spawning stock biomass (middle), and recruitment (bottom) of Pacific bluefin tuna (*Thunnus orientalis*) (1952-2020) estimated from the base-case model. The solid line is the point estimate and dashed lines delineate the 90% confidence interval.

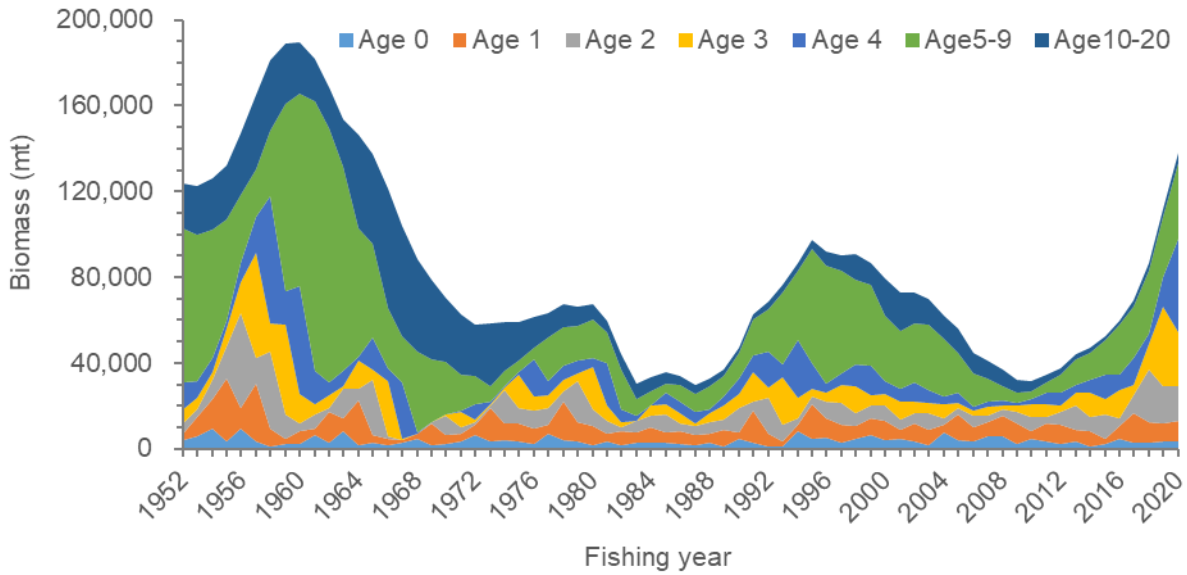

Figure PBF-2. Total biomass (tonnes) by age of Pacific bluefin tuna (*Thunnus orientalis*) estimated from the base-case model (1952-2020).

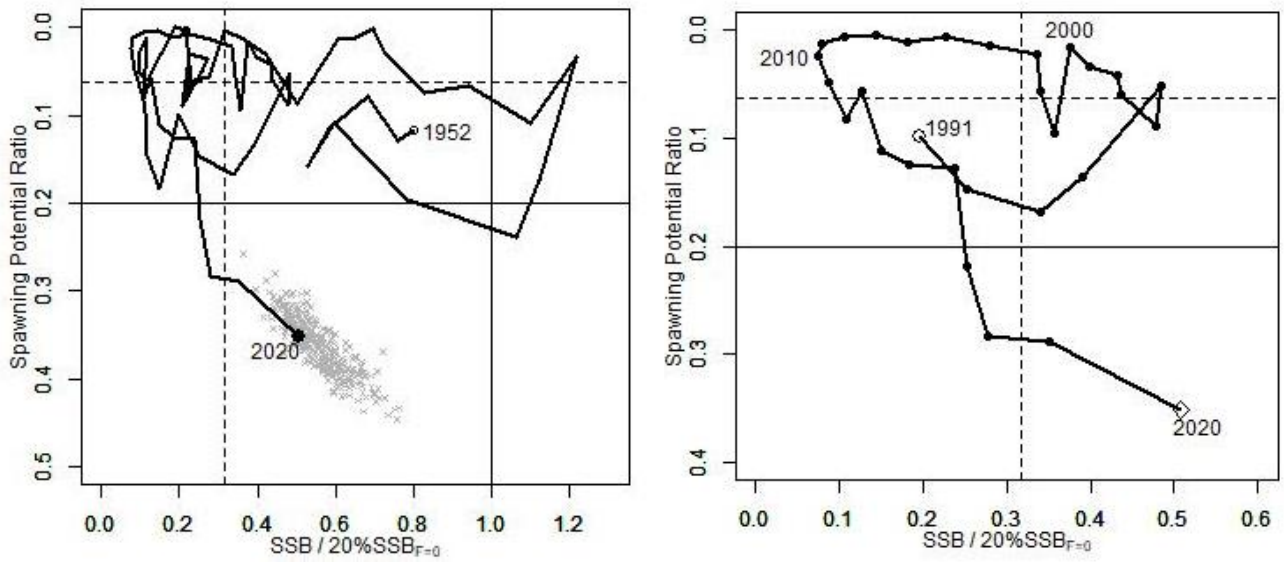

Figure PBF-3. Kobe plots for Pacific bluefin tuna (*Thunnus orientalis*) estimated from the base-case model. The X-axis shows the annual SSB relative to 20%SSB_0 and the Y-axis shows the spawning potential ratio (SPR) as a measure of fishing mortality. Vertical and horizontal solid lines in the left figure show 20%SSB_0 (which corresponds to the second biomass rebuilding target) and the corresponding fishing mortality that produces SPR, respectively. Vertical and horizontal broken lines in both figures show the initial biomass rebuilding target (SSB_{MED} = 6.3%SSB_0) and the corresponding fishing mortality that produces SPR, respectively. SSB_{MED} is calculated as the median of point estimates of SSB over 1952-2014 by the base case model. The left figure shows the historical trajectory, where the open circle indicates the first year of the assessment (1952), solid circles indicate the last five years of the assessment (2014-2020), and grey crosses indicate the uncertainty of the terminal year estimated by bootstrapping. The right figure shows the trajectory of the last 30 years.

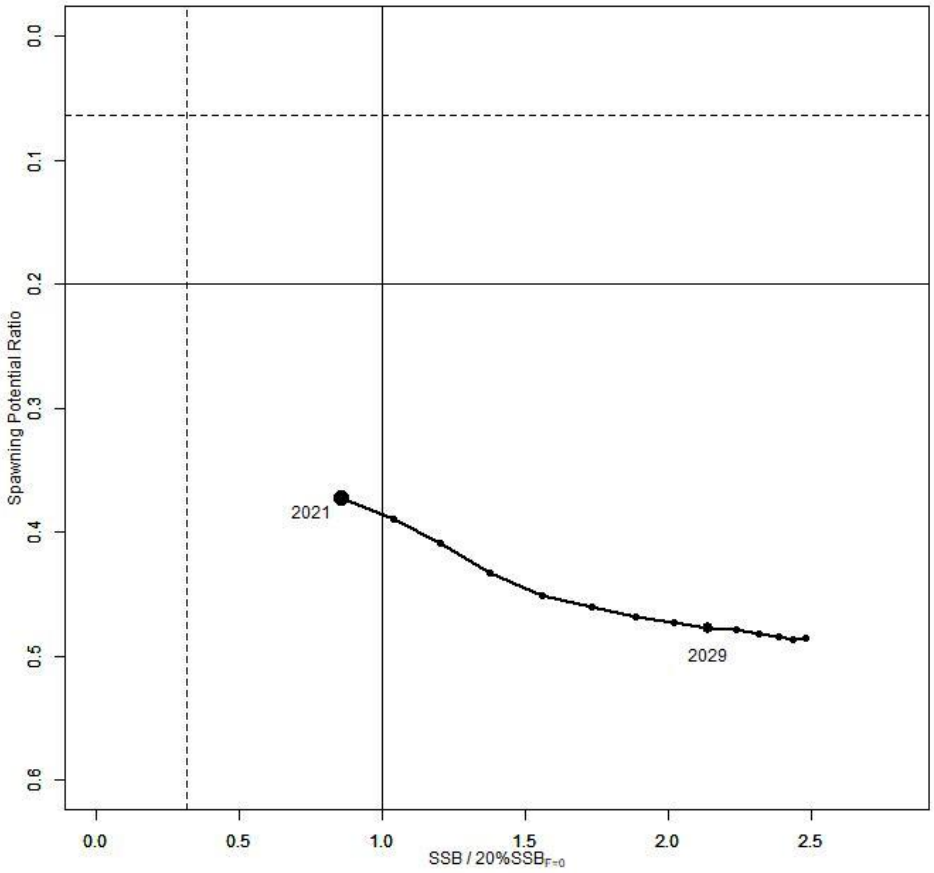

Figure PBF-4. "Future Kobe Plot" of projection results for Pacific bluefin tuna (*Thunnus orientalis*) from Scenario 1 from Table PBF-3.

3.2 WCPO sharks

3.2.1 Southwest Pacific blue shark (*Prionace glauca*)

3.2.1.1 Towards providing scientific advice for Southwest Pacific blue shark (Project 107b)

45. P. Neubauer presented SC18-SA-WP-03 (*Report on WCPFC project 107b: Improved stock assessment and structural uncertainty grid for Southwest Pacific blue shark*), which is a response to SC17 recommendations to assess performance of each model and evaluate the plausibility of the uncertainty grid before approving the results for providing management advice using several diagnostic tests.

3.2.1.2 Provision of scientific information

a. Status and trends

46. **A description of the structural uncertainty grid with associated weighting that was used to define stock status and characterize uncertainty in the Southwest Pacific blue shark (SBSH) assessment is included in Table SBSH-1.**

47. **SC18 noted the improvement of the structural uncertainty grid and the use of 228 models, with *a priori* weighting, and the reduced grid complexity compared to the 2021 version.**

48. **SC18 noted the stock biomass was low throughout the region through the early 2000s following the expansion of longline fishing effort in the region, but the estimates across the uncertainty grid of 228 models largely indicated that the stock has been recovering since then.**

49. **SC18 noted that the median value of relative recent dynamic spawning biomass depletion for Southwest Pacific blue shark ($SB_{2017-2020}/SB_{F=0}$) was 0.71 (90th percentiles 0.37 and 0.82). Alternatively, relative recent equilibrium spawning biomass depletion for South Pacific blue shark ($SB_{2017-2020}/SB_{0}$) was = 0.80 (90th percentiles 0.43 and 0.90).**

50. **SC18 noted that the median value of $SB_{2017-2020}/SB_{MSY}$ was 1.64 (90th percentiles 0.88 and 1.87; Table SBSH-2) with 87% likelihood (according to the 228 weighted models) that the biomass is above SB_{MSY}.**

51. **SC18 noted that the fishing mortality has declined over the last decade and is currently relatively low with the median $F_{2017-2020}/F_{MSY}$ = 0.65 (90th percentiles 0.43 and 0.86; Table SBSH-2).**

52. **SC18 noted that there was a 1% likelihood (according to the 228 weighted models) that the recent fishing mortality ($F_{2017-2020}$) was above F_{MSY}.**

Table SBSH-1. Description of the seven axes for the updated 2022 structural uncertainty grid. Base settings used under the diagnostic case are highlighted in bold. Weights used for alternative values in the weighting of the grid axes are given in parentheses.

Axis	Description
Catch scenario	**Base (0.9)**, high (0.1)
Discard scenario	Low (0.25), **base (0.5)**, high (0.25)
Initial F	**base (0.9)**, high (0.1)
High latitude CPUE	**New Zealand (1),** low weight (0.5), remove (RM) early New Zealand (0.5)
Low latitude CPUE	**Japan (1)**, Australia (0.5), remove EU CPUE
Survival fraction	**Base**, low, high
Growth	**Manning and Francis (2005)**, Joung et al. (2018)

Table SBSH-2. Summary of reference points and stock status for the subset of 228 grid model in the structural uncertainty grid, after sub-setting the grid for model runs that showed acceptable retrospective patterns and estimates for natural mortality. Grid axes are weighted by prior input weights. The symbols used in the yield and stock status are described in Table 3 of SC18-SA-WP03.

(catch in mt)

	Mean	Median	Min	10%	90%	Max
C_{latest}	5,965	5671	3707	3978	7593	9601
C_{recent}	6,912	6744	4322	4596	8926	9577
MSY	11,413	9993	8968	9313	16333	25629
SB_0	22,772	20603	15686	18524	32263	53503
$SB_{F=0}$	25,894	22658	17559	20161	38033	66434
SB_{MSY}	11,104	9985	7564	9008	15854	26684
SB_{latest}	18,420	17904	12973	15902	20424	38004
SB_{recent}	16,344	15907	11320	14000	17670	33654
SB_{latest}/SB_0	0.85	0.90	0.42	0.49	1.01	1.19
SB_{recent}/SB_0	0.76	0.80	0.37	0.43	0.90	1.05
$SB_{latest}/SB_{F=0}$	0.76	0.79	0.32	0.43	0.93	1.29
$SB_{recent}/SB_{F=0}$	0.67	0.71	0.29	0.37	0.82	1.15
SB_{latest}/SB_{MSY}	1.75	1.84	0.85	1.00	2.10	2.47
SB_{recent}/SB_{MSY}	1.55	1.64	0.76	0.88	1.87	2.19
F_{MSY}	0.144	0.142	0.134	0.136	0.158	0.181
$F_{lim,AS}$	0.228	0.225	0.211	0.214	0.248	0.291
$F_{crash,AS}$	0.325	0.320	0.299	0.304	0.351	0.419
F_{latest}	0.073	0.072	0.039	0.051	0.093	0.120
F_{recent}	0.094	0.094	0.048	0.065	0.117	0.160
F_{latest}/F_{MSY}	0.51	0.52	0.24	0.35	0.67	0.78
F_{recent}/F_{MSY}	0.65	0.65	0.30	0.43	0.86	1.06
$F_{latest}/F_{lim,AS}$	0.32	0.33	0.15	0.22	0.43	0.50
$F_{recent}/F_{lim,AS}$	0.41	0.41	0.19	0.27	0.55	0.68
$F_{latest}/F_{crash,AS}$	0.23	0.23	0.11	0.15	0.30	0.35
$F_{recent}/F_{crash,AS}$	0.29	0.29	0.13	0.19	0.39	0.48

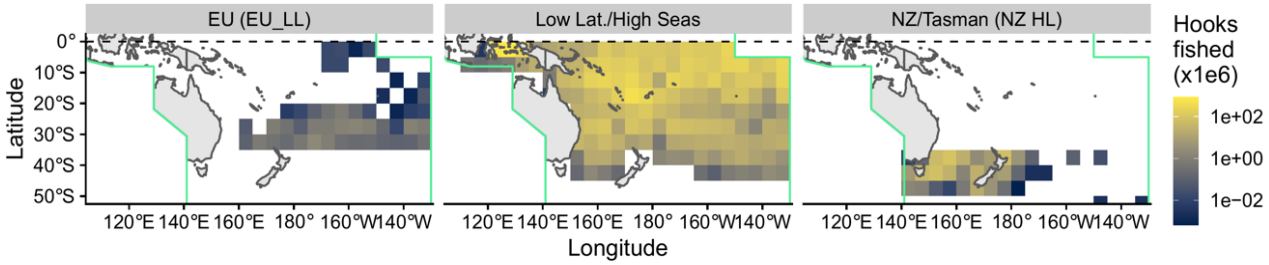

Figure SBSH-1. Spatial structure used in the 2022 stock assessment model.

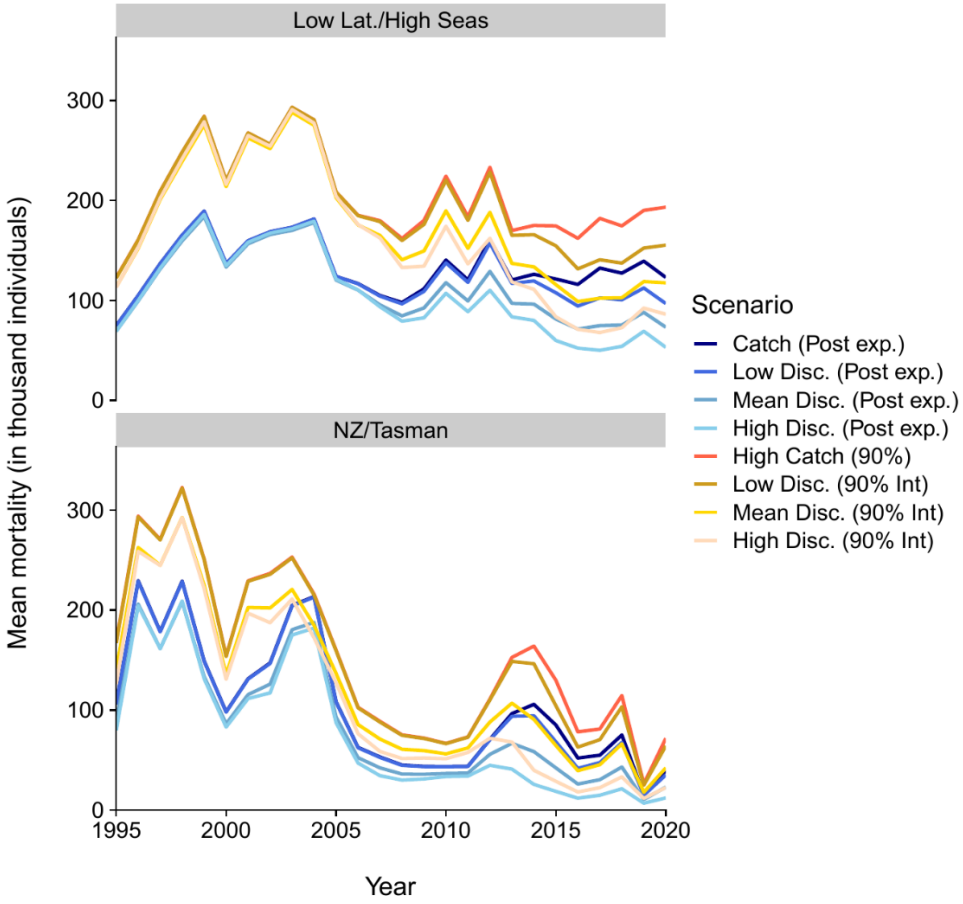

Figure SBSH-2. Top panel: Time series of total reported annual Southwest Pacific BSH catch for the EU-SP fleet (mt), Bottom panels: Predicted total fishing related mortality by latitudinal stratum (high [≥ 35 degree South] and low latitude [< 35 degree South]), including 17% post release mortality for live-discarded blue sharks. Interactions refer to the posterior median (50%) and 90th percentile (90%) of the predicted catch from the observer catch rate model. Low, median and high discard scenarios refer to the 25%, 50% (median) and 75% discard estimates. All discard estimates were applied at flag and latitudinal stratum level to overall interactions.

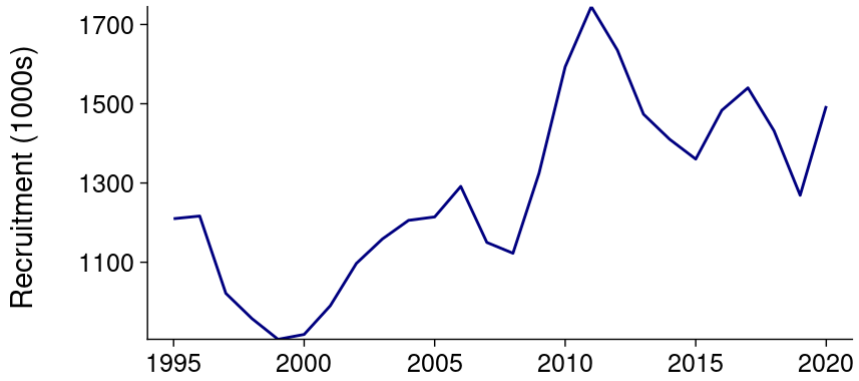

Figure SBSH-3. Estimated annual recruitment for the diagnostic case model

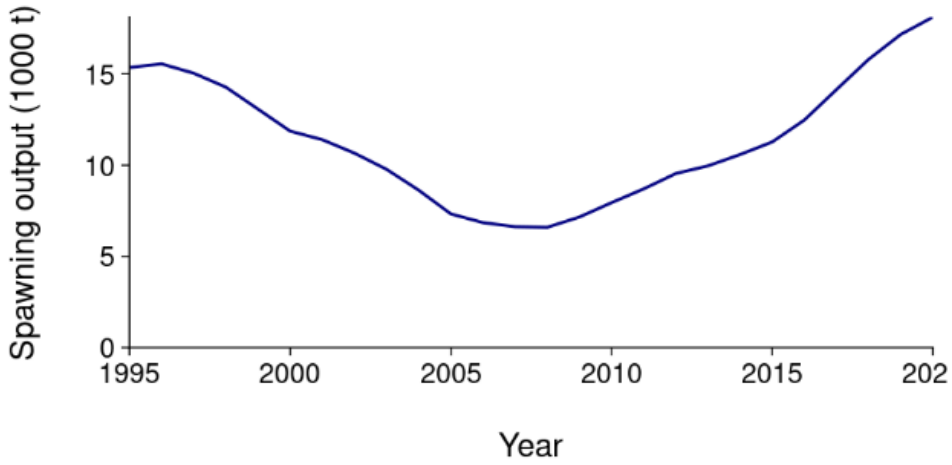

Figure SBSH-4. Estimated annual spawning potential by model region for diagnostic case model

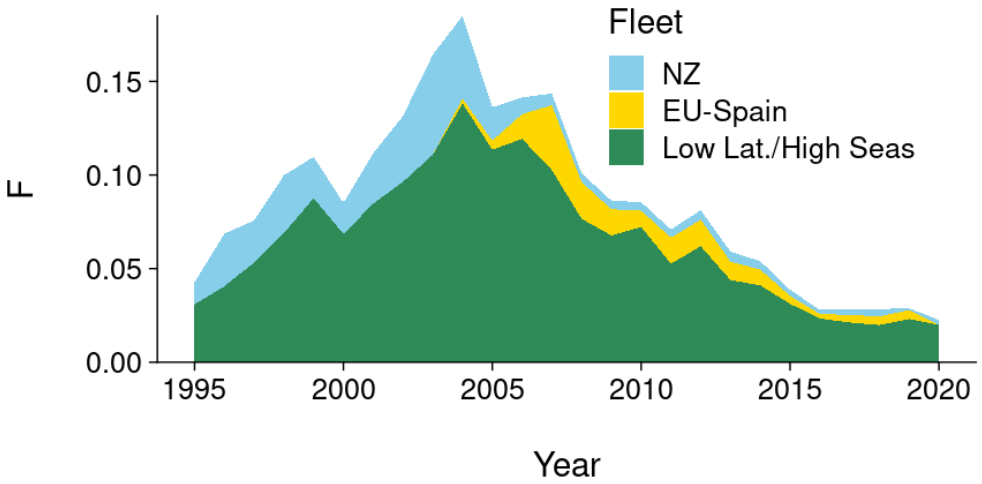

Figure SBSH-5. Estimated annual fishing mortality for the diagnostic case model

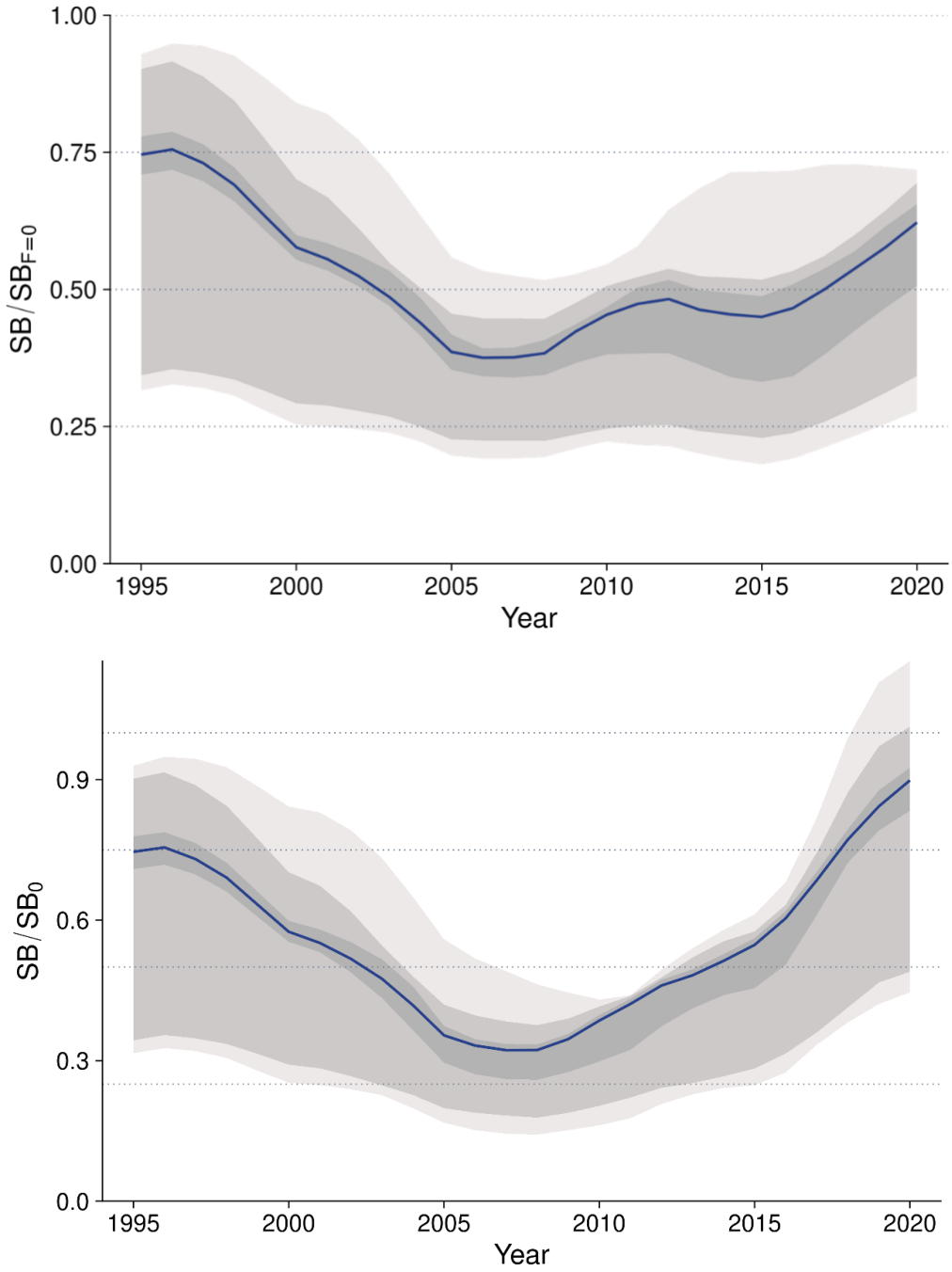

Figure SBSH-6. Plot showing the quantiles of trajectories of fishing depletion (of spawning potential) for the 228 model runs included in the structural uncertainty grid

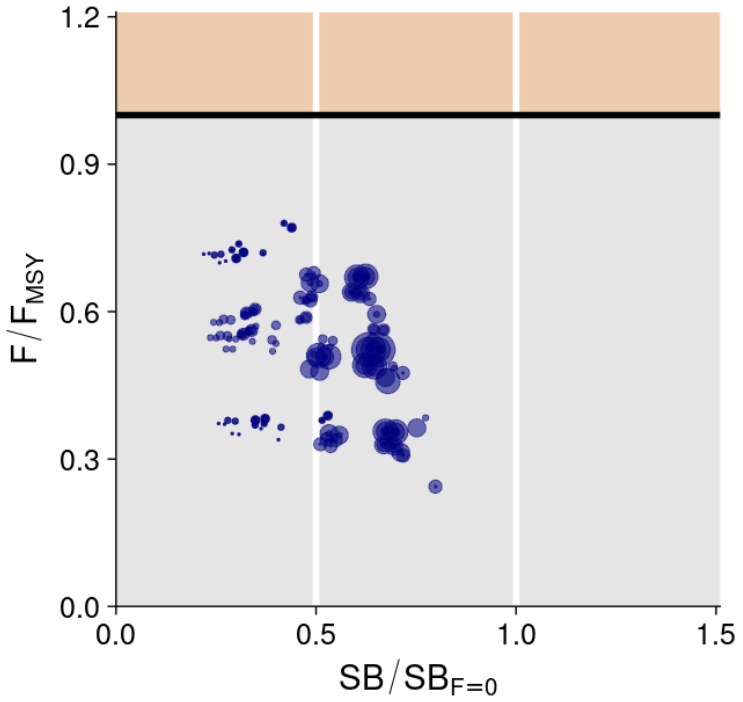

Figure SBSH-7. Majuro plot summarising the results for each of the models in the structural uncertainty grid. Size indicates weight of each model in the grid, darker shading indicates multiple models with similar outcomes.

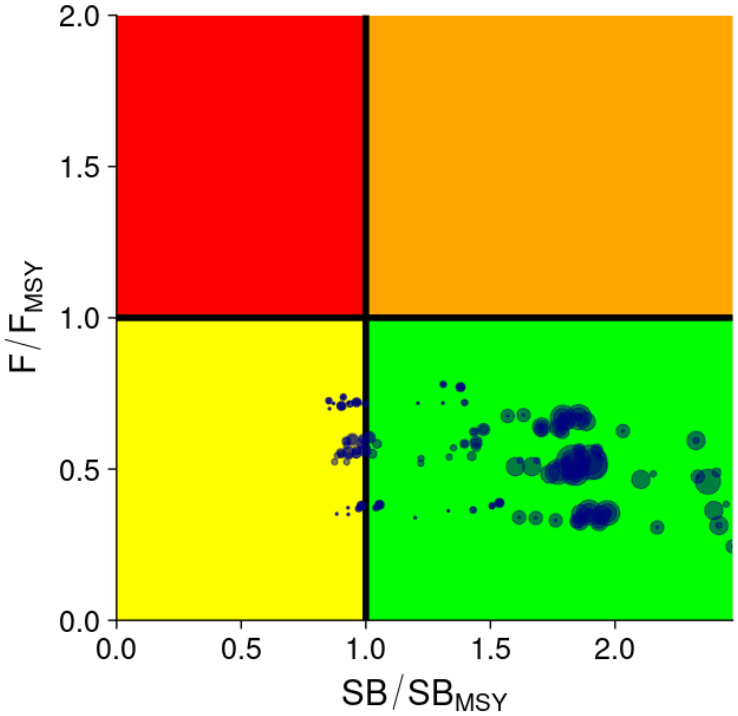

Figure SBSH-8. Kobe plot summarising the results for each of the models in the structural uncertainty grid. Size indicates weight of each model in the grid, darker shading indicates multiple models with similar outcomes.

b. Management advice and implications

53. **SC18 welcomed the reduction and refinement of the grid of models for Southwest Pacific blue shark as well as the approach to the weighting of the model.**

54. **Based on the above information, SC18 advised the Commission that the Southwest Pacific blue shark is unlikely to be overfished and it is unlikely that overfishing is occurring when considered against MSY and depletion-based reference points.**

c. Future research recommendations

55. **SC18 noted the following research recommendations to achieve improvement in future shark assessments:**

- **(i) Providing more time, either as inter-session projects, or by extending time-frames for shark data analyses. This will allow more thorough investigation of input data quality and trends, which shape assessment choices. In addition, it would allow input analyses to be completed in time to be presented to the SPC's Pre-assessment Workshop prior to the stock assessment. In addition, allowing more time for the assessments themselves will allow a more thorough investigation of alternative model structures, which may include comparisons with low-information methods such as spatial risk assessments.**
- **(ii) Increased effort to reconstruct catch histories for sharks (and other bycatch species) from a range of sources. Our catch reconstruction models showed that model assumptions and formulation can have important implications for reconstructed catches. Additional data sources, such as log-sheet reported captures from reliably reporting vessels, may be incorporated into integrated catch-reconstruction models to fill gaps in observer coverage.**
- **(iii) Additional tagging be carried out using satellite tags in a range of locations, especially known nursery grounds in South-East Australia and New Zealand, as well as high seas areas to the north and east of New Zealand, where catch-rates are high. Such tagging may help to resolve questions about the degree of natal homing and mixing of the stock.**
- **(iv) Tagging may also help to obtain better estimates of natural mortality, if carried out in sufficient numbers. This could be taken up as part of the WCPFC Shark Research Plan to assess the feasibility and scale of such an analysis.**
- **(v) Additional growth studies from a range of locations could help build a better understanding of typical growth, as well as regional growth differences. Current growth data are conflicting, despite evidence that populations at locations of current tagging studies are likely connected or represent individuals from the same population.**
- **(vi) Genetic/genomic studies could be undertaken to augment the tagging work to help resolve these stock/sub-stock structure patterns. To support this work, a strategic tissue sampling program for sharks is recommended with samples to be stored and curated in the Pacific Marine Specimen Bank.**

3.2.2 Southwest Pacific shortfin mako shark (*Isurus oxyrinchus*)

3.2.2.1 Review of 2022 Southwest Pacific shortfin mako shark stock assessment (Project 111)

56. Kath Large (Dragonfly) presented SC18-SA-WP-02 (*Stock assessment of Southwest Pacific Shortfin Mako shark*), which assesses southwest Pacific shortfin mako shark stock in the WCPO (referred to as the southwest Pacific stock).

3.2.2.2 Provision of scientific information

a. Status and trends

57. **The authors noted that the assessment models had high estimation uncertainty and were sensitive to a range of inputs. Assessment results were deemed preliminary and were not recommended for providing management advice and that alternative assessment approaches be explored. Therefore, SC18 found it was unable to provide stock status or trends information on Southwest Pacific mako shark to the Commission, as the status remains unknown.**

b. Management advice and implications

58. **SC18 does not regard the South Pacific mako shark assessment to be robust enough to provide management advice. As such, SC18 is unable to provide management advice and implications for South Pacific mako shark to the Commission. SC18 notes that a large number of CCMs currently release (cut sharks free) shortfin mako sharks. This practice may result in a reduction in fishing mortality and SC18 encourages CCMs to continue to maintain this practice as a precautionary measure for a slow growing, unproductive species with unknown stock status.**

c. Future research recommendations

59. **Given some of the fundamental uncertainties highlighted above, SC18 recommended:**

- **Future assessments should spend increased effort to reconstruct spatiotemporal abundance patterns for shortfin mako, and develop a better understanding of how these patterns drive regional abundance indices.**
- **Providing more time, either as inter-sessional projects, or by extending time-frames for shark analyses will allow more thorough investigation of input data quality and trends, which shape assessment choices. In addition, this approach would allow input analyses to be completed in time to be presented to the SPC's Pre-assessment Workshop prior to the stock assessment commencing. Moreover, this will provide more time for the assessments themselves allowing a more thorough investigation of alternative model structures or assessment approaches.**
- **Increased effort should be made to re-construct catch histories for sharks (and other bycatch species) from a range of sources. Our catch reconstruction models showed that model assumptions and formulation can have important implications for reconstructed catch. Additional data sources, such as log-sheet reported captures from reliably reporting vessels, may be incorporated into integrated catch-reconstruction models to fill gaps in observer coverage.**
- **Additional tagging should be carried out using satellite tags in a range of locations, especially known nursery grounds off southeast Australia and New Zealand, as well as high seas areas to the north and east of New Zealand, where catch-rates are high. Such tagging may help to resolve questions about the degree of natal homing and mixing of the stock.**
- **Tagging may also help to obtain better estimates of natural mortality, if carried out in sufficient numbers. This could be taken up as part of the WCPFC Shark Research Plan to assess the feasibility and scale of such an analysis.**
- **Additional growth studies and validation of aging methods from a range of locations could help build a better understanding of typical growth, as well as regional growth differences. Current growth data are conflicting, despite evidence that populations at locations of current tagging studies are likely connected or represent individuals from the**

same population.

- **Genetic/genomic studies could be undertaken to augment the tagging work to help resolve the stock/sub-stock structure patterns. To support this work, a strategic tissue sampling program for sharks is recommended with samples to be stored and curated in the Pacific Marine Specimen Bank.**
- **Aggregated data are currently submitted as annual totals for the WCPFC area only, making them uninformative for a stock specific assessment. Therefore, shortfin mako shark aggregated data (and probably other Key Sharks) should be reported by ocean area not simply as WCPO and, where possible, these data should be retrospectively corrected. As such we propose that paragraph 1 bullet point 3 of the Scientific Data to be Provided to the Commission should include the following sentence: "For Key Sharks, estimates of annual catch should be separated into catch north and south of the Equator. The WCPFC secretariat should work with CCMs to get these data retrospectively corrected where possible."**

3.2.3 North Pacific blue shark (*Prionace glauca*)

3.2.3.1 Review of 2022 North Pacific blue shark stock assessment

60. Nicholas Ducharme-Barth (USA) presented SC18-SA-WP-06 **(***Stock assessment and future projections of blue sharks in the North Pacific Ocean through 2020*), which presents the results of the stock assessment for blue sharks in the North Pacific Ocean conducted by the ISC SHARKWG using a fully integrated, size-based, age-, and sex-structured model.

3.2.3.2 Provision of scientific information

a. Stock status and trends

61. **SC18 thanked ISC for the updated stock assessment for North Pacific blue shark and noted the following conclusions on the stock status provided by ISC.**

> Target and limit reference points have not yet been established for pelagic sharks in the Pacific Ocean by either the WCPFC or the IATTC. Stock status was reported in relation to MSY-based reference points. The following information on the status of North Pacific BSH was provided.
>
> The median of the annual spawning stock biomass (SSB) from the model ensemble had a steadily decreasing trend until 1992 and slightly increased until recent years. The median of the annual F from the model ensemble gradually increased in the late 1970s and 1980s and suddenly dropped around 1990, which slightly preceded the high-seas drift gillnet fishing ban, after which it has been slightly decreasing. The median of the annual age-0 recruitment estimates from the model ensemble appeared relatively stable with a slightly decreasing trend over the assessment period except for 1988, which shows a large pulse. The historical trajectories of stock status from the model ensemble revealed that North Pacific BSH had experienced some level of depletion and overfishing in previous years, showing that the trajectories moved through the overfishing zone, overfished and overfishing zone, and overfished zone in the Kobe plots relative to MSY reference points. However, in the last two decades, median estimates of the stock condition returned into the not overfished and not overfishing zone.
>
> Based on these findings, the following information on the status of the North Pacific BSH is provided:

1) Median female SSB in 2020 was estimated to be 1.170 of SSB_{MSY} (80^{th} percentile, 0.570 - 1.776) and is likely (63.5% probability) not in an overfished condition relative to MSY-based reference points.
2) Recent annual F ($F_{2017-2019}$) is estimated to be below F_{MSY} and overfishing of the stock is very likely (91.9% probability) not occurring relative to MSY-based reference points.
3) The base case model results show that there is a 61.9% joint probability that NPO BSH stock is not in an overfished condition and that overfishing is not occurring relative to MSY based reference points.

62. **SC18 noted that the current assessment is an improvement over the previous assessment and supports the model ensemble approach taken in the 2022 stock assessment as a more comprehensive way of characterizing structural uncertainty in stock status. However, SC18 noted that the model ensemble did not consider some key uncertainties, in particular natural mortality or stock-recruitment steepness and SC18 recommended a more thorough use of the model ensemble approach is recommended to better represent uncertainty for future assessments.**

b. Management advice and implications

63. **SC18 noted the following conservation information from ISC.**

Stock projections of biomass and catch of NPO BSH from 2020 to 2030 were performed assuming four different harvest policies: $F_{current}$ (2017-2019), F_{MSY}, $F_{current}$+20%, and $F_{current}$-20% and evaluated relative to MSY-based reference points. Based on these findings, the following conservation information is provided:

1) Future projections in three of the four harvest scenarios ($F_{current}$ (2017-2019), $F_{current}$+20%, and $F_{current}$-20%) showed that median SSB in the North Pacific Ocean will likely (>50 probability) increase; the F_{MSY} harvest scenario led to a decrease in median SSB.
2) Median estimated SSB of BSH in the North Pacific Ocean will likely (>50 probability) remain above SSB_{MSY} in the next ten years for all scenarios except F_{MSY}; harvesting at F_{MSY} decreases SSB below SSB_{MSY} (Figure 5E, SC18-SA-WP-06).
3) There remain some uncertainties in the time series based on the quality (observer vs. logbook) and timespans of catch and relative abundance indices, limited size composition data for several fisheries, the potential for additional catch not accounted for in the assessment, and uncertainty regarding life history parameters. Continued improvements in the monitoring of BSH catches, including recording the size and sex of sharks retained and discarded for all fisheries, as well as continued research into the biology, ecology, and spatial structure of BSH in the North Pacific Ocean are recommended.

64. **SC18 noted that recent estimated recruitment was below the average level from the Beverton-Holt stock recruit relationship, and that if these low recruitments persist into the future then the projection results could be overly optimistic.**

3.3 WCPO billfishes

3.3.1 North Pacific striped marlin (*Kajikia audax*)

3.3.1.1 Review of 2022 North Pacific striped marlin stock assessment

65. H. Ijima (ISC) presented SC18-SA-WP-07 **(***Modelling improvements for the Western and Central north Pacific Ocean striped marlin (Kajikia audax) to be implemented in the benchmark stock assessment in 2023*).

3.3.1.2 Provision of scientific information

a. Status and trends

66. **The SC18 concurred with the ISC22 Plenary, which reviewed new modelling and data improvements for the Western and Central North Pacific Ocean striped marlin (WCNPO MLS) stock and concluded that this report is a work in progress, but new stock status and conservation and management advice was not available. SC18 stated it looks forward to the ISC BILLWG workplan to explore the growth curve and complete a benchmark WCNPO MLS assessment for approval at ISC23.**

b. Management advice and implications

67. **SC18 agreed that the Conservation and Management advice for North Pacific striped marlin will be carried forward from 2019.**

3.4 Peer Review

3.4.1 Progress of the peer review (Project 65)

68. CCMs agreed that the upcoming results of the peer review will have the potential to affect future stock assessments, and should be discussed in advance of SC19.

Recommendation

69. **SC18 noted that the in-person peer review workshop for the 2020 WCPO yellowfin tuna stock assessment will occur from the 7-13 September 2022 at SPC in Noumea. SC18 agreed that the results of the peer review would be initially considered through the submission of a draft review paper to an online discussion forum later in 2022 with participation by invitation; results of the peer review would subsequently be discussed at the 2023 Pre-assessment Workshop, either by SPC or a peer review panel member, and used to inform the 2023 stock assessment work; and the final peer review outcomes would be presented in a working paper at SC19 by either SPC or, if possible, a peer review panel member.**

3.4.2 Characterization of stock assessment uncertainty

70. **SC18 noted that, related to the characterization of stock assessment uncertainty, a project Terms of Reference for P18X2 (*Further development of ensemble model approaches for presenting stock assessment uncertainty*) was provided in SC18-SA-IP-09, following the request from SC17, and will be considered by the Commission for funding in 2023.**

AGENDA ITEM 4 — MANAGEMENT ISSUES THEME

71. The Management Issues (MI) theme was convened by R. Campbell (Australia).

4.1 Development of the Harvest Strategy Framework for key tuna species

4.1.1 Skipjack tuna

4.1.1.1 Skipjack tuna TRP analyses

72. Graham Pilling (SPC-OFP) presented SC18-MI-WP-09 (*Further updates to WCPO skipjack tuna projected stock status to inform consideration of an updated target reference point*).

Recommendations

73. **Noting the Commission is scheduled to adopt a target reference point (TRP) for skipjack tuna in 2022, and the request from WCPFC18 for SC18 to review any additional information on TRPs for skipjack tuna, SC18 reviewed SC18-MI-WP-09 (*Further updates to WCPO skipjack tuna projected stock status to inform consideration of an updated target reference point*).**

74. **SC18 noted that the updated stock assessment for skipjack tuna (accepted by SC18) indicates that the median value of $SB_{recent}/SB_{F=0}$ relative to the spawning potential depletion in 2012 was 0.85. Based on preliminary deterministic projections, the ratio of $SB_{recent}/SB_{F=0}$ to the level of projected equilibrium spawning potential depletion reached under 2012 fishing conditions was 1.00. $SB_{recent}/SB_{F=0}$ relative to the average of these two values, as maybe used to recalibrate a TRP, was 0.93. Alternatively, the ratio of $SB_{recent}/SB_{F=0}$ to the interim TRP of $50\%SB_{F=0}$ is 1.02.**

75. **Several CCMs noted that one of the challenges with the specification of absolute depletion-based TRPs is their possible susceptibility to changes in the perception of stock status when successive stock assessments predict different stock trajectories or levels. To counter this, it was recommended the Commission adopt TRPs specified in terms of a reference year, or a set of years.**

76. **SC18 was informed that the interim TRP for skipjack tuna is 50% of the spawning biomass in the absence of fishing ($SB_{F=0}$) as set out in CMM 2015-06, and while the TRP is still under review, no agreement had been reached at WCPFC18.**

77. **SC18 requested the Scientific Service Provider update SC18-MI-WP-09 (Table 2) to include evaluations based on the 2022 skipjack assessment (the Scientific Services Provider noted that this will need to wait until updates to the current software are completed). This update should be performed using the same settings as SC18-MI-WP-09 and include the projected outcomes from a set of candidate TRP options ranging between 40% to 60% depletion ratios and should continue to assess the change in purse seine effort from 2012 levels for the different candidate TRPs, the change in depletion relative to 2018-2021 average levels, as well as the projected impacts on equilibrium yields and the risk of breaching the LRP.**

78. **SC18 recommended that this update be provided to WFCPF19, and that the Commission take appropriate management action to ensure that the biomass depletion level fluctuates around the TRP (e.g., through the adoption of a harvest control rule).**

4.1.1.2 Skipjack operating models

79. R. Scott (SPC) presented SC18-MI-WP-01 **(***Operating models for skipjack tuna in the WCPO*).

Recommendations

80. **Noting the Commission is scheduled to adopt a management procedure (MP) for skipjack tuna in 2022, and the request from WCPFC18 for SC18 to review and recommend an agreed grid of operating models (OMs) that reflect important sources of uncertainty and plausible states of nature**

for WCPO skipjack, SC18 reviewed SC18-MI-WP-01 (*Operating models for skipjack tuna in the WCPO*).

81. **SC18 noted the settings and configurations of the models that comprise the reference set of OMs for skipjack tuna are working well. While there were some differences, the range of uncertainty in the trajectories of spawning potential depletion estimated by the reference set spanned the results of the 2022 stock assessment, especially in recent years. Noting that stock assessments focus on historical uncertainty while OMs focus on future uncertainty, updating the reference set of OMs to be based on the 2022 assessment was unlikely to result in any changes in the relative performance of candidate MPs.**

82. **SC18 also noted that the OM grid should not require updating each time a new assessment is accepted unless new evidence is provided that indicates that population dynamics or key uncertainties are substantially outside of the bounds of that encompassed by the OM sets. Such an instance would be covered under exceptional circumstances.**

83. **SC18 also noted that further expansion of the axes of uncertainty at this time, as suggested by some CCMs, would unlikely change the relative performance of candidate MPs.**

84. **SC18 agreed to accept the reference set of 96 OMs as currently specified in SC18-MI-WP-01, noting the broad range of uncertainty encompassed by the grid axes, and recommended this reference set be adopted by WCPFC19.**

85. **SC18 agreed, and recommended to WCPFC19, to provisionally adopt the robustness set of OMs as listed in Table 1 of SC18-MI-WP-01, noting that SC18 also discussed expanding this set of models to include additional uncertainties. These included models that could account for effort-creep in the Japanese pole-and-line fisheries, likely changes on skipjack productivity due to the impacts of climate change, and a lower productivity (lower recruitment) 'stress test'. This further work is an integral part of the MSE and will be presented to SC19 and where possible key elements will be presented to WCPFC19.**

86. **Noting that the Commission is scheduled to adopt a monitoring strategy for skipjack tuna in 2023, SC18 noted that further discussion will be undertaken at SC19.**

4.1.1.3 Skipjack management procedure (MP) and evaluations

87. R. Scott (SPC) presented SC18-MI-WP-02 (*Evaluations of candidate management procedures for skipjack tuna in the WCPO*) and SC18-MI-IP-12 (*Consideration of the robustness set of operating models for skipjack tuna in the WCPO*), the latest information on the MSE framework for WCPO skipjack tuna. The results of all evaluations are available online at https://ofp-sam.shinyapps.io/pimple2022/.

Recommendations

88. **Noting the Commission is scheduled to adopt an MP for skipjack tuna in 2022, and the request from WCPFC18 for SC18 to review further progress on developing and testing the performance of candidate MPs for WCPO skipjack, SC18 reviewed the analyses included in SC18-MI-WP-02 (*Evaluations of candidate management procedures for skipjack tuna in the WCPO*).**

89. **SC18 thanked the Scientific Service Provider for the latest information on the testing of candidate MPs for skipjack tuna and noted that the continued development of the PIMPLE software package had been particularly useful in evaluating candidate harvest control rules (HCRs). However,**

noting the similar performance of many candidate HCRs, and the limited ability of the current suite of performance indicators to distinguish between them, SC18 expressed support for the development of an overall performance measure that allows for alternative weighting of indicators. Inclusion in PIMPLE of information on the values of the threshold points in each HCR was also supported. It was also suggested that the "Compare performance" button should go to the box plots by default (rather than the bar charts) to prioritize the display of uncertainty (a key aspect of comparing performance).

90. **One CCM also suggested that the results of robustness testing be included within PIMPLE and welcomed discussion and potential inclusion of additional models within the robustness set.**

91. **Several CCMs supported running the MP every three years, as it replicates, more or less, the timescale of the current assessment cycle for WCPFC tuna stocks. However, the additional burden this would place on the Scientific Services Provider, and also on WCPFC members providing supporting analyses, was noted.**

92. **One CCM recommended that WCPFC19 note that the current candidate MPs are evaluated against the 2012 depletion ratio calculated from the current OM grid that is based on 2019 assessment, which is about 42%$SB_{F=0}$, and cannot be automatically modified to a different target level when future assessments show a different level of depletion for 2012. SC18 noted the earlier explanation of the Scientific Services Provider on how performance relative to the TRP can be used when evaluating performance. This CCM also expressed their concern about having effort control for purse-seine fisheries while other fisheries are controlled by catch.**

93. **SC18 noted that additional agreed performance indicators will need to be reported on through the monitoring strategy after an MP is adopted. In this regard one CCM also supported the future development of a performance indictor for measuring the impact on small-scale fisheries.**

94. **SC18 noted that all candidate HCRs should allow for minimal fishing mortality below the LRP as part of their initial design as completely closing the fishery would result in information loss, preventing ongoing assessment of the status of the stock. SC18 further noted that, from the results of the evaluations, the likelihood of the stock falling below the LRP was extremely small.**

95. **SC18 agreed that the framework necessary for evaluating candidate MPs for skipjack tuna is now fully established and ready for consideration by the Science-Management Dialogue and WCPFC19 for the adoption of an MP on schedule in 2022. However, SC18 did not see that its role was to recommend any particular MP but to furnish the Commission with the tools to do so, and noted the use of the PIMPLE tool for this purpose. Nevertheless, SC18 noted that on biological grounds none of the candidate MPs should be recommended for rejection on the basis of LRP risk. SC18 also noted that there will be further discussion concerning MPs for skipjack at the upcoming Science-Management Dialogue.**

4.1.1.4 Skipjack MP implementation

96. R. Scott (SPC) presented SC18-MI-WP-03 (*WCPO skipjack management procedure: dry run*), SC18-MI-IP-13 (*Functions of the monitoring strategy for WCPO skipjack*) and SC18-MI-IP-14 (*Data collection programme to support a management procedure for WCPO skipjack tuna*) describing a skipjack MP 'dry run' analysis to illustrate the function, performance, and implications of a hypothetical management procedure.

Recommendations

97. **Noting the Commission is scheduled to adopt an MP for skipjack tuna in 2022, SC18 reviewed an example of how a skipjack MP could be implemented to illustrate the function, performance, and implications of a hypothetical MP as outlined in SC18-MI-WP-03 (*WCPO skipjack management procedure: dry run*).**

98. **SC18 thanked the Scientific Service Provider for the 'dry run' analysis and agreed that it was very helpful in illustrating the function, performance, and implications of a hypothetical MP.**

99. **SC18 noted that based on the analyses presented, there was sufficient data in the monitoring strategy to generate the inputs to run the estimation model and to provide a reliable estimate of stock status. As the estimation model is part of the MP, this was seen as a step forward in the development of an MP for skipjack tuna which should make it easier to adopt an MP by the end of 2022.**

100. **SC18 also noted that the estimation model is based on fixed parameter settings and that only the stock status in the terminal year of the estimation model is used in the MP. It is the combined output of the estimation model and the harvest control rule that determines the performance of an MP.**

101. **Several CCMs supported undertaking the full stock assessment and running the MP in different years in order to separate the processes of running the MP to set new management levels, and running the full stock assessment to monitor the performance of the MP.**

102. **Noting that a monitoring strategy for skipjack tuna is scheduled to be adopted by the Commission in 2023, SC18 supported further discussion on this issue at SC19, including mechanisms for the collection of data for the range of agreed performance indicators not generated by the MSE framework (such as economic PIs). Several CCMs also noted that exceptional circumstances should be defined in relatively simple and broad terms and avoid being overly prescriptive as flexibility is needed to adapt to future unpredictable situations. It was noted that draft exceptional circumstances text submitted to the ODF under Topic 17 (SC18-MI-IP-03) generally conformed with this approach.**

4.1.2 South Pacific albacore tuna

4.1.2.1 South Pacific albacore TRP

103. Graham Pilling (SPC OFP) presented SC18-MI-WP-04 (*Further analyses to inform discussions on South Pacific albacore objectives and the TRP*).

Recommendations

104. **Noting the concerns expressed at WCPFC18 regarding the delayed process to implement an interim TRP adopted in 2018 and the need to achieve a long-term TRP, and the request from WCPFC18 for SC18 to review any additional information on TRPs for South Pacific albacore tuna, SC18 reviewed the information in SC18-MI-WP-04 (*Further analyses to inform discussions on South Pacific albacore objectives and the TRP*).**

105. **SC18 noted the implications of a potential MP to be developed across the South Pacific, particularly with the areas outside of the WCPFC jurisdiction, and sought advice on how an MP that only applied to the WCPO could be developed. The Scientific Service Provider explained that this could be undertaken in a similar manner as done for skipjack tuna, where fishing in WCPO archipelagic waters is not controlled by the MP. The MP would be designed so it only applied to the WCPO, and not to the EPO.**

106. **Noting the request for additional catch scenarios to inform management options to clarify management objectives, several CCMs suggested a 10% and 20% reduction in catch from the 2017-2019 baseline for consideration.**

107. **SC18 recommended forwarding this updated working paper to WCPFC19 for its deliberations on alternative target reference points for south-Pacific albacore tuna.**

4.1.2.2 South Pacific albacore operating models

108. R. Scott (SPC) presented the first part of SC18-MI-WP-05 (*Progress update and technical challenges for the South Pacific albacore MSE framework*), outlining the work conducted to date to develop harvest strategies for South Pacific albacore.

Recommendations

109. **Noting the Commission is scheduled to adopt an MP for South Pacific albacore tuna in 2022, SC18 reviewed the current grid of OMs that has been developed to reflect all important sources of uncertainty and plausible states of nature for South Pacific albacore as outlined in SC18-MI-WP-05 (*Progress update and technical challenges for the South Pacific albacore MSE framework*).**

110. **SC18 noted the two alternative sets of OMs listed in Table 1 of SC18-MI-WP-05 – one based on the 2018 assessment (WCPO area only) and one based on the 2021 assessment (including the EPO) – but also noted that it was not able to definitively agree on the reference set of OMs for South Pacific albacore tuna because it was necessary for the Commission to decide whether or not to consider the impacts of fishing within the EPO in their decision making. Nevertheless, SC18 agreed to specify an OM grid for both options so there is a clear way forward for this work pending the Commission's decision.**

111. **SC18 noted the axes of uncertainty currently outlined in each set of OMs and recommended that additional axes be considered for inclusion in each (if practical). For the 2018 grid a movement axis should be considered, while for the 2021 grid the addition of an axis exploring CPUE uncertainty should be considered. For both grids, axes examining effort creep and hyperstability should be explored.**

112. **One CCM also noted that both options exhibit some retrospective bias and suggested that adjustment of terminal estimates to account for retrospective bias in projections might be included as another axis of uncertainty (i.e., with or without bias adjustment).**

113. **SC18 sought advice from WCPFC19 on whether the impacts of fishing within the EPO need to be included in a set of OMs for South Pacific albacore tuna, and recommended that both the Science-Management-Dialogue and the Commission note the further additions recommended to the alternative sets of OMs.**

4.1.2.3 SP Albacore management procedures

114. R. Scott (SPC) presented the second part of SC18-MI-WP-05 (*Progress update and technical challenges for the South Pacific albacore MSE framework*).

Recommendations

115. **Noting the Commission is scheduled to adopt an MP for South Pacific albacore tuna in 2022, SC18 reviewed the progress on developing and testing MPs for South Pacific albacore tuna as outlined in SC18-MI-WP-05 (*Progress update and technical challenges for the South Pacific albacore MSE framework*).**

116. **SC18 noted the progress on the development of MPs using model-based approaches (SPiCT[4]) for South Pacific albacore tuna and recommended that candidate HCRs for this species be adapted from those already considered for skipjack tuna.**

117. **SC18 recommended that both the Science-Management Dialogue and WCPFC19 take note of the progress to date on the development of an MSE framework for South Pacific albacore tuna and that further work is required prior to adoption of an MP.**

4.1.3 Mixed fishery MSE framework

4.1.3.1 Bigeye and yellowfin tuna TRP analyses

118. There was no working paper to be presented against this agenda item, but referred to SC18-MI-IP-04, which had also been presented to WCPFC18.

Recommendations

119. **Noting the Commission is scheduled to adopt a TRP for both bigeye tuna and yellowfin tuna in 2022, that the results of the analyses on candidate TRPs for bigeye and yellowfin had been reviewed by SC17 and presented to WCPFC18, and noting that no further analyses had been undertaken since, SC18 was unable to provide any further advice or recommendations to the Commission on this issue and reiterates the advice provided by SC17, as follows (subparagraphs i-v below):**

- **(i) SC17 noted that these analyses (see SC17-MI-WP-01) reflected the original request made by SC16, and the additional request by the Commission for additional information. SC17 also noted the usefulness of these updates as they facilitate an improved understanding of multispecies implications of alternative harvest levels.**
- **(ii) SC17 noted that impacts on skipjack tuna depletion associated with relative changes to fishing levels to achieve a candidate bigeye tuna TRP are contingent on the proportion of fishing scalars related to purse seine fishing that target skipjack tuna. The relative change in fishing scalars to achieve candidate TRPs assume equal proportionality in purse seine and longline fishing scalars, provided for comparative purposes from the SC16 request.**
- **(iii) SC17 noted that the analyses will greatly aid in considering candidate TRPs for bigeye and yellowfin tuna.**
- **(iv) SC17 also noted that the risks of breaching the LRPs outlined in the paper are dependent on the treatment of uncertainty in any assessment and may underestimate uncertainty.**
- **(v) SC17 recommended forwarding this working paper to the Commission for its deliberations on target reference points for bigeye and yellowfin tuna and that the results be taken into account at the next Tropical Tuna Workshop.**

4.1.3.2 Mixed fishery update

[4] Stochastic Production model in Continuous Time

120. SC18 was informed that Agenda Item 4.1.3.2 would be considered in conjunction with 4.1.3.3.

4.1.3.3 Mixed fishery performance indicators

121. F. Scott presented SC18-MI-WP-06 (*Mixed fishery harvest strategy update)*, which also covered SC18-MI-WP-07 (*Mixed-fishery harvest strategy performance indicators*) and SC18-MI-IP-05 (*Including South Pacific albacore in the WCPFC mixed-fishery harvest strategy framework*).

Recommendations

122. **Noting the work reviewed by SC17 in developing a multi-species modelling framework for including mixed fishery interactions when developing and testing harvest strategies for the four main WCPO tuna stocks, SC18 reviewed an update on the development of this framework outlined in SC18-MI-WP-06 (*Mixed fishery harvest strategy update*) and SC18-MI-WP-07 (*Mixed-fishery harvest strategy performance indicators*).**

123. **SC18 thanked the Scientific Service Provider for the progress in developing the mixed fishery harvest strategies and noted the encouraging results in including South Pacific albacore in the multi-species modelling framework. However, SC18 also noted that considerable work remains to be completed, such as building a full suite of OMs for bigeye and yellowfin tuna and considering candidate MPs for the tropical longline fisheries.**

124. **SC18 noted that most of the performance indictors used in the working paper were useful and easy to understand, but also noted that the indicators may need to be separated for fisheries, and the set of performance indicators could be further developed (such as an indicator related to stability and impacts on SIDS). SC18 also noted that the question about what indicators are necessary is generally a management or policy decision.**

125. **Several CCMs, in noting that the analysis outlined in SC18-MI-WP-07 indicated a larger impact by the purse-seine fleet on bigeye tuna than the impact of the tropical longline fleet, explained that they had not yet agreed on the mixed fisheries MSE framework outlined in this paper (e.g., the order in which the individual MPs are implemented). They suggested, for instance, that a stock status-based approach could be considered while another CCM suggested a stock productivity-based approach may also be considered. However, the difficulty in implementing such approaches was acknowledged.**

126. **Several CCMs noted they would not be able to support any proposed MP outcomes unless those outcomes are designed to ensure that there is no disproportionate burden transfer. They also noted that it will not usually be possible to achieve all the TRPs at the same time and that there will need to be trade-offs.**

127. **SC18 supported continuing the work on the development of the mixed fishery MSE framework and recommended that both the Science-Management Dialogue and WCPFC19 take note of the progress to date and provide feedback.**

4.1.4 Review of the WCPFC Harvest Strategy Workplan

Recommendations

128. **SC18 noted the adoption by WCPFC18 of the updated *Indicative Workplan for the Adoption of Harvest Strategies under CMM 2014-06* (Attachment I, WCPFC18 Summary Report) and that**

further discussion on this workplan would more appropriately take place during the upcoming Science-Management Dialogue.

129. **Several CCMs noted that the adoption of the skipjack MP remains on track for 2022 but that adoption of TRPs for bigeye and yellowfin tuna and an MP for South Pacific albacore may need to be delayed pending further work. Some concern was also expressed in relation to how such delays may impact on MSC certification.**

130. **SC18 also noted the views expressed by several CCMs that a better understanding on how the Harvest Strategy Work Plan is progressing had been achieved during SC18, and this should help inform discussions at the Science-Management Dialogue.**

4.2 South Pacific Swordfish Conservation and Management Measure

131. D. Bromhead (Australia) presented SC18-MI-WP-08 (*A revised draft conservation and management measure for southwest Pacific swordfish in the WCPFC Area*).

Recommendations

132. **SC18 welcomed the opportunity to review and provide scientific and technical feedback on the draft CMM for Southwest Pacific Ocean (SWPO) swordfish that had been submitted by Australia and outlined in SC18-MI-WP-08 (*A revised draft conservation and management measure for South Pacific Swordfish in the WCPFC Area*).**

133. **SC18 noted that this draft CMM had taken into consideration the updated stock assessment for Southwest Pacific broadbill swordfish reviewed by SC17 (SC17-SA-WP-04), Australia's updated paper on bycatch management options submitted to SC17 (SC17-MI-IP-10), the projections of this stock as outlined in WCPFC18-2021-20-rev1 (*Southwest Pacific Swordfish projections)* and WCPFC18-2021-21 (*Reference Document for the Review of CMM 2009-03 (Southwest Pacific swordfish)*).**

134. **Most CCMs supported this draft CMM, stressing the importance of developing a strengthened measure for this stock, noting that SC17 highlighted that the current measure (CMM 2009-03) for SWPO swordfish does not contain provisions to limit total fishing mortality on the stock and subsequently puts at risk the future sustainability of the stock, future fishery development opportunities for SIDS, and ongoing economic viability of current fisheries targeting this stock. They also noted the Commission now has a comprehensive suite of data and technical information with which to inform and base a revised and strengthened measure for this stock. They noted and supported provisions in the measure that seek to prevent any transfer of disproportionate burden to SIDS while at the same time, recognising coastal state sovereign rights, a commitment to zone-based management, and protecting and explicitly allowing for future fishery development opportunity for SIDS. Of the two alternate management options proposed for fisheries taking swordfish as bycatch, bycatch limits were seen as the most easily implemented and monitored, noting that swordfish bycatch contributes a very significant component of the overall fishing mortality.**

135. **Two CCMs stated that further consideration needed to be given to the effectiveness and consequences of implementing some gear-based measures, such as changing bait, as this may not reduce the fishing mortality or CPUE of the bycatch and could result in changes to the catch rates of other species. Two CCMs raised concerns that the uncertainties in the latest stock assessment had not been adequately captured in the projections, and that these uncertainties could impact the proposed catch limit. One CCM stated that they support actions to mitigate fishing mortality on**

bycatch fisheries, but do not consider a full review of the measure should be undertaken on the basis of the stock assessment and projections. This CCM noted that, even when catch-based projections might include very unrealistic scenarios, all of them resulted on average in levels well above the MSY in 10 years. Furthermore, projections indicated increases in recent effort of up to 20% resulted in almost the same depletion levels as in 2019. One CCM, while supporting the need for strengthening management, also noted that the current CMM does not contain all the elements of a harvest strategy, including a harvest control rule.

136. **SC18, noting that it is important to ensure CMMs are effective and are updated in the light of new information available, encouraged all CCMs with an interest in this measure to work collaboratively with Australia prior to Australia's submission of a revised draft CMM to WCPFC19.**

4.3 Limit Reference Points for Species Other than Tuna

4.3.1 Limit reference points for elasmobranchs

137. Noting that WCPFC18 had not provided any specific instructions to SC18 on LRPs for elasmobranch, and that there was no working paper against this agenda item, .the MI Theme Convener welcomed additional input from SC18 on this issue.

Recommendations

138. **SC18 noted that no further progress in developing appropriate LRPs for non-target WCPO elasmobranchs has been made since SC17, and that the recommendations and need for further research made by SC17 had been adopted by WCPFC18.**

139. **Noting the need to appraise a broader range of reference points to assess their applicability to WCPO elasmobranchs, and to avoid undesirable consequences on allowable catch levels of target species, SC18 recommended that SC19 consider reviewing and including the further research identified at SC17 in the WCPFC's Shark Research Plan 2021-2025 (Project 97)[5].**

4.3.2 Review of appropriate LRPs for SWP striped marlin and other billfish (Project 104)

140. WCPFC18 did not provide any specific instructions on the LRP for SWP striped marlin and other billfish.

Recommendations

141. **SC18 noted that no further progress in developing appropriate LRPs for WCPO billfish species has been made since SC17, and that the recommendations and need for further research made by SC17 had been adopted by WCPFC18.**

142. **SC18 recommended that SC19 consider reviewing and including the further research identified at SC17 in the Scientific Committee's Billfish Research Plan 2023-2027 (Project 18X1 listed in the SC18-GN-IP-07).**

[5] https://meetings.wcpfc.int/node/11739

AGENDA ITEM 5 — ECOSYSTEM AND BYCATCH MITIGATION THEME

143. The Ecosystem and Bycatch Mitigation (EB) theme was convened by Y. Swimmer (USA).

5.1 Ecosystem and climate indicators

144. S. Nicole presented SC18-EB-WP-01 (*Ecosystem and Climate Indicators*), which updates SC18 on progress regarding development of the candidate ecosystem and climate indicators for the Western and Central Pacific Ocean (WCPO).

Recommendations

145. **SC18 noted that the Scientific Services Provider has selected a suite of candidate indicators for monitoring ecosystems and climatic trends across the WCPO.**

146. **SC18 recommended making "Ecosystem and Climate Indicators" a standing agenda item of the Ecosystem and Bycatch Mitigation theme session. This would provide a mechanism for the Scientific Committee to annually consider adopting candidate indicators presented to the Committee but also review and respond to existing trends/triggers identified in adopted indicators.**

147. **SC18 recommended the development and testing of "Ecosystem and Climate Indicators" as a project of the Scientific Committee. This would provide a mechanism for the Scientific Committee to easily track its progress towards evaluating and adopting candidate indicators.**

148. **SC18 recommended that available information and updates on the impacts of climate change be included or combined with status of stocks reporting.**

5.2 Review of potential mitigation measures to reduce fishing-related mortality on silky and oceanic whitetip sharks (Project 101)

149. K. Bigelow presented SC18-EB-WP-02 (*Future Stock Projections of Oceanic Whitetip Sharks in the Western and Central Pacific Ocean (Update on Project 101)*).

Recommendations

150. **SC18 noted the updated projections on the impact of banning shark lines, wire leaders, or both and estimates of catchability and probability of post release mortalities on oceanic whitetip sharks (under Project 101) using observer data on gear configurations by flag for 110,154 longline sets. The biomass of oceanic whitetip sharks is projected to increase if either catch reductions or mitigation methods such as prohibiting both wire leaders and shark lines in the area 20° S to 20° N are adopted and implemented. If no action is taken, the stock biomass is projected to remain at a very depleted level.**

151. **SC18 noted the substantial scientific research that indicates the use of monofilament branchlines can significantly reduce bycatch and mortality of oceanic whitetip sharks without negatively affecting target catches. SC18 also noted from relevant research (in SC18-EB-IP-20) that trailing gear composed of monofilament did not break apart even after 360 days. In contrast, branchlines with wire leaders began to break at the crimps after approximately 60 days.**

152. **SC18 noted that the analysis (in SC18-EB-IP-19) revealed that switching from wire leader material to monofilament has a small improvement in survival rates while trailing gear length, and**

handling condition have a significant impact on post-release survivorship for Oceanic Whitetip sharks.

153. **SC18 encouraged further research into biodegradable monofilament and variable combination of possible approaches (i.e., recommended trailing lengths, leader type, handling condition) to further reduce mortality of oceanic whitetip sharks.**

154. **SC18 recommended the Commission consider revising the Conservation Management Measure for Sharks (CMM 2019-04), taking into account the results of Project 101 and previous studies, which considered several options, including the prohibition of branchlines of wire trace and shark lines, in order to reduce fishing mortality on oceanic whitetip shark and silky sharks in the WCPO.**

155. **SC18 noted with concern that oceanic whitetip sharks are overfished and experiencing overfishing according to the 2019 stock assessment and silky sharks are experiencing overfishing according to the 2018 stock assessment.**

5.3 Seabird bycatch mitigation

5.3.1 Seabird bycatch mitigation methods

156. D. Ochi presented SC18-EB-WP-04 (*Consideration for tori-line and tori-pole design suitable for small-scale tuna longline vessels in the North Pacific based on experimental results*).

Recommendations

157. **SC18 recommended the Commission note a global decline in specific Agreement on the Conservation of Albatrosses and Petrels (ACAP) seabird population trends, which are vulnerable to threats posed by longline fisheries in the WCPO.**

158. **SC18 recommended the Commission conduct a review of the current seabird mitigation measure (CMM 2018-03) in 2023 or 2024 whereby new bycatch mitigation studies would be evaluated with respect to bycatch mitigation effectiveness and compared against current ACAP Best Practices.**

159. **With regard to seabird bycatch mitigation, SC18 noted the following:**

a) **Tori-lines have been proven to be an effective and practical means to reduce seabird bycatch in small vessels in the North Pacific;**
b) **Trade-offs between modification of tori-line characteristics, such as the weight of streamers and keeping sufficient aerial extent should be taken into account when designing a tori-line; and**
c) **Recent scientific evidence indicates that the use of blue-dyed bait and offal management are ineffective as seabird mitigation measures, despite being mitigation options in the seabird measure (CMM 2018-03) for the North Pacific.**

5.3.2 ACAP advice on seabird mitigation

160. J. P. Seco-Pon presented SC18-EB-WP-03 (*Conservation Status of Albatrosses and Petrels and Advice on Reducing their Bycatch in WCPFC Fisheries*), and no specific recommendation was made.

5.4 Issues arising from the Online Discussion Forum

5.4.1 Graphics associated with the Best Handling Practices for the Safe Handling and Release of Cetaceans

161. SC18 ODF (under Topic 23) reviewed the graphics associated with the cetacean best handling guidelines.

Recommendation

162. **SC18 noted the *Graphics for Best Practices for the Safe Handling and Release of Cetaceans*[6] and forwarded these to TCC18 and WCPFC19 for consideration and possible adoption.**

5.4.2 FAD Management Options IWG issues

163. As requested in Paragraph 19 of CMM 2021-01, SC18-EB-IP-06 (*Guidelines for Non-entangling and Biodegradable FAD Materials* and SC18-EB-IP-13 *Preliminary Review of Available Information on Biodegradable FADs*) were reviewed through the ODF (as Topic 21).

Recommendations

164. **SC18 noted that in the ODF there was support / no objection to the proposed IATTC definition of biodegradable and categories of biodegradable FADs (paragraph 10, SC18-EP-IP-13). Responding to the Commission's tasks under the CMM 2021-01, SC18 supported the definition of "biodegradable" and several preliminary categories of biodegradable FADs to be considered for its gradual implementation as stated in paragraph 10, SC18-EP-IP-13 and listed below:**

- **"Non-synthetic materials [7] and/or bio-based alternatives that are consistent with international standards[8] for materials that are biodegradable in marine environments. The components resulting from the degradation of these materials should not be damaging to the marine and coastal ecosystems or include heavy metals or plastics in their composition."**
- **The different categories to be considered in this gradual implementation process are (These definitions do not apply to electronic buoys attached to FADs to track them):**
- **Category I. The FAD is made of 100% biodegradable materials.**
- **Category II. The FAD is made of 100% biodegradable materials except for plastic-based flotation components (e.g., plastic buoys, foam, purse-seine corks).**
- **Category III. The subsurface part of the FAD is made of 100% biodegradable materials, whereas the surface part and any flotation components contain nonbiodegradable materials (e.g., synthetic raffia, metallic frame, plastic floats, nylon ropes).**
- **Category IV. The subsurface part of the FAD contains non-biodegradable materials, whereas the surface part is made of 100% biodegradable materials, except for, possibly, flotation components.**
- **Category V. The surface and subsurface parts of the FAD contain nonbiodegradable materials.**

165. **SC18 noted that these categories are preliminary and will be further examined by the**

[6] SC18-EB-IP-12 https://meetings.wcpfc.int/node/16340

[7] For example, plant-based materials such as cotton, jute, manila hemp (abaca), bamboo, or animal-based such as leather, wool, lard.

[8] International standards such as ASTM D6691, D7881, TUV Austria, European or any such standards approved by the WCPFC CCMs.

FADMO-IWG, SC, TCC for Commission's consideration.

166. **SC18 further recommended to the Commission that the FADMO-IWG continues its work on exploring a timeline for the stepwise introduction of biodegradable FADs, potential gaps/needs and any other relevant information for Commission's consideration. SC18 noted that the FADMO-IWG may seek advice from SC and TCC.**

AGENDA ITEM 6 — OTHER RESEARCH PROJECTS

6.1 Pacific Marine Specimen Bank (PMSB, Project 35b)

167. **SC18 endorsed the recommendations made by the PMSB Steering Committee in the *Project 35b Report* (SC18-RP-P35b-01), and:**

- **noted its continued support for initiatives to increase rates of observer biological sampling, noting that this contribution is essential to the ongoing success of the WCPFC's work;**
- **incorporated the identified Project 35b budget into SC's proposed 2023 budget and the 2024-25 indicative budgets, as development of the WCPFC PMSB is intended to be ongoing and is considered essential;**
- **supported efforts to obtain further super-cold storage capacity to ensure longevity of PMSB samples; and**
- **endorsed that the work plan in Section 4 of SC18-RP-P35b-02 should be pursued by the Scientific Services Provider, in addition to standard duties associated with maintenance and operation of the WCPFC PMSB in 2022-2023, and noting that detailed terms of reference for Project 35b are available in SC18-GN-IP-07.**

6.2 Pacific Tuna Tagging Project (Project 42)

168. **SC18 noted the ongoing progress in implementing the PTTP, as detailed in SC18-RP-PTTP-01, and:**

- **noted the successful 2021 CP15 tagging voyage, despite the unfolding COVID-19 pandemic;**
- **noted the critical importance of effective tag seeding to informing stock assessment, and supported an urgent increase (when feasible) in deployment and fleet coverage of tag seeding experiments and assistance in developing alternative approaches to understand the flow of tags through tuna product networks;**
- **noted the need for continued CCM participation and support in tag reporting;**
- **supported the 2023 tagging programme and associated budget;**
- **supported the 2024-2025 tagging programme and associated indicative budget; and**
- **considered and supported the PTTP Workplan for 2022-2025.**

6.3 WPEA Project Update

169. **SC18 noted the WPEA-ITM Project Update (SC18-RP-WPEA-01) and:**

a) **recommended extending the initiative into 2024 at "no cost" due to current allocated budget underspend, which will mean most, if not all, of the WPEA-ITM activities will be completed; and**

b) **recommended development of a new project proposal for the next phase of WPEA work that is relevant to the WCPFC, to begin immediately after the current WPEA-ITM project expires.**

AGENDA ITEM 7— FUTURE WORKPLAN AND BUDGET

7.1 Development of the 2023 work programme and budget, and projection of 2024-2025 provisional work programme and indicative budget

a. Review of 2021 SC Projects and the results of the SC17 Online Discussion Forum

170. **There were no objections raised regarding the progress and results of 2022 SC projects through the ODF, as detailed in SC18-ODF-01 (*Summary of Online Discussion Forum*).**

b. Review of proposed projects for 2023 – 2025

171. Scientific Services Provider provided the following list as the 2023 priority work:

- WCPO yellowfin tuna assessment (incorporating key recommendations from the yellowfin review in 2022);
- WCPO bigeye assessment (incorporating key relevant recommendations from the yellowfin review in 2022);
- Initial work following up on skipjack assessment recommendations (and review of implications arising from 2022 yellowfin review);
- Analytical support to tropical tuna CMM discussions in 2023;
- Ongoing work on assessment diagnostics based upon SC18 and SC19 discussions;
- Development of the requested SC19 paper on timelines for WCPO stock assessment outputs; and
- Input into the early 2023 CAPAM[9] tuna conference.

172. **SC18 recommended the proposed work program and budget for 2023 and indicative budget for 2024 – 2025 together with CCM's priority scores to the budgeted projects in Table WP-01 to the Commission.**

Table WP-01. Recommended Future Work Program and Budget for 2023 – 2025. Average score is based on Table WP-01 (SC project scoring table) of the SC17 Summary Report, with priority rankings: 6&9 = High; 3&4 = Medium; 1&2 = Low. 'No. CCMs' represent the number of CCMs which provided scores on that project.

Project Title	2023	2024	2025	Notes	Avg. Score	No. CCMs
Sub-item 1. Scientific services						
SPC-OFP scientific services	981,112	1,000,734	1,020,749	Budget: 2% annual increase	essential	
Sub-item 2. Scientific research						
SPC Additional resourcing	176,670	180,204	183,808	Budget: 2% annual increase TOR: MFCL work	essential	
P35b. WCPFC Pacific Marine Specimen Bank	105,268	107,373	109,520	Budget: 2% annual increase	essential	
P42. Pacific Tuna Tagging Program	730,000	730,000	730,000	Responsibility: SPC	essential	
P60. Purse seine species composition				Responsibility: SPC Carry over 2021 budget of $40K to 2023		
P65. Peer review of yellowfin				Responsibility: SPC		

[9] Center for the Advancement of Population Assessment Methodology

modeling				(On-going)		
P68. Seabird mortality	25,000	40,000		Responsibility: SPC Indicative budget approved at WCPFC18	4.5	22
P90. Length weight conversion (WCPFC17 endorsed the extension of P90 to 57 months until Sep. 2023)				Responsibility: SPC (On-going)		
P100c (=P17X3). Preparing WCP tuna fisheries for application of CKMR methods to resolve key SA uncertainties. (Duration: 2023 - 2025)				Responsibility: SPC Funding: WCPFC, SPC, EU, IATTC and CSIRO Budget (matching fund) approved at WCPFC18		
P108. WCPO silky shark assessment	50,000	50,000		Indicative budget approved at WCPFC18	6.2	23
P109 - Training observers for elasmobranch sampling				Responsibility: SPC (On-going)		
P18X1 (=P17X1). Billfish Research Plan 2023 - 2027	55000			Responsibility: SPC Indicative budget approved at WCPFC18	7.0	22
P18X2 (=P17X4). Further development of ensemble model approaches for presenting SA uncertainty	30,000			Responsibility: SPC Indicative budget of $20K approved at WCPFC18	7.9	21
P18X3. Improved coverage of cannery receipt data for WCPFC scientific work	35,000	60,000	35,000	Responsibility: SPC	7.4	22
P18X4. Exploring evidence and mechanisms for a long-term increasing trend in recruitment of skipjack tuna in the equatorial Pacific and the development and modelling of defensible effort creep scenarios	20,000			Responsibility: SPC	7.6	21
P18X5. Ecosystem and Climate Indicators	0			Budget to be requested for 2024 and beyond	7.2	19
P18X6. Pacific silky shark assessment (inclusion in the Project 108)	0	30,000		Project 108: WCPO Project 18X6: Pacific-wide	4.5	22
P18X7. Pacific whale shark assessment	85,000				3.0	22
P18X8. Shark Research Plan midterm review	30,000				6.2	22

Table WP-02. Provisional assessment schedules for 2023-2026. Tunas are scheduled for assessment every 3 years; swordfish every 4 years; and sharks and other billfish every 5 years.

Species	Stock	Last assessment	2022	2023	2024	2025	2026
Bigeye tuna	WCPO	2020		X			X
	Pacific	2015					
Skipjack tuna	WCPO	2022	X			X	
Yellowfin tuna	WCPO	2020		X			X
Albacore	S Pacific	2021			X		
	N Pacific	2020		X			
Pacific bluefin	N Pacific	2022	X		X		
Striped marlin	SW Pacific	2019			X		
	N Pacific	2019		X			
	SW Pacific	2017				X	

Swordfish	N Pacific	2018		X			
Pacific blue marlin	Pacific						X
Silky Shark	WCPO	2018			X		
	Pacific	2018			X		
Oceanic whitetip shark	WCPO	2019				X	
Blue shark	SW Pacific	2021/2022	X				
	N Pacific	2022	X				
Mako	SW Pacific	2022	X				
	N Pacific	2018					
Bigeye thresher	Pacific	2017					
Porbeagle	S Pacific	2017					
Whale Shark	Pacific	2018					

AGENDA ITEM 8 — ADMINISTRATIVE MATTERS

8.1 Election of officers of the Scientific Committee

173. **SC18 made no nominations to fill the vacancies for SC Vice-Chair, Management Issues Theme Co-Convener, and Ecosystem and Bycatch Mitigation Theme Co-Convener. Nominations for these positions would remain open until WCPFC19.**

8.2 Next meeting

174. **SC18 recommended to the Commission that SC19 would be held from August 16 – 24 August 2023, and that Palau would confirm to the Commission at WCPFC19 whether it was able to host SC19.**

AGENDA ITEM 9 — OTHER MATTERS

9.1 Review of online discussion forum outputs

175. The ODF will be used in the future, whether meetings are held in person or online, as this had proven to be a useful forum for advancing discussions on a number of issues.

9.2 Implications of low observer coverage on the upcoming bigeye and yellowfin tuna stock assessments

Recommendation

176. **SC18 noted the information provided by SPC regarding the impact of reduced observer coverage on purse seine species catch estimates and the resultant impact on its scientific work.**

9.3 Absence of consensus

177. **SC18 noted that it could not reach consensus on the management advice for skipjack tuna. While there was general agreement on the stock assessment outputs, several CCMs wanted to note their view that depletion in the equatorial region was greater than in other areas. However, several**

other CCMs considered this pertained to the stock status section and did not agree on its inclusion under management advice. Despite the advice of the Commission's legal advisor that the WCPFC convention states that differences in views can be expressed in the report of the Scientific Committee, the recommendation from the legal advisor did not ultimately solve this issue. SC18 sought guidance from the Commission on how to proceed in the future when consensus cannot be reached and how lack of consensus should be reflected in the SC's report.

AGENDA ITEM 10 — ADOPTION OF THE SC18 SUMMARY REPORT

178. **SC18 adopted the recommendations of the Eighteenth Regular Session of the Scientific Committee.**

179. **SC agreed that the SC18 Summary Report would be adopted intersessionally according to the following indicative schedule:**

Tentative Schedule	Actions to be taken
18 August	Close of SC18
By 27 August	Secretariat will receive Draft Summary Report from the rapporteur.
By 29 August	SC18 Outcomes Document distributed to all CCMs and observers (within 7 working days, Rules of Procedure).
By 3 September	Secretariat will clear the Draft report, and distribute the cleaned report to all Theme Convenors for review.
By 10 September	Theme conveners will review the report and return it back to the Secretariat
By 15 September	The Secretariat will post/distribute the draft Summary Report to all for CCMs' and Observers' review
By 26 October	Deadline for the submission of comments from CCMs and Observers

AGENDA ITEM 11 — CLOSE OF MEETING

180. The SC Chair closed SC18 at 12:30 Pohnpei time on 18 August 2022.

The Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean

Scientific Committee
Eighteenth Regular Session
Electronic Meeting
10–18 August 2022

SUMMARY REPORT

AGENDA ITEM 1 — OPENING OF THE MEETING

1. The Eighteenth Regular Session of the Scientific Committee of the Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean (SC18) took place for seven days during 10–18 August 2022 as an electronic meeting in response to the continuing global coronavirus disease (COVID-19) pandemic. The electronic meeting was chaired by Dr Tuikolongahau Halafihi (Tonga).

2. The following WCPFC Members, Cooperating Non-members and Participating Territories (CCMs) attended SC18: Australia, Canada, China, Cook Islands, European Union (EU), Federated States of Micronesia (FSM), Fiji, Indonesia, Japan, Kiribati, Republic of Korea, Republic of Marshall Islands (RMI), Nauru, New Zealand, Niue, Palau, Papua New Guinea (PNG), Philippines, Samoa, Solomon Islands, Chinese Taipei, Tonga, Tuvalu, United States of America (USA), Vanuatu, American Samoa, French Polynesia, New Caledonia, Tokelau, Ecuador, Nicaragua, Panama, Thailand and Vietnam.

3. Observers from the following inter-governmental organizations attended SC18: Agreement for the Conservation of Albatross and Petrels (ACAP), Inter-American Tropical Tuna Commission (IATTC), Pacific Community (SPC), Pacific Islands Forum Fisheries Agency (FFA), Parties to the Nauru Agreement (PNA), Secretariat of the Pacific Regional Environment Programme (SPREP), and The World Bank.

4. Observers from the following non-governmental organizations attended SC18: American Tunaboat Association (ATA), Australian National Centre for Ocean Resources and Security (ANCORS), Birdlife International, Conservation International (CI), International Seafood Sustainability Foundation (ISSF), Marine Stewardship Council, Pew Charitable Trust (Pew), Sustainable Fisheries Partnership (SFP) Foundation, The Ocean Foundation, World Tuna Purse Seine Organisation (WTPO) and the World Wide Fund for Nature (WWF).

5. The full list of participants can be found at **Attachment A**.

1.1 Welcome address

6. Netani Tavaga (Fiji), gave the opening prayer.

7. Ms. Jung-re Riley Kim, Chair of the WCPFC, welcomed all delegates, observers, and WCPFC Secretariat and SPC staff to SC18. She noted the importance of robust to inform WCPFC's management decisions. She stated it was very encouraging that recently assessed stocks, including skipjack and North Pacific blue shark, are maintaining a healthy status and Pacific Bluefin is showing improvement. She highlighted the Commission's harvest strategy-related works: the Harvest Strategy Work Plan, updated in 2021, commits the Commission to developing and adopting management procedures and management strategy evaluations (MSEs) for skipjack and South Pacific albacore at the WCPFC19. To that end, SC18

is tasked with agreeing on the MSE operating models and providing advice on performance of candidate management procedures for these stocks. She noted that some of the issues would also be addressed through the first Science-Management Dialogue (SMD01) to be held immediately after SC18. She stated SC18 would also review bycatch reduction measures for silky and oceanic whitetip sharks, and FAD management options, focusing on biodegradable FADs, which would inform the Commission's work on implementing the ecosystem-based approach and improving FAD management. She closed by thanking the SC Chair and Theme Conveners for their hard work and outstanding leadership, and the Secretariat and SPC for their excellent support. Her full remarks are appended as **Attachment B.**

8. The WCPFC Secretariat's Executive Director, Feleti P Teo, OBE, welcomed delegates to SC18. He noted the ongoing challenges posed by the COVID-19 pandemic, and the impact on work of the Secretariat and the Commission, stating that despite having the technical ability to conduct meetings effectively via Zoom, there are serious constraints compared to face-to-face meetings, especially given the technical nature of the issues deliberated at SC. He noted that the SC structure and format were retained from previous years, and because of the need to streamline the agenda a number of issues had been raised in the Online Discussion Forum (ODF). He stated that key issues under consideration included advice on how to close data gaps, stock assessment work, the yellowfin peer review, harvest strategy issues, management procedures for skipjack and albacore, advice on additional bycatch mitigation methods, and insights on the impacts of climate change. He stated that the work invested on this was reflected by the extensive documentation, with about 150 meeting papers posted. He noted that the bulk of these was provided by SPC, and praised the high quality of their work. He also thanked the officers of the SC and Theme Conveners, who serve voluntarily but play a lead role in managing the content of the SC meeting, and acknowledged the contributions of the Secretariat's staff and the able leadership for the SC of the Science Manager. He closed by stating that the Secretariat stood ready to support SC as it undertook its work. His full remarks are appended as **Attachment C.**

9. SC Chair Dr Tuikolongahau Halafihi welcomed participants to the 18th Regular Session of the Scientific Committee, noting with thanks the efforts of the Secretariat to organise the third consecutive SC meeting under the ongoing COVID-19 pandemic. He observed this necessitated an abbreviated agenda consisting of essential items necessary to progress the scientific work of the Commission in 2022, and that the agenda was developed by the Secretariat, in collaboration with all SC officers and SPC-OFP. He reviewed the four themes under which key issues would be discussed, and the ODF website that would be used to facilitate the progress on SC projects and other key topics that were omitted from the abbreviated agenda, and encouraged participants to make use of the ODF to efficiently progress other topics outside of the plenary agenda. He expressed particular thanks to the Theme Conveners for their hard work, and to the scientists at SPC-OFP and ISC for providing valuable scientific information and advice to SC18. Given the limited time frame of SC18, he asked all participants to fully cooperate, in a constructive manner, to produce successful outcomes. His full remarks are appended as **Attachment D.**

1.2 Meeting arrangements

10. The Chair outlined procedural matters, including the meeting schedule (WCPFC-SC18-2022-06), administrative arrangements, and the list of Theme Conveners. The conveners and their assigned theme sessions were:

Themes	Conveners
Data and Statistics (ST)	Valerie Post (USA)
Stock Assessment (SA)	Keith Bigelow (USA) and Hidetada Kiyofuji (Japan)
Management Issues (MI)	Robert Campbell (Australia)
Ecosystem and Bycatch Mitigation (EB)	Yonat Swimmer (USA)

11. Tim Jones (WCPFC IT Manager) spoke to the virtual meeting protocols.

1.3 Adoption of the agenda

12. The SC18 agenda (WCPFC-SC18-2022-03) was adopted **(Attachment E).**

1.4 Reporting arrangements

13. The Science Manager reviewed the reporting arrangements and noted that in accordance with the Rule 33 of the Commission's Rules of Procedure, the text of all decisions adopted by the SC18 would be distributed in the form of the Outcomes Document to all CCMs and Observers within seven (7) working days following their adoption. The SC18 Summary Report, including an Executive Summary, would be adopted intersessionally. The Executive Summary includes a brief overview of the meeting, all theme recommendations adopted during the meeting, including a synopsis of stock status and management advice, and any other initiatives arising from SC18.

AGENDA ITEM 2 — DATA AND STATISTICS THEME

14. The Data and Statistics (ST) theme was convened by V. Post (USA).

2.1 Data gaps of the Commission

2.1.1 Data gaps

15. The ST Theme Convener stated that there were two working papers and 11 information papers prepared for SC18.

16. P. Williams (SPC) presented SC18-ST-WP-01 (*Scientific data available to the Western and Central Pacific Fisheries Commission*). Four additional SC18 papers were referred to in the presentation: SC18-ST-IP-02 (*ROP Data management*), SC18-ST-IP-03 (*Project 60: Progress towards achieving SC17 Recommendations*), SC18-ST-IP-10 (*Tables of coverage levels for operational data fields submitted to the WCPFC*), and SC18-ST-IP-11 (*Draft PROPOSAL for a Project to improve the coverage of cannery receipt data*).

17. The review of gaps in 2020 and 2021 scientific data provisions includes the assignment of a tier-scoring evaluation level. There have not been any significant developments in some categories of the main data gaps over the past five years and readers have therefore been referred to the relevant sections in past data-gap papers. All CCMs with fleets active in the WCPFC Convention Area provided 2021 annual catch estimates by the deadline of the 30th April 2022. The issues previously reported in annual catch estimates have been further reduced and the lack of any estimates for key shark species remains the main gap for some CCMs, particularly for years before 2017.

18. Aggregate catch/effort data for 2021 were provided by the deadline of 30th April 2022 for all fleets. The quality of aggregate data provided continues to improve with a reduction in the number of data-gap notes assigned to the aggregate data in recent years. The other main data gap concerns the low coverage of operational data available to generate aggregate data for the Indonesia and Vietnam fleets, and the anticipated under-reporting of key shark species in general.

19. Most CCMs with active fleets provided operational catch/effort data for 2021, with the main gaps

being:

- The low coverage in the data provided for the Indonesia and Vietnam fleets;
- the non-provision of certain required fields in the Indonesia operational data; and
- catches of key shark species are not included in the Indonesia fleet data.

20. The coverage of 2021 operational data for some fleets is not complete (100%), although there was some improvement in coverage compared to the 2020 data, and SPC expects there will be additional operational data submissions in the coming year. There were noted gaps in the provision of 2021 size data for several fleets where the impacts of COVID-19 prevented any size data collection (mainly through observers). Tables providing a breakdown of the coverage levels for each operational data field by year and fleet have been prepared in response to a SC17 recommendation. These tables have been included in SC18-ST-IP10 for SC18 review. SPC-OFP has already started the process to engage with relevant CCMs to resolve some of the gaps presented in these tables. The continuation of work on how the impacts (due to COVID-19) of the reduced observer coverage in the purse seine fishery on the precision of tuna catch estimates is presented in Peatman et al. (2022). The results of the sub-sampling analysis in this latest study suggests that the reduction in observer coverage rates in 2020 and 2021 has significantly reduced the precision in estimated species proportions, with increases in CVs in the region of 90 to 250% depending on the species and set type. This study also recognized the importance of processor (cannery) data in the validation of purse seine species composition data.

21. Several proposals were presented for SC18 consideration.

(i) Recognizing the importance of processor (cannery) data for the validation of tuna species composition under WCPFC Project 60 (see Peatman et al., 2022), SC18 consider a future WCPFC project to cover, *inter alia*, the following areas:
   (a) The SSP or WCPFC Contractor to work with relevant CCM port and flag states to obtain purse seine processor data not yet provided, using the guidelines for cannery data submission to ensure data confidentiality.
   (b) The SSP or WCPFC Contractor to work with relevant CCMs to review the protocols for collecting purse seine processor data at each source, including species identification.
   (c) The SSP to continue the management and data quality assurance of purse seine processor data submission, including the identification of gaps and resolving duplicate processor data (e.g., when Final Outturn [FOT] data are provide from a different source).

(ii) SC18 recommend the inclusion of tables of the operational level catch and effort data fields for longline, purse seine and pole-and-line gears (see SECTION 2.5 and ANNEX 1) as an additional ANNEX of the "Scientific Data to be Provided to the Commission", with an additional paragraph under Section 3. Operational level catch and effort data as follows:

> "Annex 2 provides tables of the operational level catch and effort data fields for longline, purse seine and pole-and-line gears in order to clarify and assist members in understanding the requirements of each data field and thereby facilitate the submission of data to the WCPFC."

Discussion

22. Australia noted SPC's work with CCMs to address data gaps. It commented that the start set time is listed as a binding data field but according to Table 11 in SC18-ST-IP-10 the coverage level is zero for the Japanese fleet since 2014 and the Korean fleet since 2015. Australia inquired (i) why the coverage rates are zero, and whether the data could be recovered, noting that the start time of a set can be very important

in analyses to standardise CPUE; and (ii) whether catch discards are required to be reported, noting that in the paper annex this is listed as non-binding, but it is also mentioned as required for some CMMs. It is thus ambiguous, and there is a need for clarification. SPC stated regarding (i) that it had reached out to both Japan and Korea regarding the set time data, and expected it would be provided, noting it may have been overlooked. Regarding (ii), SPC stated reporting requirements are ambiguous and should be clarified, noting that its understanding that discard reporting is required for annual reporting but not for operational data. The paper refers only to scientific data requirements, not requirements under the CMMs. SPC agreed there is a need to resolve the ambiguity.

23. Regarding the recommendation for tables of operational data, Japan stated it has been providing these data but through specific arrangements with SPC, and would look into implications of proposal #2 as presented and discuss these during the SC18 discussion on recommendations.

24. The USA supported addition of an annex clarifying which operational data fields are binding, and supported the proposal for an SC project to improve the coverage of cannery data for Commission scientific work.

25. Vanuatu, on behalf of FFA members, supported the recommendations to further resolve issues on data gaps.

26. Nauru, on behalf of the PNA and Tokelau, thanked SPC for the paper, stating it agreed with the importance of a return to 100% purse seine observer coverage for a number of reasons, including ensuring the accuracy of purse seine catch species composition. They stated PNA and Tokelau observer providers are assigning this a high priority. They supported the proposal for a project to advance the collection of cannery data, noting the need for any outcome to be consistent with the Commission's Rules for Data Access. They also supported the inclusion of the explanatory Annex to the Commission's Scientific Data Rules. As explained in SC18-ST-IP09 (*FAD Minimum Data Fields to be Recorded by WCPFC Purse Seine Vessel Operators*), PNA and Tokelau stated they are applying new requirements for FAD data provision by vessel operators following the approach agreed at WCPFC12; they expect this will require future changes to the Scientific Data Rules to apply compatible requirements with associated changes to the ROP minimum data fields for FADs.

27. The EU stated that the analysis helped in understanding some previously unidentified data issues. It noted that the EU had some fields with low coverage, and stated it would work with SPC to try and fill some gaps. It thanked SPC for the inclusion of tables for the operational catch and effort data fields and supported their inclusion in the annex, and supported the work proposed related to processor data for estimation of species composition.

28. Indonesia highlighted efforts made over the prior year, with technical guidance from SPC, to better understand data collection and submission. It supported the provision of additional assistance to developing states to help fulfil the data requirements. Indonesia highlighted the importance of cannery data, as well as the challenges in collecting the data because of limited resources. Indonesia also noted that organisational changes in its national administration had slowed submission of data, and that the upcoming year would hopefully be more stable.

29. Australia echoed the FFA support for the two proposals/recommendations provided in SC18-ST-WP-01, noting some CCMs needed additional time to consider these. Regarding the operational data fields, Australia stated that it is encouraging that a process to improve acquisition of this important missing data is underway, and reiterated that it would welcome hearing from the relevant CCMs at SC18 about how this issue can be resolved. Australia proposed that SC18 recommend that the Commission note the potential impacts of incomplete provision of some operational data fields on the work of the SC.

30. Korea, regarding tables on operational catch and effort, stated that it already has that information by vessel in the reporting system in Korea, and that following internal discussion about that information it would provide the data to SPC.

Recommendations

31. **SC18 recommended WCPFC support a project to improve the coverage and quality of purse seine processor data.**

32. **SC18 recommended the inclusion of tables of the operational level catch and effort data fields for longline, purse seine and pole-and-line gears, as a guideline and without the column of "binding" and adding the title of "Annex 2, guidelines for data submission of operational level catch and effort data fields for fisheries", as an additional ANNEX of the "Scientific Data to be Provided to the Commission", with an additional paragraph under Section 3. Operational level catch and effort data as follows:**

> **"Annex 2 provides tables of the guidelines of operational level catch and effort data fields for longline, purse seine and pole-and-line gears in order to clarify and assist members in understanding the requirements of each data field and thereby facilitate the submission of data to the WCPFC."**

33. **Noting the inconsistency in the data reporting requirements between the Scientific Data to be Provided by the Commission (SciData), and other WCPFC reporting obligations (e.g., in CMMs), and the need to improve the data available for stock assessments, SC18 recommended that the Scientific Services Provider undertake a review of the minimum data reporting requirements and report to SC19 in 2023. SC18 requested CCMs to submit proposals for additional or amended data field, with associated justification, before 30th March 2023. For example, the proposal for including FAD minimum data fields recorded by vessel operators in the SciData which was presented to SC18 should be forwarded to SC19 for consideration.**

2.2 Other commercial fisheries for bigeye, yellowfin and skipjack tuna

34. F. Satria (Indonesia) presented SC18-ST-WP-02 (*An update on the options for a baseline of the "large-fish" Handline fishery fishing in Indonesia's EEZ (IEEZ) with vessels >30GT for the WCPFC Tropical Tuna Measure*). He noted that Indonesia's handline fishery has two main components, one of which targets large yellowfin tuna and another that generally catches small tuna (yellowfin, bigeye and skipjack tuna). The Indonesia small-scale hook-and-line fisheries are restricted to territorial seas and archipelagic waters but a certain component of the catch of the Indonesian "large-fish" handline fishery taken from Indonesia's EEZ and may be relevant to paragraph 51. Available data to breakdown for the baseline are only available from the annual catch estimates from 2014 to the present. In addition, some documents relevant to the handline fishery have been provided collaboratively by Indonesia's Ministry of Marine Affairs and Fisheries and SPC. Given the lack of data available for the baseline period of 2001-2004, Indonesia stated it is proposing a baseline of 12,682 MT as the maximum annual catch in the period 2013-2016.

35. Japan noted it was helpful to have better data to inform a decision. Regarding the proposal to recommend maximum catch as a baseline, it stated that this is not a scientifically based decision, and indicated it had difficulty with this approach.

36. Tuvalu, on behalf of FFA members, stated that at WCPFC18, FFA members expressed their concern that the information provided by Indonesia had not been considered by the SC and the TCC in the

same way that the baselines for the other relevant fisheries covered by paragraph 47 had been. Furthermore, they also maintained that this review is important, both for the purpose of ensuring due process, and also to ensure that the implications of the different baseline period can be considered. They stated that it is important that a precedence not be set where limits are set outside the period stipulated by a CMM. They requested that SPC provide guidance on possible implications of setting limits on a different baseline from that of 2001-2004 or 2004.

37. The EU agreed that there is no scientific basis to make a recommendation, and suggested this is a matter for the Commission to consider. It supported the comment by Japan.

38. The USA stated that TCC16 recommended a status of "CMM review" for paragraph 51 of the CMM 2018-01 recognizing the difficulty of the application of this paragraph in terms of the scope of "other commercial fisheries" in Indonesia and the Philippines. Based on a request from WCPFC15, the Philippines and Indonesia submitted papers to SC16 and TCC16, but the virtual format of the meetings prevented them from being reviewed. WCPFC17 thus tasked SC17 and TCC17 to review the information and to provide advice to the Commission to facilitate a decision by WCPFC18 on the application of paragraph 51 of CMM 2018-01. SC17 and TCC17 reviewed the papers and provided the advice on the application of paragraph 51 to various fisheries, and which fisheries there was information to generate a baseline for. SPC and Indonesia submitted WCPFC18-2021-24 to WCPFC18 that provides a breakdown of annual catch estimates for the domestic "large-fish" Handline fishery in Indonesian waters for the period 2013-2016, distinguishing between the catches taken in Indonesia's EEZ, and the catches taken inside archipelagic waters (which are outside the scope of the tropical tuna measure). The paper suggests that WCPFC18 consider the baseline of 12,682 MT (as the maximum annual catch in the period 2013-2016) listed in Table 1 as the limit to be applied to the Indonesia "large-fish" handline fishery for vessels >30GT in the Indonesia's EEZ under paragraph 51 of CMM 2020-01. SC18-ST-WP-02 presents essentially the same information as was presented in WCPFC18-2021-24, though it does not suggest a baseline limit.

39. The ST Theme Convener stated it was clear all CCMs were not comfortable with recommending a catch limit, as this was more of a policy question. She suggested noting the information provided by Indonesia and not addressing the implications.

40. Indonesia noted that its fisheries are complex but that it had undertaken several activities in cooperation with NGOs for data collection. It conducted workshops to understand the nature of fisheries and data for bigeye and yellowfin catch, The size data is collected from several ports to estimate catch of small and large fish. In 2017 Indonesia shifted to a national data collection program which entailed a transition, but stated that data collection has improved since 2018. Data collection is handled through an online system so data can be tracked by location. There are several landing places for data reference and validation. That information is provided in the WPEA-ITM Project report (SC18-RP-WPEA-01) and addressed in SC18-ST-WP-02. Indonesia stated additional time was needed to provide more specific data.

41. SPC stated that catches of this fishery in Indonesia's archipelagic waters do not apply to the CMM 2021-01 limit, but SPC does account for the total catches both inside and outside of archipelagic waters in WCPFC scientific work. As explained in previous papers, estimates for this particular fishery do not exist for the baseline period; furthermore, Indonesia's fishery estimates in general for years prior to the WPEA project have been acknowledged as unreliable, and at least for the small-scale fisheries, under-reported. The main issue for setting limits using a different baseline period is that the limit might be higher than the original baseline-year catches (if these were known). SPC has no data for the tropical tuna baseline period of 2001–2004 other than the estimates for other fisheries submitted by Indonesia. There appears to be some qualitative evidence that at least one of the main processing plants for the large-fish handline fishery existed during the baseline years. There were also considerable catches in the Philippines large-fish handline fishery in adjacent/overlapping waters during these baseline years. Annual catch estimates for the

Indonesian large-fish handline fishery are only available for 2013-2016 (and not estimated after 2016). However, to ensure consistency when estimates for this fishery are used for WCPFC scientific work, the catch levels for years 2014-2016 (when estimates were available) have been carried over for years 2017 through 2020. These (carry-over) catch estimates have been used in the recent WCPFC scientific work (e.g., yellowfin stock assessments and projections), so at least the approximate level of catch proposed with this limit has been accounted for in recent scientific work. The main impact of a baseline is on stock projections. At present, for catch projections, SPC assumes future catches will be at the level of the 2016-2018 average, noting that for this fishery, SPC is using the catch estimates for 2016 provided for this fishery as shown in Table 1 of SC18-ST-WP-02 and carried forward for 2017 and 2018. A changed baseline would not impact the stock assessment unless the level of catches currently estimated for that fishery were to be changed as the result of new information (for example, if estimates for 2017 and beyond for this fishery become available). As an indication, and referring to the 2020 yellowfin stock assessment, the proposed limit for large-fish handline represents about 10% of the total yellowfin catch for what is termed the "MISCELLANEOUS GEARS" for the Indonesia and Philippine fleets in Region 7 for recent years, noting that the fishery impacts by region are shown in Figure 58 of S16-SA-WP-04 (Rev 3). SPC stated that with these constraints noted, hopefully enough information was provided for SC18 to consider an appropriate baseline.

42. The Theme Convener noted that this issue would be included in the ODF (as Topic 30) to enable further discussion.

Recommendation

43. **SC18 noted the information provided by Indonesia related to options for a baseline of the "large-fish" handline fishery fishing in Indonesia's EEZ. SC18 observed the decision on this fishery's baseline is a policy decision, and that it did not believe it appropriate to provide any recommendations on a baseline, but recommended the Commission consider the information provided in the relevant SC18 papers and the comments in the SC18 Online Discussion Forum (ODF)[10] on the topic in its decisions making.**

AGENDA ITEM 3 — STOCK ASSESSMENT THEME

44. The stock assessment (SA) theme was convened by K. Bigelow (USA) and H. Kiyofuji (Japan). They reviewed the proposed report format for the SA theme, and outlined there were seven working papers that would be addressed in presentations, as well as 19 information papers that would serve as background for the discussions (eight of which were included in the ODF). The Theme Co-Conveners provided an overview regarding the input sought from CCM delegations regarding the stock assessments.

3.1 WCPO Tunas

3.1.1 Skipjack tuna (*Katsuwonus pelamis*)

3.1.1.1 Review of 2022 skipjack tuna stock assessment

SC18-SA-WP-04 (Quantifying Rates of Mixing in Tagged, WCPO Skipjack Tuna)

45. J. Scutt Phillips (SPC) presented SC18-SA-WP-04 **(***Quantifying Rates of Mixing in Tagged, WCPO Skipjack Tuna*).

[10] https://forum.wcpfc.int/c/sc-18/23

46. In the Western and Central Pacific Ocean (WCPO), programmes of large-scale tagging experiments have been carried out on skipjack, yellowfin and bigeye tuna, to aid estimation of movement and mortality parameters through the stock assessment model MULTIFAN-CL. The integration of tagging data in this context includes critical assumptions about the period of time it takes for tagged fish to mix with the equivalent untagged population in an assessment region. In previous stock assessments, this mixing period has been fixed for all tag release groups, regardless of any perceived difference across regions or time-periods. Sensitivity analyses have shown that the current assessment model for WCPO skipjack tuna is highly sensitive to the selection of a pre-defined mixing period, which has been assumed to be either one or two quarters. However, previous attempts to quantify the degree to which complete mixing of the tagged and untagged populations takes place have generally concluded that the process is likely to be highly variable in space and time.

47. Two existing models of the spatial and fishery dynamics of Pacific skipjack tuna, SEAPODYM and Ikamoana, are used to examine potential variation in mixing for 20 years of tag releases from the Pacific Tuna Tagging Programme (PTTP) and Japanese Tagging Programme (JPTP). SEAPODYM is a full, Eulerian population dynamics model for tuna-like species, with parameters estimated using Pacific-wide environmental, fisheries, catch and tagging data. Ikamoana provides a Lagrangian, individual-based analogue to the movement and mortality components of SEAPODYM, allowing the tracing of individual fish or school trajectories, and the recording of their mortality over time. Using the most recent SEAPODYM parameterisation for Pacific skipjack tuna as an operating model, we simulate the movement and mortality of tagged skipjack in Ikamoana, alongside the corresponding untagged population, to quantify their degree of mixing under assumed mixing periods of zero to three quarters. We simulated tag release events corresponding to historical events from the PTTP and JPTP and calculated the distribution of overall recapture probability for groups of releases, after allowing dispersion during different assumed mixing periods, as a measure of mixing with the untagged population. Using a non-parametric statistic of dissimilarity to compare these distributions, we provided a quantitative and objective measure of mixing for use in selecting an appropriate mixing period in stock assessments of this species.

48. SPC's results show that mixing does indeed vary greatly between release groups. In general, mixing was faster in smaller and more oceanic assessment regions, and poorer in regions where fishing effort was spatially heterogenous and focused in the same area as tag release events. Using different values of the dissimilarity statistic as a minimum level of appropriate mixing, we demonstrate how mixing periods can be assigned at release group level using this approach. This includes some groups having a mixing period of zero quarters which, while impossible in reality, is due to the temporal evolution of their experienced fishing pressure quickly matching that of the untagged population so that effectively, they mix in a much shorter period of time than one quarter.

49. SPC discusses these results in the context of improving the choice of mixing period in stock assessments of WCPO skipjack tuna, the design of future tagging experiments, and the appropriate use of tagging data to maximise its ability to inform population level parameters in assessment models.

50. SPC invited SC18 to:

- Note the use of tag mixing estimates developed here in the 2022 skipjack tuna assessment
- Adopt the use of the method for selection of mixing periods within assessment model grids
- Support the development of the individual-based model Ikamoana, for hypothesis testing and analysis of tuna data in the WCPO
- Note the utility of the approach for informing future tagging cruises and assessment model spatial structures

Discussion

51. Japan thanked the presenter, stating that the approach is promising. They stated their understanding that data from Japan is contained in SEAPODYM, and thus this information reflects Japan's data. Japan posed two questions: (i) how precisely can this predict recapture location, and is there any difference in goodness of fit between regions? And (ii) regarding particle behaviour in northern areas, are skipjack seasonal temperature-related movements (avoiding temperatures below 18°C) reflected in the model? The presenter acknowledged that movement parameters estimated in SEAPODYM use Japanese tagging and fishery data along with environmental data. How well simulated tagging events match observed recaptures is a good question. In theory these have already been fit to tag-recapture groups in SEAPODYM, but an explicit simulation study comparing to actual tag recaptures within Ikamoana has not been done. Some issues such as tag shedding and tag reporting are not currently incorporated in the model. He stated that SPC would like to pursue this, while noting that SEAPODYM is fit to recapture data, with validation of simulated tag recaptures already published. Regarding the seasonal influences, those are replicated to a degree with the SEAPODYM habitat forcing, but the influence on degrees of mixing is something to note. The expectation would be to see a very low number or no tags in the northern region during seasons 1 and 4.

52. New Zealand noted the very interesting simulation development, stating it helped in understanding issues that may affect tag mixing, and its utility, especially the spatiotemporal component. New Zealand stated that simulation models are very useful to help develop understanding, but suggested that determining whether tags are actually mixed should be based on estimation and statistical testing using real world data; in general a simulation model such as Ikamoana would be used to explore possible states of nature, but these simulations are hypotheses, which are not the same as real world data. The Ikamoana model is built on top of the SEAPODYM model, which conditions the tag movements based on recaptures, which are affected by where the fleets are fishing. There will also be fish movement behaviour that is not included in either SEAPODYM or the simulation model, either because you don't know about it or because you can't model its complexity. These might be very important factors such as behavioural transitions at particular sizes, responses to FADs (which New Zealand noted don't seem to be in the models) or to environmental factors that aren't in SEAPODYM, or attachment to particular locations. New Zealand stated that it is risky to use the results of a simulation to structure the assessment, and observed that the paper did not appear to include a comparison of the simulated tag distributions with the real world; it inquired how well those comparisons match – how well does the simulated mixing match the observed mixing? New Zealand referenced statistical tests that directly model the real-world tag recapture data, which were developed by SPC, applied to data from the 2011 skipjack assessment, and peer reviewed and published in 2015. They showed very clearly that on average, skipjack tags were unmixed even after 6 quarters. This was a problem, because a mixing period of 6 quarters will effectively remove most of the tags from the model. But equally, using too short a mixing period will bias the results. In response to these findings, the skipjack regional structures were changed to add more regions, but New Zealand stated the tests have not been rerun, even to check if the new structures actually solved the original problem. Since 2011 far more tags have been released and recovered, and New Zealand suggested it would be sensible to rerun those statistical tests to determine the appropriate mixing period; this would use the real-world data to configure the model, instead of relying on a simulation which might be significantly different from the real world. There should be enough real-world data to get a very clear picture of tag mixing. New Zealand noted that it raised this issue at SPC's Pre-assessment Workshop, and recommended that modelling of the real-world data should be a high priority for future work. The presenter agreed that it would be good to rerun some of the previous work to see if mixing was occurring in historical events. But tagging was sporadic, and thus past analyses can't be run on all the release groups; this raises the question of what to do with all the tagging data we want to simulate for the assessment? There are also assumptions in those statistical methods about fish diffusion and mixing, and so there may be utility in using the simulation model to test the limits of those past analyses to see where they may be able to ID a lack of mixing. He acknowledged the need to maximize the use of

real-world data wherever possible. He highlighted that the fit to the behavioural model, although it remains a simulation, was done with real tagging data, and there has been some interrogation of the model as it pertains to real data. True historical releases had already been validated using this behavioural model within SEAPODYM. Regarding behaviours that are not included, there are some—such as the influence of FADs at local scales— that are abstracted into the fishing mortality in different fleets, but this is something that SPC is actively starting to build into the model.

53. The USA echoed comments by New Zealand and Japan regarding the comparison of the simulations with empirical observations about where tags are recovered, noting the simulations are quite informative about what theoretical levels of mixing could be, but the results are strongly conditioned on the assumption that the SEAPODYM-Ikamoana operating model represent reality. It would be useful to provide a good check to show that results for simulated tags are comparable to observed recaptures. The USA stated that when comparing the simulated distribution of recapture probability for tagged and untagged individuals, a choice was made to compare the distribution at the limit of the simulation at 8 quarters, but noted that using the probability of recapture at the limit of the comparison doesn't provide information about whether tagged individuals are representative of the untagged population for the period between the mixing period up to the limit of the simulation. There is concern that using the comparisons at the limit of 8 quarters would introduce a bias to underestimate the length of the mixing period, and this could result in overly high fishing mortality (F) estimates. The USA suggested that it may be better to calculate the difference (the D parameter) between tagged and untagged individuals in the simulation as the integral of all time steps between the mixing and the limit of the simulation, rather than taking a snapshot at the end of the simulation. The presenter stated they had already touched on simulated vs. observed tag recaptures, and stressed that a comparison has been done, because the behavioural model driving the movement and mortality of those fish has been fit to tagging data within SEAPODYM along with much other data assimilation. He stressed that this was not purely a thought experiment. He acknowledged there would be some benefit in doing such a comparison, although more to interrogate SEAPODYM parameter estimation. Regarding the dissimilarity at the limit, SPC stated it would like to address this, while noting that recapture probabilities are the cumulative effect of all the fishing pressure experienced by all simulated individuals. It compares the cumulative effect over time, not just whether the fish are mixed at 8 quarters. However, having an integrated value of the D would capture the rate of change immediately post- assumed mixing. SPC stated it would like to discuss with interested CCMs how to apply this in the next iteration.

54. Australia noted the useful visuals to further understanding of how the model operates, and the work to apply Ikamoana to refine understanding of the dynamics of tagged individuals and improve our treatment of tag datasets in tuna stock assessments. However, it noted that despite this development, there remains considerable uncertainty with regards to the dynamics of tagged individuals compared to the overall modelled population. As such, Australia stated it supports the decision to continue to include a grid axis representing this uncertainty in the set of model runs used to assess stock status for skipjack. It also supported ongoing development of Ikamoana to analyse tagging data and test hypotheses that can inform stock assessment models in the WCPFC.

Australia posed two questions:

(i) Australia noticed that there were no real caveats included in the Discussion, despite a high number of strong assumptions about animal behaviour and fleet dynamics underpinning the analysis, and inquired which SEAPODYM or Ikamoana assumptions are most likely to impact the estimated mixing periods?

(ii) The presence of high concentrations of FADs has been shown to impact fish behaviour and you would think that mixing rates would be different in regions with high FAD density. Is this accounted for in the way fishing effort is implemented in the model and do you think it would impact and has impacted estimated mixing rates?

55. The presenter stated regarding (ii) that the influence of FADs is not explicitly incorporated, but the estimated fishing mortality at the subregional scale (quarter degree) is trying to capture the effect of the purse seine fleets in the model. SPC stated it was possible that FADs at this finer sub-grid scale concentrate FAD fishing effort, and it could be very important to understand how that concentration is affecting which fish are caught at the cell or MULTIFAN regional scale. SPC stated it was further developing earlier work on this. The effect of FADs is included to the degree that the separate purse seine fleets have differing mortality rates that are expressed in the model. Regarding (i), the main caveats are firstly the estimation of the untagged population distribution in the region. E.g., SEAPODYM estimates a considerable amount of biomass in the south of Region 6, where there is little fishing pressure. This is in effect a cryptic biomass, and has a significant impact on the mixing period (or dissimilarity estimates) in the study. SPC ran an alternative study in which the size of Region 6 was reduced to be much closer to the archipelagic waters of Solomon Islands, PNG and the Solomon Sea. This significantly improved the level of mixing for tagged fish there. Those tagged fish provide important information about the fishing pressure in that area, but not so much about all the untagged fish in the region. So that is the first caveat: the untagged population truth that is compared to the tag release events. The second caveat is that true tag recaptures are believed to be highly influenced by reporting rate, and this is not included in the estimation of the behavioural model within SEAPODYM; SPC will consider how to incorporate this.

56. The EU stated the work was very interesting because it removes assumptions about constant mixing periods, and stated it would like to see it further developed. However, the EU shared the concerns expressed by other CCMs, and supported the proposal from Australia about including traditional approaches in the uncertainty grid. The EU posed two questions: (i) formerly the mixing periods took into account the quarter of release with no differentiation about when in the quarter this occurred. Has this been taken into account in some way? (ii) Intuitively the assumption is longer the mixing period the better, as over time the tagged and untagged populations would mix perfectly. But this has implications due to the relative weight of the tagging data vs. other sources, thus it is a problem of data weighting rather than of mixing period; the EU asked for SPC's thoughts on this. SPC stated regarding (i) that in the last stock assessment the mixing period was based on the true date of release. Within this study, where SPC sought to inform the use of that data within the release group, it aggregated all data to the mid-quarter level. This limits the use of computing resources. SPC could use the actual release date; it would double the simulations, but could be done, with more time. For the stock assessment the mixing data was not based on the real date of release, although this had been done during the previous yellowfin tuna assessment in 2020. Regarding (ii) SPC agreed that long mixing periods are ideal, but with skipjack there tends to be no tagging data left after long mixing periods, so it is necessary to take a realistic approach to maximize information and minimize bias in terms of unrealistic fishing pressure. This approach provides a quantitative approach that can be scaled.

57. Indonesia posed the following questions: (i) is there any information regarding the percentage of tags used for each region for this study? Is there any impact on the study from the different number of tags for each region, noting there is very little tagging for region 5 archipelagic waters? (ii) Regarding fish size, does this study account for small skipjack, noting that the project uses pole and line data, with fish that are quite similar in size. And (iii): is there any comparison of the impact of anchored vs. drifting FADs? SPC made the following replies. (i) This study has not taken into account the absolute number of tags in each region, but seeks to characterize the results through space and fishing effort of tagged fish given the initial release locations; thus SPC does not weight by the number of tags. SPC raised the question of given what we think we know about how fish move and fishing effort how many tags are enough to get useful information? SC stated that is could seek to answer this for region 5, but the caveats discussed previously would apply. (ii) The influence of size and age are incorporated, but simulated based on the historical size classes that are occur in the actual data (this is detailed in the paper). However, SPC can simulate any size class that it is interested in. Regarding (iii) the influence of FADs, this is of interest to all, but there is much that is not known about how and why aggregations of tuna occur around anchored or drifting FADs. SPC is using electronic tagging to try to better understand the very local influences of FADs, which could then

be used in analyses and behavioural models such as this one.

58. PNG inquired whether there were any plans to increase the number of release groups to the east of the model area? The presenter stated that the model framework can release fish anywhere. In terms of real tag releases in the east, this is very important, particularly in terms of the potential expansion of warm pool and climate change. It is important to monitor skipjack throughout the WCPO, but SPC is very limited by logistics for those kinds of releases, and must charter existing pole and line vessels for mass skipjack tag release events. There are releases further east, but these are one or two magnitudes below the volume that is possible with the pole and line vessels. SPC noted some excellent work by Japan, which has access to longer-range pole and line vessels that are specifically designed to do this, and stated the results have helped significantly, but that the number of tags remains quite low. Without suitable bait grounds in the eastern CPO, it is very hard to get this kind of data. SPC stated it is working with Japan to try and do this, and would look to support from CCMs for this kind of work.

SC18-SA-WP-01 (Stock assessment of skipjack tuna in the western and central Pacific Ocean)

59. C. Castillo-Jordán (SPC) presented SC18-SA-WP-01 **(***Stock assessment of skipjack tuna in the western and central Pacific Ocean*). The paper describes the 2022 stock assessment of skipjack tuna (*Katsuwonus pelamis*) in the western and central Pacific Ocean. An additional three years of data were available since the previous assessment in 2019, and the model extends through to the end of 2021. The assessment applies the same 8–region model structure that was used for management advice from the 2019 assessment. New developments to the stock assessment include:

- Application of a new MFCL catch conditioned approach to the estimation of fishing mortality, plus inclusion of survey fisheries and a likelihood component for the indices from those survey fisheries.
- Application of a self-scaling approach to estimate effective sample size, the Dirichlet-multinomial likelihood, with growth estimation within the diagnostic model.
- Application of variable tag mixing periods for tag release groups based on simulations using individual based modelling of tag mixing processes.
- Development of an alternative growth model based on tag recapture growth increments and daily aging from otoliths.
- Development of new CPUE indices based on unassociated (free-school) fishing for the purse seine fisheries in equatorial model regions using a novel travel distance effort metric, truncation of the pole-line-index in Region 8, and grouping of selected CPUE indices to inform regional biomass scaling.

60. This assessment is supported by the analysis of catch and effort data for pole-and-line and purse seine fisheries (Teears et al., 2022),[11] a novel approach to estimating tag mixing periods (Scutt Phillips et al., 2022),[12] a review and new analysis of skipjack growth (Macdonald et al., 2022),[13] re-analysis of tag seeding experiments to inform tag reporting rate priors (Peatman, 2022),[14] and a new analysis of tagger

[11] Teears, T., Aoki, Y., Matsubura, N., Tsuda, Y., Castillo Jordon, C., Hampton, J., Schneiter, E., Scutt Phillips, J., Peatman, T., and Hamer, P. (2022). Background analyses and data inputs for the 2022 skipjack tuna stock assessment in the WCPO. Technical Report WCPFC-SC18-2022/SA-IP-05.

[12] Scutt Phillips, J., Lehodey, J., Hampton, J., Senina, I., and Nicol, S. (2022). Quantifying Rates of Mixing in Tagged, WCPO Skipjack Tuna. Technical Report WCPFC-SC18-2022/SA-WP-04.

[13] Macdonald, J., Day, J., Magnusson, A., Maunder, M., Aoki, Y., McKechnie, S., Teears, T., Castillo Jordán, C., Hampton, J., and Hamer, P. (2022). Review and new analyses of skipjack growth in the Western and Central Pacific Ocean. Technical Report WCPFC-SC18-2022/SA-IP-06.

[14] Peatman, T. (2022). Analysis of tag seeding data and reporting rates for purse seine fleets. Technical Report WCPFC-SC18-2022/SA-IP-19.

effects (Peatman et al., 2022).[15]

61. The main influential change in the progression from the 2019 to 2022 diagnostic model was the introduction of grouped survey fisheries with a separate likelihood component as part of the switch to a catch conditioned model. This resulted in a large increase in estimated spawning potential and a more optimistic stock status compared to the 2019 diagnostic model. We note that conversion to the catch conditioned model without the survey fisheries and their related likelihood component, had minimal impact. The other changes and data updates had minor influences compared to the inclusion of survey fisheries. In addition to the diagnostic model, we report the results of one-off sensitivity models to explore the impact of key data and model assumptions for the diagnostic model on the stock assessment results and conclusions. We also undertook a structural uncertainty analysis (model grid) for consideration in developing management advice that includes combinations of those areas of uncertainty considered important. It is recommended that management advice is formulated from the results of the structural uncertainty grid. The results below are based on equal weighting of all models.

62. Across the 18 models of the structural uncertainty grid run in this assessment, the most important factors when evaluating stock status were the thresholds used to determine the variable tag mixing periods based on the tag mixing simulation studies, and the alternative growth models. The tag mixing scenarios that allocated longer tag mixing periods (more conservative) resulted in scaling up of the spawning potential and estimated a more optimistic stock status compared to those that allocated shorter mixing periods. However, the temporal dynamics of spawning potential and spawning depletion were similar across the scenarios. The application of the externally estimated growth also resulted in increased levels of spawning potential and a slightly less depleted stock trajectory, but showed some difference in the temporal dynamics compared to the diagnostic model where growth was estimated within the model. There were three outlying models in the structural uncertainty grid that estimated higher spawning potential and less spawning depletion. These models involved the most conservative tag mixing scenario and the external growth.

63. The general conclusions of this assessment are as follows:

- Spawning potential has remained relatively stable, with fluctuations, until around 2010, after which it declines gradually, driven by trends in the equatorial regions. Spawning depletion has declined gradually since the start of the model period. This decline is largely due to the increasing estimates of the unfished spawning potential and recruitment from 1980 to the recent period, informed by stable CPUE trends.
- Average fishing mortality rates for juvenile and adult age-classes increase throughout the period of the assessment.
- Overall median depletion from the model grid for the recent period (2018-2021; $SB_{recent}/SB_{F=0}$) is estimated at 0.51 (80^{th} percentile range 0.43-0.64).
- No models from the structural uncertainty grid estimate the stock to be below the LRP of 20% $SB_{F=0}$.
- Recent (2017-2020) median fishing mortality (F_{recent}/F_{MSY}) was 0.32 (80^{th} percentile range 0.18-0.45).

64. The most notable feature of the assessment is the estimation that the stock is becoming increasingly depleted over time, a trend which is largely driven by the equatorial regions. Importantly, this trend is driven by an increasing trend in the model estimates of the unfished spawning potential over time, rather than a long-term decrease in the estimates of spawning potential. The assessment is indicating that the spawning potential, as informed by a number of CPUE indices, has not changed substantially in the face of the notable increases in catches over the last 20–30 years, and that the increased catches have been sustained by

[15] Peatman, T., Scutt Phillips, J., Potts, J., and Nicol, S. (2022). Analysis of tagging data for the2022 skipjack tuna assessment: corrections for tagging conditions. Technical Report WCPFC-SC18-2022/SA-IP-20.

increased recruitment levels. The interpretation of stock status based of the ($SB_{recent}/SB_{F=0}$) reference point should bear this in mind.

65. A number of key research needs have been identified in undertaking this assessment that should be investigated either internally or through directed research. These include: 1. Continued work on abundance indices to explore effort metrics related to travel distance for both the purse seine and pole-and-line fisheries, along with exploration of hyperstability and effort creep, focussing on developing effort creep scenarios for the Japanese pole-and-line fishery. 2. Conduct a study to explore the plausibility and evidence for the model predicted long-term increasing trend in skipjack recruitment. 3. Consider epigenetic approaches for improving growth estimation. 4. Further work on the skipjack model to test alternative model structures to obtain a positive definite Hessian solution and reduce data conflicts. 5. Conduct studies to explore meta-population structure of skipjack, particularly focussed on improving understanding of the linkages between populations in the east Asian waters and those in the broader western and central Pacific.

Discussion

a. Technical considerations

66. Japan commented that all models seem to have a non-positive definite Hessian, and that it was hoped reducing the contrast by applying the new catch- conditioned model would resolve the convergence issues were present in past assessments. Japan noted that this was not working in that way for skipjack, and that CPUE has a systematic residual pattern; it stated more diagnostics are required to understand what led to this result, and which component informed the biomass trend. Japan requested that SPC show the Age Structured Production Model results or other diagnostics, and addressed the lower depletion in region 2 compared with the previous stock assessment. Japan stated that the high proportion of recruitment in region 2 appears to have driven the result, but noted that this was not realistic given the movement of skipjack south during winter (in quarters 1 and 4). It also noted that recruitment in region 2 should be lower, because it does not occur throughout the year, and that setting recruitment to 0 in quarter 1 and 4 in region 2 would be more realistic. Japan stated that its understanding is that recruitment is estimated by the model to explain the catch in region 2, and suggested it may be necessary to revise movement rates between regions. SPC noted the region could be redefined (or truncated) by temperature to match skipjack thermal tolerances. A preliminary model with this thermal truncation in the northern model regions produced a decline in recruitment in region 2; SPC suggested this approach needed more exploration, but seems like a good idea. It was not applied in the 2019 assessment. Regarding additional diagnostics, and the age-structure production model, this could be considered; diagnostics were limited because of time constraints.

67. The EU noted a continued increase in recruitment, almost 3-fold from the 1970s to 2000, and an increase in biomass, by about 50% in the diagnostic case over the same period (this was not observed to the same extent previously). It suggested this could be explained by factors such as an increase in fishing efficiency or an underestimation of stock productivity, and asked for SPC to comment. SPC stated that the increasing recruitment trend has been a feature for some time. It arises primarily because of relatively stable long-term CPUE trends through the mid-2000s, while the catch was rapidly expanding to the levels that have been seen in recent years. The model's only real way to explain this is to increase recruitment; it could be explained through a decrease in natural mortality, but SPC assumes stable natural mortality and movement. SPC stated it has often commented that recruitment may not be constant over time; some work suggests that skipjack productivity may be increasing, resulting in increased biomass. It is possible that the expanding size of the warm pool is increasing the spawning habitat, and that there is a decrease in large predators in the region. These issues need to be further examined.

68. New Zealand noted that skipjack is one of the world's biggest and most valuable fisheries, and also a very complex stock that's difficult to assess. There has been a lot of work done in a number of areas, but

the fundamental approaches used in the model are consistent with the approach used for the last 15 years. The assessment has always been difficult to fit, and despite the technical improvements that were made, New Zealand suggested that some of the issues were now becoming fairly significant. It offered the following comments:

(i) The likelihood profile shows a lot of conflict between the data types. The survey (CPUE) and some other parameters are pushing biomass higher, while tag data and size data are pushing the biomass lower, indicating that the model has a lot of internal inconsistency. Other signs of inconsistency and conflict include parameters estimated on the boundary, and posterior estimates that are a long way from the priors. New Zealand stated that there is a principle in stock assessment that if two information sources are in conflict, they can't both be true, including model misspecification. The normal response to this conflict would be to run alternative models where each alternative gives preference to a different source of information and doesn't have that internal conflict. But here the internal conflict is not being addressed, all the models have a lot of conflict, and most of it is not included in the grid.

(ii) New Zealand stated that model problems are also suggested by the unusual recruitment pattern, which shows a steady increase of about 2% per year with low variability until the mid-2000s, when it stabilizes at more than 2x the level in the 1970s and then starts to decline. The estimated biomass has a similar pattern. This increase followed by decline would be a remarkable change in productivity across the ocean; such long-term steady trends in productivity are not expected given a noisy biological system. The warming trend could technically be called an increase in the size of the warm pool, but evidence is needed before assuming the warming Pacific is increasing skipjack productivity. The last skipjack stock assessment showed a much smaller recruitment trend over the same period, and the larger trend in this assessment is caused by changes to the model. The change from increasing to declining recruitment in the mid-2000s doesn't coincide with cooling but rather with when the new purse seine CPUE indices are introduced; there is thus an increase with the pole and line CPUE and a decrease with the purse seine CPUE. These kinds of recruitment trends in early drafts of a stock assessment are quite common. Recruitment trends are often used as diagnostics, to suggest that the model configuration might be wrong, and New Zealand stated that this looks very much like a model configuration problem.

(iii) The recruitment trend can be linked to effort creep. The report acknowledges understanding of effort creep is poor, and states that more work is needed. Poor understanding or uncertainty is a basic component of stock assessments, typically addressed through the uncertainty grid. However, having a poor understanding of effort creep is not a good reason to assume that it doesn't occur – i.e., that Japanese pole and line fishermen didn't improve their efficiency for 50 years from 1970 to 2020. Gear and technology and communication and science are progressing, and in the long-term fishermen use them to get better at catching fish. In a grid we could consider a distribution of possible effort creep estimates from 1% to 3% per year. SC18-SA-IP-16 estimates a rate of about 1% per year, though this analysis only included a few factors, and didn't include important issues like improved communication between vessels and the mainland with cell phones and satellite phones to share information, and the progress of science leading to better understanding of oceanography and fish behaviour, which helps vessels to find fish. From 1975 to 2010 recruitment increased at just over 2% per year, so effort creep of 2% per year could go a long way towards removing that recruitment trend. A reasonable uncertainty range of effort creep would be 1% to 3% per year, but the assessment only considers the possibility of effort creep through a sensitivity analysis. The assessment model runs assume effort creep of 0% per year, an assumption which is unlikely and very influential.

69. SPC stated that effort creep was not included in the mode grid because it is not possible to assign defensible non-arbitrary values without further work, and that project P18X4 (*Exploring evidence and*

mechanisms for a long-term increasing trend in recruitment of skipjack tuna in the equatorial Pacific and the development and modelling of defensible effort creep scenarios) was being put proposed at SC18 to address this.

70. Australia congratulated the SPC for progressing several issues with the current skipjack assessment, noting that the stock remains a challenging one to assess; it welcomed the collaboration with analysts across different skillsets, noting that the number and breadth of technical developments in the updated skipjack assessment is impressive. However, Australia stated that SC needed to be able to review each of these new developments to fully understand their impact on key assessment outcomes, which relies on the provision of detailed diagnostics and exploratory analyses to support the improvements. Australia stated several diagnostics and sensitivities were either missing or hard to interpret in the 2022 report, which hindered its in-depth review of the suitability of the technical updates. Australia further noted that two issues from the 2019 assessment are exacerbated in the current version: the tag reporting rates hitting the boundaries and the positive trend in recruitment over time. From the likelihood profile, the current assessment appears driven by very different sources of information compared to the previous one. In the 2019 assessment the tagging data was driving the spawning biomass up and the LF and CPUE were driving it down, in the current assessment the tagging data is driving the spawning biomass down and the CPUE is pushing it up. Australia asked SPC to comment on the likely cause of this inversion in the influence of tagging data vs. CPUE data. The use of the Dirichlet multinomial to estimate effective sample size should be an improvement but Australia stated it is not possible to examine its validity based on the diagnostics provided. Notably, the step where the Dirichlet multinomial is implemented occurs simultaneously with the addition of a new growth curve; Australia asked SPC to comment on what they think the effect of introducing the Dirichlet multinomial is? Australia also commented that there were minimal diagnostics included for the pole-and-line standardisation and no comparison between the nominal and standardised CPUE. Some of this was reviewed at PAW but as this index appears to be very influential in the assessment so it would be good to be able to review the diagnostics, including influence plots, for the final version. SPC stated regarding the reporting rates that it did some side experiments to check the reporting rates on upper bounds and see if they would settle below an increased bound to 0.99. They found that four of the 10 reporting rates on the 0.9 upper bound settled below 0.99. The prior stock assessment had tighter bounds particularly for the SSAP groups, but we know little about reporting rates for this early tagging program, thus for this assessment SPC supplied a much less informative prior for the SSAP. Reporting rates are a problematic area, and may warrant consideration of fixing some reporting rates and inclusion of alternatives in the structural uncertainty gird, although internal estimation is generally the preferred approach. The solution is not clear, however; reporting rates would not be constant over time, and among tag reporting groups, SPC needs to increase the prior information content through more tag seeding experiments. Regarding the influence of the tag and CPUE data, this has switched; SPC is not exactly sure why, and needs to investigate, noting that the objective function has changed when going to a catch condition approach with survey fisheries and this seems to have altered how data types influence the likelihood. Regarding recruitment trends, comparing post-2010 recruitment estimates and pre-1980 recruitment: in the 2019 stock assessment the post-2010 to pre-1980 trend was 1.5, for this assessment it is 1.85, both referring to the diagnostic case. Thus, the trend is somewhat stronger in the current stock assessment, but not to the extent stated in earlier comments. SPC stated it is now able to estimate the standard deviation of the growth more appropriately with the model internal growth estimation using the Dirichlet multinomial.

71. The USA commented that the 2022 WCPO skipjack tuna stock assessment incorporated several technical advancements in order to address issues raised in the 2019 assessment report. Moving to a catch conditioned framework reduced the number of estimable parameters, using a self-scaling likelihood eliminated an arbitrary data weighting axis in the uncertainty grid, and redefining the effort to standardize equatorial free-school purse seine CPUE as a function of VMS distance travelled attempted to address issues caused by changing search patterns. For the first time, the possibility of effort creep in the historical Japanese pole and line CPUE was explicitly addressed in the assessment report by way of a sensitivity

analysis. However, issues noted in previous assessments remain and appear to be more extreme in the current assessment. These include the apparent correlation between recruitment and fishery removals, large temperate biomass estimates serving as buffer to equatorial depletion, and tag reporting rates estimated to be on the upper bound. While some of these issues could potentially be explained by changing productivity regimes, they could also be symptomatic of data mis-specification in the form of hyperstable CPUE or inappropriate regional scaling factors. Another concern is the absence of a positive definite Hessian solution for yet another spatially complex, WCPFC tuna stock assessment. This is concerning because it indicates that the model may not have converged to a stable solution, key parameters may be poorly determined and that the model is unable to provide reliable estimates of parameter uncertainty. Additionally, it may be indicative that the current assessment model is too complex given the quality and availability of the data. The USA concurred with the assessment authors that critical research needs to take place to improve the quality of the abundance indices, explore the feasibility of CKMR, improve data available for growth estimation, corroborate tag mixing simulations with real-world observations, and re-evaluate the model structure to develop an assessment model that meets accepted convergence criteria. The USA also noted that the fm.regression penalties attract a large penalty in the likelihood profile. This actually appears to shift the MLE between Phase 8 and Phase 9 (Figure 15.1, Rev4). The USA inquired whether the assessment results are based on the Phase 8 value or the Phase 9 values? If Phase 9, it asked SPC to comment on why the MLE shifts that much. Is it just the addition of the fm.regression, or is something else occurring in that terminal phase that would shift the MLE? SPC stated the results are based on phase 9, with phase 8 used to compare what is happening without the effort-fishing mortality regressions. The final phase was used for the results to be consistent with the projections to come after the stock assessment. SPC is also trying to understand the slight differences in likelihood when we implement the fishing mortality fishing effort relationship. The projections are a critical part of the stock assessment so SPC wants to run them from the same point using the same model as the assessment. In terms of management reference points it is not a big difference, but it is noteworthy. SPC stated it is still learning the finer details of the catch conditioning and the effort-fishing mortality regression approach; in phase 9 SPC is attempting to estimate a time series for the purse seine fisheries, as we need to the catchability estimate for the projections. Seven-node splines are used for each purse seine fishery, and each has a penalty weight that needs to be estimated; these could be changed, or the number of spline nodes increased. Given time more options can be explored.

72. Australia commented that the number of new technical developments and methodological issues explored unfortunately raises the issue as to whether the SC now has enough time to sufficiently review each of these new developments to fully understand the impact that they have on the assessment outcomes. They stated that as a long-term participant at SC, it is interesting to look back at the papers presented to the SA-Theme at past meetings. Many of the working papers summarised methodological issues such as the CPUE analyses, and other technical developments used in the stock assessments (indeed, there was 5 supporting working papers presented to SC15 in 2019 when skipjack was last assessed), while at more recent meetings many of the papers describing such features are simply provided as information papers and as such do not get the full review that they deserve. Australia noted this was not a criticism of the analysts, who continue to exceed their remit, but an acknowledgement of the increasing complexity of the assessments and the increasing workload of the SPC, the SC and the Commission. Australia also stated that as noted in the presentation, the introduction of the survey fishery indices resulted in the largest stepwise differences in spawning biomass away from the 2019 assessment. Grouping the survey indices informs the regional scaling in the model. For example, the area-weighted CPUE indices shown in Fig 11 of SC18-SA-IP-05, indicate that the abundance in region 4 is substantially greater than that estimated for region 7, and this difference is reflected in the outcomes of the assessment (c.f. Fig 48). However, the biomass scaling between these two regions seems to conflict with the observed annual catches taken within these regions, as annual catches have generally been smallest in region 4 and highest in region 7 (Fig 4 of SC18-SA-WP-01). This seems unusual as fishers usually fish where biomass is high. Similar differences can also be seen between other regions. However, it is possible that use of the 'grouped' indices can lead to problems with the relative scaling across regions if the index in one or more regions is poorly estimated. For example,

region 4 is large and being on the periphery of the skipjack distribution has generally been poorly sampled. If estimates of biomass in sampled areas are used to interpolate estimates in unsampled areas this could upwardly bias the predicted biomass across the total region, and consequently over-inflate the regional scaling factor for this region. Australia inquired whether discrepancies between model inputs of distribution of stock abundance and the distribution of actual catches appear realistic, or are these indicating potential data conflicts and potential problems with the manner that the regional std-CPUE indices may have been calculated? And could this have a bearing on the large step-wise differences in biomass noted earlier and the likelihood profiles which indicates that the CPUE data wants to drive estimates of biomass up? And given the influence of the survey indices on the assessment, would it have not been useful to include some form of sensitivity to these indices in the uncertainty grid, especially in light of the comments from NZ in relation to effort creep? SPC remarked on the complexity of estimating relative abundance in the regions. In the pole and line fishery, based on Japan's pole and line CPUE analysis, which takes the Vector Autoregressive Spatio-Temporal (VAST) approach, abundance estimates are estimated on 1-degree cells, and then summed to obtain abundance of a given region. The size of the region is important, and not just the relative CPUE, which is more of an index of density rather than abundance. Region 4 is large. When you sum the 1° cells from the VAST model you clearly get a greater number than across Region 7. That said the VAST model will extrapolates into 1° cells in which there is little effort and little catch. This needs to be considered, but the alternatives are also not so attractive. This is often a problem with these assessments. SPC has to infer something about abundance even where there is little or no fishing. The VAST model uses the available data in a reasonable statistical fashion to extrapolate across the assumed regions. If the regions were trimmed by the nature of where the fishery has occurred results would differ, because we would assume fish do not occur in areas that are not fished. Many factors influence where vessels fish, not simply fish availability. This issue is most relevant to the pole-and-line CPUE indices. SPC uses purse seine CPUE to index abundance in the equatorial regions, and don't really consider size of catch as a stand-alone factor.

73. Australia noted that assessments for southern bluefin tuna had the same problem, and it developed hypotheses of what might happen in areas that were unfished. It noted that it would be useful to do this in the tuna stock assessments, and suggested this could be a good topic for the PAW in 2023.

74. Japan addressed the tag reporting rate, noting that some estimates are on upper bound and thus not well estimated, and most are higher than the mean of the prior distribution. Japan inquired whether actual data was available by tag seed experiments, noting that rates should be fixed through experimental results, rather than estimated in MULTIFAN-CL. SPC stated that it uses the tag seeding-based estimates of reporting rate and their statistical uncertainty as the basis for specifying the priors (which are quite informative) for the tropical purse seine fisheries. The model is then allowed to estimate the rate for other fisheries that are not informed by informative priors. The model looks at the extent and catch at age for the fisheries. The model tries to predict the number of tag returns that should have been recaptured by the other fisheries. Then with the objective function for the tagging data you have the observed numbers, and the model will tend to use a reporting rate that matches the observed and reported as closely as possible for those fisheries. The model balances the catch by age for fisheries for which we do and don't have good information on tag reporting from tag seeding experiments. If we had no information on tag reporting rates for any fisheries, we would have problems. Fixing the reporting rates for the fisheries for which we have the greatest volume of tag seeding would essentially make the prior have a very low standard deviation, but could be done.

75. The USA inquired regarding natural mortality estimation at age, stating that in comparing the 2019 stock assessment with the current assessment, there is a difference in the scale in Figure 43 (in SC18-SA-WP-01) and Figure 40 of the 2019 assessment (SC15-SA-WP-05). The USA asked for a comparison of the diagnostic case for both assessments. It also noted the different shape of natural mortality at age depending on the growth scenario assumed for the ensemble in Figure 43, stating that growth pattern G1 has a W

shape, and growth pattern G2 has a U shape, more consistent with the Hampton 2000 study[16] and the Watanabe theory of senescence in tunas. It inquired regarding confounding between the growth assumptions and natural mortality, and if is it possible to diagnose that with some information about the estimated Hessian matrix? SPC acknowledged that estimated natural mortality at age is different between the 2019 and 2022 assessments. SPC noted that a recent paper by Vincent et al. (still in draft form) looked at natural mortality estimates in these stock assessments, and may help to clarify some of these issues around differences in the natural mortality estimates.

76. SPC made a number of comments to help inform discussions on further research and development to improve skipjack assessments. They acknowledged that there have been some significant changes to the 2022 skipjack assessment, including catch conditioning; implementing the Dirichlet-multinomial likelihood; survey fisheries and a CPUE likelihood component; and a new approach to specifying tag mixing. These were made to both improve and simplify the assessment, as requested by SC and supported at the Pre-assessment Workshop (PAW). SPC provided the following detailed comments regarding data conflicts, model estimated recruitment trends and effort creep.

(i) **Data conflicts.** SPC noted that it acknowledged the data conflicts within the model, which focus mainly on the tag and CPUE data. Tag data in the 2022 assessment favour lower biomass and a more pessimistic status, and the CPUE data favour higher biomass. SPC noted that the tag mixing grid axis substantially alters the influence of the tag data on the model estimation, the conservative (T1) tag mixing scenario removes around 90% of the recaptures, the T3 (least conservative) removes only about 10% of the recaptures. SPC stated that this is a large sensitivity in relation to the influence of the tag data, which are highly influential on outcomes. While this does not explicitly deal with all conflicts it does include their implications in the uncertainty grid. SPC noted that previous experience suggests that a viable model cannot be obtained with removal of all tagging data, and it expects this is also the case if removing long-term CPUE indices. In relation to the CPUE indices, SPC stated it agrees with Australia's comment that more fishery-specific likelihood profiling will be useful to better understand if there are particular CPUE data that are driving conflicts with tagging data and this may help with developing strategies to reduce conflict, and would like to explore this given more time. SPC would also run the likelihood profile for the T1 model to see to what extent data conflict is removed. It noted that CPUE has always been an Achilles heel of this assessment. If a grid axis is warranted for CPUE this would open many options to explore and SPC suggested it would require a dedicated SC project, that would report to SC on new options for use of fishery-dependent CPUE in the skipjack assessment. SPC stated it would welcome suggestions on how to better manage these conflicts or include them in some expanded uncertainty grid, which could then inform the project design.

(ii) **Recruitment trends.** With regards to the increasing recruitment trend predicted by several assessments, the trends are slightly more pronounced in 2022, with the key observation being that the sustained trends occur across different assessments and their apparent relationship with catch. This supports stable CPUE data as the main source providing information on biomass trends. SPC stated that it clearly acknowledged the issue of stable CPUE in the paper. SPC stated it had not made an explicit assumption that the increasing trend is due to the climatic influences on the extent of the warm pool; it noted that there have been significant contemporaneous ecosystem changes that could be related, but makes no assumption. SPC acknowledged there are alternative hypotheses that need to be thoroughly explored, and noted the related SC18 project proposal (P18X4) to investigate this further.

(iii) **Effort creep.** SPC stated that effort creep is an important uncertainty that needs more work, especially in relation to the Japanese pole-and-line fishery, and that it appreciates that Japan

[16] Hampton J. Natural mortality rates in tropical tunas—size really does matter. *Canadian Journal of Fisheries and Aquatic Sciences 2000*; 57:1002–10.

has been proactive in looking into this, as detailed in SC18-SA-IP-16. SPC noted that this is a useful start, and their initial estimates are in the range of those considered in a sensitivity analysis presented within the 2022 stock assessment report, stating that if that is indeed the realistic level of effort creep, it does not appear to remove the challenges found within the current analysis. SPC also noted that effort creep appears to have led to stepwise improvements in fishery performance, rather than smooth continuous trends, which needs to be considered in developing effort creep scenarios to model. SPC noted the amount of work on standardisation models and issues faced with data on covariates etc. — particularly in the more historical period — that may limit the ability of these models to adequately account for effort creep in pole-and-line CPUE. The Project PI8X4 proposal to SC18 aims to continue this work and develop some well-considered effort creep scenarios, and consider alternative effort metrics that will hopefully lead to some improvement in the reliability of these indices to track abundance trends in recent years and in future. In relation to including an effort creep axis in the model grid used for management advice, while this is a valid approach, SPC suggested that the values of that axis should not be arbitrarily assigned, as this will lead to a subjective weighting of such a grid axis without clear prior information on the likelihood of the different options. SPC suggested providing the PAW/SC with some well-considered options and taking their guidance on what if any effort creep scenarios to include is a preferred approach. SPC welcomed advice on this from SC18.

b. Discussion on the structural uncertainty grid

77. The SA Theme Co-Convener outlined that the 2022 skipjack stock assessment included a structural uncertainty grid with 3 axes and a total of 18 models.

78. USA stated it had no preference for either growth curve (internally or externally estimated).

79. The EU stated it had no preference on weighting of axes, and inquired whether SPC had any preferences. SPC stated it had no suggestions on differential weighting.

80. Japan stated that putting weight on specific scenarios would be premature, and recommended equal weighting.

81. PNG, on behalf of PNA and Tokelau, noted that SC18-SA-IP-03 (*Developments in the Multifan-CL software 2021-22*) provided a very interesting approach to assess a priori model selection. That paper assessed the grid objectively and used the model outputs to weight the grid post hoc, but with no biased selection of the model runs. They stated that the approach is useful and while challenging is the best approach to groom a grid and weight it. They stated that in the case of skipjack CCMs appeared able to select model runs they like, to retain or remove and weight or down weight those they do not, like knowing the impact when averaging the grid. They stated that this approach is inappropriate, meaning that SC18 should keep the grid as it currently stands and use an unweighted mean for providing management advice.

82. **SC18 agreed to accept the 2022 skipjack stock assessment and uncertainty grid, and to use equal weighting for formulating management advice.**

c. Initial discussion on future recommendations

83. There was initial discussion on future recommendations. Some CCMs indicated a preference for a review of the 2022 skipjack stock assessment. The SC decided to defer discussion on a skipjack assessment until SC19 considering a peer-review of the 2020 WCPO yellowfin tuna that is scheduled to occur in

September 2022 whereby some components may be applicable to skipjack.

84. During the ensuring discussions CCMs encouraged making use of forthcoming reports from the Center for the Advancement of Population Assessment Methodology (CAPAM) "Good practices" stock assessment workshop in Rome in October 2022, an extra CAPAM workshop focusing on good practices for tuna stock assessment is being planned for early March 2023 in Wellington, NZ, as well as reports from previous CAPAM stock assessment workshops when drafting future recommendations and relevant recommendations from the 2022 yellowfin tuna peer review. Alternatively, additional recommendations could be based on a working group meeting attached to the 2023 PAW workshop.

85. **SC18 agreed on several recommendations, which are included after management advice.**

d. Discussion on management advice

86. In response to a query from the USA, SPC stated that the projections based on the 2022 skipjack stock assessment accepted by SC18 would be conducted prior to WCPFC19 for the full ensemble model, assuming ongoing software development (needed to enable the analyses) is completed on schedule by SPC.

87. Japan stated that given SC had accepted the 2022 stock assessment, and assuming a specific period (i.e., 2012) is adopted for calculating the target, the recommended target would be the depletion at the 2012 level based on the 2022 stock assessment; on that basis Japan suggested the projection should include how to achieve that level. SPC requested a clarification, noting its understanding that SPC had been requested in the recent analyses to look at a two-pronged TRP development, which is the stock status in 2012 and where stock would end up if projected forward under 2012 conditions. As to the what changes would be required to get to the TRP on average, that could be incorporated. Japan stated that SC had adopted the 2022 stock assessment, and that maintaining 2012 conditions in the analysis coincidentally resulted in 2012 biomass levels, due to equilibrium conditions. Japan noted that this would not always be the case, and that the target must be based on either biomass or effort level. Japan stated its understanding that SC's desired target is the biomass depletion level, and that SC needed advice on how to achieve that. SPC inquired which fisheries would be adjusted to achieve that TRP level, stating that its previous analyses assumed that the Philippines, Indonesia and Vietnam catches would stay at more recent, higher levels, and proposed adjusting the purse seine fishery effort to achieve the TRP. Japan supported SPC's suggestion that its approach should be the same as it used for other scenarios.

88. Tokelau, on behalf of the PNA and Tokelau, stated that some ambiguity remained regarding the skipjack target. They recalled that the Legal Advisor previously advised that the TRP is 50% of the spawning biomass without fishing as set out in CMM 2015-06. PNA and Tokelau had some difficulty with that approach considering that the TRP was still under review as provided for in CMM 2015-06. The view of PNA and Tokelau is that the level of the skipjack TRP is still under review. Certainly, there is no Commission decision to adopt any different TRP from that in CMM 2015-06 of 50%, and the Commission has not adopted a TRP of 60% of unfished biomass. The Commission did consider the skipjack TRP at WCPFC18 but there was no agreement in that session. In particular there was no agreement on the proposal to adopt the 2012 depletion ratio as the TRP. They suggested at this point that the SC should repeat its management advice from 2019 to avoid a discussion on this issue that is not likely to be productive. That advice was that the Commission take appropriate management action to ensure that the biomass depletion level fluctuates around the TRP (e.g., through the adoption of a harvest control rule).

89. The Theme Convener confirmed his understanding that the Commission had adopted an interim TRP of 50%.

90. Regarding the TRP, Japan agreed that the current interim TRP is 50%. Japan noted its

understanding from prior discussions at SC18 that SPC proposed to use a timeframe to provide a TRP, i.e., to use a depletion ratio of a certain period such as 2012. However, given the understanding that 50% is the interim TRP, Japan expressed uncertainty whether SC was recommending a use of a certain period or a percentage, noting that this apparent confusion was also present in papers presented to SC18.

3.1.1.2 Provision of scientific information

a. Status and trends

91. **SC18 noted that the total catch in 2021 was 1,547,945t, a 10% decrease from 2020 and a 14% decrease from the 2016-2020 average. Purse seine catch in 2021 (1,254,022t) was a 11% decrease from 2020 and a 13% decrease from the 2016-2020 average. Pole and line catch (97,908t) was a 39% decrease from 2020 and a 37% decrease from the 2016-2020 average catch. Catch by other gears totalled 192,182t and was a 25% increase from 2020 and 5% decrease from the average catch in 2016-2020.**

92. **SC18 adopted the 2022 assessment and a structural uncertainty grid was used to develop management advice which included axes for tag mixing (three options), growth (two options) and steepness (three options), resulting in 18 models (Table SKJ-01). All models within the grid were equally weighted. The assessment grid of models estimated that the overall median recent spawning depletion ($SB_{recent}/SB_{F=0}$) is 0.51 (80^{th} percentile 0.43-0.64), which is close to the interim target reference point (TRP) of 0.50 (CMM 2021-01). No grid models were below the limit reference point (LRP) of 0.20 $SB_{F=0}$. The median of F_{recent}/F_{MSY} was 0.32 (80^{th} percentile 0.18-0.45) (Table SKJ-02). The 2022 stock assessment of skipjack tuna for the WCPO, indicated that according to WCPFC reference points the stock is not overfished, nor undergoing overfishing.**

93. **Catches of skipjack tuna in the WCPO have increased from approximately 250,000 metric tonnes in the late 1970s to a peak catch of approximately 2,000,000 metric tonnes in 2019; catches have dropped from 2019 to 2021 (Figure SKJ-02). Catches are dominated by purse seine fisheries in equatorial regions 6, 7, and 8, and purse seine and other gears in region 5 (Figure SKJ-03). Catches are dominated by pole-and-line in the northern regions 1–4 and continue to be low compared to those in the equatorial regions (Figures SKJ-03 and SKJ-04). The spawning potential and total biomass, while showing variability over time, do not show sustained long-term declining trends (Figures SKJ-05 and SKJ-08). In contrast, the trajectory of spawning potential depletion ($SB/SB_{F=0}$) shows a long-term trend towards a more depleted status (Figure SKJ-09). The spawning potential depletion trajectory was largely driven by the model estimates of increased levels of unfished spawning potential over time which are in turn driven by the model estimates of increasing recruitment over time (Figure SKJ-05). The model estimated increased recruitment over time to account for the increased catches in the face of a relatively stable biomass that is partly informed by several long-term stable CPUE indices of abundance (i.e., pole-and-line fishery indices) within the assessment. However, it is noted that spawning potential, recruitment and total biomass are estimated to have declined since around 2010 (Figure SKJ-05).**

94. **Fishing mortality continues to increase over time for the adult and juvenile components of the stock, with fishing mortality being consistently higher for adults (Figure SKJ-06).**

95. **Fishery impact analyses show that the purse seine fisheries continue to dominate the impact in the equatorial regions 6, 7, and 8, with similar impacts by the 'associated' and 'unassociated' components, except for region 8 where 'associated' fishing appears to have more impact (Figure SKJ-07). Fishery impacts in region 5 are dominated by purse seine and other gears, and in regions 1-4, by pole-and-line, but with increasing impact of purse seine over time (Figure SKJ-07).**

96. **The influences of the structural uncertainty grid axes on key management quantities are shown in Figure SKJ-10. Tag mixing assumptions that applied longer tag mixing periods, and the externally estimated growth curve, resulted in more optimistic estimates of spawning potential depletion and spawning potential and lower fishing mortality.**

97. **Majuro and Kobe plots summarising stock status for the 18 models in the structural uncertainty grid are included for the 'latest' (2021, Figure SKJ-11) and 'recent' periods (2018-2021, Figure SKJ-12). These plots show that the stock status estimates across the 18 models are all within the zones indicating that the stock is not overfished nor undergoing overfishing.**

98. **The assessment provided a range of diagnostic analyses derived from the diagnostic model that indicated conflict between tag and CPUE data and instability in the convergence minima. Despite this, the model showed low retrospective bias and the important spawning potential depletion management quantities were robust to the differences in model convergence. However, as noted by several CCMs, data conflicts and the instability in model convergence minima require follow-up work and should be improved.**

Table SKJ-01. Structural uncertainty grid for the 2022 WCPO skipjack tuna stock assessment. Bold values indicate settings for the diagnostic case.

Axis	Levels	Option 1	Option 2	Option 3
Tag mixing	3	T1, D=0.1 (longer period)	**T2,** D=0.2 (intermediate)	T3, D=0.3 (shorter)
Growth	2	**G1,** Internally estimated (Dirichlet-multinomial)	G2, Externally estimated (otolith and tagging data)	
Steepness	3	0.65	**0.8**	0.95

Table SKJ-02. Summary of reference points over the 18 individual models in the structural uncertainty grid.

	Mean	Median	Min	10%ile	90%ile	Max	Diagnostic model
C_{latest}	1530209	1530208	1530207	1530207	1530212	1530212	1530207
F_{MSY}	0.23	0.23	0.18	0.19	0.27	0.28	0.24
fmult	3.61	3.18	1.88	2.22	5.54	8.08	2.86
F_{recent}/F_{MSY}	0.32	0.32	0.12	0.18	0.45	0.53	0.35
MSY	2933489	2648400	2046000	2167840	4777200	4868000	2416000
SB_0	7958888	7204500	5317000	5611000	12842000	14390000	5686000
$SBF=0$	8073171	7616930	5953338	6156944	12310363	12744728	6147339
SB_{latest}/SB_0	0.48	0.48	0.37	0.41	0.56	0.60	0.48
$SB_{latest}/SB_{F=0}$	0.47	0.46	0.35	0.38	0.60	0.61	0.44
SB_{latest}/SB_{MSY}	2.82	2.68	1.65	1.95	3.81	4.62	2.54
SB_{MSY}	1419366	1335000	806300	870530	1984600	2925000	1073000
SB_{MSY}/SB_0	0.18	0.18	0.13	0.13	0.22	0.22	0.19
$SB_{MSY}/SB_{F=0}$	0.17	0.17	0.11	0.13	0.22	0.23	0.17
$SB_{recent}/SB_{F=0}$	0.52	0.51	0.41	0.43	0.64	0.66	0.50
SB_{recent}/SB_{MSY}	3.12	2.98	1.92	2.20	4.22	4.97	2.88
$Y_{Frecent}$	1896888	1892400	1621600	1683880	2116000	2282800	1762400
$(SB_{recent}/SB_{F=0})/(SB_{2012}/SB_{F=0})$	0.84	0.85	0.82	0.82	0.86	0.87	0.85

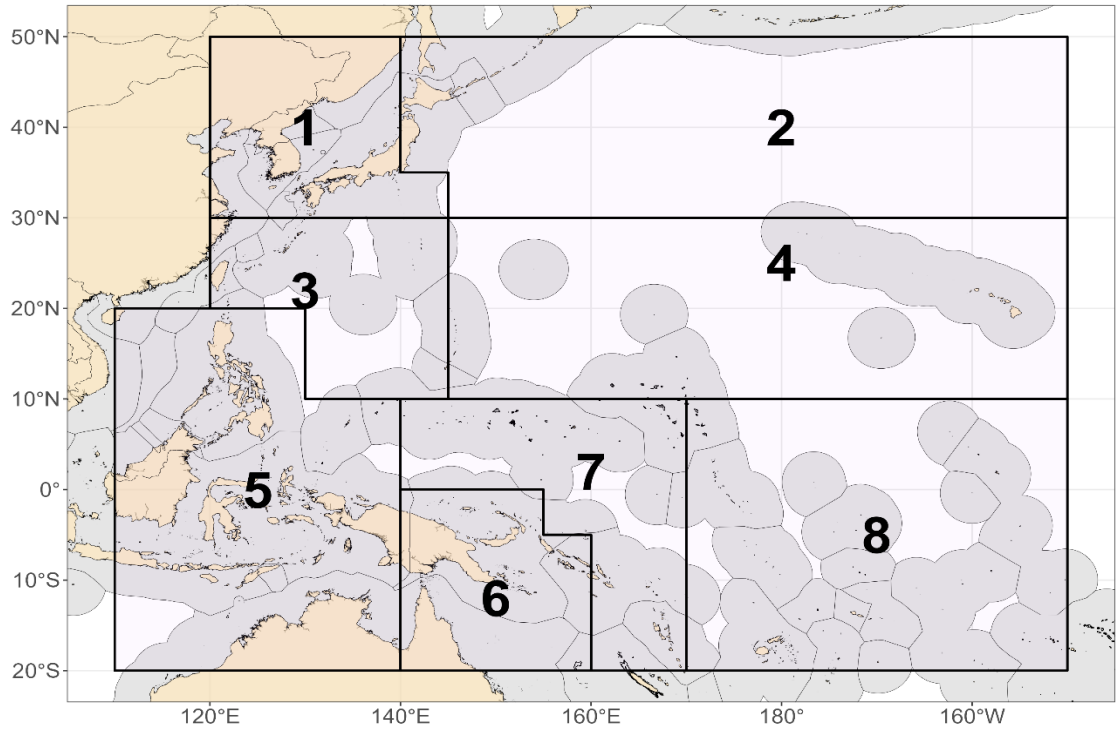

Figure SKJ-01. The geographical area covered by the stock assessment and the boundaries of the eight model regions used for 2022 WCPO skipjack assessment.

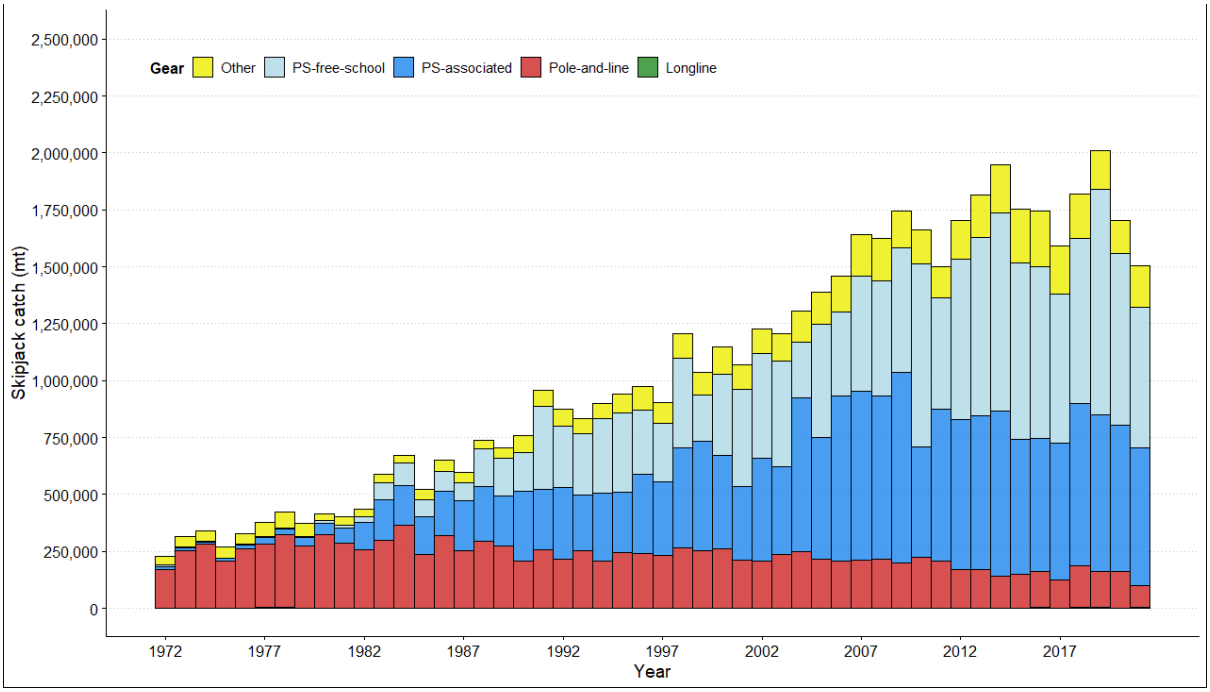

Figure SKJ-02. Annual catches of skipjack by gear type in the WCPO area covered by the assessment.

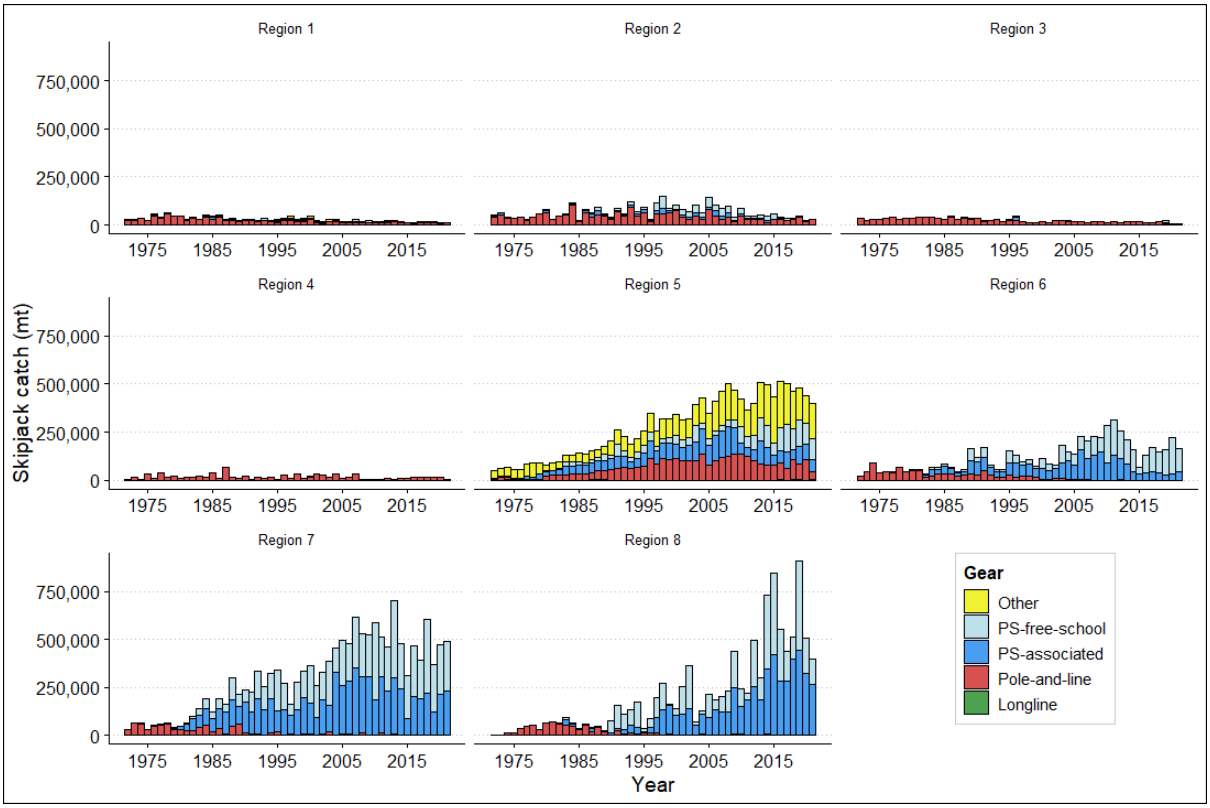

Figure SKJ-03. Annual catches of skipjack by gear type for each of the eight model regions.

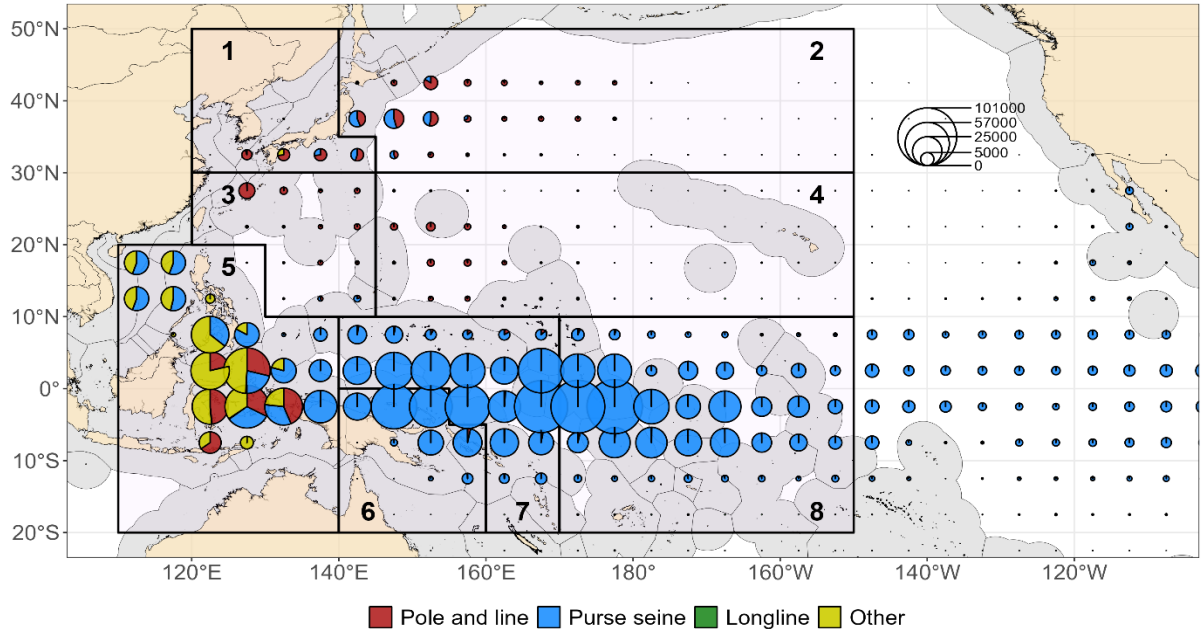

Figure SKJ-04. Distribution and magnitude of skipjack catches (mt) by gear type summed over the last 10 years (2012-2021) for 5 x 5 degree cells.

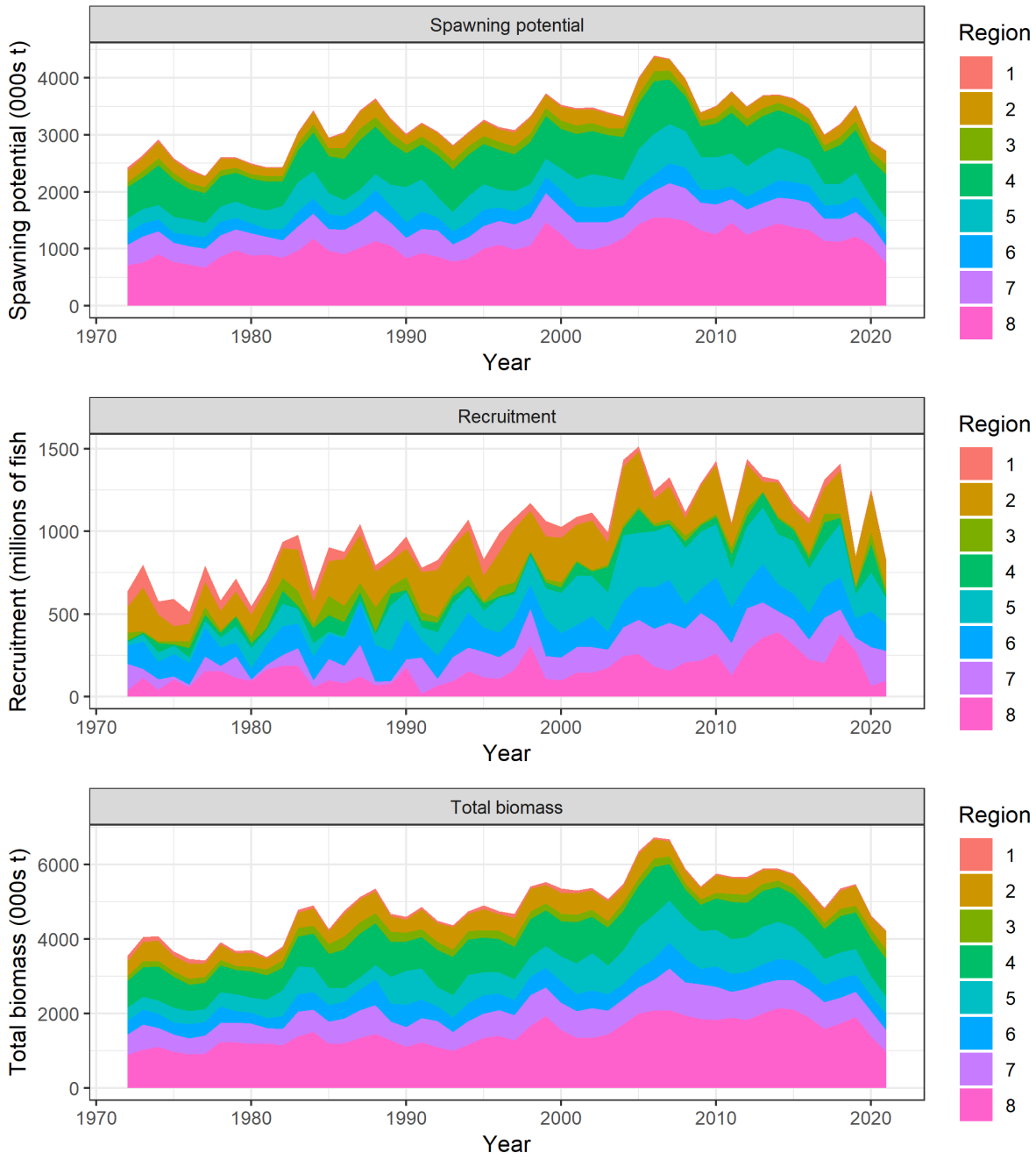

Figure SKJ-05. Estimated average quarterly recruitment, spawning potential and total biomass by model region from 1972-2021 for the 2022 skipjack diagnostic model, showing the relative proportions among regions.

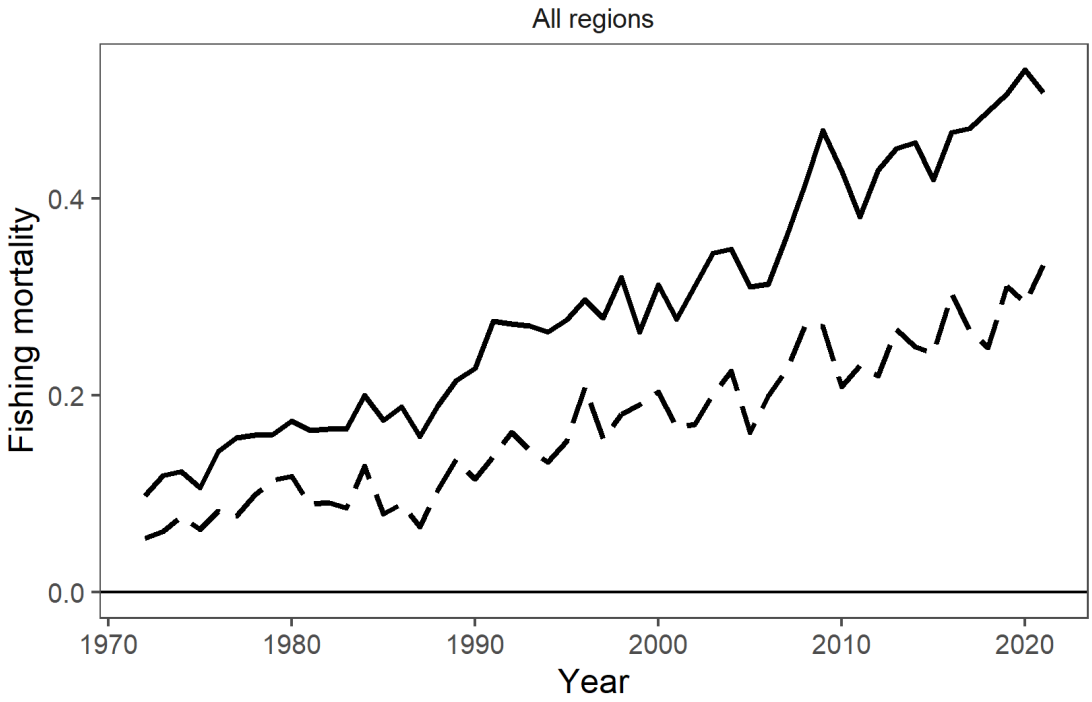

Figure SKJ-06. Estimated average quarterly adult (solid line) and juvenile (dashed line) fishing mortality for the diagnostic model from 1972-2021.

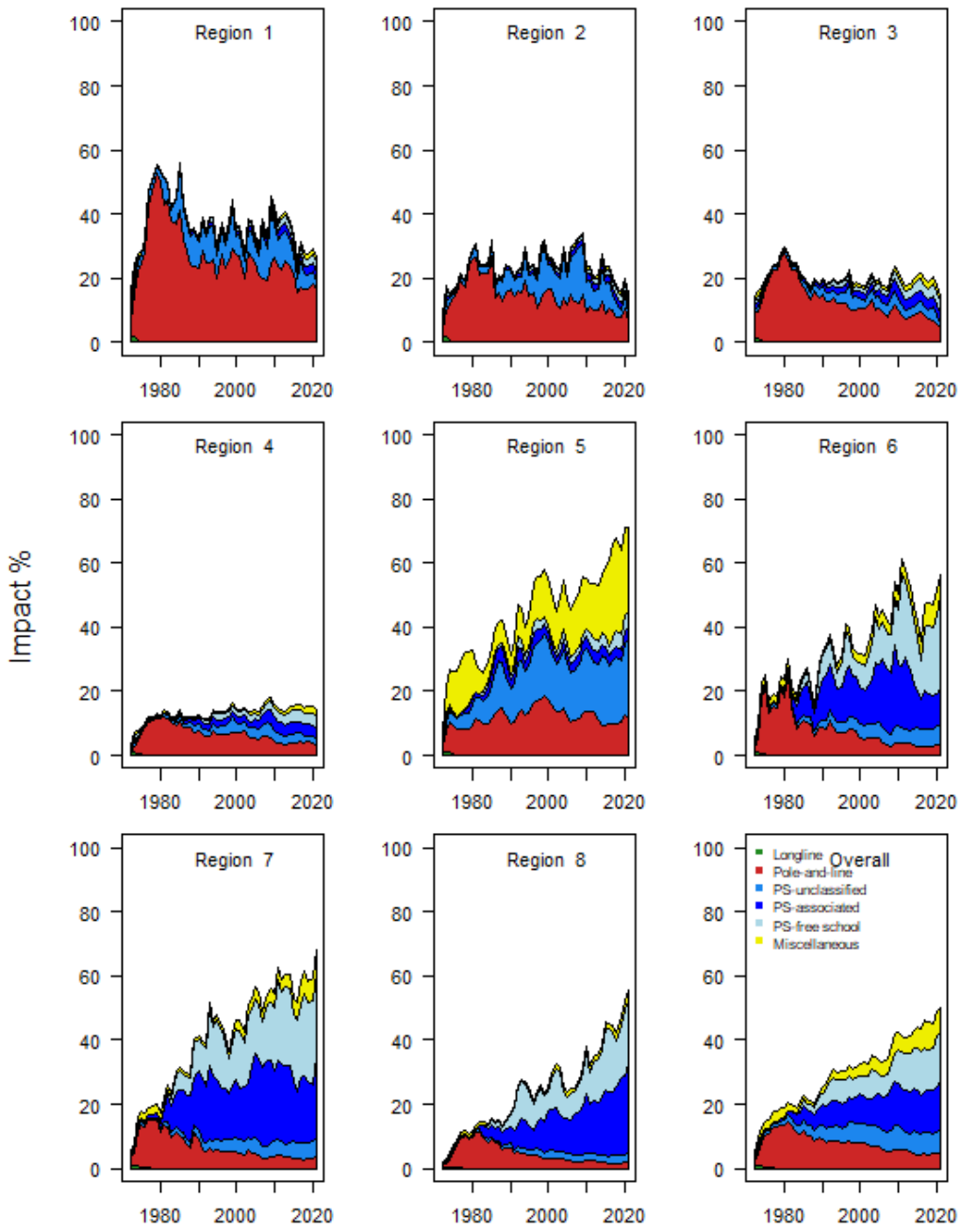

Figure SKJ-07. Estimates of reduction in spawning potential due to fishing (Fishery Impact = 1–$SB_{latest}/SB_{F=0}$) by region, and over all regions (lower right panel), attributed to various fishery groups for the diagnostic model.

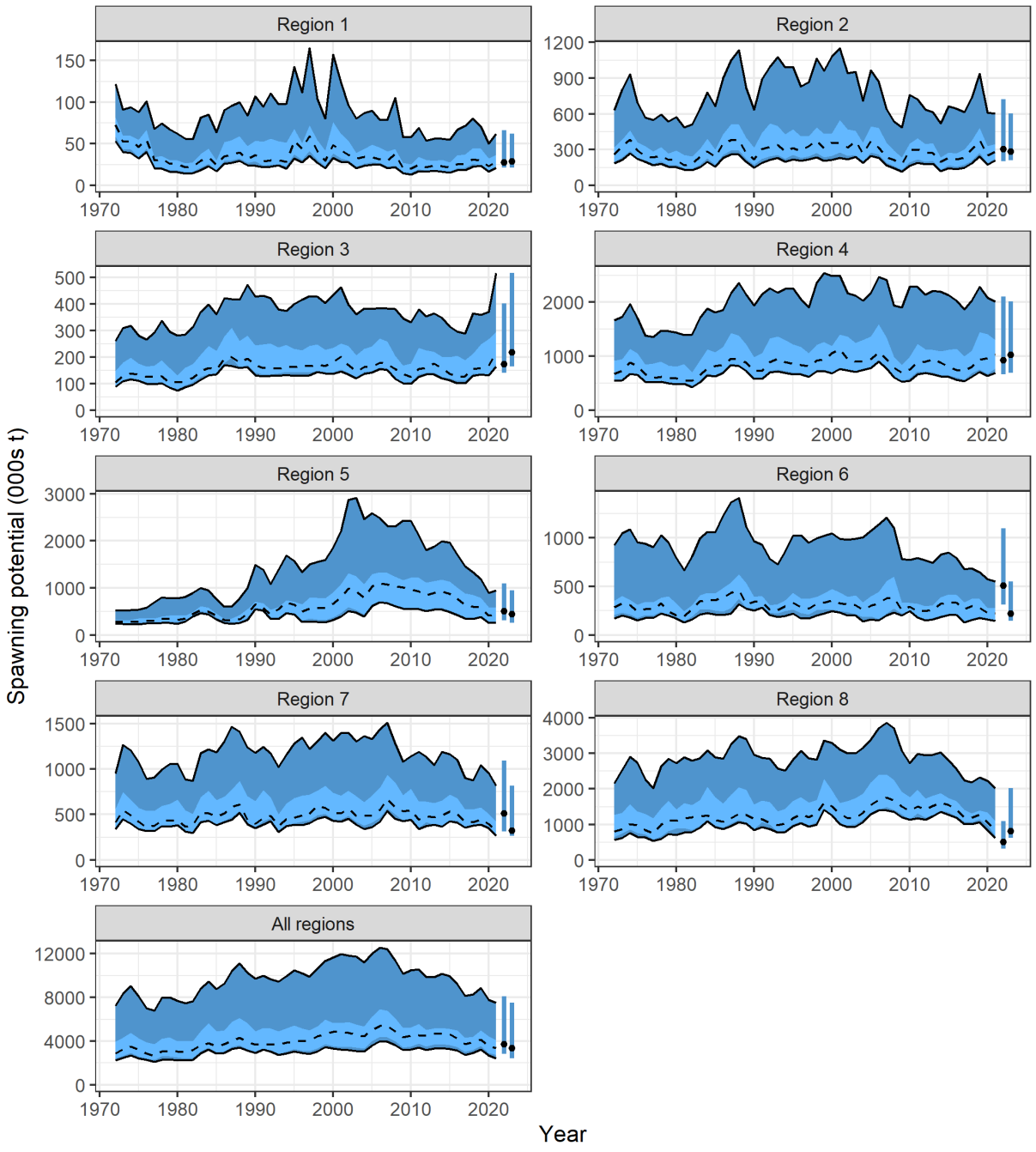

Figure SKJ-08. Trajectories of spawning potential (SB) across all models in the structural uncertainty grid over the period 1972-2021. The dashed line represents the median. The lighter band shows the 50th percentile, and the dark band shows the 80th percentile of the model estimates. The bars at the right of each ribbon indicate the median (black dots) and 80th percentile range for (left bar) SB_{recent} and (right bar) SB_{latest}.

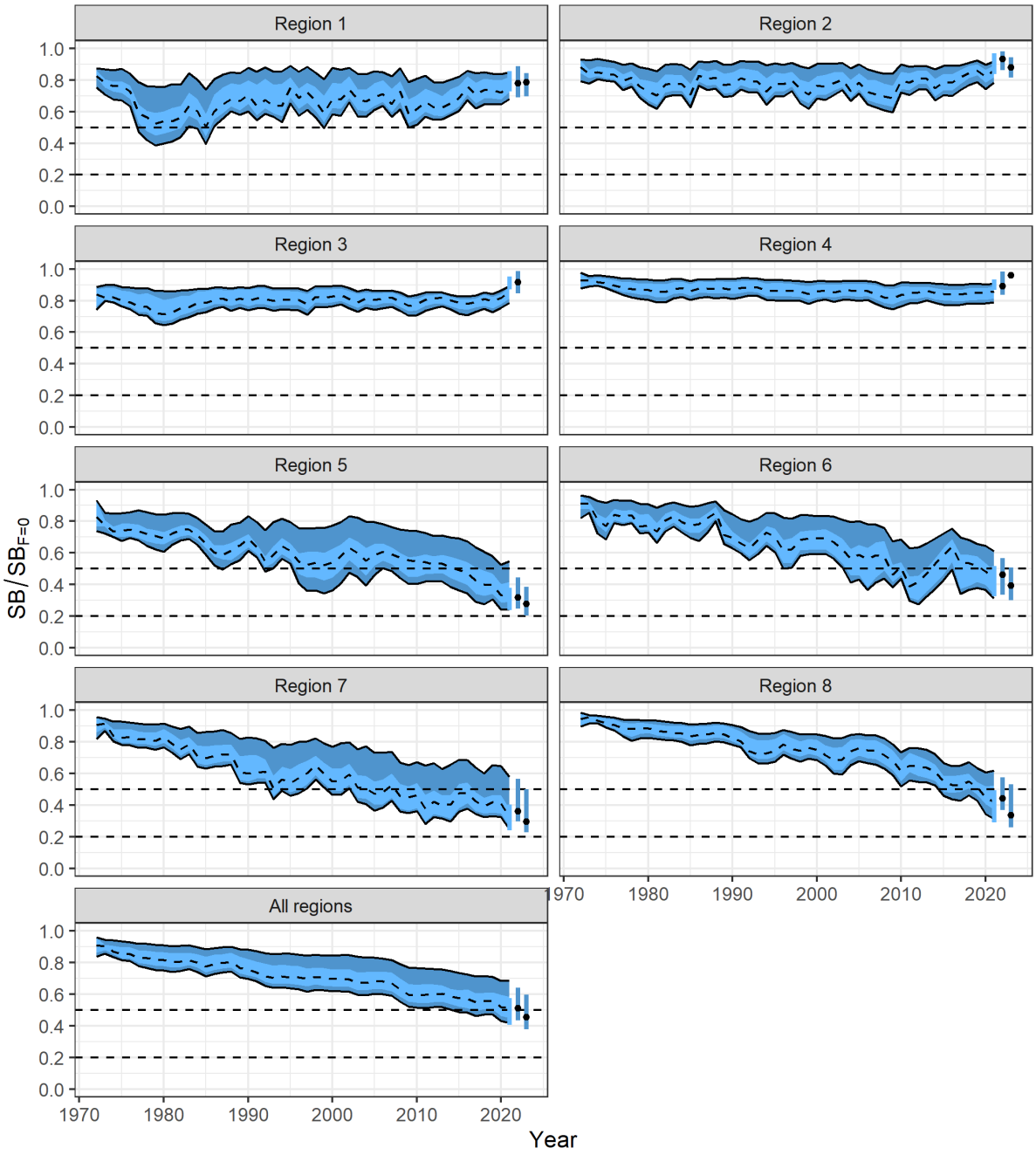

Figure SKJ-09. Trajectories of spawning potential depletion across all models in the structural uncertainty grid over the period 1972-2021. The dashed line represents the median. The lighter band shows the 50th percentile, and the dark band shows the 80th percentile of the model estimates. The bars at the right of each ribbon indicate the median (black dots) and 80th percentile range for (left bar) $SB_{recent}/SB_{F=0}$ and (right bar) $SB_{latest}/SB_{F=0}$.

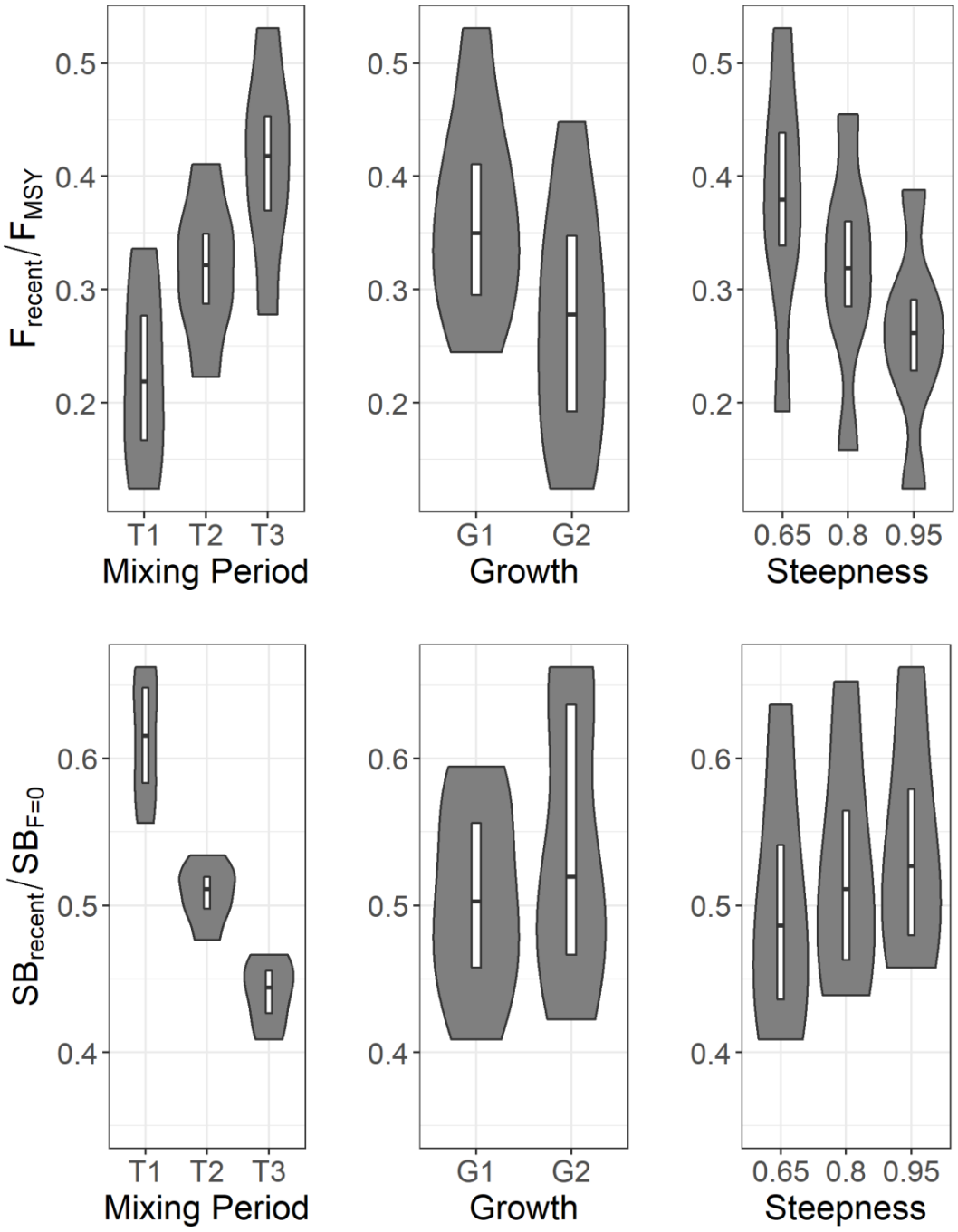

Figure SKJ-10. Box and violin plots summarizing (Top) the estimated F_{recent}/F_{MSY} and (Bottom) $SB_{recent}/SB_{F=0}$ for each of the models in the structural uncertainty grid grouped by uncertainty axes (growth, tag mixing and steepness). The line in the white box is the median of the estimates, while the box shows the 50th percentile. The shaded area shows the probability distribution (or density) of the estimates of all models of the structural uncertainty grid.

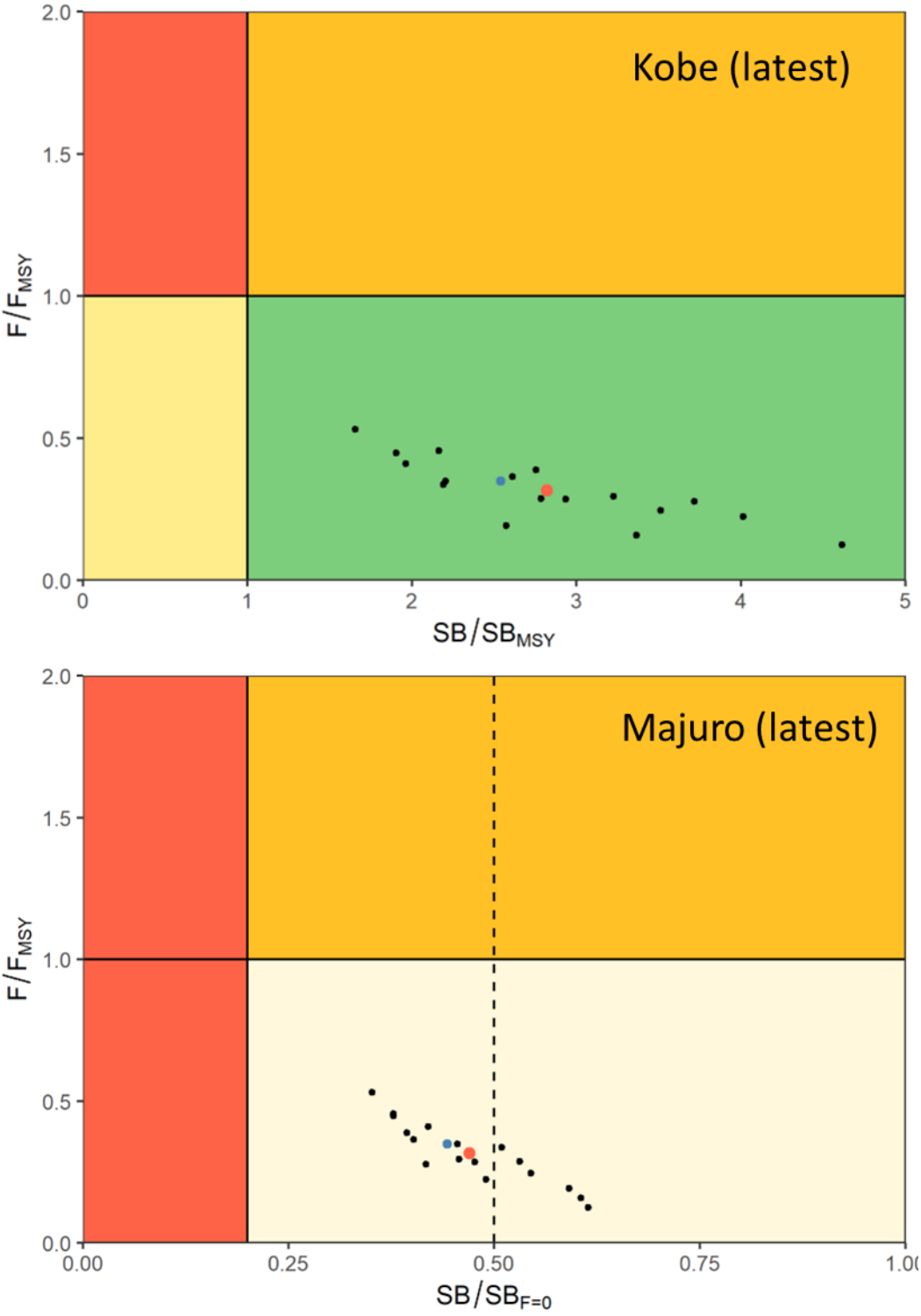

Figure SKJ-11. Kobe (top) and Majuro (bottom) plots summarising the results for each of the models in the structural uncertainty grid for the 'latest' (2021) period. The vertical dotted line on the Majuro plot is included to indicate the interim TRP of $0.50SB_{F=0}$ for the WCPFC-CA skipjack stock as specified in CMM 2021-01. The blue point is the diagnostic model, and the red point is the median.

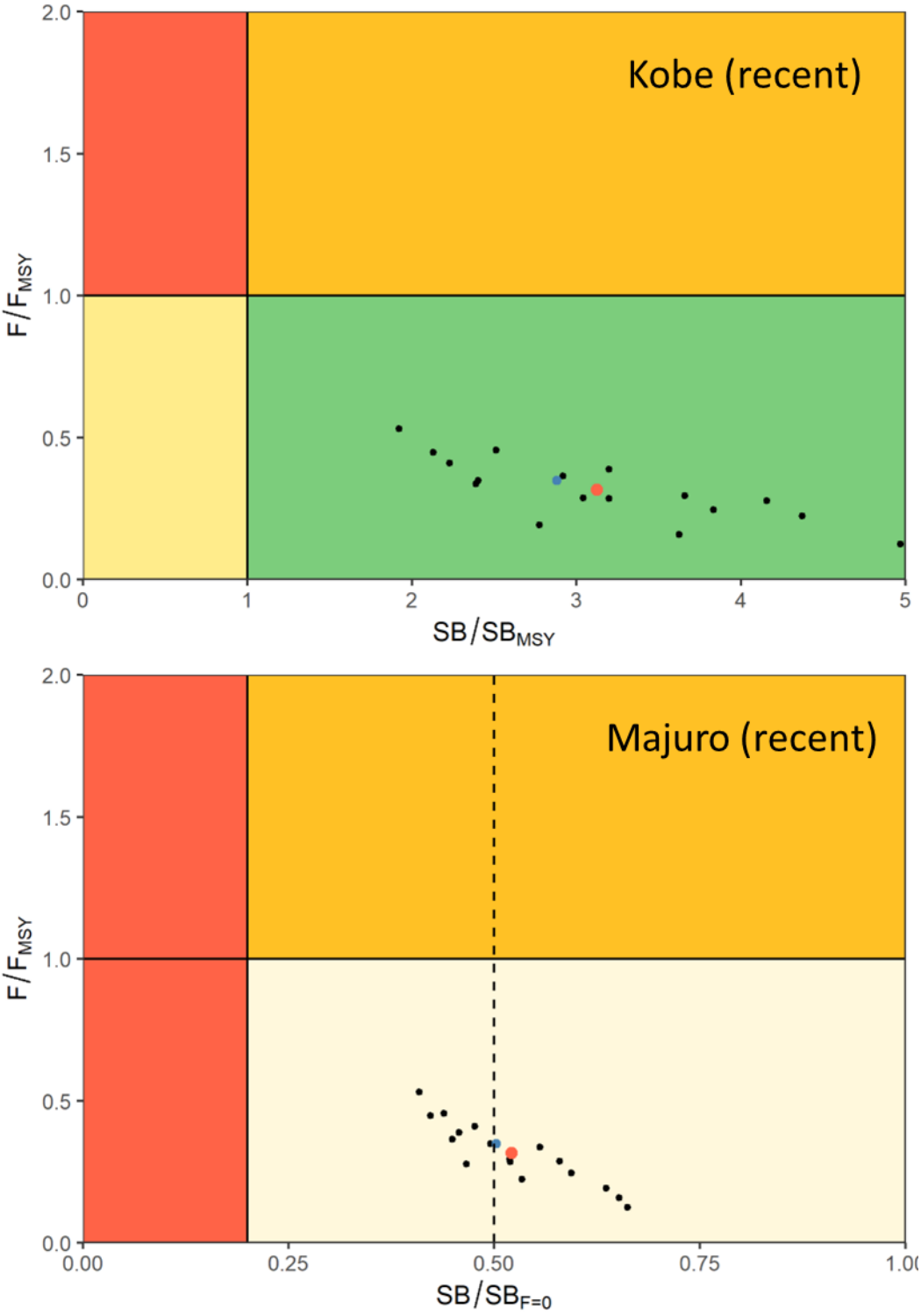

Figure SKJ-12. Kobe (top) and Majuro (bottom) plots summarising the results for each of the models in the structural uncertainty grid for the 'recent' (2018-2021) period. The vertical dotted line on the Majuro plot is included to indicate the interim TRP of $0.50SB_{F=0}$ for the WCPFC-CA skipjack stock as specified in CMM 2021-01. The blue point is the diagnostic model, and the red point is the median.

99. **SC18 noted that the skipjack assessment continues to show that the stock is currently moderately exploited and the level of fishing mortality is sustainable.**

100. **SC18 noted that the stock was assessed to be above the adopted LRP and fished at rates below F_{MSY} with 100% probability. Therefore, the skipjack stock is not overfished, nor subject to overfishing. At the same time, it was also noted that fishing mortality is continuously increasing for both adult and juvenile stages while the estimated spawning potential has shown a declining trend since the mid to late 2000s, and spawning potential depletion reached a historically low level in recent years.**

101. **SC18 noted that levels of fishing mortality and depletion differ between regions, and that fishery impact was highest in the tropical region (Regions 5, 6, 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.**

b. Management advice and implications

(i) Management advice specific to skipjack

102. **SC18 did not achieve a consensus on the management advice for skipjack tuna in the WCPO.**

(ii) General recommendations for WCPFC stock assessments

103. **SC18 noted the challenge of fully reviewing the key inputs into WCPFC stock assessments and providing feedback within the time available. SC recommended that approaches that may address this issue be discussed at SC19 and recommended that the Scientific Services Provider develop a discussion paper to inform those discussions.**

Model diagnostics

104. **Model diagnostics serve an important function in the stock assessment process. They are integral to the development of a sensible assessment model, and are critical for reviewers to assess whether proposed models are suitable for the provision of management advice. This is especially true at the SC where reviewers have a short period of time to review assessments and obtain clarification from the Scientific Services Provider about areas of concern.**

105. **Key diagnostics are required for both the diagnostic case model and for models included in the structural uncertainty grid. In the case of 2022 WCPO skipjack SC18 thanked the assessment authors for updating the assessment report to include these diagnostics and note that the Shiny app[17] is a useful tool. However, SC18 also noted a lack of consistency in the level of available diagnostics between assessments of different species. In light of this, SC18 recommended that SC19 consider guidelines for WCPFC stock assessments defining:**

- **The minimum set of diagnostics that should be provided for each model being considered for management advice;**
- **Consideration of the importance and interpretation of alternative model diagnostics depending on how the assessment is used to provide management advice (i.e., single best model vs. ensembles and structural uncertainty grids);**
- **For key input analyses, such as the preparation of standardized indices of abundance, the**

[17] R Shiny app for exploring the diagnostics and outputs from the 2022 WCPO skipjack stock assessment is available at: https://ofp-sam.shinyapps.io/GridSKJ2022/

minimum set of diagnostics that should be included in the supporting working paper or information paper describing the analysis; and

- **Guidelines for the graphical presentation of diagnostics to ensure legibility.**

(iii) Research recommendations specific to the WCPO skipjack assessment

106. **SC18 identified a wide range of cross-cutting research recommendations for inclusion within the WCPFC tuna research plan for consideration, prioritisation and sequencing at SC19. SC18 noted the research recommendations made in SC18-SA-WP-01 (*Stock assessment of skipjack tuna in the western and central Pacific Ocean: 2022*) and suggested the following items for consideration as high-priority research areas:**

- **Hyperstability and effort creep in the CPUE indices, and incorporation of CPUE uncertainty in assessment results (i.e. inclusion as an axis in the structural uncertainty grid), including alternative model assumptions related to regional scaling**
- **Data conflicts that affect assessment outcomes, and approaches to resolving them.**
- **Review the model specification with the goal of conforming to the set of diagnostic criteria to determine whether an assessment model is suitable to provide management advice.**
- **Assumptions dealing with the parametrization of key model settings, such as the fishing effort regression used in the catch-conditioned approach to minimize their impact on estimates of stock status**
- **Tag mixing, including estimation using observed data, simulation, and simulation validation.**

107. **SC18 noted the terms of reference (TOR) for Project 18X2a and 18X2b (*Further development of ensemble model approaches for presenting stock assessment uncertainty*) and Project 18X4 (*Exploring evidence and mechanisms for a long-term increasing trend in recruitment of skipjack tuna in the equatorial Pacific and the development and modelling of defensible effort creep scenarios*) in SC18-GN-IP-07[18], which would address further issues of importance.**

108. **SC18 noted additional items that had relevance for both skipjack and wider WCPFC tuna stock assessments considered by the SC and ISC. These and additional items to consider where possible are further detailed below. Items also relevant to the upcoming WCPO yellowfin tuna peer review are denoted with an asterisk (*).**

xi) Indices of abundance: *

- **Investigate a range of hypotheses which encompass the uncertainties in the spatial-temporal dynamics of the stock and the fishing effort.**
- **Refine effort creep scenarios for the Japanese pole-and-line fishery and equatorial purse seine fisheries.**
- **Develop alternative approaches for the interpolation of abundance into unfished areas when spatially averaging predictions to compute regional scalers. The use of preferential sampling models for standardizing CPUE data should be considered.**
- **Consider the biological limits to the spatiotemporal distribution of skipjack when making predictions of biomass in unfished areas with spatiotemporal models.**
- **Conduct analyses to incorporate additional process error in CPUE indices**
- **Evaluation of alternative sources of CPUE time series, such as FAD echo sounder buoys or additional indices for the purse seine fishery.**

[18] https://meetings.wcpfc.int/node/16222

xii) Data conflicts *

- **Likelihood profiles show conflict between data sources included in the model. The cause of these conflicts should be identified and methods to address them should be explored.**

xiii) Trend in estimated recruitment:

- **Estimated WCPO skipjack recruitment steadily increased between 1975 and 2010. Possible explanations for this trend should be researched, including model misspecification. If the trend is related to model misspecification options to resolve it within the model should be presented, The SC noted the TOR for Project 18X4 (*Exploring evidence and mechanisms for a long-term increasing trend in recruitment of skipjack tuna in the equatorial Pacific and the development and modelling of defensible effort creep scenarios*) in SC18-GN-IP-07.**

xiv) Recruitment distribution by region and season

- **Consider the thermal limits to the spatiotemporal distribution of skipjack recruitment within the model settings.**

xv) Growth *

- **Model diagnostics for each growth curve indicate poor fit to some components of the size data. Given the potential for spatial and temporal growth variation which any assessment cannot represent, recommend approaches to modeling growth and fitting size data that are robust to the potential for bias due to systematic lack of fit.**
- **Support epigenetic aging for skipjack in the long-term while work progressing age validation and age estimation using otolith and spines should still be pursued.**

xvi) Tag mixing *

- **Examine the utility of alternative approaches for including tagging data in the assessment, such as estimating movement and harvest rate parameters outside the assessment model and including them as priors.**
- **Review evidence for rates of tag mixing based on the tagging data included in the stock assessment.**
- **Consider the role of the Ikamoana simulation model in exploring scenarios of tag mixing, and the need for validation by comparing simulated and observed tag recovery patterns.**

xvii) Tag reporting rates *

- **Identify approaches to prevent tag reporting rates being estimated on the boundary, as these indicate some form of model misspecification such as incomplete tag mixing or data conflicts.**

xviii) Model structure enabling a converged solution *

- **Review the model structure as it relates to achieving a converged solution. This includes consideration of the spatial structure as well as confirming that estimated parameters are identifiable and well-determined. Consider the utility of such models for the provision of management advice, including evaluation of relevant CMMs.**

xix) Specification of the catch-conditioned model *

- **Estimation of the required fishing mortality spline regression parameters attracted a large penalty in the likelihood and modified population scale. The impact of parameterization on estimated quantities should be examined.**

xx) Dirichlet-Multinomial set-up *

- **Review grouping assumptions when setting up the Dirichlet-Multinomial likelihood for size composition data, and identify if the model is sensitive to grouping assumptions.**

109. **SC18 recommended that SC19 consider the need for a review of the skipjack tuna stock assessment taking into account the outcomes of the 2023 yellowfin review.**

3.1.2 Pacific Bluefin Tuna *(Thunnus orientalis)*

3.1.2.1 Review of 2022 Pacific bluefin tuna stock assessment

110. The SA Theme Co-Convener noted that the ISC[19] has conducted benchmark stock assessments every four years since 2012. Between the consecutive benchmark assessments, ISC conducts an updated assessment to track the current stock status using additional data observations. The last benchmark assessment was conducted in 2020, and the data update assessment in early 2022.

111. H. Fukuda (Japan), the lead modeler for the ISC Pacific Bluefin Tuna Working Group (PBFWG), presented SC18-SA-WP-05 (*Stock assessment of Pacific bluefin tuna in the Pacific Ocean*), which details the latest stock assessment for Pacific bluefin tuna conducted in March 2022. As this assessment was a data update assessment, the ISC PBFWG developed the base case model, which is basically consistent with the 2020 assessment, with the most recent two years (2019-2020 fishing year (FY)) data. Based on the model diagnostics, the 2022 base case model captures the production function of Pacific bluefin tuna well and the model is internally consistent, thus its estimated biomass scale is reliable. A 10-years hind-casting diagnostics shows that the model has good predictability. Based on these observations, the ISC concluded that the 2022 assessment model reliably represents the population dynamics and is the best available scientific information for the PBF stock.

112. The base-case results (Table PBF-1, Figure PBF-1) show that: (1) spawning stock biomass (SSB) fluctuated throughout the assessment period (1952-2020); (2) SSB steadily declined from 1996 to 2010; (3) the SSB has increased since 2011 resulting in the 2020 SSB being back to the 1996 level, which is higher than the initial rebuilding target of this stock (historical median SSB during 1952-2014); (4) total biomass after 2011 continued to increase with an increase in young fish (Figure PBF-2), creating the 2nd highest biomass peak in the assessed history in 2020; (5) fishing mortality ($F_{\%SPR}$), which declined to a level producing about 1% of SPR in 2004-2009, returned to a level producing 30.7% of SPR in 2018-2020 (Table PBF-2, Figure PBF-3); and (6) SSB in 2020 was 10.2% of SSB_0, an increase from the 5.6% of SSB_0 estimated for 2018 in the 2020 assessment (2018 was the last year of the 2020 assessment).

113. The projection results (Table PBF-3) from all examined scenarios showed that the second rebuilding target of the WCPFC and the IATTC, rebuilding to 20%SSB_0 by 2029 FY (10 years after reaching the initial rebuilding target) with at least 60% probability, is reached, and the risk of SSB falling below the historical lowest SSB at least once in 10 years is negligible. The ISC PBFWG evaluated projection results of sensitivity models with lower natural mortality, larger asymptotic length in the growth function, lower steepness, or the recent recruitment monitoring index fit. Though projection results from

[19] International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean

these lower productivity models are more pessimistic than that from the base-case model, the ISC PBFWG concluded that the current advice is robust to these alternative model assumptions.

Discussion

114. Japan stated it appreciates the work done by ISC. It noted that the results had been presented to the Joint IATTC and WCPFC-NC Working Group Meeting in July where discussions were held relating to future management actions. Japan stated that no CMMs had sought to make any changes to the current measure.

115. SPC noted that the report refers to SSB_0 and $SSB_{F=0}$, and inquired if these were interchangeable, and if they referred to a static or dynamic SSB_0, or to both? SPC indicated the potential for model mis-specification, especially for a model with such a sharp increase in stock status at the end of the time series, stating that the retrospective pattern is likely to be a result of this increase, as a result of good recent recruitment in 2016, and possibly lower recent fishing mortality. SPC recommended that the authors consider including some of the of standard stock synthesis diagnostics showing the bias adjustment and estimates of the uncertainty on the individual recruitment estimates, especially at the end of the time series. Considering a low recruitment scenario for the most recent recruitment deviation and for future recruitment deviations may be prudent in the case that either the recent good recruitment estimates (e.g., 2016) do not eventuate, or are moderated in future assessments. The presenter stated that SSB_0 is a static SSB_0, and noted that the ISC would conduct further research regarding the retrospective analysis.

116. SPC inquired regarding about how the likelihood profile is done on $\log(R_0)$: is the temporal recruitment deviation constrained to 0 or allow some flexibility? The presenter stated this was discussed in the working group, and the assumption was not changed; they used a zero-sum assumption for the whole likelihood profile grid. If a smaller $\log(R_0)$ was used the model might have tendency toward more discrepancies and this may be one reason for the high penalty for these profiles. Importantly the analyses don't decide the population scale, and results are similar to those from other processes.

117. The EU noted that this is a robust assessment and shows a positive trend in spawning biomass, noting that management actions are good and should be continued, but that management advice could be improved by directly incorporating key sources of uncertainty. For example, while the models seem to be robust to the uncertainties explored, ISC identified in the sensitivity analyses that projections using the model with the recruitment monitoring index might differ from those using the base case. Similarly, the estimate of depletion is notably lower when smaller steepness values are assumed. Therefore, the EU recommended the use of a structural uncertainty grid approach to better incorporate uncertainty into the management advice.

118. Solomon Islands, on behalf of FFA members, noted that the results from the base-case model suggests that the spawning stock biomass of Pacific bluefin tuna has gradually increased over the last decade and fishing mortality is on the decline. They also noted that the projection results show that increases in catches are possible without adversely affecting the attainment of the second rebuilding target. FFA members stated that while the gradual improvement of the Pacific bluefin tuna stock is a step in the right direction, it must be remembered that the current spawning biomass of the stock is only 10.2% of the unfished level. This is well below the limit reference point of 20% adopted for the key tuna species in WCPFC and suggests the Pacific bluefin tuna stock remains overfished. Given this, FFA members strongly encouraged a precautionary approach towards the management of Pacific bluefin tuna until such time as the second rebuilding target is met, especially as the stock assessment and projection results are based on certain assumptions, including those on future recruitment, that may not always be met. FFA members expressed their support for the continued monitoring of recruitment and spawning stock biomass, and

research on a recruitment index for the stock assessment given the uncertainty in future recruitment and the influence of recruitment on stock biomass, as well as the impact of changes in fishing operations due to management changes. Finally, FFA members noted that CMM 2021-02 is currently open-ended with no expiry date, and recommended that the CMM be revised to include a fixed period of application.

119. Japan suggested that SC note it welcomed the recovery of the stock; it observed that this is the intent of the current CMM, and the stock is now beyond the initial rebuilding target. Regarding the CMM, it concurred with FFA members that even though stock is recovering, biomass remains below the LRP for tropical tunas, but also as noted by FFA a small increase in fishing would not harm achievement of the rebuilding target. It noted the recommendation from the EU that seeks to include structural uncertainty in the model. Japan stated that this discussion had been held in the past but that there were some practical and philosophical issues. Japan reflected on the model approach used and on the fact the data are internally consistent. It noted that the use of a structural uncertainty grid would likely be further explored.

120. The SA Theme Co-Convener noted the importance of these issues and welcomed the opportunity to have further discussions on this, including with SPC scientists.

3.1.2.2 Provision of scientific information

a. Status and trends

121. **SC18 welcomed successful completion of an updated Pacific bluefin tuna (PBF) stock assessment and noted the following stock status and conservation information provided by ISC.**

> PBF spawning stock biomass (SSB) has gradually increased in the last 10 years, and the rate of increase is accelerating. These biomass increases coincide with a decline in fishing mortality, particularly for fish aged 0 to 3, over the last decade. The latest (2020) SSB is estimated to be 10.2% of SSB_0.
>
> 3) No biomass-based limit or target reference points have been adopted for PBF, but the PBF stock is overfished relative to the potential biomass-based reference points ($20\%SSB_0$) adopted for other tuna species by the IATTC and WCPFC. On the other hand, SSB reached its initial rebuilding target ($SSB_{MED} = 6.3\%SSB_0$) in 2019, 5 years earlier than originally anticipated by the RFMOs.
> 4) No fishing mortality-based reference points have been adopted for PBF by the IATTC and WCPFC. The recent (2018-2020) $F_{\%SPR}$ is estimated to produce a fishing intensity of 30.7%SPR and is below the level corresponding to overfishing for many F-based reference points proposed for tuna species (Table PBF2), including SPR20%.

122. **SC18 noted that while the gradual improvement of the Pacific bluefin tuna stock is a step in the right direction, it must be remembered that the current spawning biomass of the stock is only 10.2% of the unfished level. This is well below the LRP of 20% adopted for the key tuna species in WCPFC and suggests the Pacific bluefin tuna stock remains overfished relative to the LRP of key tuna species.**

123. **SC18 noted some CCMs encourage a precautionary approach towards the management of Pacific bluefin tuna until such time as the second rebuilding target is met, especially as the stock assessment and projection results are based on certain assumptions, including those on future recruitment, that may not always be met.**

124. **SC18 supported the continued monitoring of recruitment and spawning stock biomass, and research on a recruitment index for the stock assessment given the uncertainty in future recruitment**

and the influence of recruitment on stock biomass, as well as the impact of changes in fishing operations due to management changes.

b. Management advice and implications

125. **SC18 noted that the updated stock assessment presented at SC18 indicates that the stock is likely recovering as planned or possibly faster, which suggests that the measures incorporated in CMM 2021-02 appear to be working as intended.**

126. **SC18 recommended that the Commission exercise a precautionary approach, and noted that the PBF stock is still in a depleted state (10.2% of SSB_0) when it considers any revisions to the current CMM. Consideration of any increases to the catch limit needs to be weighted against reducing the probability of recovering to the second rebuilding target.**

127. **SC18 further welcomed ISC's effort on further investigation of structural uncertainty to incorporate it in future management advice.**

128. **SC18 noted the following management information from ISC:**

After the steady decline in SSB from 1996 to the historically low level in 2010, the PBF stock has started recovering, and recovery has been more rapid in recent years, consistent with the implementation of stringent management measures. The 2020 SSB was above the initial rebuilding target but remains below the second rebuilding target adopted by the WCPFC and IATTC. However, stock recovery is occurring at a faster rate than anticipated by managers when the Harvest Strategy to foster rebuilding (WCPFC HS 2017-02) was implemented in 2014. The fishing mortality ($F_{\%SPR}$) in 2018-2020 has been reduced to a level producing 30.7%SPR, the lowest observed in the time series. Based on these findings, the following information on the conservation of the Pacific bluefin tuna stock is provided:

6) The PBF stock is recovering from the historically low biomass in 2010 and has exceeded the initial rebuilding target ($SSB_{MED1952-2014}$) five years earlier than expected. The rate of recovery is increasing and under all projection scenarios evaluated, it is very likely the second rebuilding target ($20\%SSB_0$ with 60% probability) will be achieved (probabilities > 90%) by 2029 (Table PBF-3). The risk of SSB falling below the historical lowest observed SSB at least once in 10 years is negligible.
7) The projection results show that increases in catches are possible without affecting the attainment of the second rebuilding objective. Increases in catch should consider both the rebuilding rate and the distribution of catch between small and large fish.
8) The projection results assume that the CMMs are fully implemented and are based on certain biological and other assumptions. For example, these future projection results do not contain assumptions about discard mortality. Although the impact of discards on SSB is small compared to other fisheries, discards should be considered in future harvest scenarios.
9) Given the uncertainty in future recruitment and the influence of recruitment on stock biomass as well as the impact of changes in fishing operations due to the management, monitoring recruitment and SSB should continue and research on a recruitment index for the stock assessment should be pursued.
10) The results of projections from sensitivity models with lower productivity assumptions show that this conservation information is robust to uncertainty in stock productivity.

Table PBF-1. Total biomass, spawning stock biomass, recruitment, and spawning potential ratio of Pacific bluefin tuna (*Thunnus orientalis*) estimated by the base-case model, 1952-2020.

Year	Total Biomass (t)	Spawning Stock Biomass (t)	Recruitment (1,000 fish)	Spawning Potential Ratio	Depletion Ratio
1952	134,789	103,359	14,008	11.6%	16.1%
1953	136,421	97,912	20,617	12.9%	15.2%
1954	146,892	88,019	34,911	7.9%	13.7%
1955	156,701	75,353	13,343	11.4%	11.7%
1956	176,167	67,818	33,476	15.8%	10.5%
1957	193,973	77,053	11,635	10.8%	12.0%
1958	202,415	100,943	3,203	19.5%	15.7%
1959	209,868	136,650	7,709	23.9%	21.2%
1960	202,700	144,704	7,554	17.3%	22.5%
1961	194,047	156,534	23,235	3.4%	24.3%
1962	177,257	141,792	10,774	10.9%	22.0%
1963	166,291	120,933	27,842	6.6%	18.8%
1964	154,459	106,314	5,689	7.5%	16.5%
1965	142,916	93,572	10,955	3.0%	14.5%
1966	120,164	89,589	8,556	0.1%	13.9%
1967	105,483	83,751	10,951	1.1%	13.0%
1968	91,650	77,872	14,356	1.4%	12.1%
1969	80,731	64,561	6,450	8.6%	10.0%
1970	74,490	54,181	7,182	2.9%	8.4%
1971	66,467	47,017	12,407	1.3%	7.3%
1972	64,098	40,725	22,890	0.3%	6.3%
1973	62,899	35,510	11,251	5.6%	5.5%
1974	65,165	28,711	13,983	6.3%	4.5%
1975	65,978	26,420	11,223	8.9%	4.1%
1976	65,030	29,152	8,071	3.1%	4.5%
1977	74,864	35,066	25,589	3.7%	5.4%
1978	76,566	32,974	14,317	5.0%	5.1%
1979	73,608	27,866	12,876	8.2%	4.3%
1980	72,844	29,713	6,554	6.2%	4.6%
1981	57,749	27,591	13,360	0.3%	4.3%
1982	40,714	24,235	6,454	0.0%	3.8%
1983	33,472	14,773	10,090	6.0%	2.3%
1984	37,662	12,895	9,063	5.3%	2.0%
1985	39,805	12,957	9,654	2.7%	2.0%
1986	34,473	15,316	7,939	1.1%	2.4%
1987	32,080	14,105	5,980	8.2%	2.2%
1988	38,238	15,059	9,483	11.0%	2.3%
1989	42,074	14,888	4,291	14.6%	2.3%
1990	57,971	18,994	17,436	18.4%	3.0%
1991	69,431	25,290	10,617	9.8%	3.9%
1992	76,142	32,456	3,968	14.7%	5.0%
1993	83,395	43,890	4,430	16.8%	6.8%
1994	97,472	50,177	29,319	13.5%	7.8%
1995	93,999	62,246	16,012	5.2%	9.7%
1996	96,300	61,563	17,964	8.8%	9.6%
1997	90,121	56,179	11,082	6.0%	8.7%
1998	95,748	55,612	16,075	4.2%	8.6%
1999	91,805	51,374	22,755	3.4%	8.0%
2000	76,307	48,461	14,385	1.7%	7.5%
2001	77,426	46,059	17,302	9.5%	7.2%
2002	75,311	43,899	13,541	5.7%	6.8%
2003	67,904	43,152	7,157	2.3%	6.7%
2004	65,640	35,881	27,746	1.4%	5.6%
2005	55,074	29,159	15,118	0.7%	4.5%
2006	43,314	23,294	13,540	1.1%	3.6%
2007	42,659	18,424	22,227	0.5%	2.9%
2008	38,290	13,716	21,072	0.6%	2.1%
2009	33,985	10,195	8,277	1.2%	1.6%
2010	36,969	9,761	17,952	2.4%	1.5%
2011	38,817	11,183	13,526	4.9%	1.7%
2012	42,482	13,902	7,169	8.2%	2.2%
2013	52,764	16,313	13,169	5.7%	2.5%
2014	53,075	19,185	3,641	11.1%	3.0%
2015	59,220	23,640	8,653	12.5%	3.7%
2016	69,494	30,516	16,690	12.8%	4.7%
2017	82,681	32,538	10,895	21.9%	5.1%
2018	103,849	35,741	11,145	28.3%	5.6%
2019	129,972	45,173	11,843	28.8%	7.0%
2020	156,517	65,464	11,316	35.1%	10.2%
Median(1952-2020)	74,864	35,881	11,635	6.2%	5.6%
Average(1952-2020)	89,353	49,845	13,390	8.3%	7.7%

Table PBF-2. Ratios of the estimated fishing mortalities (Fs and 1-SPRs for 2002-04, 2011-13, 2016-18) relative to potential fishing mortality-based reference points, and terminal year SSB (t) for each reference period, and depletion ratios for the terminal year of the reference period for Pacific bluefin tuna (*Thunnus orientalis*) from the base-case model**.** F_{max}: Fishing mortality (F) that maximizes equilibrium yield per recruit (Y/R). $F_{0.1}$: F at which the slope of the Y/R curve is 10% of the value at its origin. F_{med}: F corresponding to the inverse of the median of the observed R/SSB ratio. $F_{x\%SPR}$: F that produces given % of the unfished spawning potential (biomass) under equilibrium condition.

Reference Period				(1-SPR)/(1/$SPR_{xx\%}$)				Estimated SSB for terminal year of each period (ton)	Depletion rate for terminal year of each period (%)
	Fmax	F0.1	Fmed	$SPR_{10\%}$	$SPR_{20\%}$	$SPR_{30\%}$	$SPR_{40\%}$		
2002-2004	1.96	2.89	1.16	1.08	1.21	1.38	1.61	35,881	5.6%
2011-2013	1.54	2.27	0.87	1.04	1.17	1.34	1.56	16,313	2.5%
2018-2020	0.75	1.14	0.33	0.77	0.87	0.99	1.15	65,464	10.2%

Table PBF-3. Future projection scenarios for Pacific bluefin tuna (*Thunnus orientalis*) and their probability of achieving various target levels by various time schedules based on the base-case model.

Harvesting scenarios					Peformance indicators						
Reference No	WCPO		EPO		The fishing year expected to achive the 2nd rebuilding target with >60% probability	Risk to breach SSB_{loss} at least once by 2030	Probability of achiving the 2nd rebuilding target at 10 years after achieving initial rebuilding target [2029]	Median SSB at 10 years after achieving initial rebuilding target [2029]	Median SSB at 2034	Fishery impact ratio of WPO fishery at 10 years after achieving the initial rebuilding target [2029]	Fishery impact ratio of EPO fishery at 10 years after achieving the initial rebuilding target [2029]
	Small	Large	Small	Large							
1	New CMM				2023	0%	98.8%	262,795	307,336	81.1%	18.9%
2	New CMM	500 tons increase on the New CMM	500 tons increase on the New CMM		2023	0%	98.2%	256,170	298,867	80.3%	19.7%
3	10% increase on the New CMM				2023	0%	96.9%	245,333	280,687	82.3%	17.7%
4	20% increase on the New CMM				2023	0%	94.0%	227,183	253,598	83.4%	16.6%
5	-580 tons	+853 tons	New CMM		2023	0%	99.3%	269,289	319,863	80.2%	19.8%
6	+30%	+30%	+190%		2023	0%	64.1%	154,417	150,121	75.5%	24.5%
7	New CMM	+130%	+190%		2029	0%	60.0%	147,931	157,963	75.2%	24.8%
8	+60%	+60%	+90%		2023	0%	61.3%	147,275	135,698	80.6%	19.4%
9	New CMM	+230%	+90%		2030	0%	58.6%	145,058	160,473	78.3%	21.7%
10	Old CMM (50% of 2002-04 average level)	Old CMM (2002-04 average level)	Old CMM		2023	0%	99.4%	272,845	320,885	82.1%	17.9%
11	0	0	0		2022	0%	100.0%	478,465	578,729	83.0%	17.0%

* The Reference number of Scenario is different from those given by the IATTC-WCPFC NC Joint WG meeting.
* Fishing mortality for scenario 1 is specified as average level of age-specific fishing mortality during 2002-2004, which is the reference years in the WCPFC. Higher levels of the fishing mortality are specified for other scenarios to fulfill their quota in those projections.
* The Japanese unilateral measure (transferring 250 mt of catch upper limit from that for small PBF to that for large PBF during 2020-2034) is reflected in the projections.

Table PBF-4. Expected yield for Pacific bluefin tuna (*Thunnus orientalis*) under various harvesting scenarios based on the base-case model.

Reference No	Harvesting scenarios						Future expected catch							
	Catch upper limit increments from status quo			Catch upper limit in the projection			2024				2034			
	WCPO		EPO	WCPO		EPO	WCPO		EPO		WCPO		EPO	
	Small	Large	Commercial	Small	Large	Commercial	Small	Large	Commercial	Sport	Small	Large	Commercial	Sport
1	New CMM			4,475	7,860	3,995	4,496	7,884	4,008	1,228	4,497	7,922	4,012	1,540
2	New CMM	500 tons increase on the New CMM	500 tons increase on the New CMM	4,475	8,360	4,495	4,496	8,366	4,506	1,216	4,496	8,419	4,510	1,513
3	10% increase on the New CMM			4,948	8,621	4,395	4,965	8,610	4,404	1,189	4,965	8,674	4,407	1,430
4	20% increase on the New CMM			5,420	9,382	4,794	5,434	9,307	4,801	1,150	5,435	9,413	4,802	1,318
5	-580 tons	+853 tons	New CMM	3,895	8,713	3,995	3,916	8,749	4,009	1,250	3,917	8,787	4,013	1,616
6	+30%	+30%	+190%	5,893	10,143	11,586	5,892	10,181	11,521	996	5,889	10,018	11,247	924
7	New CMM	+130%	+190%	4,475	17,752	11,586	4,492	17,733	11,552	1,012	4,491	17,144	11,486	1,079
8	+60%	+60%	+90%	7,310	12,425	7,591	7,240	12,502	7,594	979	7,211	12,073	7,512	841
9	New CMM	+230%	+90%	4,475	25,362	7,591	4,494	23,864	7,601	1,030	4,493	24,055	7,597	1,160
10	Old CMM (50% of 2002-04 average level)	Old CMM (2002-04 average level)	Old CMM	4,475	6,841	3,300	4,497	6,866	3,317	1,243	4,497	6,888	3,319	1,580
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* Catch limits for EPO commercial fisheries are applied for the catch of both small and large fish made by the fleets.

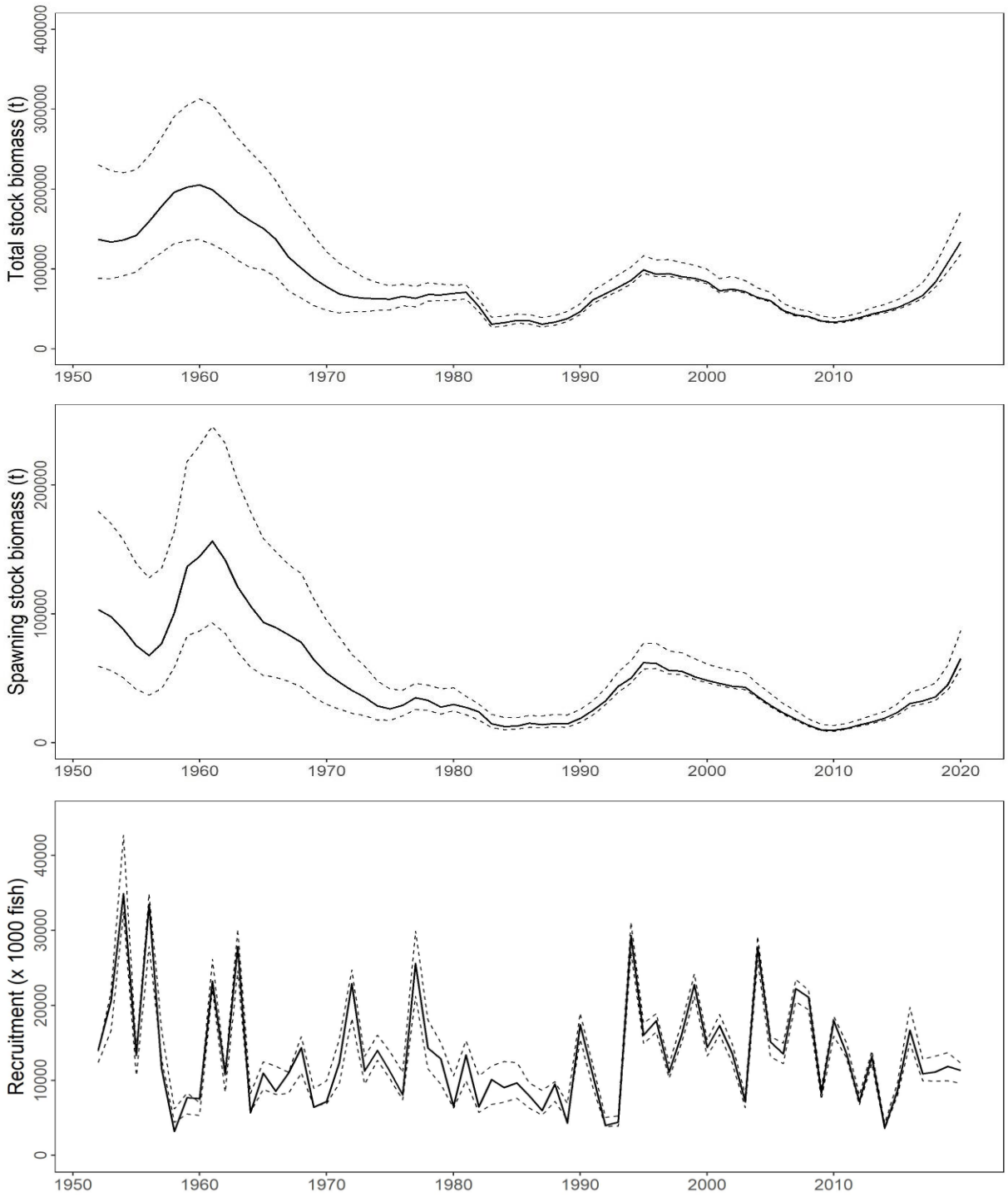

Figure PBF-1. Total stock biomass (top), spawning stock biomass (middle), and recruitment (bottom) of Pacific bluefin tuna (*Thunnus orientalis*) (1952-2020) estimated from the base-case model. The solid line is the point estimate and dashed lines delineate the 90% confidence interval.

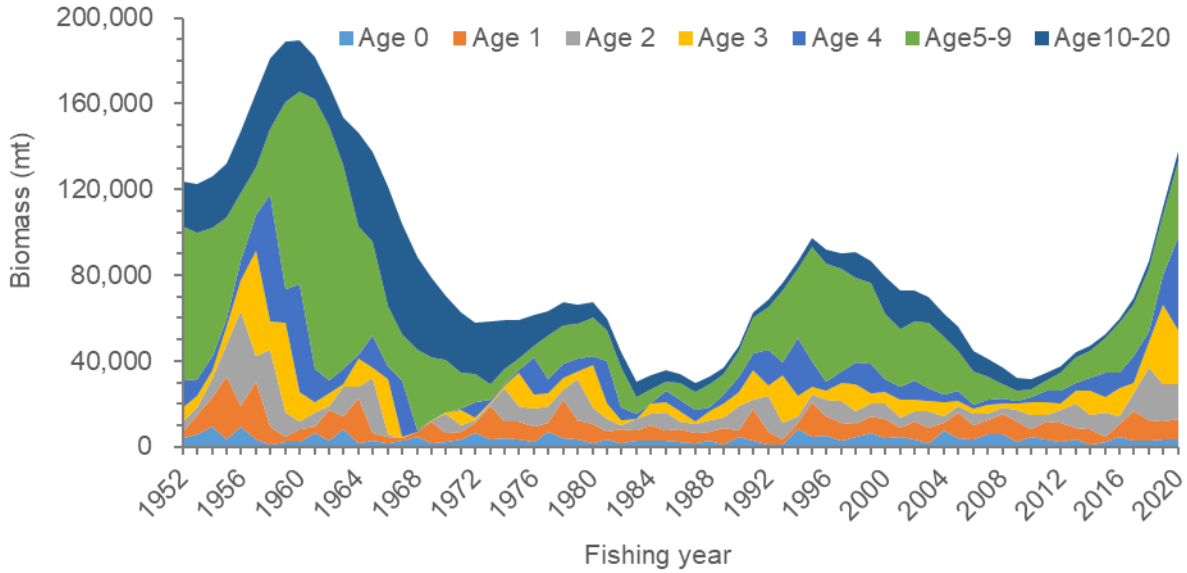

Figure PBF-2. Total biomass (tonnes) by age of Pacific bluefin tuna (*Thunnus orientalis*) estimated from the base-case model (1952-2020).

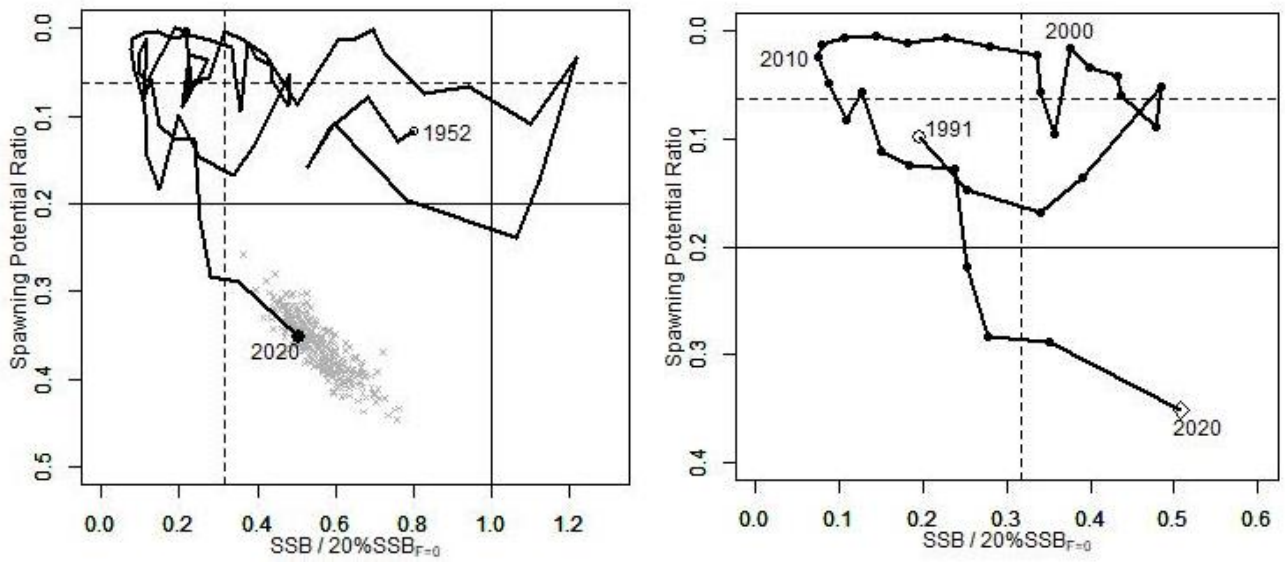

Figure PBF-3. Kobe plots for Pacific bluefin tuna (*Thunnus orientalis*) estimated from the base-case model. The X-axis shows the annual SSB relative to 20%SSB_0 and the Y-axis shows the spawning potential ratio (SPR) as a measure of fishing mortality. Vertical and horizontal solid lines in the left figure show 20%SSB_0 (which corresponds to the second biomass rebuilding target) and the corresponding fishing mortality that produces SPR, respectively. Vertical and horizontal broken lines in both figures show the initial biomass rebuilding target (SSB_{MED} = 6.3%SSB_0) and the corresponding fishing mortality that produces SPR, respectively. SSB_{MED} is calculated as the median of point estimates of SSB over 1952-2014 by the base case model. The left figure shows the historical trajectory, where the open circle indicates the first year of the assessment (1952), solid circles indicate the last five years of the assessment (2014-2020), and grey crosses indicate the uncertainty of the terminal year estimated by bootstrapping. The right figure shows the trajectory of the last 30 years.

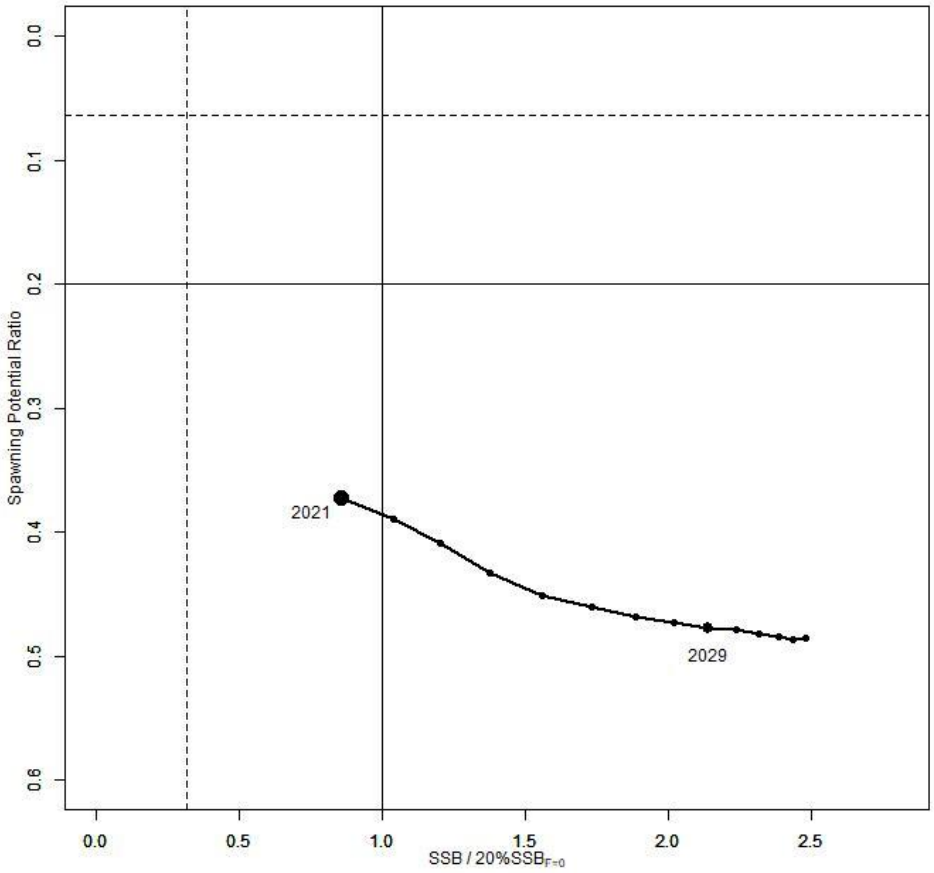

Figure PBF-4. "Future Kobe Plot" of projection results for Pacific bluefin tuna (*Thunnus orientalis*) from Scenario 1 from Table PBF-3.

3.2 WCPO sharks

3.2.1 Southwest Pacific blue shark (*Prionace glauca*)

3.2.1.1 Towards providing scientific advice for Southwest Pacific blue shark (Project 107b)

129. P. Neubauer presented SC18-SA-WP-03 (*Report on WCPFC project 107b: Improved stock assessment and structural uncertainty grid for Southwest Pacific blue shark*), which is a response to SC17 recommendations to assess performance of each model and evaluate the plausibility of the uncertainty grid before approving the results for providing management advice using several diagnostic tests. These tests include model convergence (the final gradient), stability (Hessian matrix and jitter procedure), goodness-of-fit (residuals patterns of the CPUE and length-frequency distributions), model consistency (retrospective pattern) and prediction skill (hindcasting analysis). The weighting of axes of the grid was also investigated. After applying these tests, the number of models consisting of the uncertainty grid decreased from 3888 to 228. Most (87%) of the 228 (weighted) model runs show that the biomass is above SB/SB_{MSY}. The stock biomass was low throughout the region through the early 2000s following the expansion of longline fishing effort in the region. But the estimates across the uncertainty grid of 228 models largely indicated that the stock has been recovering since then. Fishing mortality has declined over the last decade and is currently relatively low with the median F_{recent}/F_{MSY} = 0.65. These results were qualitatively similar to 2021 assessment grid outcomes.

Discussion

130. Japan noted the additional comprehensive analysis, while observing that there were still large uncertainties in the biological and physical data, as well as model settings. Japan noted the reduction in both the grid and the uncertainty, and stated that the stock status results are very robust for the key uncertainties. Japan endorsed the conclusion and recommendations for future research.

131. Australia inquired regarding the difference of the trajectories between B/B_0 and $B/B_{F=0}$. The presenter responded that caution is needed to implement the trend of the depletion rate, which is driven by the stock recruitment relationship containing the recruit deviation as a free parameter.

132. Australia noted the improvement of the structural uncertainty grid for blue shark and the productive collaboration with the USA delegation to develop a consistent set of diagnostics to assess individual grid runs. It also noted that, in this instance, increased scrutiny of biological assumptions and the handling of key sources of uncertainty were the main factors leading to a better diagnostic case to use as a starting point for the grid. Australia posed two questions:

(i) One of the predictions from the dynamic B_0 was that there was a decrease in predicted unfished spawning biomass up to 2010, followed by an increase peaking in 2020. Australia inquired whether the authors see this as a model artifact or if there are other factors that might suggest a productivity shift for blue shark over this time period?

(ii) Based on the exploration of both static and dynamic biomass-based reference points for blue shark, Australia inquired whether the authors would be able to recommend a preferred metric to inform management for this stock?

133. The presenter replied that caution was needed in interpreting the trends of the dynamic reference point, noting it is difficult to gauge without significant further exploration to what degree the trends in that reference point, which are largely driven by the recruitment deviates, are a result of the assumptions in the stock assessment, including stock recruitment. The presenter noted that they were just starting to understand the nuances of using the dynamic reference points, and indicated they are not aware of more definitive studies of how dynamic reference points interact, leading to the need for caution, particularly for somewhat data limited models. They noted recruitment deviates will pick up many things that may or may not be related to shifts in productivity; this is a useful reference point to have in the mix but it is not certain if one is better than another —it is better to have a suite of reference points.

134. China noted that the uncertainty grid included different levels of natural mortality but suggested it may be better to include age-based natural mortality, as is done in the Indian Ocean, which may be helpful to improve CPUE scaling. China inquired regarding the steepness used in the model. The presenter agreed that age-based mortality would be a good addition; they noted that the focus of the work was to produce a more consistent model and model grid, and to reduce the model complexity, but that this would be good to explore in future assessments in the SW Pacific. Regarding steepness, the model followed the blue shark stock assessment approach from the North Pacific, which uses the survival-based stock-recruitment relationship, with no steepness per se. There are several parameters that determine the level of overcompensation and the overall shape of the stock recruitment relationship. The uncertainty grid includes three combinations of those parameters that were informed by work developed for the North Pacific blue shark stock assessment; he noted that the North Pacific assessment had changed to a Beverton-Holt stock recruitment relationship. The one used here for the Southwest Pacific stock may lead to some difficulties in interpretation; these could possibly be avoided through the use of other stock recruitment relationships.

135. The USA welcomed the work, stating it opens a discussion that goes beyond blue shark. The USA supported the use of the 228 models, with its reduced complexity compared to the work done in 2021. The

USA also supported the proposed improved biological data collection and bycatch interaction reporting with the goal of improving future stock assessments.

136. Australia noted the many data uncertainties that often result in highly uncertain estimates of stock status, and inquired whether the presenter could prioritize the paper's recommendations intended to resolve some of the data uncertainties for blue shark (e.g., increased effort to reconstruct catch histories, additional tagging, additional growth studies, and further studies to help resolve stock structure). The presenter stated that two key uncertainties are stock structure and processes (migration routes), which may lead to process error that we struggle to understand. Part of this may have to do with stock structure so tagging and high-resolution genetic methods may be a priority; they noted that localized tagging (e.g., by New Zealand) results in local snapshots that give indications of stock structure. That is a high priority, and genetics could play a big role. The treatment of how the data are used for stock reconstruction and CPUE are both critical. He noted the need to extend the timeline for shark assessments, do intercessional work, and bring the plans for analyses to the SPC's pre-assessment workshops and become confident on how the data are being treated. He noted the comment from the USA that much hinges on obtaining better biological and observer data, and understanding the data we have.

137. Japan noted the current uncertainty grid is selected based on expert judgement, and requested further clarification on how this is done. Japan also inquired whether the order of events (i.e., removal of model runs with implausible behaviour, and grid weighting) could have an impact, and suggested the need to better understand what type of models were excluded. The presenter replied that the order does not matter, noting that the paper contains some information with the regression trees that show which models are associated with higher retrospective patterns; there was no strong signal that suggests a particular axis was rejected based on retrospective patterns, but rather certain combinations that led to extreme patterns were removed. The presenter stated they considered approaches to grid weighting (automated vs. based on expert judgement), and having looked at the diagnostics across the grid at large, stated they struggle to see how to automate grid weighting. They noted the TORs from SC focussed on plausibility, which comes from evaluating a range of diagnostics. They stated they looked forward to further discussions on this issue.

138. The EU noted the improvements from the prior version of the paper presented to SC17 and stated that the approach would have utility for other shark species. It supported the adoption of the model grid, and the suggested recommendations on research needs and extended timelines for complex stock assessments such as this.

139. Australia supported the US and EU proposal that SC accept the status information as provided in Table 6 of the report, consisting of 228 models with weightings applied, and stated it supported accepting the Main Assessment Conclusions provided in section 4.1 of the paper. It proposed that SC18 presents the information within the stock status and trends, and management advice and implications sections in the usual way. However, following the presenter's earlier comments, Australia suggested that in this case biomass status be expressed both in terms of B_0 (equilibrium approach) and $B_{F=0}$ (dynamic approach) reference points.

140. Samoa, on behalf of FFA members, thanked the authors for the analyses conducted for improving the southwest Pacific blue shark stock assessment and acknowledged the excellent work done to reduce uncertainties in the 2021 assessment. The stated that SC17 noted that the stock biomass is likely increasing and fishing pressure has declined through the recent decade, and noted that even with substantial restrictions to minimise the uncertainty grid, 87% of model runs showed that biomass is above SB_{MSY} and that fishing mortality is relatively low (median F_{recent}/F_{MSY} = 0.65). FFA members supported the research recommendations presented that for improvements in future assessments and recommended these be considered under the Shark Research Plan.

141. Solomon Islands, on behalf of PNA and Tokelau, noted the exceptional work, indicating that the analysis gave them confidence that the new grid removed much of the uncertainty and provided a good analytical way to select and weight the grid for providing management advice. They also noted that the authors provided an extensive range of reference point metrics as recommended in the SC17 report, which also suggested these be applied to elasmobranchs. They stated that these metrics should assist in understanding the different values, and reports of this nature will be useful when assessing lower information stocks that are limited in the metrics available to them. PNA and Tokelau stated that the analysis gave them the confidence to accept the 228 weighted grid as the best available information for providing management advice and the conclusions in the paper regarding the stock status. They recommended that SC18 accept the work and use the median and 90th percentiles from Table 6 for providing management advice to the Commission for this stock. They also proposed that SC18 advise the Commission that the south Pacific blue shark stock in the WCPO is not overfished and overfishing is not taking place, when considered against all conventional reference points.

3.2.1.2 Provision of scientific information

a. Status and trends

142. **A description of the structural uncertainty grid with associated weighting that was used to define stock status and characterize uncertainty in the Southwest Pacific blue shark (SBSH) assessment is included in Table SBSH-1.**

143. **SC18 noted the improvement of the structural uncertainty grid and the use of 228 models, with *a priori* weighting, and the reduced grid complexity compared to the 2021 version.**

144. **SC18 noted the stock biomass was low throughout the region through the early 2000s following the expansion of longline fishing effort in the region, but the estimates across the uncertainty grid of 228 models largely indicated that the stock has been recovering since then.**

145. **SC18 noted that the median value of relative recent dynamic spawning biomass depletion for Southwest Pacific blue shark ($SB_{2017-2020}/SB_{F=0}$) was 0.71 (90th percentiles 0.37 and 0.82). Alternatively, relative recent equilibrium spawning biomass depletion for South Pacific blue shark ($SB_{2017-2020}/SB_0$) was = 0.80 (90th percentiles 0.43 and 0.90).**

146. **SC18 noted that the median value of $SB_{2017-2020}/SB_{MSY}$ was 1.64 (90th percentiles 0.88 and 1.87; Table SBSH-2) with 87% likelihood (according to the 228 weighted models) that the biomass is above SB_{MSY}.**

147. **SC18 noted that the fishing mortality has declined over the last decade and is currently relatively low with the median $F_{2017-2020}/F_{MSY}$ = 0.65 (90th percentiles 0.43 and 0.86; Table SBSH-2).**

148. **SC18 noted that there was a 1% likelihood (according to the 228 weighted models) that the recent fishing mortality ($F_{2017-2020}$) was above F_{MSY}.**

Table SBSH-1. Description of the seven axes for the updated 2022 structural uncertainty grid. Base settings used under the diagnostic case are highlighted in bold. Weights used for alternative values in the weighting of the grid axes are given in parentheses.

Axis	Description
Catch scenario	**Base (0.9)**, high (0.1)
Discard scenario	Low (0.25), **base (0.5)**, high (0.25)
Initial F	**base (0.9)**, high (0.1)
High latitude CPUE	**New Zealand (1),** low weight (0.5), remove (RM) early New Zealand (0.5)
Low latitude CPUE	**Japan (1)**, Australia (0.5), remove EU CPUE
Survival fraction	**Base**, low, high
Growth	**Manning and Francis (2005)**, Joung et al. (2018)

Table SBSH-2. Summary of reference points and stock status for the subset of 228 grid model in the structural uncertainty grid, after sub-setting the grid for model runs that showed acceptable retrospective patterns and estimates for natural mortality. Grid axes are weighted by prior input weights. The symbols used in the yield and stock status are described in Table 3 of SC18-SA-WP03.

(catch in mt)

	Mean	Median	Min	10%	90%	Max
C_{latest}	5,965	5671	3707	3978	7593	9601
C_{recent}	6,912	6744	4322	4596	8926	9577
MSY	11,413	9993	8968	9313	16333	25629
SB_0	22,772	20603	15686	18524	32263	53503
$SB_{F=0}$	25,894	22658	17559	20161	38033	66434
SB_{MSY}	11,104	9985	7564	9008	15854	26684
SB_{latest}	18,420	17904	12973	15902	20424	38004
SB_{recent}	16,344	15907	11320	14000	17670	33654
SB_{latest}/SB_0	0.85	0.90	0.42	0.49	1.01	1.19
SB_{recent}/SB_0	0.76	0.80	0.37	0.43	0.90	1.05
$SB_{latest}/SB_{F=0}$	0.76	0.79	0.32	0.43	0.93	1.29
$SB_{recent}/SB_{F=0}$	0.67	0.71	0.29	0.37	0.82	1.15
SB_{latest}/SB_{MSY}	1.75	1.84	0.85	1.00	2.10	2.47
SB_{recent}/SB_{MSY}	1.55	1.64	0.76	0.88	1.87	2.19
F_{MSY}	0.144	0.142	0.134	0.136	0.158	0.181
$F_{lim,AS}$	0.228	0.225	0.211	0.214	0.248	0.291
$F_{crash,AS}$	0.325	0.320	0.299	0.304	0.351	0.419
F_{latest}	0.073	0.072	0.039	0.051	0.093	0.120
F_{recent}	0.094	0.094	0.048	0.065	0.117	0.160
F_{latest}/F_{MSY}	0.51	0.52	0.24	0.35	0.67	0.78
F_{recent}/F_{MSY}	0.65	0.65	0.30	0.43	0.86	1.06
$F_{latest}/F_{lim,AS}$	0.32	0.33	0.15	0.22	0.43	0.50
$F_{recent}/F_{lim,AS}$	0.41	0.41	0.19	0.27	0.55	0.68
$F_{latest}/F_{crash,AS}$	0.23	0.23	0.11	0.15	0.30	0.35
$F_{recent}/F_{crash,AS}$	0.29	0.29	0.13	0.19	0.39	0.48

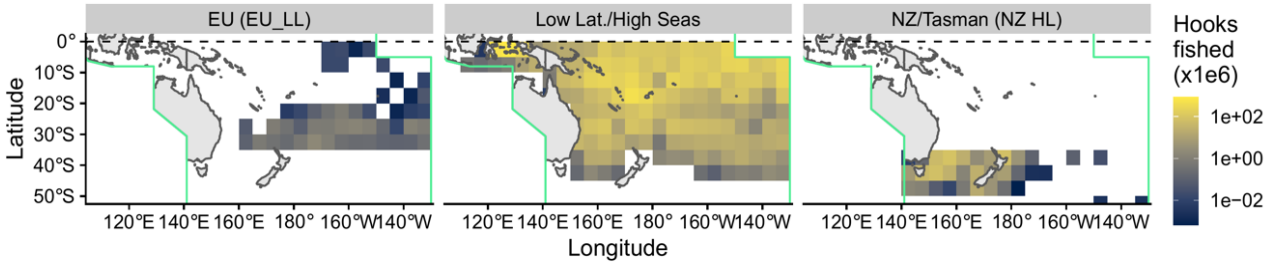

Figure SBSH-1. Spatial structure used in the 2022 stock assessment model.

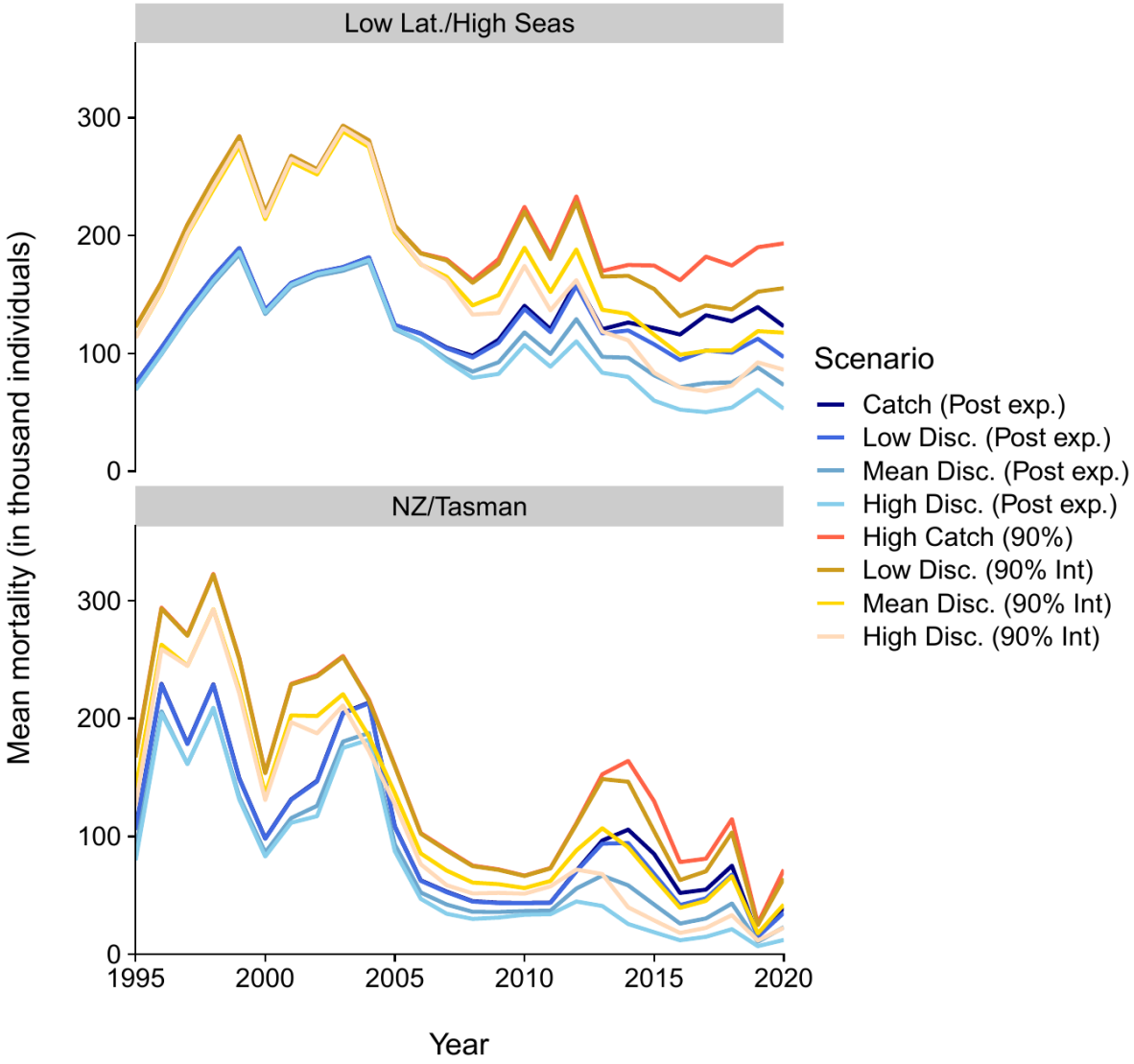

Figure SBSH-2. Top panel: Time series of total reported annual Southwest Pacific BSH catch for the EU-SP fleet (mt), Bottom panels: Predicted total fishing related mortality by latitudinal stratum (high [≥ 35 degree South] and low latitude [< 35 degree South]), including 17% post release mortality for live-discarded blue sharks. Interactions refer to the posterior median (50%) and 90th percentile (90%) of the predicted catch from the observer catch rate model. Low, median and high discard scenarios refer to the 25%, 50% (median) and 75% discard estimates. All discard estimates were applied at flag and latitudinal stratum level to overall interactions.

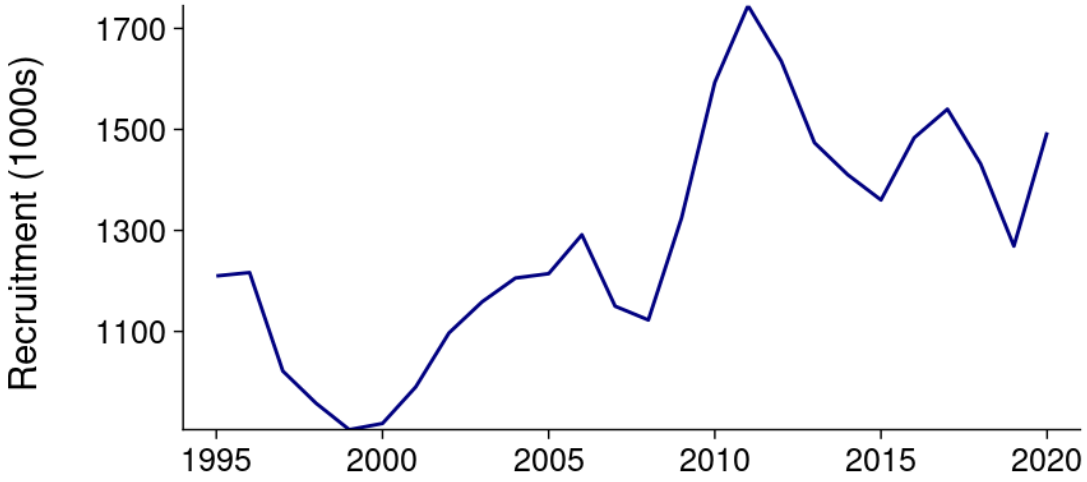

Figure SBSH-3. Estimated annual recruitment for the diagnostic case model

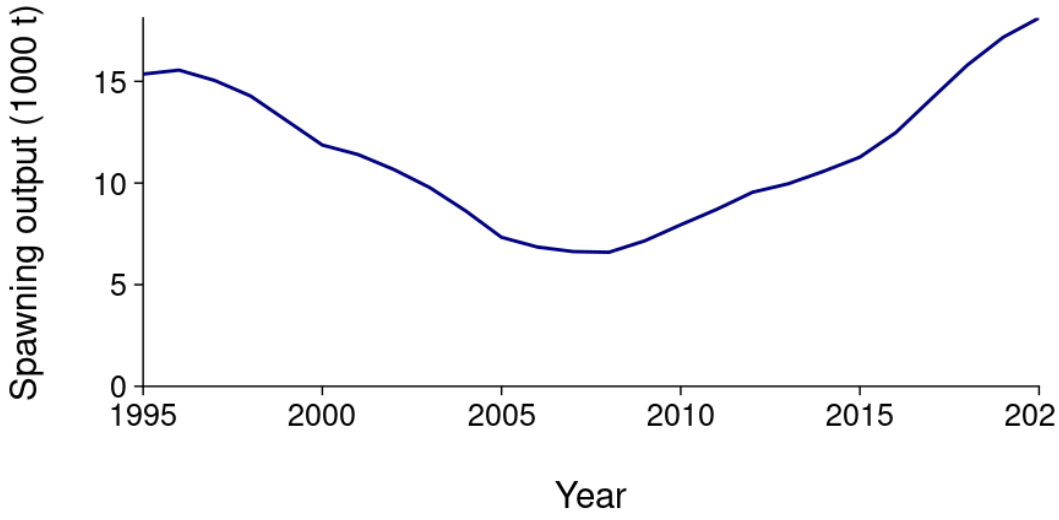

Figure SBSH-4. Estimated annual spawning potential by model region for diagnostic case model

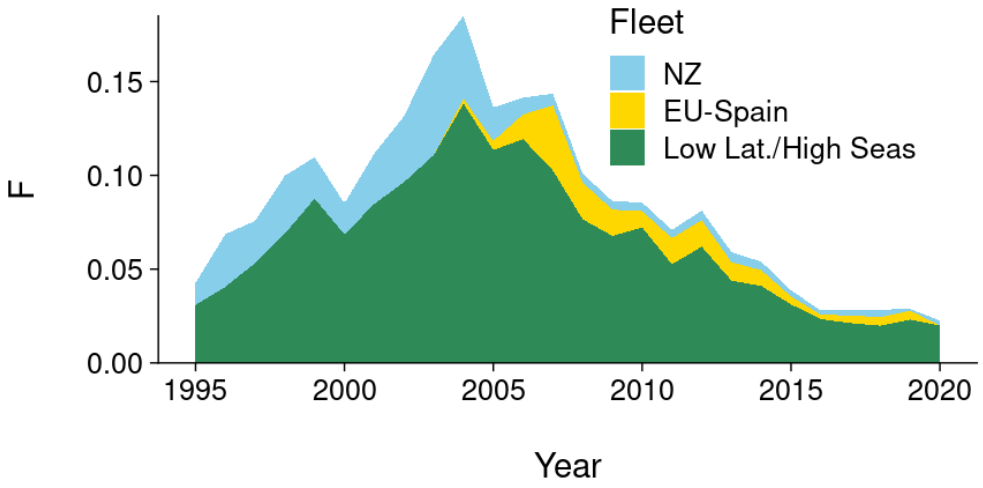

Figure SBSH-5. Estimated annual fishing mortality for the diagnostic case model

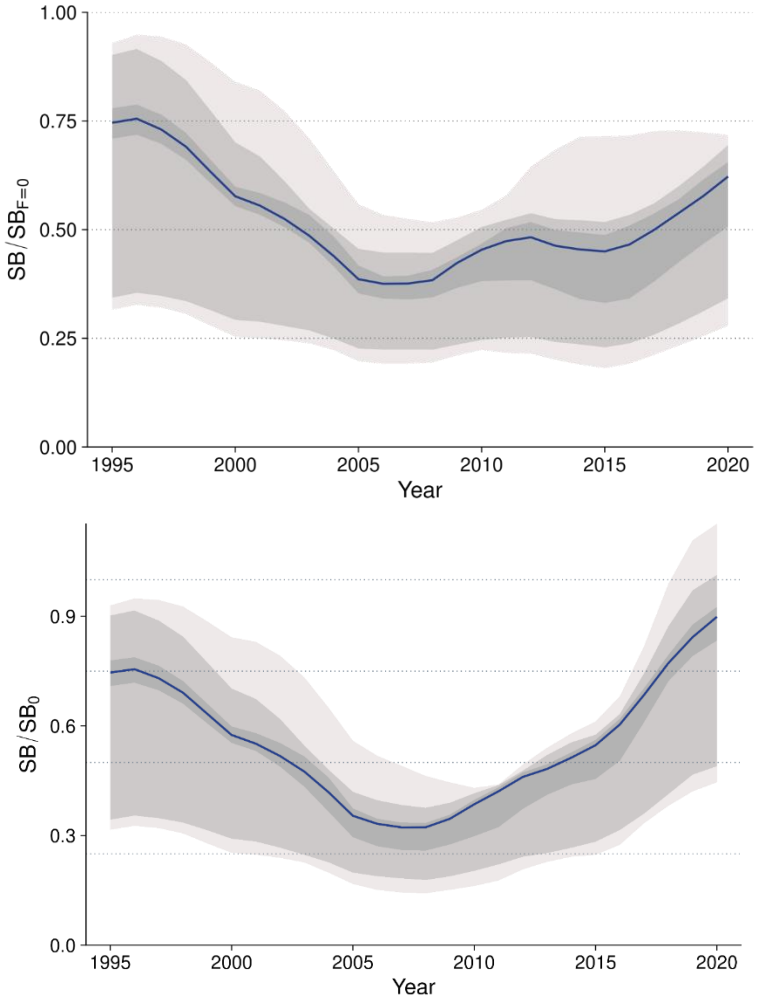

Figure SBSH-6. Plot showing the quantiles of trajectories of fishing depletion (of spawning potential) for the 228 model runs included in the structural uncertainty grid

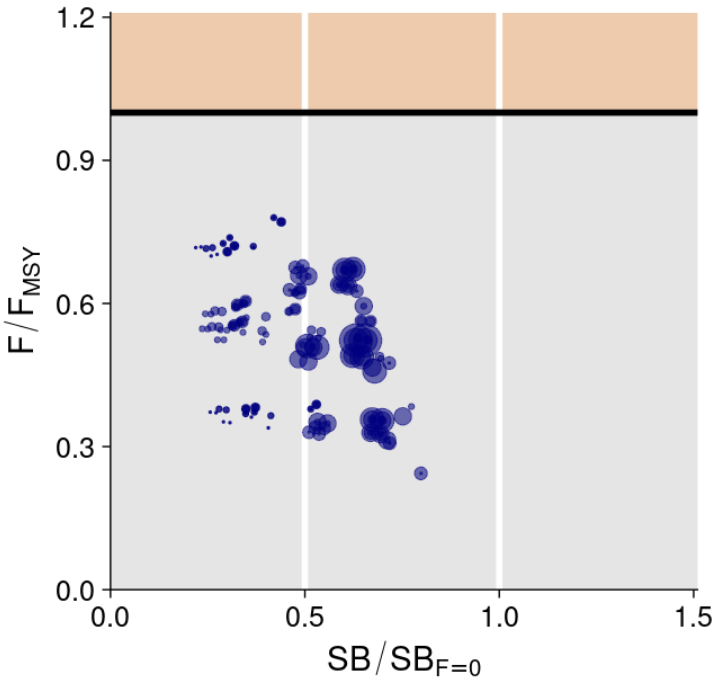

Figure SBSH-7. Majuro plot summarising the results for each of the models in the structural uncertainty grid. Size indicates weight of each model in the grid, darker shading indicates multiple models with similar outcomes.

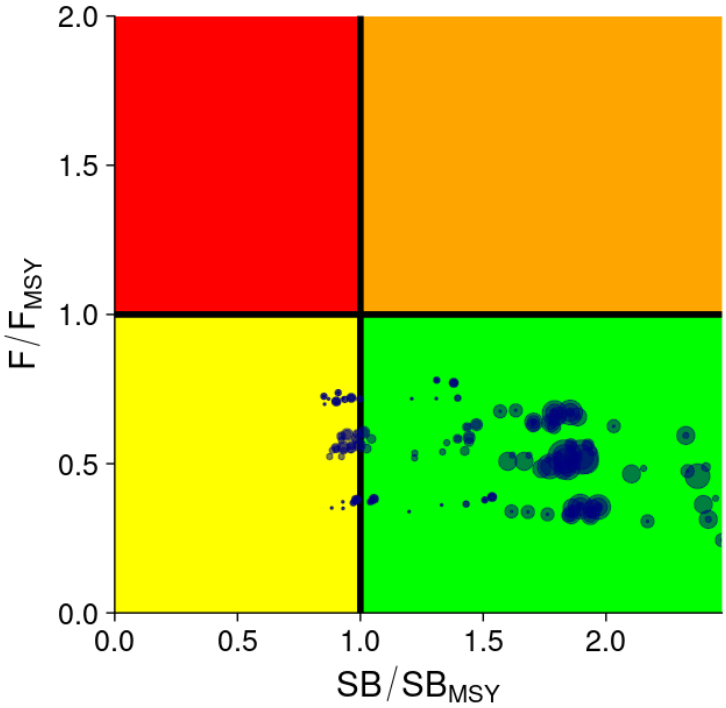

Figure SBSH-8. Kobe plot summarising the results for each of the models in the structural uncertainty grid. Size indicates weight of each model in the grid, darker shading indicates multiple models with similar outcomes.

b. Management advice and implications

149. **SC18 welcomed the reduction and refinement of the grid of models for Southwest Pacific blue shark as well as the approach to the weighting of the model.**

150. **Based on the above information, SC18 advised the Commission that the Southwest Pacific blue shark is unlikely to be overfished and it is unlikely that overfishing is occurring when considered against MSY and depletion-based reference points.**

c. Future research recommendations

151. **SC18 noted the following research recommendations to achieve improvement in future shark assessments:**

- **(vii) Providing more time, either as inter-session projects, or by extending time-frames for shark data analyses. This will allow more thorough investigation of input data quality and trends, which shape assessment choices. In addition, it would allow input analyses to be completed in time to be presented to the SPC's Pre-assessment Workshop prior to the stock assessment. In addition, allowing more time for the assessments themselves will allow a more thorough investigation of alternative model structures, which may include comparisons with low-information methods such as spatial risk assessments.**
- **(viii) Increased effort to reconstruct catch histories for sharks (and other bycatch species) from a range of sources. Our catch reconstruction models showed that model assumptions and formulation can have important implications for reconstructed catches. Additional data sources, such as log-sheet reported captures from reliably reporting vessels, may be incorporated into integrated catch-reconstruction models to fill gaps in observer coverage.**
- **(ix) Additional tagging be carried out using satellite tags in a range of locations, especially known nursery grounds in South-East Australia and New Zealand, as well as high seas areas to the north and east of New Zealand, where catch-rates are high. Such tagging may help to resolve questions about the degree of natal homing and mixing of the stock.**
- **(x) Tagging may also help to obtain better estimates of natural mortality, if carried out in sufficient numbers. This could be taken up as part of the WCPFC Shark Research Plan to assess the feasibility and scale of such an analysis.**
- **(xi) Additional growth studies from a range of locations could help build a better understanding of typical growth, as well as regional growth differences. Current growth data are conflicting, despite evidence that populations at locations of current tagging studies are likely connected or represent individuals from the same population.**
- **(xii) Genetic/genomic studies could be undertaken to augment the tagging work to help resolve these stock/sub-stock structure patterns. To support this work, a strategic tissue sampling program for sharks is recommended with samples to be stored and curated in the Pacific Marine Specimen Bank.**

3.2.2 Southwest Pacific shortfin mako shark (*Isurus oxyrinchus*)

3.2.2.1 Review of 2022 Southwest Pacific shortfin mako shark stock assessment (Project 111)

152. Kath Large (Dragonfly) presented SC18-SA-WP-02 (*Stock assessment of Southwest Pacific Shortfin Mako shark*), which assesses southwest Pacific shortfin mako shark stock in the WCPO (referred to as the southwest Pacific stock). South Pacific mako sharks have been caught in longline fisheries since

their inception in the 1950s, but have only been reported in catch records since the 1990s. They are thought to consist of two stocks, a southwest and southeastern stock which are both separated from those in the north Pacific at the Equator. Shortfin mako sharks in the north Pacific have been assessed and that stock is currently considered not to be overfished and overfishing is not taking place. This is the first attempt at undertaking an assessment of the southwest Pacific stock.

153. The stock assessment was set up in Stock Synthesis as a two-fleet model. The fisheries were structured into a low latitude high seas fleet (between 15°S and 35°S) and a high latitude fleet (between 35°S and 45°S) based on several observations that suggest: spawning may occur more often in higher latitudes; there may be lower catchability of smaller individuals in the warmer surface water in lower latitudes; and potential species identification issues in the most southern part of the fishery. The model was run for a 26-year period (1995 to 2020), given highly uncertain catches prior to 1995. The catches were reconstructed from observer data, producing relatively high catches between the mid-1990s and early 2000s, with relatively strong reductions in catch since about 2010. The catch reconstruction model also produced high uncertainties in catch between the mid-1990s and early 2000s, and in the early to mid-2010s.

154. Two CPUE series, one from New Zealand, representing high latitude fisheries capturing young-of-year and juvenile fish, and one from Japan representing low latitude fisheries on juvenile (mainly age 1+ but sub-mature) individuals, were used as indices of abundance. The high latitude index suggested a decline in the late 1990s, with subsequent increase since the early 2000s, and relatively variable, yet over-all flat trends in recent years. The low latitude index suggested a time-lagged decline compared to the New Zealand high latitude index in the later 1990s and early 2000s, but did not show a subsequent increase. Corresponding length frequencies appeared relatively consistent with indices: a decline and subsequent recovery in mean lengths for high latitude mean lengths, and relatively stable mean lengths for low latitude fisheries.

155. Despite numerous attempts, very few of the attempted models yielded plausible outcomes. In the diagnostic model, initial fishing mortality F_{init} was estimated from assumed equilibrium catches prior to the start of the time series in 1995. The resulting estimation uncertainty was large, leading to very large uncertainty around unfished biomass and stock status. The model also showed strong retrospective patterns, with only the addition of recent data providing signal to estimate scale parameters (R_0). The estimated initial equilibrium fishing mortality was largely driven by length composition data. Alternative assumptions about catch or biological parameters (e.g., M) often lead to implausible estimates for initial fishing mortality (i.e., near zero). CPUE indices appeared in conflict for both the estimation of R_0 and F_{init}. In addition, the model required highly correlated recruitment deviations to explain changes in abundance indices, suggesting that the assumed catch history alone was insufficient to explain early declines in abundance indices. Together, these patterns suggest that the model inferences are highly dependent on assumptions and input data, and that the model solution for the diagnostic model is not stable. As result we suggest that the assessment model, while delivering information on stock biomass and fishing mortality trends, is not robust enough for providing management advice.

156. Despite the documented shortcomings, the authors suggest that the present assessment delivers some useful metrics. Fishing mortality and associated reference point metrics, for example, were consistently estimated (Table 2). The assessment therefore provides preliminary indications that recent fishing mortality may have declined below critical (i.e., $F_{crash,AS}$) levels, and may currently be near levels of F_{MSY}. However, due to the inherent instability of the present model, we did not explore the sensitivity of these estimates to uncertainty in the catch and discard assumptions. Our models used an estimate of natural mortality from New Zealand studies, that was noted as being high. As a consequence, F based reference points derived here may be overly optimistic. As alternative model runs did not succeed in providing plausible outputs, we therefore caution that the present analysis is preliminary and only gives ranges of values from a single assumption of life history and our most-likely catch and discard scenarios only.

157. Main Assessment Conclusions include:

- The assessment was un-stable, with high estimation uncertainty and sensitivity to a range of inputs. We therefore consider this assessment preliminary and suggest it should not be used for providing management advice.
- Poor representation of mature females in commercial fishing data suggests that all inferences for this important partition of the stock are derived from assumptions and estimates of biological and fisheries parameters, with no direct observations to assess the appropriateness of these assumptions/estimates. In the absence of alternative data sources on trends in this component of the stock, these issues will likely remain in future, and alternative assessment approaches should be explored.
- Relatively consistent estimates of fishing mortality and related reference points suggest that recent declines in catch may have been sufficient to reduce fishing mortality below critical levels. However, we note that these statistics are based on a single set of assumptions, and further work will be required to test the robustness of these preliminary statistics.

Discussion

158. The USA agreed with the presenter's conclusion that the results should not be used to develop management recommendations. It noted that the CPUE indices are fairly poor and in conflict, and suggest that work focus on resolving these conflicts, and suggested producing a recruitment index, which could help inform the recruitment deviations. The USA also asked for clarification regarding which stock recruitment curve was used. The presenter stated that the Beverton-Holt stock recruitment relationship was used and that there was a typo in the report. The presenter agreed with the other suggestions by the USA, stating they would have liked to have pursued this had time been available. The presenter indicated NZ does produce data and analysis around the recruitment, but was uncertain how useful these data are.

159. The EU noted shortfin mako was one of the species that had been classified as high priority for research some years ago and one of the species identified as high-priority for assessment at SC16. Also, the inclusion of the species in appendix 2 of CITES, urged this work. Therefore, the first assessment of this stock was welcome, although the uncertainties around many of the inputs result in estimates highly uncertain and not sufficient for the provision of a clearer management advice. It inquired whether there could there be bias from shark misidentification (porbeagle vs. shortfin mako), and whether there were conflicts between different growth and maturity studies (some assume one band pair is deposited on their vertebrae per year, and some assume two). Estimates based on tagging data result in much faster growth rates. The EU also stated that the 2018 shortfin mako stock assessment used an age at first maturity of 10 years in females, while this study used 20-year maturity for females, which may be questionable, and needs more research. The presenter acknowledged the issues with species identification between shortfin mako and porbeagle (even for observers), and stated this was an issue they would like to investigate. Regarding growth and maturity, they acknowledged the uncertainty regarding the number of bands per year, and noted a paper by M. Francis that addresses this,[20] stating that examining growth and how it is treated in the model is a priority for this species.

160. New Zealand noted the challenges of dealing with such an uninformative data set, particularly given the limited time, but stated that much progress was made, particularly in developing the data inputs. It noted that the model includes two CPUE time series that are in conflict, and suggested it might be useful to fit separate alternative models to each of the two CPUE series, rather than combining conflicting data in the same model. However, it also noted that an assessment such as this without asymptotic selectivity in any

[20] Francis, M. P. (2016). Size, maturity and age composition of mako sharks observed in New Zealand tuna longline fisheries. *New Zealand Fisheries Assessment Report 2016/22, Ministry for Primary Industries*, 34

fishery will always be difficult to fit, with the potential for cryptic biomass, and particularly given that natural mortality and longevity are very uncertain. New Zealand stated it was also aware of the difficulty caused by the short timelines for data preparation and undertaking the stock assessment after funding became available, and supported the recommendation to extend the funding of shark assessments over a 2-year period, with the first year focused on data preparation and analysis, and the second year focused on the assessment. The presenter noted that fitting alternative models to the two CPUE series was on their agenda, given adequate time. Investigating other CPUE that would have been in the model is also a research priority.

161. FSM, on behalf of the PNA and Tokelau, noted the effort involved in the study, and the inadequacy of the underlying data that prevented obtaining a convincing result. They also noted the utility of the assessment in providing a range of reference point metrics, including some used in data-poor assessments, which helps in developing an understanding of how low information metrics compare with those conventionally used in more data-rich assessments. They stated that in their view there is merit in undertaking a wider review of shark assessments and that shortfin mako sharks would be a good test case to include as part of this review; they suggested that work be prioritised, and would be more valuable than the scheduled whale shark spatial risk assessment. They also inquired whether having 5 additional years of observer data would result in a successful assessment, provided more reliable biological data were also obtained. The PNA and Tokelau also supported the recommendations, particularly the concept extending the timeframe for shark assessments (as also noted for blue sharks). They also supported the proposed change to the provision of aggregated data, noting that a similar recommendation was made at SC17 with regard to the south Pacific blue shark stock assessment (this was accepted by SC17 and WCPFC18 but has not yet been actioned). The presenter acknowledged that another 5 years of data would be good, but that data alone would not be enough; they suggested the need for a wider review of shark assessments, with a discussion that includes many viewpoints.

162. Japan noted that the stock assessment clearly shows the direction for future work, and stated its hope that better data could be obtained for future assessments. It supported the recommendation to continue to support the shortfin mako stock assessment in the SW Pacific. The presenter thanked Japan for their timely help with the stock assessment.

163. Australia noted the challenging nature of the assessment and the authors' comprehensive review of data gaps and uncertainties in the existing data inputs for the stock. It noted the initial recommendations from the 2020 shark research plan for a data-rich assessment for this stock, and inquired, based on the authors' experience with the available data inputs, whether they believed further insights could be obtained from a medium spatial risk assessment such as eSAFE or EASI-FISH as alternative assessment approaches? The presenter stated that given some of the particular data issues and the lack of certainty about the productive aspects of the stock it is unclear how useful a risk assessment approach would be.

164. FSM, on behalf of the PNA and Tokelau, noted the comments from the presenter and other CCMs, and suggested that the Shark Research Plan, stock assessment schedule, and SC work plan should reflect that shark assessments are budgeted over two years to accommodate the extra time required for data preparation, characterization, and CPUE analysis.

165. Australia noted the comprehensive report, and inquired—given the data deficiencies noted in this report, and the number of recommendations for studies to improve these data—what metrics SC could use to assess whether there are sufficient data and information to undertake a SW shortfin mako assessment in the future? The authors noted the issues with life history and uncertainty parameters, as raised in their paper and in comments from CCMs, and stated there was little point in revisiting the stock assessment based on the existing data until those issues were resolved. They noted the need to base growth assumptions on adequate biological knowledge; if that is not done stock assessments will retain fundamental uncertainty,

even given some improvements. Australia stated that this is obviously an important point to consider as SC proceeds with its shark research plan and stock assessments.

166. Tonga, on behalf of FFA members, noted for the work undertaken to attempt the first southwest Pacific shortfin mako shark stock assessment. Due to the lack of available data, particularly for mature females, and the finding that the assessment was unstable with high uncertainty and sensitivity to a range of inputs, FFA members agreed the assessment be considered preliminary and should not be used for providing management advice. FFA members supported the recommendations in SC18-SA-WP-02 to achieve improvements in future assessments. FFA members emphasised the need for more time for analyses with assessments spanning 2 years to increase the chance of their success. However, they noted that the list for future research is lengthy and should be included and prioritised in the Shark Research Plan.

167. SPREP noted that shortfin mako is a CITES Appendix 2 species, and the need for non-detriment findings (NDFs) for landed bycatch. SPREP stated that the stock assessment would assist those CCMs that needed to prepare NDFs to enable trade. SPREP encouraged that other sources of data be used to improve the stock assessment for future management decision-making.

3.2.2.2 Provision of scientific information

a. Status and trends

168. **The authors noted that the assessment models had high estimation uncertainty and were sensitive to a range of inputs. Assessment results were deemed preliminary and were not recommended for providing management advice and that alternative assessment approaches be explored. Therefore, SC18 found it was unable to provide stock status or trends information on Southwest Pacific mako shark to the Commission, as the status remains unknown.**

b. Management advice and implications

169. **SC18 does not regard the South Pacific mako shark assessment to be robust enough to provide management advice. As such, SC18 is unable to provide management advice and implications for South Pacific mako shark to the Commission. SC18 notes that a large number of CCMs currently release (cut sharks free) shortfin mako sharks. This practice may result in a reduction in fishing mortality and SC18 encourages CCMs to continue to maintain this practice as a precautionary measure for a slow growing, unproductive species with unknown stock status.**

c. Future research recommendations

170. **Given some of the fundamental uncertainties highlighted above, SC18 recommended:**

- **Future assessments should spend increased effort to reconstruct spatiotemporal abundance patterns for shortfin mako, and develop a better understanding of how these patterns drive regional abundance indices.**
- **Providing more time, either as inter-sessional projects, or by extending time-frames for shark analyses will allow more thorough investigation of input data quality and trends, which shape assessment choices. In addition, this approach would allow input analyses to be completed in time to be presented to the SPC's Pre-assessment Workshop prior to the stock assessment commencing. Moreover, this will provide more time for the assessments themselves allowing a more thorough investigation of alternative model structures or assessment approaches.**
- **Increased effort should be made to re-construct catch histories for sharks (and other**

bycatch species) from a range of sources. Our catch reconstruction models showed that model assumptions and formulation can have important implications for reconstructed catch. Additional data sources, such as log-sheet reported captures from reliably reporting vessels, may be incorporated into integrated catch-reconstruction models to fill gaps in observer coverage.

- **Additional tagging should be carried out using satellite tags in a range of locations, especially known nursery grounds off southeast Australia and New Zealand, as well as high seas areas to the north and east of New Zealand, where catch-rates are high. Such tagging may help to resolve questions about the degree of natal homing and mixing of the stock.**
- **Tagging may also help to obtain better estimates of natural mortality, if carried out in sufficient numbers. This could be taken up as part of the WCPFC Shark Research Plan to assess the feasibility and scale of such an analysis.**
- **Additional growth studies and validation of aging methods from a range of locations could help build a better understanding of typical growth, as well as regional growth differences. Current growth data are conflicting, despite evidence that populations at locations of current tagging studies are likely connected or represent individuals from the same population.**
- **Genetic/genomic studies could be undertaken to augment the tagging work to help resolve the stock/sub-stock structure patterns. To support this work, a strategic tissue sampling program for sharks is recommended with samples to be stored and curated in the Pacific Marine Specimen Bank.**
- **Aggregated data are currently submitted as annual totals for the WCPFC area only, making them uninformative for a stock specific assessment. Therefore, shortfin mako shark aggregated data (and probably other Key Sharks) should be reported by ocean area not simply as WCPO and, where possible, these data should be retrospectively corrected. As such we propose that paragraph 1 bullet point 3 of the Scientific Data to be Provided to the Commission should include the following sentence: "For Key Sharks, estimates of annual catch should be separated into catch north and south of the Equator. The WCPFC secretariat should work with CCMs to get these data retrospectively corrected where possible."**

3.2.3 North Pacific blue shark (*Prionace glauca*)

3.2.3.1 Review of 2022 North Pacific blue shark stock assessment

171. Nicholas Ducharme-Barth (USA) presented SC18-SA-WP-06 **(***Stock assessment and future projections of blue sharks in the North Pacific Ocean through 2020*), which presents the results of the stock assessment for blue sharks in the North Pacific Ocean conducted by the ISC SHARKWG using a fully integrated, size-based, age-, and sex-structured model. The last stock assessment was conducted in 2017. Improvements and updates in the current assessment include: updated time series data through 2020 (catch, abundance indices, and sex-specific length composition from multiple fisheries), incorporation of new biological information, consideration of an alternative CPUE hypothesis for the late model period, and adoption of an ensemble modelling approach.

Discussion

172. The SA Theme Co-Convener inquired regarding the use of the ensemble approach, and how the decision to use this rather than a base case model was made. The presenter stated that substantial time was spent at the most recent shark working group assessment meeting on developing the model ensemble, which

he noted came late in the process, as they were initially planning to use a single base case model. When the working group compared the diagnostics with other models with alternate CPUE hypotheses. It was only after considerable discussion that the WG agreed to use an ensemble approach because it wasn't clear that there was a single best-case model.

173. Palau, on behalf of FFA members, thanked ISC for the updated stock assessment for north Pacific blue shark and noted the results of the assessment indicate that the stock is not likely in an overfished state and that overfishing is not occurring. Stock status appears to be trending in an increasingly positive direction, with fishing mortality and spawning stock biomass stabilising over the last 20 years. However, we note that uncertainty in the current assessment is likely underrepresented as the model ensemble did not consider key uncertainties (e.g., natural mortality or stock-recruitment resilience) and was not informed by the sensitivity analyses, which showed that stock status was sensitive to alternative stock-recruitment relationship assumptions. As noted in the assessment, a more thorough use of an ensemble of models (grid) is required to better represent uncertainty. FFA members strongly encourage this approach as representing best practice and for consistency with other WCPFC stock assessments. FFA members stated they are concerned about the different standards applied to assessments. For the 2021 south Pacific blue shark assessment, a number of ISC members expressed concern at the grid selection process used in that assessment and recommended an approach that uses some a priori selection of model. However, this approach was not used here. Why should these two assessments of the same species be held to a different standard? FFA Members sought further clarity on the basis for these apparent inconsistencies, before being able to endorse the stock status conclusions and management advice from this assessment. The presenter noted it is not correct that different standards are being applied, and stated that the stock assessment was developed by carefully scrutinising model diagnostics for each of the 3 models. It was clear there was nothing to separate those. Among the models considered the uncertainty was related to the CPUE axis, so was no way to assign a prior weight to such a data input. He noted that the approach taken is consistent with that done for SW Pacific blue shark.

174. The USA thanked the ISC for the North Pacific blue shark stock assessment and noted it is clearly an improvement over the previous assessment. The USA stated it considered the 2022 assessment as best scientific information available, and also endorsed the stock status and conservation advice proposed by the ISC. The USA also supported the model ensemble approach taken in the 2022 stock assessment as a more comprehensive way of characterizing structural uncertainty in stock status. However, it noted that there is likely still an under-presentation of uncertainty in stock status, as the model ensemble in this assessment did not consider uncertainty in natural mortality or stock-recruitment resilience which are not well-known for many shark species. The USA supported the recommendation in the assessment report that the model ensemble should be informed by the sensitivity analyses in the future. Uncertainty in key biological processes; including growth, maturity, weight-at-length, maximum age, natural mortality, and steepness; should be incorporated into estimates of stock status via a model ensemble framework in the next assessment.

175. Japan commented on the life history parameters and uncertainty (e.g., natural mortality and steepness). It noted the need to improve the accuracy of these life history parameters, but also noted that these life history parameters are more reliable than those for any other pelagic sharks. For example, sex-specific age-dependent natural mortality (rather than a sex-combined constant natural mortality, which is commonly used for pelagic sharks) has been used for the North Pacific blue shark assessment, based on reliable growth information (Fujinami et al., 2019[21]), with a constant natural mortality derived from meta-

[21] Fujinami, Y., Semba, Y., Tanaka, S. 2019. Age determination and growth of the blue shark (*Prionace glauca*) in the western North Pacific Ocean. *Fish. Bull*. 117, 107–120

analysis (Campana et al., 2005[22]). The steepness parameter is estimated using an ecological model with the best available biological parameters such as growth and maturity ogives (Kai and Fujinami, 2018[23]).

176. RMI, on behalf of PNA and Tokelau, asked for clarification on the stock status advice. The paper states that no base case could be selected, and the model ensemble approach was therefore preferred. However, in the stock status advice the paper notes that "The base case model results show that there is a 61.9% joint probability that NPO BSH stock is not in an overfished condition". They noted the need for further discussion around the apparent inconsistencies, before they could consider supporting SC18 endorsement of the stock status and management advice from this assessment.

177. The presenter clarified that the text about the base was an inconsistency in the report and should be disregarded, noting that all stock assessment results and advice were based on the 3-model ensemble.

178. CCMs discussed whether SC was prepared to accept the ISC north Pacific blue shark stock assessment. The SA Theme Co-Convener indicated that for northern stocks SC usually includes the relevant information with a note that it is presented as agreed by ISC, and inquired whether there were any objections to do doing this. In the ensuing discussion the presenter reiterated that the working group found that all three models had converged to global minima, were accepted, and formed the basis for the ensemble. Japan clarified the reason for the choice of the ensemble approach and provided further information on the development of reliable alternative abundance indices based on Japanese research and training vessel data, which shows similar trends with data from Hawaii and Taiwanese fisheries.

3.2.3.2 Provision of scientific information

a. Stock status and trends

179. **SC18 thanked ISC for the updated stock assessment for North Pacific blue shark and noted the following conclusions on the stock status provided by ISC.**

> Target and limit reference points have not yet been established for pelagic sharks in the Pacific Ocean by either the WCPFC or the IATTC. Stock status was reported in relation to MSY-based reference points. The following information on the status of North Pacific BSH was provided.
>
> The median of the annual spawning stock biomass (SSB) from the model ensemble had a steadily decreasing trend until 1992 and slightly increased until recent years. The median of the annual F from the model ensemble gradually increased in the late 1970s and 1980s and suddenly dropped around 1990, which slightly preceded the high-seas drift gillnet fishing ban, after which it has been slightly decreasing. The median of the annual age-0 recruitment estimates from the model ensemble appeared relatively stable with a slightly decreasing trend over the assessment period except for 1988, which shows a large pulse. The historical trajectories of stock status from the model ensemble revealed that North Pacific BSH had experienced some level of depletion and overfishing in previous years, showing that the trajectories moved through the overfishing zone, overfished and overfishing zone, and overfished zone in the Kobe plots relative to MSY reference points. However, in the last two decades, median estimates of the stock condition returned into the not overfished and not overfishing zone.

[22] Campana, S.E., Marks, L., Joyce, W., Kohler, N. 2005. Catch, bycatch and indices of population status of blue shark (Prionace glauca) in the Canadian Atlantic. *ICCAT Coll. Vol. Sci. Pap*. 58, 891–934.
[23] Kai, M., Fujinami, Y. 2018. Stock-recruitment relationships in elasmobranchs: Application to the North Pacific blue shark. *Fish. Res*. 200, 104–115.

Based on these findings, the following information on the status of the North Pacific BSH is provided:

1) Median female SSB in 2020 was estimated to be 1.170 of SSB_{MSY} (80^{th} percentile, 0.570 - 1.776) and is likely (63.5% probability) not in an overfished condition relative to MSY-based reference points.
2) Recent annual F ($F_{2017-2019}$) is estimated to be below F_{MSY} and overfishing of the stock is very likely (91.9% probability) not occurring relative to MSY-based reference points.
3) The base case model results show that there is a 61.9% joint probability that NPO BSH stock is not in an overfished condition and that overfishing is not occurring relative to MSY based reference points.

180. **SC18 noted that the current assessment is an improvement over the previous assessment and supports the model ensemble approach taken in the 2022 stock assessment as a more comprehensive way of characterizing structural uncertainty in stock status. However, SC18 noted that the model ensemble did not consider some key uncertainties, in particular natural mortality or stock-recruitment steepness and SC18 recommended a more thorough use of the model ensemble approach is recommended to better represent uncertainty for future assessments.**

b. Management advice and implications

181. **SC18 noted the following conservation information from ISC.**

Stock projections of biomass and catch of NPO BSH from 2020 to 2030 were performed assuming four different harvest policies: $F_{current}$ (2017-2019), F_{MSY}, $F_{current}$+20%, and $F_{current}$-20% and evaluated relative to MSY-based reference points. Based on these findings, the following conservation information is provided:

1) Future projections in three of the four harvest scenarios ($F_{current}$ (2017-2019), $F_{current}$+20%, and $F_{current}$-20%) showed that median SSB in the North Pacific Ocean will likely (>50 probability) increase; the F_{MSY} harvest scenario led to a decrease in median SSB.
2) Median estimated SSB of BSH in the North Pacific Ocean will likely (>50 probability) remain above SSB_{MSY} in the next ten years for all scenarios except F_{MSY}; harvesting at F_{MSY} decreases SSB below SSB_{MSY} (Figure 5E, SC18-SA-WP-06).
3) There remain some uncertainties in the time series based on the quality (observer vs. logbook) and timespans of catch and relative abundance indices, limited size composition data for several fisheries, the potential for additional catch not accounted for in the assessment, and uncertainty regarding life history parameters. Continued improvements in the monitoring of BSH catches, including recording the size and sex of sharks retained and discarded for all fisheries, as well as continued research into the biology, ecology, and spatial structure of BSH in the North Pacific Ocean are recommended.

182. **SC18 noted that recent estimated recruitment was below the average level from the Beverton-Holt stock recruit relationship, and that if these low recruitments persist into the future then the projection results could be overly optimistic.**

3.3 WCPO billfishes

3.3.1 North Pacific striped marlin (*Kajikia audax*)

3.3.1.1 Review of 2022 North Pacific striped marlin stock assessment

183. The Theme Co-Convener noted that the last assessment was conducted by the ISC in 2019 and

presented to SC15.

184. H. Ijima (ISC) presented SC18-SA-WP-07 (*Modelling improvements for the Western and Central north Pacific Ocean striped marlin (Kajikia audax) to be implemented in the benchmark stock assessment in 2023*). The BILLWG addressed the WCNPO MLS stock assessment and achieved consensus on data and model improvements. However, during the intersessional meeting, the BILLWG discussed the reasons for the significant difference between the 2019 and 2022 stock assessment results. Based on this discussion, the BILLWG recognized that the results are most sensitive to biological parameter differences, particularly the growth curve. Sun et al. (2011)[24] concluded that the Richards curve is the best growth assumption for the WCNPO MLS stock. However, in the 2011, 2015, and 2019 stock assessments, the SS3 model could not use the Richards curve directly and as a result the Richards curve of Sun et al. (2011) was transformed into a von Bertalanffy growth curve. In response to a perceived issue with whether the 2022 assessment model could adequately represent growth, the BILLWG agreed to use the standard von Bertalanffy growth curve reported by Sun et al. (2011), although the rationale for the change was not fully documented, and this may have contributed significantly to the differences in the 2019 and 2022 results. The BILLWG noted that SS3 can now use the Richards curve directly and will focus on exploring this option in the next year. If the BILLWG wants to compare to the base case model, then it will need to tune the model to achieve convergence. Depending on the adjustments, the result may change as follows:

i) Converge and get similar results;
ii) Converge and get completely different results; or
iii) Despite adjustments, convergence may not be achieved.

185. Considering these discussions, the BILLWG concluded that the results produced were not a suitable basis for stock status or conservation advice and recommended the following workplan:

i) Present 2022 WCNPO MLS modeling as a work in progress at ISC22 and the August 2022 WCPFC Scientific Committee (SC18) meeting;
ii) Recommend that ISC22 carry forward 2019 stock status and conservation information;
iii) Continue working on the 2022 WCNPO MLS base-case model, with a focus on the growth parameters, particularly incorporating the Richard's four-parameter growth curve directly into the SS model, for presentation to ISC23;
iv) If there is a failure to get a stable and converged model using the Richard's growth curve, the WG would refocus on a von Bertalanffy approach going forward; and
v) Conduct a benchmark assessment of WCNPO SWO building on the 2018 WCNPO SWO assessment for ISC23.

Discussion

186. Niue, on behalf of FFA members, thanked the ISC for their efforts in providing information on the status of the North Pacific Striped marlin. They noted the progress report and the improvements in the analysis and we look forward to a benchmark stock assessment presented at SC19.

187. The EU thanked the presenter and the BILLWG, stating that this is one of the few stocks that can be considered overfished and subject to overfishing, and that there are significant uncertainties that can't be solved prior to the next stock assessment. The EU recommended the BILLWG consider the inclusion of these key uncertainties in its next assessment.

188. The SA Theme Co-Convener confirmed that these issues would be worked on by the BILLWG

[24] Sun C-L., Hsu W-S., Su N.-J., Yeh S-Z., Chang Y-J. and Chiang W-C. (2011) Age and growth of striped marlin (*Kajikia audax*) in the waters off Taiwan: A revision. ISC/11/BILLWG-2/07

over the next year and that they would present a revised stock assessment to SC19.

189. Japan stated it was encouraged by the updates looked forward to receiving the revised stock assessment and advice at SC19.

3.3.1.2 Provision of scientific information

a. Status and trends

190. **The SC18 concurred with the ISC22 Plenary, which reviewed new modelling and data improvements for the Western and Central North Pacific Ocean striped marlin (WCNPO MLS) stock and concluded that this report is a work in progress, but new stock status and conservation and management advice was not available. SC18 stated it looks forward to the ISC BILLWG workplan to explore the growth curve and complete a benchmark WCNPO MLS assessment for approval at ISC23.**

b. Management advice and implications

191. **SC18 agreed that the Conservation and Management advice for North Pacific striped marlin will be carried forward from 2019.**

3.4 Peer Review

3.4.1 Progress of the peer review (Project 65)

192. CCMs agreed that the upcoming results of the peer review will have the potential to affect future stock assessments, and should be discussed in advance of SC19.

Recommendation

193. **SC18 noted that the in-person peer review workshop for the 2020 WCPO yellowfin tuna stock assessment will occur from the 7-13 September 2022 at SPC in Noumea. SC18 agreed that the results of the peer review would be initially considered through the submission of a draft review paper to an online discussion forum later in 2022 with participation by invitation; results of the peer review would subsequently be discussed at the 2023 Pre-assessment Workshop, either by SPC or a peer review panel member, and used to inform the 2023 stock assessment work; and the final peer review outcomes would be presented in a working paper at SC19 by either SPC or, if possible, a peer review panel member.**

3.4.2 Characterization of stock assessment uncertainty

194. **SC18 noted that, related to the characterization of stock assessment uncertainty, a project Terms of Reference for P18X2 (*Further development of ensemble model approaches for presenting stock assessment uncertainty*) was provided in SC18-SA-IP-09, following the request from SC17, and will be considered by the Commission for funding in 2023.**

AGENDA ITEM 4 — MANAGEMENT ISSUES THEME

195. The Management Issues (MI) theme was convened by R. Campbell (Australia), who informed the meeting that 9 working papers would be presented and that a further 14 information papers had also been

prepared, 3 of which were considered in the ODF.

4.1 Development of the Harvest Strategy Framework for key tuna species

196. The MI Theme Convener drew SC18's attention to the following updates made by WCPFC18 to the *Indicative Workplan for the Adoption of Harvest Strategies under CMM-2014-06* (Attachment I, WCPFC18 Summary Report) and the associated tasks for SC18:

- The indicative plan has been extended for an additional two years to 2024.
- South Pacific albacore and skipjack management procedures remain scheduled for adoption in 2022 (no change) and management procedures for yellowfin and bigeye are now scheduled for adoption in 2024 (new).
- TRPs for yellowfin and bigeye are now scheduled for adoption in 2022.
- For South Pacific albacore and skipjack, SC18 was tasked with agreeing on operating models, and providing advice on the performance of candidate management procedures and relevant elements of the monitoring strategy.
- For yellowfin and bigeye, SC18 was tasked with providing advice on the continued development of the multispecies MSE framework..

197. Following the recommendation made by SC17 (para.332, SC17 Summary Report), WCPFC18 agreed to hold SMD01, on a trial basis, back-to-back with SC18; the MI Theme Convener noted that recommendations made by SC18 to the Commission related to the agenda items under the MI theme were likely to be further discussed and reviewed at SMD01.

4.1.1 Skipjack tuna

4.1.1.1 Skipjack tuna TRP analyses

198. The MI Theme Convener noted that WCPFC18 reviewed WCPFC18-2021-10 (*Further updates to WCPO skipjack tuna projected stock status to inform consideration of an updated target reference point*) and noted the importance of agreeing on a TRP for skipjack, and agreed to progress this work in 2022 (Paragraphs 100-101, WCPFC18 Summary Report). He stated that the task for SC18 is to review additional analyses related to estimated fishing mortality and associated assumptions under the various harvest scenarios and provide advice to the Commission for adoption of the skipjack TRP at WCPFC19.

199. Graham Pilling (SPC-OFP) presented SC18-MI-WP-09 (*Further updates to WCPO skipjack tuna projected stock status to inform consideration of an updated target reference point*). This paper was originally prepared for and presented at WCPFC18 in response to recommendations from SC17 (WCPFC18-2021-10). All analyses were based upon the agreed 2019 skipjack assessment and summarised median specified depletion levels of skipjack tuna ($SB/SB_{F=0}$) relative to that in different baseline periods, the change in purse seine effort (scalar) necessary to achieve those levels, resulting median total equilibrium yield (as a percentage of MSY) and the associated risk of falling below the LRP. The foreword to SC18-MI-WP-09 summarises the results of deterministic projections undertaken using the grid of models presented in the 2022 skipjack stock assessment, but does not recommend that those specific results be used as the formal basis for any recalibration of the skipjack TRP given they are based upon deterministic projections only. The foreword also highlights the role of the 'formal stock assessment' and any associated recalibrated TRP value within a monitoring strategy for an adopted management procedure. Noting that the scenarios represented in the operating model (OM) grid will most likely be different from those represented in the most recent stock assessment – given the former focuses on uncertainties that will affect future stock and fishery behaviour, and the latter those that affect historical

status - it will be unlikely that both sets of models provide the same median estimate of stock status (i.e., the basis of the TRP). Using an historical baseline as the basis of the TRP is therefore noted as a useful approach. When using the 'formal stock assessment' to monitor the performance of an adopted MP, the relative performance against that same historical baseline can be used, only this time using the estimates from the stock assessment. In this way the stock assessment can be used to monitor the performance of the MP, even though the absolute estimates of stock status may differ from those of the OM grid.

Discussion

200. The MI Theme Convener asked CCMs to comment on whether SC endorsed the approach and methods employed.

201. Japan noted the need for clarity regarding the MI Theme Convener's suggestion, noting that the largest concern is managers' responses to differing TRP calculations. Japan noted that variations in stock status as calculated through different assessments is expected, but that a formal definition of the TRP is required. Japan recalled that the interim TRP is $50\%SB_{F=0'}$ and that CCMs had discussed that this level should be equivalent to the depletion level in 2012.The 2022 stock assessment reveals depletion at 2012 is around $60\%SB_{F=0}$, which is more than a 10% decrease. If this assessment is adopted this suggests the stock must be recovered by more than 10%. Japan noted the need for a clear proposal regarding what SC will recommend.

202. The MI Theme Convener stated that the definition of the TRP is a management issue, and would be raised in the upcoming SMD01. He inquired whether CCMs felt that any additional information should be passed on by SC to the Commission to enable it to adopt a TRP this year? He noted the issue with the 2022 stock assessment, which could only include deterministic projections at SC18, but asked if anything about the methods that needed to be updated to inform managers in the future.

203. Australia stated that as noted at previous SC meetings, one of the challenges with the specification of TRPs is their possible susceptibility to changes in perceptions of stock status that occur with each successive stock assessment. As has occurred with the 2022 skipjack stock assessment, the biomass depletion time series is rescaled with successive stock assessments undertaken for each of the key tuna species. Australia stated that this will continue to happen for all stocks in the future as assessments are refined and improved; SC has noted this issue in the past and proposed that target reference points be fundamentally specified with reference to a year or set of years and not in more absolute terms such as a biomass depletion percentage. Australia observed that this approach, while not perfect, provides a level of future proofing of the TRP and gives the TRP independence of any one assessment; as noted by SPC in its presentation, this applies to operating models as well where a TRP specified in terms of reference years can remain relevant in relative terms within the OM. The performance of different MPs against that TRP can also remain valid. Australia indicated that this is a very important issue, and proposed that SC18 provide a clear recommendation to the Commission that target reference points should be specified in terms of a reference year or years for skipjack, and in general.

204. Tokelau, on behalf of the PNA and Tokelau, noted that the updated 2022 stock assessment results are considered preliminary and that SPC does not recommend they be used as the formal basis for a recalibration of the skipjack TRP value. They suggested the next step in work on a skipjack TRP is for SPC to revise Table 2 of Working Paper 10 presented to WCPFC18 (WCPFC18-2021-10). They stated that the revision should include the projected outcomes from a set of candidate TRP options ranging from 40% to 60% depletion ratios. Given the changes in the fishery and the healthy stock status indicated in the 2022 stock assessment, PNA and Tokelau requested that the analysis indicate the projected change for the various options from recent depletion levels instead of 2012 levels; they stated that the analysis should continue to assess the change in effort from 2012 levels for the different candidate TRPs as well as 2012 purse seine

effort levels, and the projected impacts on equilibrium yields and the risk of breaching the LRP. SPC confirmed that this could be done once its ongoing software development was complete and the basis of the 2022 stock assessment determined.

205. The EU agreed regarding the use of reference period rather than absolute values. It requested clarification regarding the example comparison shown by SPC of MSE outputs vs. stock assessment outputs. SPC stated that the values shown are relative to the version of the TRP as calculated within the operating models, noting that the absolute values in the stock assessment and those in the operating model grid are different, which would be expected given that the stock assessment looks at historical uncertainty and the operating models at future uncertainty.

206. Japan noted the comment by FFA members and the SPC statement that it recommends that the 2022 results should not be used for recalculation of the TRP; they observed that if the results of the pending stochastic analysis are similar to the deterministic results the stock assessment would indicate the stock is some 10%-15% below the target in 2012, and that this would have to be communicated to managers. Japan noted again that the 2019 stock assessment results indicate depletion at about the 2012 level, with the 2022 stock assessment results currently suggesting depletion is some 10%-15% below that. SPC responded that if the stochastic results were similar the median value would be below the TRP, but noted the need to also consider the range (between the 10^{th} and 90^{th} percentiles), and not simply the median.

207. New Zealand supported the comment by Japan, and stated that it is very important if the 2022 stock assessment is accepted that the TRP be recalculated and the relevant table updated and reported back to SC. SPC clarified that stochastic projections for a catch depend on model software that remains under development, and would not be available until after SC18. SPC stated that it could update the information and provide it to WCPFC19. Tokelau agreed with New Zealand and Japan, and stated that once the 2022 stock assessment was accepted Table 2 of WCPFC18-2021-10 should be updated.

208. The MI Theme Convener noted that some CCMs voiced support to have TRPs based on reference years, which would be consistent with SC's previous advice. He noted the request by the PNA for further analyses to update the document, and stated that if the 2022 stock assessment is accepted the tables will be updated accordingly. He noted that there was also a desire to have the difference between the 2019 and 2022 stock assessment results presented to the Commission.

Recommendations

209. **Noting the Commission is scheduled to adopt a target reference point (TRP) for skipjack tuna in 2022, and the request from WCPFC18 for SC18 to review any additional information on TRPs for skipjack tuna, SC18 reviewed SC18-MI-WP-09 (*Further updates to WCPO skipjack tuna projected stock status to inform consideration of an updated target reference point*).**

210. **SC18 noted that the updated stock assessment for skipjack tuna (accepted by SC18) indicates that the median value of $SB_{recent}/SB_{F=0}$ relative to the spawning potential depletion in 2012 was 0.85. Based on preliminary deterministic projections, the ratio of $SB_{recent}/SB_{F=0}$ to the level of projected equilibrium spawning potential depletion reached under 2012 fishing conditions was 1.00. $SB_{recent}/SB_{F=0}$ relative to the average of these two values, as maybe used to recalibrate a TRP, was 0.93. Alternatively, the ratio of $SB_{recent}/SB_{F=0}$ to the interim TRP of 50%$SB_{F=0}$ is 1.02.**

211. **Several CCMs noted that one of the challenges with the specification of absolute depletion-based TRPs is their possible susceptibility to changes in the perception of stock status when successive stock assessments predict different stock trajectories or levels. To counter this, it was recommended the Commission adopt TRPs specified in terms of a reference year, or a set of years.**

212. **SC18 was informed that the interim TRP for skipjack tuna is 50% of the spawning biomass in the absence of fishing ($SB_{F=0}$) as set out in CMM 2015-06, and while the TRP is still under review, no agreement had been reached at WCPFC18.**

213. **SC18 requested the Scientific Service Provider update SC18-MI-WP-09 (Table 2) to include evaluations based on the 2022 skipjack assessment (the Scientific Services Provider noted that this will need to wait until updates to the current software are completed). This update should be performed using the same settings as SC18-MI-WP-09 and include the projected outcomes from a set of candidate TRP options ranging between 40% to 60% depletion ratios and should continue to assess the change in purse seine effort from 2012 levels for the different candidate TRPs, the change in depletion relative to 2018-2021 average levels, as well as the projected impacts on equilibrium yields and the risk of breaching the LRP.**

214. **SC18 recommended that this update be provided to WFCPF19, and that the Commission take appropriate management action to ensure that the biomass depletion level fluctuates around the TRP (e.g., through the adoption of a harvest control rule).**

4.1.1.2 Skipjack operating models

215. The MI Theme Convener stated that SC18 would review the current grid of operating models that has been developed to reflect important sources of uncertainty and plausible states of nature for WCPO skipjack, and recommend to the Commission an agreed grid of operating models to be used for the skipjack tuna MSE.

216. R. Scott (SPC) presented SC18-MI-WP-01 **(***Operating models for skipjack tuna in the WCPO*). The current grid of operating models has been developed to reflect important sources of uncertainty and plausible states of nature for WCPO skipjack. The grid is based on the 2019 skipjack assessment with some modifications to ensure that uncertainty in both the current status of the stock and its future dynamics are represented. It was noted that it should not be necessary to completely revise the OM grid with new stock assessment, however, some modification of the OM grid may be considered through the monitoring strategy. The OM grid remains unchanged from that presented to SC17.

Discussion

217. Fiji, on behalf of FFA members, noted the settings and configurations of the models that comprise the reference set of operating models for skipjack tuna seem to be working well and have a similar stock trajectory of estimated spawning potential depletion to the provisional results of the 2022 stock assessment. They also noted that the operating model grid should not require updating each time a new assessment is presented, stating this is important considering how depletion levels have fluctuated in each of the last three stock assessments. In that regard FFA members requested that SPC provide advice on whether the observed changes in depletion levels in the last three stock assessments would be sufficient to be categorised as 'exceptional circumstances' in a management procedure. FFA members also stated that they welcome the finding that the use of different models for the management strategy evaluation and the full stock assessment can be accommodated by using an historical baseline to define the target reference point. SPC stated regarding exceptional circumstances that the figures from the uncertainty grid show fairly good overlap, and future projections are within the bounds of uncertainty through the future projection period. SPC stated that in its view this was not the basis for exceptional circumstances, although it could be that some small adjustments would be desirable.

218. Australia stated that SC18 can, and should, adopt a reference set of OMs, and provisionally adopt

a robustness set of OMs (noting this was to be covered under the next agenda item). It stated its general position is that the OMs do not need to be revised, even if new information or data sets become available or substantially different models are developed (e.g. for assessment of stock status), unless new evidence is provided that indicates that population dynamics or key uncertainties are outside of the bounds of that encompassed by the OM sets. It noted that this is essentially the same as the definition of "exceptional circumstances conditions" but in this case it is considered before actually adopting an MP. At an appropriate point OM development should be frozen so the decision making on an MP can proceed; otherwise SC would likely be stuck in a never ending cycle, always waiting on the next assessment and trying to reach some kind of elusive perfection. Australia noted it was looking forward to the remaining skipjack assessment discussions that may have a bearing on this position, but that it did not support a complete revision of the current OM reference set to reflect the grid from this year's assessment. The 2022 assessment provides a slightly different perception of status. Australia noted that the difference in terms of biomass depletion is broadly (but not completely) encompassed by the current OMs and their uncertainty ranges. But importantly Australia noted that the new assessment does not indicate a substantial increased risk to the stock from retaining the current OMs (noting the current OMs are in fact more conservative on this metric). As FFA members noted, Australia indicated it is generally comfortable with the reference set of 96 OMs as currently specified in SC18-MI-WP-01 and noted the broad range encompassed by the axes. Australia addressed the potential update or modification to some axes (growth, tag mixing and effort creep), and inquired if SPC proposed to add these to the reference set of OMs now to include in MP evaluation in 2022 and for the consideration by WCPFC19? It noted that this appeared unfeasible this year, and questioned if these could these be considered in coming years, or as robustness tests? SPC stated the axes of uncertainty in the current grid include a growth axis, and consider two growth models (under the 2019 stock assessment). Those have been revised for the 2022 stock assessment. There are two axes for effort creep in the reference set, and three in the robustness set; these apply only for the purse seine fishery, but adding the pole and line fishery could be considered. Regarding mixing periods, an analysis will determine whether this has been captured accurately or needs to be altered in view of the 2022 stock assessment. Thus many areas of uncertainty are already covered; the question is whether the bases of those assumptions and the details remain appropriate. SPC stated it would look to make any changes and present these to SC19.

219. In response to a query from Japan as to when updated results would be available, SPC confirmed that it was not feasible to present the revised analyses quickly, given the computing time required. Japan noted the final recommendation in the presentation (inviting SC to note that the use of different models for the MSE and full stock assessment can be accommodated by using an historical baseline to define the TRP) and asked how this is done in practice? Japan referenced the illustration of the skipjack MSE uncertainty grid, and noted that the target changes under the new stock assessment. Japan inquired how the MPs tested under the old stock assessments would operate if the 2022 stock assessment was accepted. SPC stated the illustration in question was for one candidate MP, noting that many show similar behaviour, and fall within the bounds of uncertainty that are assumed. SPC stated that SC had observed how the results of stock assessments can fluctuate and be scaled. The MSE illustration indicates that had WCPFC adopted the illustrated approach the results would be about as expected (noting that small deviations from the median are expected). Japan also inquired whether SPC would update the OM to include three more years of data, and how the recruitment period was chosen, noting the 1980 recruitment (that featured low recruitment) was not chosen. SPC stated the period was 1982-2018, which is similar in outcome to 2005-2018. Recruitment prior to that was not included because the stock assessments didn't include recruitment. SPC noted that adding three years would not lead to a substantially different result, or choice of management procedure.

220. The USA stated it supported including some recent research on effort creep in the pole and line fishery in a robustness test, especially given the 2022 stock assessment discussion at SC18. Echoing the concern that Japan raised given the two TRPs being used, the USA stated that if a historical period is used

to define the TRP, and the trajectories are different, it could change perception of stock status relative to the TRP.

221. In reply to an inquiry from Australia, SPC stated that further considerations of the axis of uncertainty were unlikely to change the selection of a management procedure.

222. Japan asked SPC for its thoughts on developing criteria for determining when exceptional circumstances exist. SPC stated that this would be addressed under agenda Item 4.1.1.4, which would consider SC18-MI-WP-03 that looks at a dry run for a candidate management procedure.

223. Tokelau, also on behalf of the PNA, stated that Commission must adopt a skipjack MP in 2022 so needed to adopt OMs at SC18; they supported Australia's comments that SC not make major changes to OMs.

224. The USA stated that the configuration of the uncertainty grid in Table 1 of SC18-MI-WP-01 is a good first step. USA would be interested in future analyses to account for probable impacts of climate change on skipjack productivity, and noted the link to ENSO, which may be changing as a result of climate change.

225. Japan noted the need to consider the OM at SC18 in addition to the 2022 stock assessment. Japan recalled discussions on recruitment with respect to the 2022 skipjack assessment, and that the two time periods used for recruitment have very similar levels. Japan inquired if the MPs respond properly to low recruitment, and inquired about testing this response in the main framework or as a robustness test. SPC confirmed that the two recruitment scenarios have a similar level but stated that a key factor is the level of uncertainty. The aim is to capture climate change and ENSO effects within the robustness set of scenarios. There are no major impacts from El Nino conditions in the short term, but there may be some indicators from the warm pool that have been missed. In terms of recruitment there are some indicators in the reference set and are SPC is considering others in the robustness set. Japan noted the need to consider scenarios with reduced recruitment (regardless of whether this actually happens). The USA agreed with Japan, and noted that this is an important point. It stated that the ocean system is experiencing non-stationary conditions, with a forcing function that is not flat or stationary, and that the consideration of negative potential levels of recruitment is a good test. ENSO phenomena may increase in frequency, which could impact recruitment dynamics. The USA suggested the need to be proactive and look at both positive and negative impacts of climate change over a 5-10 year period.

Recommendations

226. **Noting the Commission is scheduled to adopt a management procedure (MP) for skipjack tuna in 2022, and the request from WCPFC18 for SC18 to review and recommend an agreed grid of operating models (OMs) that reflect important sources of uncertainty and plausible states of nature for WCPO skipjack, SC18 reviewed SC18-MI-WP-01 (*Operating models for skipjack tuna in the WCPO*).**

227. **SC18 noted the settings and configurations of the models that comprise the reference set of OMs for skipjack tuna are working well. While there were some differences, the range of uncertainty in the trajectories of spawning potential depletion estimated by the reference set spanned the results of the 2022 stock assessment, especially in recent years. Noting that stock assessments focus on historical uncertainty while OMs focus on future uncertainty, updating the reference set of OMs to be based on the 2022 assessment was unlikely to result in any changes in the relative performance of candidate MPs.**

228. **SC18 also noted that the OM grid should not require updating each time a new assessment is accepted unless new evidence is provided that indicates that population dynamics or key uncertainties are substantially outside of the bounds of that encompassed by the OM sets. Such an instance would be covered under exceptional circumstances.**

229. **SC18 also noted that further expansion of the axes of uncertainty at this time, as suggested by some CCMs, would unlikely change the relative performance of candidate MPs.**

230. **SC18 agreed to accept the reference set of 96 OMs as currently specified in SC18-MI-WP-01, noting the broad range of uncertainty encompassed by the grid axes, and recommended this reference set be adopted by WCPFC19.**

231. **SC18 agreed, and recommended to WCPFC19, to provisionally adopt the robustness set of OMs as listed in Table 1 of SC18-MI-WP-01, noting that SC18 also discussed expanding this set of models to include additional uncertainties. These included models that could account for effort-creep in the Japanese pole-and-line fisheries, likely changes on skipjack productivity due to the impacts of climate change, and a lower productivity (lower recruitment) 'stress test'. This further work is an integral part of the MSE and will be presented to SC19 and where possible key elements will be presented to WCPFC19.**

232. **Noting that the Commission is scheduled to adopt a monitoring strategy for skipjack tuna in 2023, SC18 noted that further discussion will be undertaken at SC19.**

4.1.1.3 Skipjack management procedure (MP) and evaluations

233. The MI Theme convener noted that WCPFC18 agreed to defer consideration of management procedures for skipjack until 2022. SC18 would review further progress undertaken by SPC on developing and testing the performance of candidate management procedures for WCPO skipjack (in particular candidate HCR designs), evaluations of performance indicators, procedures for selecting the 'best performing' MP, definition of fisheries and fishery controls within the harvest strategy, any other technical issues to be addressed in selecting preferred MPs, and recommend any agreed approaches to the Commission.

234. R. Scott (SPC) presented SC18-MI-WP-02 (*Evaluations of candidate management procedures for skipjack tuna in the WCPO*) and SC18-MI-IP-12 (*Consideration of the robustness set of operating models for skipjack tuna in the WCPO*), the latest information on the MSE framework for WCPO skipjack tuna. It provides an overview of the framework and a summary of the results of recent evaluations of candidate management procedures. The modelling framework is well advanced and has changed very little from that presented to SC17. Specific details of the framework are provided in the appendices of the report including information on how to access the input data and code used to run the evaluations. The results presented in this report include a number of harvest control rules that have been proposed by members. The results of all evaluations are available online at https://ofp-sam.shinyapps.io/pimple2022/.

Discussion

235. Fiji, on behalf of FFA members, noted the information on the testing of candidate management procedures for skipjack tuna and SPC's continued development of the PIMPLE software package, stating the latter to be particularly useful in identifying several candidate harvest control rules that could be used in a skipjack tuna management procedure. FFA members noted the limited ability of the current suite of performance indicators to distinguish between candidate harvest control rules, and supported the

development of an overall performance measure that would allow for alternative weighting of indicators. They also supported running the MP every three years, as it replicates, more or less, the timescale of the current assessment cycle for WCPFC tuna stocks and fisheries.

236. Japan noted SC had discussed the kinds of indicators needed, and that some indicators could not be included, despite interest in them on the part of CCMs. Japan noted that in constructing HCRs, the target is based on the 2019 stock assessment, and stated that this target can change based on the stock assessment. Japan suggested rather than constructing the HCR based on a particular assessment that it should be made relative (to, for example, the 2012 depletion value). Japan suggested that SC make a recommendation to the Commission, as follows:

> SC18 recommends that WCPFC19 notes that the current candidate MPs are evaluated against the 2012 depletion ratio calculated from the current OM grid that is based on 2019 assessment, which is about 42%$SSB_{F=0}$, and cannot be automatically modified to a different target level when future assessments show different level of depletion for 2012.

Japan also stated that it lacked full support from its stakeholders for using effort control for purse seine fisheries while employing catch control for other fisheries. Japan noted it did not oppose the current structure but did not have full support domestically for this approach.

237. The USA posed two questions:

(i) The USA noted that all HCRs allow for some level of fishing mortality below the LRP (in the table 20% of the catch/effort multiplier), and asked for the rationale? SPC stated that the idea is that the fishery should not be closed, because then all sources of information on what is happening are lost, thus some low level of fishing is allowed even with low stock levels. SPC stated that in reality the fishery does not reach this level, because the purpose of the HCR is to keep the stock at a safe and sustainable level. Thus, this is theoretical, and almost never happens.

(ii) The USA stated that in looking at HCRs, it was difficult to tell where the threshold points are if they are not at 20% or the dotted line of 42%, and asked if this could be provided in the PIMPLE App, noting this might help in explaining this to managers. The USA also echoed Japan's concerns regarding reference years, and asked how the shape of the HCR would be affected if it changes from period to period? SPC stated that in explaining the TRPs to managers, it tends to focus on the relative performance of the MPs, rather than on the shape; the focus is on whether an MP achieves the desired performance, based on the indicators.

238. Australia stated that if the current OM grid was agreed, Australia would be broadly happy that SC18 can provide advice to the Commission on the performance of candidate MPs for skipjack according to SC18-MI-WP-02 and also through the PIMPLE tool. It noted and supported the current set of performance indicators, which includes those that can be estimated within the MSE framework, but also noted there are additional agreed performance indicators that are important, and that will need to be reported on through the monitoring strategy after an MP is adopted (it noted SC15-MI-WP-03). Australia also noted that some of the many MPs under consideration have very similar performance, which may make choosing one difficult. Australia stated that SC's role is not to recommend a particular model but to furnish the Commission with the tools to do so, but stated that on biological grounds none of the candidate MPs should be recommended for rejection by SC18 on the basis of LRP risk. Regarding PIMPLE, Australia suggested that the "compare performance" button could take users to the box plots by default (rather than the bar charts) to ensure the uncertainty (which is a key aspect of comparing performance) is not missed. It noted that it could be too late to change this given that users have become familiar with the app. Australia suggested that robustness testing also be included in PIMPLE. Regarding the robustness set, Australia proposed that SC18 provisionally adopt a robustness set of operating models (covered in SC18-MI-IP-12) noting that these can be added to as needed through time. It supported the inclusion of the following as specified in SC18-MI-IP-12:

- Model error in hyper-stability
- Implementation error in effort creep (USA proposal?)
- Alternative assumptions for archipelagic water catches (new)

Australia also welcomed discussion and potential inclusion of additional models within the robustness set.

239. Tokelau, on behalf of the PNA and Tokelau, stated its understanding that SC18-MI-WP-02 evaluates differing MPs, including HCRs, and that SC18, in providing advice to the Commission on progressing a harvest strategy for skipjack, should recommend the HCRs that could be considered for evaluation. PNA and Tokelau suggested HCR 9 for assessment as reflected in the PIMPLE tool, noting it would need to be adjusted in terms of the centre of the step being at whatever the depletion ratio level is associated with the revised TRP. They stated that other CCMs may have other HCRs that they would like to see considered. PNA and Tokelau noted that HCR 9 allows some fluctuation around the TRP level to account for variability in outcomes and allows for a deceleration of the fishery on the downward trajectory, in a manner that allows for management action to take effect. HCR 9 also allows for increases in the fishery if consecutive assessments show improvements in the underlying spawning stock biomass. PNA and Tokelau stated they provisionally agreed regarding the proposed robustness set.

240. The EU inquired about how the hyperstability and effort creep scenarios have been implemented, and whether the increased values in the robustness tests have been applied in the projection phase only or if they have been used to condition the OMs? SPC stated that effort creep is applied into the future but not taken into consideration in this component. The EU noted that the presentational work would be key for the development of the SMD and for the Commission decisions. Regarding the impact of using a TRP based on a reference period instead of on absolute values, the EU stated its understanding is that there should be no difference, as long as there are no strong retrospective patterns in the OM grid; the merit of using a reference period is that it might provide consistency between the OMs and the monitoring strategy. SPC stated that, regarding concerns about using a TRP based on a reference period rather than an absolute value, that in the absence of a strong retrospective pattern in the reference grid it is valid. SPC noted that diagnostics and model outputs are available in the online app (https://ofp-sam.shinyapps.io/hierophant/, under the "model consistency tab"), while SC16-MI-IP-07 provides an overview of a common set of diagnostics and model outputs for MULTIFAN-CL, and presents a simple user interface for exploring the diagnostic outputs of the grid of OMs that form the basis of the evaluations.

Recommendations

241. **Noting the Commission is scheduled to adopt an MP for skipjack tuna in 2022, and the request from WCPFC18 for SC18 to review further progress on developing and testing the performance of candidate MPs for WCPO skipjack, SC18 reviewed the analyses included in SC18-MI-WP-02 (*Evaluations of candidate management procedures for skipjack tuna in the WCPO*).**

242. **SC18 thanked the Scientific Service Provider for the latest information on the testing of candidate MPs for skipjack tuna and noted that the continued development of the PIMPLE software package had been particularly useful in evaluating candidate harvest control rules (HCRs). However, noting the similar performance of many candidate HCRs, and the limited ability of the current suite of performance indicators to distinguish between them, SC18 expressed support for the development of an overall performance measure that allows for alternative weighting of indicators. Inclusion in PIMPLE of information on the values of the threshold points in each HCR was also supported. It was also suggested that the "Compare performance" button should go to the box plots by default (rather than the bar charts) to prioritize the display of uncertainty (a key aspect of comparing performance).**

243. **One CCM also suggested that the results of robustness testing be included within PIMPLE and welcomed discussion and potential inclusion of additional models within the robustness set.**

244. **Several CCMs supported running the MP every three years, as it replicates, more or less, the timescale of the current assessment cycle for WCPFC tuna stocks. However, the additional burden this would place on the Scientific Services Provider, and also on WCPFC members providing supporting analyses, was noted.**

245. **One CCM recommended that WCPFC19 note that the current candidate MPs are evaluated against the 2012 depletion ratio calculated from the current OM grid that is based on 2019 assessment, which is about 42%$SB_{F=0}$, and cannot be automatically modified to a different target level when future assessments show a different level of depletion for 2012. SC18 noted the earlier explanation of the Scientific Services Provider on how performance relative to the TRP can be used when evaluating performance. This CCM also expressed their concern about having effort control for purse-seine fisheries while other fisheries are controlled by catch.**

246. **SC18 noted that additional agreed performance indicators will need to be reported on through the monitoring strategy after an MP is adopted. In this regard one CCM also supported the future development of a performance indictor for measuring the impact on small-scale fisheries.**

247. **SC18 noted that all candidate HCRs should allow for minimal fishing mortality below the LRP as part of their initial design as completely closing the fishery would result in information loss, preventing ongoing assessment of the status of the stock. SC18 further noted that, from the results of the evaluations, the likelihood of the stock falling below the LRP was extremely small.**

248. **SC18 agreed that the framework necessary for evaluating candidate MPs for skipjack tuna is now fully established and ready for consideration by the Science-Management Dialogue and WCPFC19 for the adoption of an MP on schedule in 2022. However, SC18 did not see that its role was to recommend any particular MP but to furnish the Commission with the tools to do so, and noted the use of the PIMPLE tool for this purpose. Nevertheless, SC18 noted that on biological grounds none of the candidate MPs should be recommended for rejection on the basis of LRP risk. SC18 also noted that there will be further discussion concerning MPs for skipjack at the upcoming Science-Management Dialogue.**

4.1.1.4 Skipjack MP implementation

249. The MI Theme Convener noted that SPC would present a skipjack MP 'dry run' analysis to illustrate the function, performance, and implications of a hypothetical management procedure, and to show how the latest stock assessment would be used to monitor performance of the MP; he requested that SC18 review the analysis related to the monitoring strategy indicators and provide any technical advice and recommendations to the Commission.

250. R. Scott (SPC) presented SC18-MI-WP-03 (*WCPO skipjack management procedure: dry run*), SC18-MI-IP-13 (*Functions of the monitoring strategy for WCPO skipjack*) and SC18-MI-IP-14 (*Data collection programme to support a management procedure for WCPO skipjack tuna*) describing a skipjack MP 'dry run' analysis to illustrate the function, performance, and implications of a hypothetical management procedure. The analysis also showed how the latest stock assessment would be used to monitor performance of the MP. The presentation also outlined in broad terms the components of a monitoring strategy and the elements of a data collection programme to support the WCPO skipjack MP.

Discussion

251. In response to a query from the EU, SPC stated that in looking at the estimation model the only

value of interest is the terminal level of stock status, which is fed into the HCR and determines the catch and effort; the interim information is not used.

252. Tuvalu, on behalf of FFA members, stated that the skipjack tuna management procedure 'dry run' analysis was extremely helpful in illustrating the function, performance, and implications of a hypothetical management procedure, and that it was very pleasing to note that based on the analyses presented, there was sufficient data in the monitoring strategy to generate the inputs to run the estimation method and to provide a reliable estimate of stock status. They stated that this was a step forward in the development of a skipjack tuna MP that would hopefully make it easier to select and adopt an MP at WCPFC19. Regarding the monitoring strategy, FFA members stated that they prefer that the full stock assessment and MP are run in different years to provide a more defined separation between the processes of running the management procedure to set new management levels, and running the full stock assessment to monitor the performance of the management procedure.

253. The USA stated that the authors noted it is critical to accurately document the estimation model setup and assumptions, and observed this had been done for the most part, but that there is a lack of documentation of how natural mortality at age was treated in the estimation model in SC18-MI-WP-03. The USA also noted that there is also a moderate mismatch between the fixed growth curve used in the estimation model in SC18-MI-WP-03 and the treatment of growth in the now accepted 2022 skipjack stock assessment (which asserts 2 growth sub-models: an internally estimated and an externally estimated growth curve). The USA noted that this mismatch, along with other differences between the estimation model in this analysis and the 2022 assessment ensemble, lead to some differences between the MSE and 2022 assessment results, raising the question of whether the estimation models put forward in the dry run trial MP and in the 2022 assessment are consistent enough to provide a robust estimation for the ongoing MP analyses for skipjack, as shown in Figure 22 of SC18-MI-WP-03, and if the match between estimation models could be improved by using a different treatment of growth in either the MP estimation or MSE model versus in the draft stock assessment? The USA stated it would be useful to provide further explanation of the apparent differences shown in Figure 22. SPC stated that Figure 22 shows only the OM and 2022 assessment; the estimation model is not shown because it doesn't make sense to compare it, given that the final stock status is the only value of interest. SPC noted that the estimation model is part of the MP. If the estimation model is changed, this could be compensated for by changing the HCR. The coordinated output of the estimation model and the HCR determine whether the MP is successful or not, and this is reported through the indicators.

254. The EU noted that for the MP only the terminal year of estimation model is used, and inquired if the TRP is reformulated based on the reference period, would this not require recalculation of the entire trend? SPC stated that the TRP consideration is based on the most recent stock assessment and the OM grid, and the future projections under that grid, and that the estimation model doesn't feed into the TRP considerations.

255. Japan noted the identification of what constitutes "exceptional circumstances" is an integral component of the monitoring strategy, and inquired how exceptional circumstances criteria could be developed. SPC suggested the criteria should not be too prescriptive, but should include (i) data availability — meaning can the MP be run? — noting that if important data are missing and the estimation model or the MP can't be run, this would constitute an exceptional circumstance; and (ii) if the MP misbehaves, and doesn't perform as expected.

256. Australia stated that as noted by others it is pleasing to see no substantial issues identified in the trial implementation of the specified MPs. Regarding exceptional circumstances, Australia noted the draft definition and processes surrounding exceptional circumstances that were posted under ODF Topic 17, and

stated that its general position is that exceptional circumstances should be defined in relatively simple and broad terms and avoid being overly prescriptive because there is a need to retain flexibility to adapt to different situations that can occur; SC should not seek to prescribe all situations that may arise. The proposed exceptional circumstances text under Topic 17 of the forum follows this approach and Australia stated it generally supported it, and stated that such text would be necessary to include in a CMM for a skipjack management procedure. Regarding the broader monitoring strategy, Australia noted that, under the Indicative Harvest Strategy Workplan the Commission is scheduled to adopt the full monitoring strategy for skipjack in 2023. This was deliberately scheduled for one year after the adoption of the management procedure in 2022 to try and balance the workload of the SSP and the SC. Hence, Australia is expecting a more in-depth discussion of the wider skipjack monitoring strategy at SC19. This will include mechanisms for the collection of data for the range of agreed performance indicators not generated by the MSE framework (such as economic performance indicators).

Recommendations

257. **Noting the Commission is scheduled to adopt an MP for skipjack tuna in 2022, SC18 reviewed an example of how a skipjack MP could be implemented to illustrate the function, performance, and implications of a hypothetical MP as outlined in SC18-MI-WP-03 (*WCPO skipjack management procedure: dry run*).**

258. **SC18 thanked the Scientific Service Provider for the 'dry run' analysis and agreed that it was very helpful in illustrating the function, performance, and implications of a hypothetical MP.**

259. **SC18 noted that based on the analyses presented, there was sufficient data in the monitoring strategy to generate the inputs to run the estimation model and to provide a reliable estimate of stock status. As the estimation model is part of the MP, this was seen as a step forward in the development of an MP for skipjack tuna which should make it easier to adopt an MP by the end of 2022.**

260. **SC18 also noted that the estimation model is based on fixed parameter settings and that only the stock status in the terminal year of the estimation model is used in the MP. It is the combined output of the estimation model and the harvest control rule that determines the performance of an MP.**

261. **Several CCMs supported undertaking the full stock assessment and running the MP in different years in order to separate the processes of running the MP to set new management levels, and running the full stock assessment to monitor the performance of the MP.**

262. **Noting that a monitoring strategy for skipjack tuna is scheduled to be adopted by the Commission in 2023, SC18 supported further discussion on this issue at SC19, including mechanisms for the collection of data for the range of agreed performance indicators not generated by the MSE framework (such as economic PIs). Several CCMs also noted that exceptional circumstances should be defined in relatively simple and broad terms and avoid being overly prescriptive as flexibility is needed to adapt to future unpredictable situations. It was noted that draft exceptional circumstances text submitted to the ODF under Topic 17 (SC18-MI-IP-03) generally conformed with this approach.**

4.1.2 South Pacific albacore tuna

4.1.2.1 South Pacific albacore TRP

263. The MI Theme Convener stated that WCPFC18 noted (i) SC17's advice related to recalibration of the interim TRP for South Pacific albacore (Para. 171, WCPFC18 Summary Report) and (ii) concerns

regarding the delayed process to implement an interim TRP adopted in 2018, and the need to take action to rebuild the stock to support the economic viability of fleets and achieve a long-term TRP (Para. 195, WCPFC18 Summary Report). He noted that SC18 would review the updated analyses related to the recalibration of the interim South Pacific albacore TRP with the objective of advising the Commission for further consideration at WCPFC19.

264. Graham Pilling (SPC OFP) presented SC18-MI-WP-04 (*Further analyses to inform discussions on South Pacific albacore objectives and the TRP*). SC17 requested that the TRP be recalibrated based upon the new assessment of this stock agreed in 2021. Those results were presented to WCPFC18 and indicated that to achieve the objective of longline catch rates 8% higher than those in 2013, a greater catch reduction was required than previously estimated. At the Commission meeting, it was clear that those reductions were not acceptable for managers. The South Pacific albacore Roadmap Chair requested further analyses to help inform discussion and clarify manager's objectives for the fishery. SC18-MI-WP-04 therefore presents stock and fishery outcomes of different potential future changes in longline and troll catches in the WCPFC Convention Area (WCPFC-CA) or South Pacific-wide to highlight trade-offs between objectives involved in alternative 'candidate TRP' levels in terms of catch reductions and increases in vulnerable biomass (a CPUE proxy) of the WCPO southern longline fishery. Results where changes in catch are within the WCPFC-CA region only are summarised in the table. Management of catches across the whole of the South Pacific allows comparable increases in vulnerable biomass to be gained with slightly smaller reductions in WCPFC-CA catches. The paper recommends that desired changes in the fishery are pursued through the application of a tested management procedure within the harvest strategy approach.

Discussion

265. Vanuatu, on behalf of FFA members, suggested 10% and 20% reduction from the 2017-2019 baseline for consideration as additional performance indicators to clarify management objectives. Regarding development of a potential MP across the South Pacific, FFA members sought further guidance from SPC on how such an MP is to be developed and its potential implications, for example in the case of the EPO, which is outside of the WCFPC's jurisdiction. It noted that while the work could be progressed by looking at testing the MP across the entire South Pacific the Commission must be aware of the implications when entering into management discussions. SPC stated the situation was similar to what has been done for skipjack, where the archipelagic waters are not controlled by the MP; in the example for albacore the MP would only control fishing in WCPO fisheries while catch or effort in the EPO would remain stable. This would show how a management procedure applied to the WCPFC only would perform in those conditions.

Recommendations

266. **Noting the concerns expressed at WCPFC18 regarding the delayed process to implement an interim TRP adopted in 2018 and the need to achieve a long-term TRP, and the request from WCPFC18 for SC18 to review any additional information on TRPs for South Pacific albacore tuna, SC18 reviewed the information in SC18-MI-WP-04 (*Further analyses to inform discussions on South Pacific albacore objectives and the TRP*).**

267. **SC18 noted the implications of a potential MP to be developed across the South Pacific, particularly with the areas outside of the WCPFC jurisdiction, and sought advice on how an MP that only applied to the WCPO could be developed. The Scientific Service Provider explained that this could be undertaken in a similar manner as done for skipjack tuna, where fishing in WCPO archipelagic waters is not controlled by the MP. The MP would be designed so it only applied to the WCPO, and not to the EPO.**

268. **Noting the request for additional catch scenarios to inform management options to clarify management objectives, several CCMs suggested a 10% and 20% reduction in catch from the 2017-2019 baseline for consideration.**

269. **SC18 recommended forwarding this updated working paper to WCPFC19 for its deliberations on alternative target reference points for south-Pacific albacore tuna.**

4.1.2.2 South Pacific albacore operating models

270. The Theme Convener stated SC18 would review the current grid of operating models that has been developed to reflect all important sources of uncertainty and plausible states of nature for South Pacific albacore and try to reach agreement on the grid of operating models to be used for the SP albacore tuna MSE.

271. R. Scott (SPC) presented the first part of SC18-MI-WP-05 (*Progress update and technical challenges for the South Pacific albacore MSE framework*), outlining the work conducted to date to develop harvest strategies for South Pacific albacore. With regards the choice of OM grid, the stock assessment uncertainty grids are considered to represent the best available information on the stock and fishery dynamics and provide the most appropriate basis for the OM grid reference set. Either the 2018 or the 2021 model grids could be selected. This choice largely depends on whether EPO fishing activity is considered important and necessary to include in the MSE framework.

Discussion

272. Tonga, on behalf of FFA members, noted the progress of the work and sought guidance from SPC on whether the OM grid had to be determined in 2022, stating that in their view more time is needed. They noted their prior comment regarding development of an MP across the South Pacific, and sought guidance from SPC on whether this meant the 2021 grid is not suitable as a basis for the OM grid? SPC stated that the work would continue to try to identify the best parameter space for the OM grid to operate as well as some further issues requiring research and ongoing work. Some are quite difficult to address, for instance the issue around the retrospective patterns. How much of a problem it will be for MSE evaluations is uncertain. In the context of stock assessments it indicates data conflicts, but when it comes to evaluating future performance in a MSE framework the impact on performance still needs to be investigated. SPC noted there is ongoing work in a number of areas. If SC18 does not make a decision SPC will have to proceed with both the 2018 and 2021 models, which limits the progress that can be made.

273. Australia stated its view that SC18 was not in a position to definitively agree on the OMs for albacore at SC18 because it is first necessary to ask the SMD/Commission whether they wish to consider the EPO impacts in their decision making. Australia stated its proposal is for SC18 to explain the two options (2019 or update to 2021) to the SMD/Commission along with the strengths and weaknesses of each approach. SC18 should specify an OM grid for both of these options so there is a clear way forward for this work no matter which pathway is decided upon. This would be efficient and allow the work to continue. The grids would be as follows: Option 1: the 2019 grid with addition of a movement axis (if this is practical) + effort creep and hyperstability, or alternatively Option 2: the 2021 grid with addition of a CPUE axis (if this is practical) + effort creep and hyperstability.

274. The USA noted that both of the options proposed by Australia exhibit some retrospective bias. Since this retrospective bias is a persistent feature of both South pacific albacore modelling efforts, it seems that adjustment of terminal estimates to account for retrospective bias in projections might be included as another axis of uncertainty, i.e., with or without bias adjustment. Option 1 would support the 2018 treatment

of uncertainty, which appears to underestimate the complexity of the South Pacific albacore fishery system dynamics because it does not account for the uncertainties in movement-based and spatial recruitment distribution and also lacks information on the EPO impacts.These considerations suggest that modifying both Options 1 and 2, with inclusion of additional axes of uncertainty for movement or CPUE along with retrospective bias adjustment, may be a positive way to proceed.

275. Chinese Taipei supported the recommendation from Australia that the OM should fully address all sources of uncertainty, and especially uncertainty in CPUE. It stated that standardised CPUE had issues in the South Pacific albacore assessment, potentially having to do with time varying catchability and the effect of La Nina on catch rates. CPUE uncertainty should be included in the 2021 grid and fully accounted for in the operating model.

Recommendations

276. **Noting the Commission is scheduled to adopt an MP for South Pacific albacore tuna in 2022, SC18 reviewed the current grid of OMs that has been developed to reflect all important sources of uncertainty and plausible states of nature for South Pacific albacore as outlined in SC18-MI-WP-05 (*Progress update and technical challenges for the South Pacific albacore MSE framework*).**

277. **SC18 noted the two alternative sets of OMs listed in Table 1 of SC18-MI-WP-05 – one based on the 2018 assessment (WCPO area only) and one based on the 2021 assessment (including the EPO) – but also noted that it was not able to definitively agree on the reference set of OMs for South Pacific albacore tuna because it was necessary for the Commission to decide whether or not to consider the impacts of fishing within the EPO in their decision making. Nevertheless, SC18 agreed to specify an OM grid for both options so there is a clear way forward for this work pending the Commission's decision.**

278. **SC18 noted the axes of uncertainty currently outlined in each set of OMs and recommended that additional axes be considered for inclusion in each (if practical). For the 2018 grid a movement axis should be considered, while for the 2021 grid the addition of an axis exploring CPUE uncertainty should be considered. For both grids, axes examining effort creep and hyperstability should be explored.**

279. **One CCM also noted that both options exhibit some retrospective bias and suggested that adjustment of terminal estimates to account for retrospective bias in projections might be included as another axis of uncertainty (i.e., with or without bias adjustment).**

280. **SC18 sought advice from WCPFC19 on whether the impacts of fishing within the EPO need to be included in a set of OMs for South Pacific albacore tuna, and recommended that both the Science-Management-Dialogue and the Commission note the further additions recommended to the alternative sets of OMs.**

4.1.2.3 SP Albacore management procedures

281. The Theme Convener stated that SPC would provide an update on the progress of developing and testing MPs for South Pacific albacore to inform SC18's review and discussion of the methods for estimating stock status and candidate HCR designs, fishery definitions and controls within the harvest strategy, and other technical issues to be addressed in selecting preferred MPs. He noted that the MSE for skipjack is fairly developed at this point but SPC is still seeking guidance from SC on several issues for South Pacific albacore, and that there was an opportunity to provide feedback to guide the development of MSE for SP albacore.

282. R. Scott (SPC) presented the second part of SC18-MI-WP-05 (*Progress update and technical challenges for the South Pacific albacore MSE framework*). Following guidance from SC17, recent work to develop management procedures for South Pacific albacore has focussed on model-based approaches. An approach for implementing model-based MPs was illustrated along with HCR designs that manage a stock towards a target whilst constraining catch reductions over time. Further work will be undertaken to further develop this approach.

Discussion

283. Fiji, on behalf of FFA members, noted the progress on the development of candidates HCRs and the MPs by the SSP, and suggested that candidate HCRs for South Pacific albacore be adapted from the candidates already considered for skipjack.

Recommendations

284. **Noting the Commission is scheduled to adopt an MP for South Pacific albacore tuna in 2022, SC18 reviewed the progress on developing and testing MPs for South Pacific albacore tuna as outlined in SC18-MI-WP-05 (*Progress update and technical challenges for the South Pacific albacore MSE framework*).**

285. **SC18 noted the progress on the development of MPs using model-based approaches (SPiCT[25]) for South Pacific albacore tuna and recommended that candidate HCRs for this species be adapted from those already considered for skipjack tuna.**

286. **SC18 recommended that both the Science-Management Dialogue and WCPFC19 take note of the progress to date on the development of an MSE framework for South Pacific albacore tuna and that further work is required prior to adoption of an MP.**

4.1.3 Mixed fishery MSE framework

287. The MI Theme Convener noted that SC17 reviewed an update on the development of mixed fishery MSE framework outlined in SC17-MI-WP-05 (*Mixed-fishery harvest strategy developments*), which demonstrated an initial attempt at considering multi-species and mixed fisheries interactions based on single stock operating models for skipjack, bigeye and yellowfin. This proof-of-concept analysis demonstrated that the technical challenges involved in implementing the multi-species modelling framework can be addressed and the conceptual approach remains tractable. SC17 further endorsed the work outlined in SC17-MI-WP-05 and noted the next steps to progress this work, including i) building a full suite of OMs for bigeye and yellowfin, ii) developing candidate MPs for bigeye for the tropical longline fishery, iii) the inclusion of South Pacific albacore in the modelling framework, and iv) agreeing multi-species performance indicators (Paragraph 320, SC17 Summary Report). Considering the complexity of developing the mixed fishery MSE framework in the WCPO, SC18 was requested to review the progress of this approach and provide specific feedback on the approaches for mixed fishery interactions.

4.1.3.1 Bigeye and yellowfin tuna TRP analyses

288. The MI Theme Convener stated that WCPFC18 reviewed the results of the analyses on candidate TRPs for bigeye and yellowfin (WCPFC18-2021-11: *Updated WCPO bigeye and yellowfin TRP*

[25] Stochastic Production model in Continuous Time

evaluations), and having noted the importance of agreeing on TRPs for bigeye and yellowfin, agreed to progress this work in 2022. He reminded SC18 that the Commission was due to adopt TRPs for bigeye and yellowfin in 2022 and that SC18 had been requested to review any updated information on TRPs for bigeye and yellowfin tuna for the Commission's consideration at WCPFC19. He noted that there was no working paper to be presented against this agenda item, but referred to SC18-MI-IP-04, which had also been presented to WCPFC18. This paper is very similar to the working paper reviewed by SC17 but was expanded to include South Pacific albacore in the TRP evaluations. He noted that no further analyses had been undertaken on this issue.

Recommendations

289. **Noting the Commission is scheduled to adopt a TRP for both bigeye tuna and yellowfin tuna in 2022, that the results of the analyses on candidate TRPs for bigeye and yellowfin had been reviewed by SC17 and presented to WCPFC18, and noting that no further analyses had been undertaken since, SC18 was unable to provide any further advice or recommendations to the Commission on this issue and reiterates the advice provided by SC17, as follows (subparagraphs i-v below):**

- **(i) SC17 noted that these analyses (see SC17-MI-WP-01) reflected the original request made by SC16, and the additional request by the Commission for additional information. SC17 also noted the usefulness of these updates as they facilitate an improved understanding of multispecies implications of alternative harvest levels.**
- **(ii) SC17 noted that impacts on skipjack tuna depletion associated with relative changes to fishing levels to achieve a candidate bigeye tuna TRP are contingent on the proportion of fishing scalars related to purse seine fishing that target skipjack tuna. The relative change in fishing scalars to achieve candidate TRPs assume equal proportionality in purse seine and longline fishing scalars, provided for comparative purposes from the SC16 request.**
- **(iii) SC17 noted that the analyses will greatly aid in considering candidate TRPs for bigeye and yellowfin tuna.**
- **(iv) SC17 also noted that the risks of breaching the LRPs outlined in the paper are dependent on the treatment of uncertainty in any assessment and may underestimate uncertainty.**
- **(v) SC17 recommended forwarding this working paper to the Commission for its deliberations on target reference points for bigeye and yellowfin tuna and that the results be taken into account at the next Tropical Tuna Workshop.**

4.1.3.2 Mixed fishery update

290. The Theme Convener noted that SC17 reviewed the initial approach for inclusion of mixed fishery interactions into the development of a harvest strategy framework for the four main WCPO tuna stocks and that SC18 would review an updated multi-species modelling framework as noted by SC17 and provide recommendations to the Commission for further research. SC18 was informed that Agenda Item 4.1.3.2 would be considered in conjunction with 4.1.3.3.

4.1.3.3 Mixed fishery performance indicators

291. The MI Theme Convener noted that the multi-species modelling framework will allow the calculation of a range of multi-species performance indicators. For example, multi-species indicators that relate impacts on stock status and catches can be calculated in response to changes in fishing pressure from the individual single stock management procedures. That is, indicators can be developed that evaluate the impacts on the yellowfin and bigeye stocks and catches from changes in purse seine fishing pressure that would be managed through the skipjack MP. He stated that SC18 would review functioning of the mixed

fishery performance indicators presented by SPC and provide any specific feedback for further development of the indicators.

292. F. Scott presented SC18-MI-WP-06 (*Mixed fishery harvest strategy update*), which also covered SC18-MI-WP-07 (*Mixed-fishery harvest strategy performance indicators*) and SC18-MI-IP-05 (*Including South Pacific albacore in the WCPFC mixed-fishery harvest strategy framework*). The multi-species modelling framework presented in SC17-MI-WP-05 that includes skipjack, bigeye and yellowfin tuna was used to develop four mixed-fishery performance indicators. These indicators were calculated for an example set of different skipjack and bigeye management procedures. There was no dynamic bigeye management procedure, and instead different assumptions were made about the future catches by the tropical longline fisheries. The indicators were: probability of each stock falling below the limit reference point, the SB/SBF=0 of each stock, catches of each stock by different fishery segments and the 'impact' of each management procedure on each stock. It was noted that the role of the mixed-fishery performance indicators is to support the selection of preferred management procedures and that an ideal indicator is easy to interpret. If an indicator is unclear, or hard to interpret, then maybe it should not be considered further. Developments of the multi-species modelling framework were also covered, in particular, the inclusion of South Pacific albacore. This paves the way for all stocks to be included in the multi-species modelling framework.

Discussion

293. Japan stated that the question about which indicators are needed is a policy decision and should be taken up during the SMD01. It noted that the yellowfin and bigeye indicators are the bare minimum standards, with risk and catch also provided. Catch is useful when separated between longline and purse seine, but should not be combined. Impact is useful as well, and should be provided to the managers, as is stability. In the case of the longline MP, the set level is the status quo, so does not raise an issue with regard to stability . However, when a dynamic MP is developed, there will be a need for a stability indicator. As shown in the impact analysis, about 40% of the impact is by the purse seine fishery, while longline is less than 20%. Japan noted that it had raised this previously, along with other CCMs. The skipjack MP is run first, and then the bigeye MP. Although about 40% of the impact on bigeye is from purse seine, the purse seine MP is controlled not by the status of bigeye, only by the status of skipjack. Japan stated it had not agreed on such a cascading approach, and suggested this be reconsidered, and noted the need to consider bigeye tuna status as well. Japan stated it could not agree to the outlined approach at present.

294. Tonga, on behalf of FFA members, noted the encouraging results in including South Pacific albacore in the multi-species modelling framework. They also noted the work on progressing the development of mixed-fishery performance indicators. While substantial progress has been made in developing the multi-species modelling framework, they stated that a lot of work remains such as:

- building a full suite of operating models for bigeye and yellowfin tuna; and
- considering candidate management procedures for the tropical longline fisheries.

Since the multi-species modelling framework will be critical to the future management of tuna stocks in the WCPO, FFA members fully supported SPC continuing its work to further develop this framework.

295. Solomon Islands, on behalf of FFA members, noted the progress on development of mixed-fishery harvest strategies, and stated that the performance indicators related to 'the probability of the spawning biomass depletion being above the limit reference point', 'expected spawning biomass depletion' and 'expected catches' were very helpful and relatively easy to interpret. However, it noted that the same cannot be said for the performance indicator that tries to measure the 'impact' of each management procedure on each stock. By the time the impact of the skipjack, bigeye and South Pacific albacore management procedures is calculated across all combinations of skipjack and bigeye management procedures, there is a large amount of information to consider, not all of which helped with the selection of preferred management

procedures. For this reason, they questioned the usefulness of this performance indicator and suggested it not be considered further. FFA members also recommended that SPC continue to review and refine the mixed fishery performance indicators until there are enough indicators to support the selection of preferred single stock management procedures.

296. USA stated the presentation of fishery impacts was very informative. It echoed some of Japan's concerns, in particular because a mixed fisheries framework has not been agreed upon, and stated it could be good to consider various hierarchies; stock status and stock productivity could also be considered.

297. Samoa, on behalf of FFA members, noted the encouraging results in including South Pacific albacore in the evaluation framework and supported continuous development of this approach, particularly as it paves the way for all four WCPO tuna stocks to be included in the multi-species modelling framework, noting that as the work progresses, it will be possible to use this approach to determine the impact of the skipjack, bigeye and South Pacific albacore management procedures on yellowfin tuna.

298. Kiribati, on behalf of PNA and Tokelau, supported in principle the approach set out in the paper. They stated that the mixed fisheries approach raises a number of important issues for PNA and Tokelau. They noted the requirement to avoid a disproportionate burden on SIDS in the Harvest Strategy CMM, which means that there will have to be some information on impacts of SIDS in mixed fisheries such as through Performance Indicator 5. PNA and Tokelau would not support any proposed MP outcomes unless those outcomes are designed to ensure that there is no disproportionate burden transfer. They noted that it will not usually be possible to achieve all the TRPs at the same time – there will need to be trade-offs.

299. SPC acknowledged the helpful comments, and stated it presented two alternative approaches to the mixed fishery harvest strategy to SC15. SC then agreed SPC should focus on the single stock management approach. SPC also noted the alternate approach would be technically very difficult to implement. SPC stated it would continue to focus on the single stock MP for now, but was open to suggestions from SC.

300. The MI Theme Convener stated that this paper would also be presented to the SMD01 for their input.

Recommendations

301. **Noting the work reviewed by SC17 in developing a multi-species modelling framework for including mixed fishery interactions when developing and testing harvest strategies for the four main WCPO tuna stocks, SC18 reviewed an update on the development of this framework outlined in SC18-MI-WP-06 (*Mixed fishery harvest strategy update*) and SC18-MI-WP-07 (*Mixed-fishery harvest strategy performance indicators*).**

302. **SC18 thanked the Scientific Service Provider for the progress in developing the mixed fishery harvest strategies and noted the encouraging results in including South Pacific albacore in the multi-species modelling framework. However, SC18 also noted that considerable work remains to be completed, such as building a full suite of OMs for bigeye and yellowfin tuna and considering candidate MPs for the tropical longline fisheries.**

303. **SC18 noted that most of the performance indictors used in the working paper were useful and easy to understand, but also noted that the indicators may need to be separated for fisheries, and the set of performance indicators could be further developed (such as an indicator related to stability and impacts on SIDS). SC18 also noted that the question about what indicators are necessary is generally a management or policy decision.**

304. **Several CCMs, in noting that the analysis outlined in SC18-MI-WP-07 indicated a larger impact by the purse-seine fleet on bigeye tuna than the impact of the tropical longline fleet, explained that they had not yet agreed on the mixed fisheries MSE framework outlined in this paper (e.g., the order in which the individual MPs are implemented). They suggested, for instance, that a stock status-based approach could be considered while another CCM suggested a stock productivity-based approach may also be considered. However, the difficulty in implementing such approaches was acknowledged.**

305. **Several CCMs noted they would not be able to support any proposed MP outcomes unless those outcomes are designed to ensure that there is no disproportionate burden transfer. They also noted that it will not usually be possible to achieve all the TRPs at the same time and that there will need to be trade-offs.**

306. **SC18 supported continuing the work on the development of the mixed fishery MSE framework and recommended that both the Science-Management Dialogue and WCPFC19 take note of the progress to date and provide feedback.**

4.1.4 Review of the WCPFC Harvest Strategy Workplan

307. The MI Theme Convener stated that WCPFC18 adopted the updated *Indicative Workplan for the Adoption of Harvest Strategies under CMM 2014-06* (Attachment I, WCPFC18 Summary Report), and that the workplan had been extended to 2024. Noting that a re-evaluation and further discussion of the Indicative Workplan would take place during the SMD01, he asked SC18 to review and provide any needed technical assistance for the Commission's decision to meet the progress of the Workplan.

308. Australia commented as follows:

(i) South Pacific albacore: While the SPICT model-based estimator looks promising, SC18 is not yet in a position to agree to the OMs and is not a position to put forward candidate MPs. The SMD and the Commission need to decide whether to include EPO impacts within the operating models, however, it is clear that the Commission will not be in a position to adopt the MP in 2022;

(ii) Bigeye and yellowfin TRP: The FFA's request of deferring the adoption of TRPs is noted; and

(iii) Skipjack MP: Australia welcomes the significant progress on skipjack and notes that, technically, the way is clear for the Commission to adopt an MP in 2022.

309. Cook Islands, on behalf of FFA members, stated they are pleased to note that the adoption of the skipjack management procedure remains on track for 2022, but that it seems unlikely that by the end of 2022 there will be agreement on preferred TRPs for bigeye and yellowfin tuna or that the South Pacific albacore management procedure will be adopted, as is currently scheduled under the indicative Harvest Strategy Work Plan. It stated the hope that by the end of SC18, everyone will have a much better understanding on how the Harvest Strategy Workplan is progressing, which would help inform discussions at the upcoming SMD01 on what needs to be done, and when, to progress the timely execution of the Harvest Strategy Workplan, which is critical to the management of WCPO tuna stocks.

310. Tuvalu, on behalf of PNA and Tokelau, supported the priority given to work on Harvest Strategies in 2022. They stated that discussion on the Workplan would likely be more appropriate at the SMD, and indicated that there is apparently a problem in relation to the WCPFC Harvest Strategy for bigeye in the MSC process. PNA and Tokelau expect that some revision to the Workplan and/or CMM 2014-06 might be useful to address the issue.

311. French Polynesia acknowledged that it is hard to get through the harvest strategy issues at SC, but noted that French Polynesia has an MSC certified fishery, and that making progress on South Pacific albacore at the upcoming SMD01 was important to ensure continued MSC certification.

Recommendations

312. **SC18 noted the adoption by WCPFC18 of the updated *Indicative Workplan for the Adoption of Harvest Strategies under CMM 2014-06* (Attachment I, WCPFC18 Summary Report) and that further discussion on this workplan would more appropriately take place during the upcoming Science-Management Dialogue.**

313. **Several CCMs noted that the adoption of the skipjack MP remains on track for 2022 but that adoption of TRPs for bigeye and yellowfin tuna and an MP for South Pacific albacore may need to be delayed pending further work. Some concern was also expressed in relation to how such delays may impact on MSC certification.**

314. **SC18 also noted the views expressed by several CCMs that a better understanding on how the Harvest Strategy Work Plan is progressing had been achieved during SC18, and this should help inform discussions at the Science-Management Dialogue.**

4.2 South Pacific Swordfish Conservation and Management Measure

315. The MI Theme Convener noted the updated stock assessment for southwest Pacific broadbill swordfish reviewed by SC17, the review of WCPFC18-2021-20-rev1 **(***Southwest Pacific Swordfish projections)* and WCPFC18-2021-21 (*Reference Document for the Review of CMM 2009-03 (Southwest Pacific swordfish)*), the intersessional work led by Australia to strengthen CMM 2009-03, and the request that SC18 review the draft CMM for southwest Pacific swordfish submitted by Australia for consideration and discussion.

316. D. Bromhead (Australia) presented SC18-MI-WP-08 (*A revised draft conservation and management measure for southwest Pacific swordfish in the WCPFC Area*). The revised draft CMM has been developed because the current measure for this stock (CMM 2009-03) lacks any restrictions on fishing mortality in the high seas area north of 20°S and contains flag-based limits south of 20°S which, in combination with unconstrained catches north of 20°S, may be too high to prevent future overfishing. Consequently, CMM 2009-03 lacks the overall provisions required to ensure the ongoing sustainability of the stock and does not protect either future fishery development opportunities for SIDS nor the economic viability of either current fisheries that target swordfish or fisheries for which swordfish is an important economic bycatch. Consistent with the WCPFC Convention, the draft CMM has been designed to apply to the entire area of the stock, take into account the latest scientific information and analyses, ensure stock sustainability, accommodate zone-based management, recognise the sovereign rights of coastal states, and recognise the special requirements of, and avoid transferring a disproportionate burden of conservation upon, SIDS and Participating Territories. The objective of the draft measure is to maintain spawning biomass depletion ratio at or above recent (2019 as a reference year) levels. This objective ensures the sustainability of the stock but importantly also aims to maintain future fishery development opportunities for SIDS, protect the economic viability of existing swordfish fisheries as well as bycatch fisheries that swordfish catches make an economic contribution to. Based on catch projections (WCPFC-2021-21; SPC 2021) and consistent with achieving the draft objective, the measure proposes a total catch limit of 7558t (equivalent to status quo catch projection scenario). Significantly higher catches would lead to further stock depletion and reductions in catch rates, with associated economic impacts. To achieve the objective and remain within the catch limit the measure contains a set of provisions to control fishing mortality. These include application of catch limits for swordfish targeting fisheries, in EEZs and on high seas, and two

alternate measures (bycatch limits or restrictions on squid bait and light stick use) for major swordfish bycatch fisheries on the high seas. The draft measure aims to avoid disproportionate burden upon SIDS through a 150t/year trigger for the application of alternate measures, while at the same time providing a mechanism for future swordfish fishery development for SIDS. The draft measure also seeks to commit the Commission to a decision on an LRP by no later than 2024. Feedback is requested from the SC on technical/scientific elements of the draft measure, including the need for any additional scientific information to support Commission decisions.

Discussion

317. NZ, on behalf of FFA members, welcomed the opportunity to review and provide scientific and technical feedback on the draft CMM for southwest Pacific Ocean (SWPO) swordfish that has been submitted by Australia. They stressed the importance of developing a strengthened measure for this stock, noting that SC17 highlighted that the current measure (CMM 2009-03) for SWPO swordfish does not contain provisions to limit total fishing mortality on the stock. FFA members noted that the largest sources of fishing mortality for this fishery can be attributed to distant water fishing fleets, either targeting or taking swordfish as bycatch on the high seas. Unless the catch of these fleets, and others that significantly contribute to the fishing mortality of the SWPO swordfish stock, can be controlled, it puts at risk the ongoing future sustainability of the stock, future fishery development opportunities for SIDS, and ongoing economic viability of current FFA fisheries targeting this stock. They noted it is important that the CMM have a strong scientific foundation, and stated that through the work of SPC, SC and Australia, the Commission now has a comprehensive suite of data and technical information to inform and on which to base a revised and strengthened CMM for this stock. These include: the most recent stock assessment; up-to-date catch statistics for the fishery, including by flag and area (EEZ and high seas); the suite of catch and effort projections presented to WCPFC18; and a range of observer and scientific information pertaining to swordfish life status and post-release mortality that can be used to inform the consideration of management approaches for fisheries taking swordfish as bycatch. They noted that the draft CMM uses this information, and in particular the catch projections, to identify a total catch limit that would achieve an objective of preventing further depletion of the stock in future. The proposed catch limit supports the key objective of the draft measure that aims to simultaneously protect both the ongoing sustainability of the stock, future fishery development opportunities for SIDS, and the ongoing economic viability of current FFA fisheries targeting this stock, and other fisheries for which this stock is an important economic bycatch. FFA members welcomed and supported provisions in the CMM that seek to prevent any transfer of disproportionate burden to SIDS while at the same time recognising coastal state sovereign rights, FFA's commitment to zone-based management, and protecting and explicitly allowing for future fishery development opportunity for FFA SIDS. FFA members noted that the draft CMM also proposes two alternate management options for fisheries taking swordfish as bycatch in the form of bycatch limits and fishing gear restrictions. FFA members considered that bycatch limits will be the most easily implemented and monitored, and that such limits should be adopted by those fleets fishing on the high seas, noting these make the highest contribution to overall fishing mortality. This would reduce the level of uncertainty regarding future potential total catches of the stock and increase the likelihood of achieving the CMM's objective. FFA members supported the recommendations made by the authors of the 2021 stock assessment, including studies to better understand movement patterns and an expansion of minimum reporting requirements for longline operational characteristics, to mitigate against the uncertainties in the stock assessment.

318. Japan shared its concern regarding alternatives to managing swordfish bycatch, such as changing squid bait to fish bait, which experimental results suggest could lead to changes in CPUE, and suggested further consideration be given on how the gear switch will impact the swordfish bycatch. The presenter welcomed further discussion on this topic with Japan.

319. The EU thanked Australia for taking the lead on the initiative and stated it is important to ensure CMMs are effective and are updated in the light of new information available. However, they stated that in their view the revision of the CMM would not be adequate, and listed a series of concerns. While noting that the stock assessment is the best scientific information available, and that the EU supported its endorsement by SC, the EU referenced issues that suggest (as indicated in the draft CMM's preamble), that caution should be employed when using it to guide management decisions. As FFA members indicated, management advice should be based on sound scientific information. The EU stated that only 25 out of the 384 models in the uncertainty grid were retained. In spite of a better, on average, perception of stock status, this results in wide confidence intervals. Logically, when such an uncertainty is assumed, some runs may fall in the overfished area, but there are also others that result in a very optimistic situation of the stock, even in the worst-case scenarios. It also noted the limitations of catch-based projections, which sometimes make little sense, particularly in the case of bycatch fisheries. In those runs that estimate a decrease in biomass, catches are still assumed constant. In practical terms, in the maximum catch or fully caught limits scenarios, this would imply that the fleets exert two or three times the current levels of effort, and that is in the 10-year projections; the 30-year projections would require even more. This could only occur if the number of vessels was increased by almost that amount. Therefore, the EU suggested effort scenarios are more realistic, and the SQ effort +20% results on average in almost the same depletion level as in 2019. In addition, looking at SB/SB_{MSY}, none of the 10-year projections, (even in the worst scenarios and when looking at the 10^{th} percentile of the results), end in overexploitation. The EU stated that there is no scientific evidence indicating concerns regarding the sustainability of swordfish stocks. The EU stated it supports any action to mitigate fishing mortality on bycatch fisheries, but does not consider that the broad review of the current CMM should be undertaken, given the lack of scientific support for it, and its relative low priority. The presenter stated that the stock assessment is the best available science, endorsed by the SC, and as such should be used to inform revision of the CMM. He acknowledged that the catch projections can't perfectly model how catch might be taken in the future but do estimate depletion levels should catch increase. He noted that the draft measure is not only aiming to ensure stock sustainability but also the economics of fisheries that target or rely on the stock, and future development opportunities for SIDS. He noted the connection between biomass depletion and CPUE, and stated the goal is to ensure CPUE, closely linked to fishery economic viability, is not impacted by further stock depletion.

320. Chinese Taipei stated it agrees with the EU, and noted that there is significant unresolved uncertainty in the prior stock assessment that could impact catch limits. It noted that caution was needed when interpreting the results of the stock assessment to guide management decisions. The current presentation shows that catch among various fisheries (in the high seas or EEZ) is declining slowly, indicating a slow decline in fishing mortality in recent years; it also includes a projection indicating that the most important impact is from the southern ocean. There is little information on the impact of gear limitations on South Pacific swordfish mortality or the mortality of other species being targeted (e.g., bigeye). Chinese Taipei suggested this be examined in the projection analyses.

321. French Polynesia noted Australia's substantial work and leadership on the swordfish CMM, stating that although CMM 2009-03 contains some management measures intended to limit expansion of fishing on swordfish, it does not contain all the elements of a harvest strategy, including a harvest control rule. It stated that these elements are not only necessary to make sure future WCPFC management is strong enough to ensure the sustainability of the overall fishery in the region, but are also important for French Polynesia to maintain its MSC certification, which was granted in 2021 for South Pacific swordfish. It stated the proposal includes interesting elements to strengthen the current CMM and paves the way to progress on harvest strategies for the stock, and that French Polynesia looks forward to working collaboratively with Australia on future drafts of the CMM, and ensuring it grants SIDS and territories development opportunities.

322. The USA inquired as to the basis for proposing 2019 as the baseline year. The presenter stated they

looked at a suite of catch projections to determine a total catch limit that would avoid further stock depletion. The catch projections show the status quo level of catch results in future depletion level just above the recent (2019) depletion level and as such achieves those objectives.

323. The presenter thanked French Polynesia for its support and Chinese Taipei for their comments, and stated Australia looked forward to further discussions with all interested CCMs.

Recommendations

324. **SC18 welcomed the opportunity to review and provide scientific and technical feedback on the draft CMM for Southwest Pacific Ocean (SWPO) swordfish that had been submitted by Australia and outlined in SC18-MI-WP-08 (*A revised draft conservation and management measure for South Pacific Swordfish in the WCPFC Area*).**

325. **SC18 noted that this draft CMM had taken into consideration the updated stock assessment for Southwest Pacific broadbill swordfish reviewed by SC17 (SC17-SA-WP-04), Australia's updated paper on bycatch management options submitted to SC17 (SC17-MI-IP-10), the projections of this stock as outlined in WCPFC18-2021-20-rev1 (*Southwest Pacific Swordfish projections)* and WCPFC18-2021-21 (*Reference Document for the Review of CMM 2009-03 (Southwest Pacific swordfish)*).**

326. **Most CCMs supported this draft CMM, stressing the importance of developing a strengthened measure for this stock, noting that SC17 highlighted that the current measure (CMM 2009-03) for SWPO swordfish does not contain provisions to limit total fishing mortality on the stock and subsequently puts at risk the future sustainability of the stock, future fishery development opportunities for SIDS, and ongoing economic viability of current fisheries targeting this stock. They also noted the Commission now has a comprehensive suite of data and technical information with which to inform and base a revised and strengthened measure for this stock. They noted and supported provisions in the measure that seek to prevent any transfer of disproportionate burden to SIDS while at the same time, recognising coastal state sovereign rights, a commitment to zone-based management, and protecting and explicitly allowing for future fishery development opportunity for SIDS. Of the two alternate management options proposed for fisheries taking swordfish as bycatch, bycatch limits were seen as the most easily implemented and monitored, noting that swordfish bycatch contributes a very significant component of the overall fishing mortality.**

327. **Two CCMs stated that further consideration needed to be given to the effectiveness and consequences of implementing some gear-based measures, such as changing bait, as this may not reduce the fishing mortality or CPUE of the bycatch and could result in changes to the catch rates of other species. Two CCMs raised concerns that the uncertainties in the latest stock assessment had not been adequately captured in the projections, and that these uncertainties could impact the proposed catch limit. One CCM stated that they support actions to mitigate fishing mortality on bycatch fisheries, but do not consider a full review of the measure should be undertaken on the basis of the stock assessment and projections. This CCM noted that, even when catch-based projections might include very unrealistic scenarios, all of them resulted on average in levels well above the MSY in 10 years. Furthermore, projections indicated increases in recent effort of up to 20% resulted in almost the same depletion levels as in 2019. One CCM, while supporting the need for strengthening management, also noted that the current CMM does not contain all the elements of a harvest strategy, including a harvest control rule.**

328. **SC18, noting that it is important to ensure CMMs are effective and are updated in the light of new information available, encouraged all CCMs with an interest in this measure to work collaboratively with Australia prior to Australia's submission of a revised draft CMM to WCPFC19.**

4.3 Limit Reference Points for Species Other than Tuna

4.3.1 Limit reference points for elasmobranchs

329. The MI Theme Convener noted that WCPFC16 requested that SC17 identity appropriate LRPs for elasmobranchs to inform development of LRPs given their importance in harvest strategies.[26] SC17 reviewed the outcomes of Project 103[27] and recommended that the Commission take note of this work and the recommendations outlined in SC17-MI-WP-07, together with the conclusions reached by SC17 and the need for further work identified in Paragraph 347 of the SC17 Summary Report. Noting that WCPFC18 had not provided any specific instructions to SC18 on LRPs for elasmobranch, and that there was no working paper against this agenda item, .the MI Theme Convener welcomed additional input from SC18 on this issue.

Discussion

330. Fiji, on behalf of FFA members, noted the lack of further progress in developing appropriate LRPs for non-target WCPO elasmobranchs since SC17, and the recommendations and conclusions made by SC17 that were adopted by the Commission. FFA members reiterated their concerns and feedback provided by FFA members at SC15, SC16 and SC17 regarding the need to appraise a broader range of reference points to assess their applicability to WCPO elasmobranchs, so as to avoid undesirable consequences on allowable catch levels of target species.

331. The MI Theme Convener suggested that the Shark Research Plan Working Group could consider how to progress LRPs for elasmobranchs.

Recommendations

332. **SC18 noted that no further progress in developing appropriate LRPs for non-target WCPO elasmobranchs has been made since SC17, and that the recommendations and need for further research made by SC17 had been adopted by WCPFC18.**

333. **Noting the need to appraise a broader range of reference points to assess their applicability to WCPO elasmobranchs, and to avoid undesirable consequences on allowable catch levels of target species, SC18 recommended that SC19 consider reviewing and including the further research identified at SC17 in the WCPFC's Shark Research Plan 2021-2025 (Project 97)[28].**

4.3.2 Review of appropriate LRPs for SWP striped marlin and other billfish (Project 104)

334. The MI Theme Convener noted the agreed outcome from WCPFC16 to revisit the identification of an appropriate limit reference point for South Pacific striped marlin[29]. SC17 reviewed the outcomes of

[26] Paragraph 484, WCPFC16 Summary Report
[27] SC17-MI-WP-07 *(Appropriate Limit Reference Points for WCPO Elasmobranchs)*
[28] https://meetings.wcpfc.int/node/11739
[29] *The Commission noted with concern the current status of South Pacific striped marlin and agreed to revisit the limit reference point in 2020 at WCPFC17*. (Paragraph 459, WCPFC16 Summary Report)

Project 104 (SC17-MI-WP-08 *Appropriate LRPs for Southwest Pacific Ocean Striped Marlin and Other Billfish*), and agreed that the project had developed a good framework for progressing the development and identification of appropriate LRPs for WCPO billfish; SC17 recommended that the Commission take note of these conclusions and the need for further work to determine and recommend appropriate LRPs. However, WCPFC18 did not provide any specific instructions on the LRP for SWP striped marlin and other billfish. SC18 may consider how to further address the Commission's request on identifying appropriate LRPs for SWP striped marlin and other billfish and provide recommendations to the Commission as needed.

335. Pew noted the lack of comments at SC18 and suggested this be revisited at SC19.

Recommendations

336. **SC18 noted that no further progress in developing appropriate LRPs for WCPO billfish species has been made since SC17, and that the recommendations and need for further research made by SC17 had been adopted by WCPFC18.**

337. **SC18 recommended that SC19 consider reviewing and including the further research identified at SC17 in the Scientific Committee's Billfish Research Plan 2023-2027 (Project 18X1 listed in the SC18-GN-IP-07).**

AGENDA ITEM 5 — ECOSYSTEM AND BYCATCH MITIGATION THEME

338. The Ecosystem and Bycatch Mitigation (EB) theme was convened by Y. Swimmer (USA).

5.1 Ecosystem and climate indicators

339. S. Nicole presented SC18-EB-WP-01 (*Ecosystem and Climate Indicators*), which updates SC18 on progress regarding development of the candidate ecosystem and climate indicators for the Western and Central Pacific Ocean (WCPO). Candidate indicators are proposed and summarised in Annex 2 of the working paper. SPC advised that while it has developed criteria for developing and testing candidate indicators, it has not yet discussed and agreed upon a process for adopting indicators and communicating trends and trigger points derived from those indicators (either to WCPFC or external stakeholders). The working paper provides some options for addressing this gap. These include:

(i) Working papers are presented to the Scientific Committee on an occasional basis, at which point the Committee can assess them against the above criteria. This would represent the status-quo arrangement. Note that this option would not provide any clarity on the use of these indicators.

(ii) Make "Ecosystem and Climate Indicators" a standing agenda item of the Ecosystem and Bycatch Theme. This would provide a mechanism for the Scientific Committee to annually consider adopting candidate indicators presented to the Committee but also review and respond to existing trends/triggers identified in adopted indicators. It would also facilitate discussion on how best the Scientific Committee would like adopted indicators to be presented (e.g. report cards, dashboards, annual working papers, etc.).

(iii) Establish the development and testing of "Ecosystem and Climate Indicators" as a project of the Scientific Committee. This would provide a mechanism for the Scientific Committee to easily track its progress towards evaluating and adopting candidate indicators. A draft Terms of Reference for such a project is provided as Annex 3 to this working paper.

340. SPC stated it considers both options (ii) and (iii) as preferred approaches as they allow for greater

transparency and efficiency for future reporting.

Discussion

341. Tokelau, on behalf of FFA members, noted the submission of the report from SPC and the outcomes of the 4th Steering Committee, with proposed indicators and sample report cards, and recommended SC18 endorse SPC's recommendations, particularly recommendations (ii) and (iii). They supported the suggestion that available information and updates on the impacts of climate change be included or combined with status of stocks reporting.

342. Tuvalu, on behalf of PNA and Tokelau, fully supported the work to develop candidate ecosystem and climate indicators. PNA and Tokelau also supported proposal (ii) and (iii) by SPC, as these would provide a mechanism for SC to annually consider adopting candidate indicators presented to the Committee and to review and respond to existing trends and triggers identified in adopted indicators. PNA and Tokelau noted that CCMs would require assistance and support to understand how to interpret potential indicators, their appropriate reference levels and baselines, and reliability for prediction.

343. The USA supported both options (ii) and (iii), noting that once SPC and SC had produced Ecosystem and Climate Indicators report cards, including a short description of how each indicator affects WCPFC fisheries (especially scale and timeline of effects), could be helpful for fisheries managers to consider.

344. ~~for fisheries managers to consider.~~

Recommendations

345. **SC18 noted that the Scientific Services Provider has selected a suite of candidate indicators for monitoring ecosystems and climatic trends across the WCPO.**

346. **SC18 recommended making "Ecosystem and Climate Indicators" a standing agenda item of the Ecosystem and Bycatch Mitigation theme session. This would provide a mechanism for the Scientific Committee to annually consider adopting candidate indicators presented to the Committee but also review and respond to existing trends/triggers identified in adopted indicators.**

347. **SC18 recommended the development and testing of "Ecosystem and Climate Indicators" as a project of the Scientific Committee. This would provide a mechanism for the Scientific Committee to easily track its progress towards evaluating and adopting candidate indicators.**

348. **SC18 recommended that available information and updates on the impacts of climate change be included or combined with status of stocks reporting.**

5.2 Review of potential mitigation measures to reduce fishing-related mortality on silky and oceanic whitetip sharks (Project 101)

349. K. Bigelow presented SC18-EB-WP-02 (*Future Stock Projections of Oceanic Whitetip Sharks in the Western and Central Pacific Ocean (Update on Project 101)*). The updated stock assessment for oceanic whitetip shark presented to SC15 (Tremblay-Boyer et al., 2019) showed that the stock was overfished and undergoing overfishing, but also highlighted a small reduction in stock depletion, with increases in recruitment and a reduction in fishing mortality relative to reference points under certain catch scenarios. However, since oceanic whitetip sharks are late-maturing and fishing mortality on juveniles is high,

uncertainty remains as to the level of effectiveness of the non-retention measure active for the last 4 years of the assessment and the impacts of CMMs (CMM-2011-04 non-retention of the species, and CMM 2014-05 a ban on wire trace or shark lines) on the timeline for recovery. The stock assessment characterized the uncertainty in the data and model parameters via a structural uncertainty grid where multiple (648) combinations of data and parameter values were used to show the range of plausible uncertainty to the inputs. This study updates the projections of Rice et al. (2021) with contemporary estimates of mortality at longline retrieval, post-release mortality, catch reductions and prohibitions of wire branchlines and shark lines. The study used the same representative subset of the structural uncertainty (108 runs) as in Rice et al. (2021) for projections. Future projections for the 2019 WCPO oceanic whitetip stock assessment are presented for five scenarios to assess the impacts of various potential management measures. Population projections illustrate a summary of spawning biomass in the latest time period (2031) relative to the equilibrium unfished spawning biomass ($SB_{2031}/SB_{F=0}$).

Discussion

350. Fiji, on behalf of FFA members, thanked those who, through their submissions, added to the body of knowledge on shark bycatch mitigation measures. They agreed with the assessment that adding the remaining 10% ROP and non-ROP data directly from CCMs would not substantially alter the findings, and was not necessary. They recognised the findings of the studies and assessment, that moving towards monofilament appears to reduce bycatch and mortality of oceanic whitetip sharks without negatively affecting target catches. They noted that these results further support FFA members' position on banning the carrying of wire traces as branchlines, and banning the use of branchlines directly off the longline floats or droplines (CMM 2019-04:14). FFA members encouraged further research into biodegradable monofilament to further reduce mortality of oceanic whitetip sharks.

351. Chinese Taipei stated that a wire leader is needed to fish for oil fish (*Lepidocybium flavobrunneum* and *Ruvettus pretiosus*), and inquired whether it was possible to verify the simulation with data collected after the CMM entered into force? Chinese Taipei stated that after the CMM banned catch retention, it had been very hard to verify the results from logbook or observer data, and that this was very important to verify. The presenter stated that there was a 5-year timeframe to achieve the reductions in mortality, and that the reductions were determined from the observer data, and applied to effort from 20°N to 20°S.

352. Palau, on behalf of PNA and Tokelau, requested clarification on the impact of fishing mortality on oceanic whitetip sharks and on the effectiveness of banning shark lines and wire leaders. They asked if the impacts of the non-retention policy and removing shark lines and wire traces is additive. They supported continuing Project 101 to provide adequate options towards appropriate shark mitigation approaches. The presenter stated that these figures were not additive, and also that having no fishing effort removes all mortality; that is the most optimistic, though not tractable. He stated that the recovery to 2031 probably represents about 15 years of oceanic whitetip sharks (two or three generations). He noted cause for some optimism, but stated the need to wait and see.

353. In response to comments from Japan regarding the need to consider additional scenarios, including variable length of trailing gear, the presenter stated that research clearly indicated that longer branch lines increase mortality, and that use of monofilament increases the ability to cut off trailing gear.

354. Japan supported further investigation. The presenter noted a paper on post-release mortality that would be published as soon as information on the remaining tags was received. The EB Theme Convener

referenced SC18-EB-IP-20 (*What's the catch? Examining optimal longline fishing gear configurations to minimize negative impacts on non-target species*).

355. Australia stated it appreciates the updates from recent findings (such as post-release mortality) to improve the inputs to the projections and the reliability of the conclusions. It echoed the comments of its FFA colleagues, stating it is comfortable proceeding with the observer data currently included in the analysis and considered that SC18 could make recommendations on the basis of the paper. Australia proposed that SC18 draw the Commission's attention to the results contained in SC18-EB-WP-02, and suggested SC18 note that, without further action, the poor status of oceanic whitetip shark is likely to continue with biomass remaining at a very depleted level. Australia also proposed that SC18 recommend that the Commission consider the options for reducing the mortality of oceanic whitetip sharks (either catch reductions or mitigation methods such as prohibiting both wire leaders together and shark lines contained in SC18-EB-WP-02) to promote recovery of this stock. Australia also inquired whether such a projection could be done for silky shark. The presenter stated that given the projection software this could be done, but that it would be beneficial to do another stock assessment prior to doing such a projection.

356. The USA stated it continues to be deeply concerned about the status of oceanic whitetip sharks and silky sharks, and that oceanic whitetip sharks in particular are overfished and experiencing overfishing according to the 2019 stock assessment. It stated that the Commission should consider ways to reduce fishing mortality for both species, and noted that in 2021 it proposed a revision to CMM 2019-04 because action needs to be taken as soon as possible. That effort was unsuccessful as some CCMs indicated that they wanted to wait for updated results from Project 101 before considering potential revisions. The USA concurred with prior comments by Australia and FFA members and stated that SC should provide advice to the Commission that describes options based on this analysis and their potential impacts to reduce fishing mortality for oceanic whitetip sharks. Noting the depleted status of these species, and particularly oceanic whitetip sharks, the USA stated action is warranted, and that it intended to resubmit a proposal to WCPFC 19 to try and reduce fishing mortality for these stocks.

Recommendations

357. **SC18 noted the updated projections on the impact of banning shark lines, wire leaders, or both and estimates of catchability and probability of post release mortalities on oceanic whitetip sharks (under Project 101) using observer data on gear configurations by flag for 110,154 longline sets. The biomass of oceanic whitetip sharks is projected to increase if either catch reductions or mitigation methods such as prohibiting both wire leaders and shark lines in the area 20° S to 20° N are adopted and implemented. If no action is taken, the stock biomass is projected to remain at a very depleted level.**

358. **SC18 noted the substantial scientific research that indicates the use of monofilament branchlines can significantly reduce bycatch and mortality of oceanic whitetip sharks without negatively affecting target catches. SC18 also noted from relevant research (in SC18-EB-IP-20) that trailing gear composed of monofilament did not break apart even after 360 days. In contrast, branchlines with wire leaders began to break at the crimps after approximately 60 days.**

359. **SC18 noted that the analysis (in SC18-EB-IP-19) revealed that switching from wire leader material to monofilament has a small improvement in survival rates while trailing gear length, and handling condition have a significant impact on post-release survivorship for Oceanic Whitetip sharks.**

360. **SC18 encouraged further research into biodegradable monofilament and variable combination of possible approaches (i.e., recommended trailing lengths, leader type, handling**

condition) to further reduce mortality of oceanic whitetip sharks.

361. **SC18 recommended the Commission consider revising the Conservation Management Measure for Sharks (CMM 2019-04), taking into account the results of Project 101 and previous studies, which considered several options, including the prohibition of branchlines of wire trace and shark lines, in order to reduce fishing mortality on oceanic whitetip shark and silky sharks in the WCPO.**

362. **SC18 noted with concern that oceanic whitetip sharks are overfished and experiencing overfishing according to the 2019 stock assessment and silky sharks are experiencing overfishing according to the 2018 stock assessment.**

5.3 Seabird bycatch mitigation

5.3.1 Seabird bycatch mitigation methods

363. D. Ochi presented SC18-EB-WP-04 (*Consideration for tori-line and tori-pole design suitable for small-scale tuna longline vessels in the North Pacific based on experimental results*). CMM 2015-03 (replaced by CMM 2018-03) requires that in WCPFC waters north of 23°N, small tuna longline vessels under 24 m in length use one of several bycatch mitigation measures, including tori-lines. The tori-line specifications recommended in these CMMs are tentative and require review based on experimental results. Since 2011, the authors have collected information and conducted cruise- and land-based experiments to verify the streamer-less tori-line and tori-pole specifications suitable for Japanese small-scale tuna longline vessels. Based on this work, the paper discusses effective and practical specifications for Japanese small longline vessels in the North Pacific.

Discussion

364. Birdlife International stated that it supports these efforts, but noted that bycatch rates using the design tested by Japan were still unacceptably high compared to situations where no tori lines are used. It stated that some designs had been endorsed by ACAP, but none are streamerless; all could be adopted by CCMs. Enforcement of CMM 2018-03 implementation is hampered by low or absent observer coverage. Birdlife International requested that CCMs implement CMM 2018-03 before trialling methods that have not been endorsed. Birdlife International also referenced its statement provided to SC18[30].

365. Japan commented that the bycatch rate reported in the paper reflected that the longline research vessel was operating in an area with very high seabird density. The bycatch rate recorded is thus not comparable to the levels that would be found in the areas normally fished.

366. The USA noted, with respect to effective tori line designs for small-scale longline vessels, recent research done in the Hawaii deep-set longline fleet to explore tori line designs, as presented in SC18-EB-IP-14 (*Practicality and Efficacy of Tori Lines to Mitigate Albatross Interactions in the Hawaii Deep-set Longline Fishery*), which also took into consideration aerial extent, pole materials, and tori line strength, and specifically examined the effectiveness of tori lines with short streamers and 50m-long aerial sections. It noted that a number of small deep-set longline vessels (< 24m) participated in the study. It suggested that the research may provide a good example of effective tori line design options that could reasonably be implemented on deep-setting longline vessels less than 24 m in length. It also highlighted SC's prior commitment to make findings and recommendations at SC18 with respect to the effectiveness of

[30] *Birdlife International Statement: Electronic Monitoring must be prioritised to ensure improved data collection on the bycatch of seabirds* https://meetings.wcpfc.int/node/16394

streamerless tori line designs in order to inform the Commission's review of the current seabird measure. It noted SC previously reviewed the two papers submitted by Japan regarding the effectiveness of streamerless tori lines, at which time SC12 recommended continued experimental trials of tori line designs and procedures adapted to the activities of small-scale longline vessels. The USA stated that it was unaware of further trials to determine the effectiveness of streamerless tori lines since that time. It recognized that with the limited amount of time available during SC18 it might not be possible to make a determination, but stated it would be interested in hearing from CCMs on how to plan to progress the issue in the future, hopefully during SC19.

367. The EB Theme Convener reminded CCMs to consider SC18-EB-IP-14 and SC18-EB-IP-15 (regarding tori lines); SC18-EB-IP-09 and SC18-EB-IP-10 (regarding Antipodean albatross population and distribution); and SC18-EB-IP-21 and SC18-EB-IP-22 (regarding tori lines).

368. FFA members noted the decline in albatross and petrel populations globally, as well as in the WCPFC Convention Area. Based on the findings presented they recommended making tori lines compulsory for longline vessels across the WCPFC Convention Area. Furthermore, they recommended the use of streamers for larger vessels, and possibly also for smaller vessels.

369. New Zealand stated that it appreciates the further trials of seabird mitigation techniques by the Japan Fisheries Resources Institute. With regard to this ongoing research, it noted the following:

- there are deep-diving seabird species which forage in the north Pacific and are vulnerable to the longline fishery. In this respect, and also given the possibility of rough swells, it is important to ensure that seabird mitigations allow for the protection of hooks to a greater depth than 2.5 metres.
- An aerial extent of the tori line of 75 metres would provide greater protection for seabirds.

New Zealand also welcomed the conclusions of the USA-led research, which it stated provides quantitative evidence that the use of blue-dyed bait is ineffective as a seabird mitigation, despite being a mitigation option in CMM 2018-03 for the North Pacific. The USA-led research also demonstrates that tori lines are effective and practical for small vessels in the North Pacific. It stated that this is consistent with ACAP advice, which lists tori lines as one of the three best practices to mitigate seabird bycatch, and the FFA position on tori lines.

Recommendations

370. **SC18 recommended the Commission note a global decline in specific Agreement on the Conservation of Albatrosses and Petrels (ACAP) seabird population trends, which are vulnerable to threats posed by longline fisheries in the WCPO.**

371. **SC18 recommended the Commission conduct a review of the current seabird mitigation measure (CMM 2018-03) in 2023 or 2024 whereby new bycatch mitigation studies would be evaluated with respect to bycatch mitigation effectiveness and compared against current ACAP Best Practices.**

372. **With regard to seabird bycatch mitigation, SC18 noted the following:**

a) **Tori-lines have been proven to be an effective and practical means to reduce seabird bycatch in small vessels in the North Pacific;**
b) **Trade-offs between modification of tori-line characteristics, such as the weight of streamers and keeping sufficient aerial extent should be taken into account when designing a tori-line; and**
c) **Recent scientific evidence indicates that the use of blue-dyed bait and offal management are ineffective as seabird mitigation measures, despite being mitigation options in the seabird measure (CMM 2018-03) for the North Pacific.**

5.3.2 ACAP advice on seabird mitigation

373. J. P. Seco-Pon presented SC18-EB-WP-03 (*Conservation Status of Albatrosses and Petrels and Advice on Reducing their Bycatch in WCPFC Fisheries*). Incidental mortality (bycatch) of seabirds in longline and trawl fisheries continues to be a serious global concern, especially for threatened albatrosses and petrels, resulting in a Conservation Crisis being declared by ACAP in 2019. The need for international cooperation in addressing this concern was a major reason for establishing ACAP. There are currently 31 species listed in Annex 1 of the Agreement. Of the 22 species of albatrosses, 17 breed and/or forage in the WCPFC Convention Area, as do six of the nine listed petrel species. This paper provides a summary of the population status and current trends of these 23 species as well as information on high priority populations that occur in the WCPFC Area, and provides an update on ACAP best practice bycatch mitigation advice for pelagic longline fisheries and other resources relevant to seabird bycatch, including new guidance on observer programme and electronic monitoring data collection.

374. New Zealand stated it is deeply concerned about the threat to many species of seabird, particularly albatrosses and petrels, from bycatch in longline fisheries. New Zealand submitted two information papers relating to the status of Antipodean albatross: (i) SC18-EB-IP-09 (*Antipodean albatross population assessment*) sets out recent population modelling. Based on a field study, simulations suggest a significant on-going decline in population of almost 5% per year; and (ii) SC18-EB-IP-10 (*Antipodean albatross spatial distribution and fisheries overlap*), which reports on the first two years of a study that tracks seabirds and their overlap with longline fishing activity. Noting the ACAP paper on seabird mitigation, and the discussion on seabird mitigation in the North Pacific, New Zealand stated it supports a review of the current seabird mitigation measure (CMM 2018-03) in 2023, with the goal of ensuring that effective mitigation methods are required and used by the longline fishery in the high-risk areas of the Convention Area.

375. The USA supported a review of the current CMM 2018-03 mitigation requirements in the next few years. It noted ongoing research it is conducting to explore the effectiveness of seabird mitigation measures in the Hawaii longline fleet.

376. Japan stated that seabird bycatch is currently being discussed by the Commission for the Conservation of Southern Bluefin Tuna (CCSBT), and that the progress of those discussion could be reported to WCPFC in the future.

377. Australia supported the recommendation that a detailed review of CMM 2018-03 be made against ACAP best practice advice, and suggested this be added to the list of projects, stating it was open to having this report back in 2023 or 2024 as the USA noted.

378. Niue, on behalf of FFA members, again noted with concern the serious decline in albatross and petrel populations. They supported an assessment of CMM 2018-03 against ACAP best practices, especially in light of the findings presented in agenda item 5.3.1.

5.4 Issues arising from the Online Discussion Forum

5.4.1 Graphics associated with the Best Handling Practices for the Safe Handling and Release of Cetaceans

379. The EB Theme Convener stated that as requested by SC17 (Para 389, SC17 Summary Report), the SC18 ODF (under Topic 23) reviewed the graphics associated with the cetacean best handling guidelines.

Recommendation

380. **SC18 noted the *Graphics for Best Practices for the Safe Handling and Release of Cetaceans*[31] and forwarded these to TCC18 and WCPFC19 for consideration and possible adoption.**

5.4.2 FAD Management Options IWG issues

381. The EB Theme Convener noted Paragraph 19 of CMM 2021-01, which states SC18 will review available research results on the use of biodegradable materials on FADs, and is expected to provide specific recommendations for Commission's consideration at WCPC19 in December 2022 on a biodegradable FAD definition, a timeline for the stepwise introduction of biodegradable FADs, potential gaps/needs and any other relevant information. SC18-EB-IP-06 (*Guidelines for Non-entangling and Biodegradable FAD Materials*) and SC18-EB-IP-13 (*Preliminary Review of Available Information on Biodegradable FADs*) were reviewed through the ODF (as Topic 21), and a number of CCMs made comments.

382. French Polynesia noted SC18-EB-IP-03 (*Preliminarily analyses of the regional database of stranded drifting FADs in the Pacific Ocean*), which highlights that stranded FADs are a major issue for French Polynesia and other SIDS in the Pacific, as they represent a source of marine debris and pollution, damage reefs and corals when stranding onshore, and present high risks for navigation. French Polynesia stated that the issue was also presented in July 2022 at the United Nations Ocean Conference in Lisbon, and should now be addressed by both WCPFC and IATTC. French Polynesia acknowledged the important and necessary work done on biodegradable FADs, and supported the work done to improve the use of biodegradable or non-entangling FADs, and FAD marking and monitoring, which represent important steps towards more sustainable fisheries. However, it noted effort must be made by the WCPFC and IATTC to strengthen effective management of FADs. French Polynesia requested that WCPFC again address the issues of FAD monitoring, identification, and tracking, and appropriate limits on the number of FADs. It also asked WCPFC and IATTC to work together on solutions to prevent FADs from drifting into French Polynesia's EEZ and stranding on its shores. It noted that the constraints posed by COVID-19 prevented SC from dedicating enough time to FADs issues, but stated that it was time for SC to recommend that the FADMO-WG and the Commission to again address these issues.

Recommendations

383. **SC18 noted that in the ODF there was support / no objection to the proposed IATTC definition of biodegradable and categories of biodegradable FADs (paragraph 10, SC18-EP-IP-13). Responding to the Commission's tasks under the CMM 2021-01, SC18 supported the definition of "biodegradable" and several preliminary categories of biodegradable FADs to be considered for its gradual implementation as stated in paragraph 10, SC18-EP-IP-13 and listed below:**

- **"Non-synthetic materials [32] and/or bio-based alternatives that are consistent with international standards[33] for materials that are biodegradable in marine environments. The components resulting from the degradation of these materials should not be damaging to the marine and coastal ecosystems or include heavy metals or plastics in their composition."**
- **The different categories to be considered in this gradual implementation process are (These definitions do not apply to electronic buoys attached to FADs to track them):**

[31] SC18-EB-IP-12 https://meetings.wcpfc.int/node/16340

[32] For example, plant-based materials such as cotton, jute, manila hemp (abaca), bamboo, or animal-based such as leather, wool, lard.

[33] International standards such as ASTM D6691, D7881, TUV Austria, European or any such standards approved by the WCPFC CCMs.

- **Category I. The FAD is made of 100% biodegradable materials.**
- **Category II. The FAD is made of 100% biodegradable materials except for plastic-based flotation components (e.g., plastic buoys, foam, purse-seine corks).**
- **Category III. The subsurface part of the FAD is made of 100% biodegradable materials, whereas the surface part and any flotation components contain nonbiodegradable materials (e.g., synthetic raffia, metallic frame, plastic floats, nylon ropes).**
- **Category IV. The subsurface part of the FAD contains non-biodegradable materials, whereas the surface part is made of 100% biodegradable materials, except for, possibly, flotation components.**
- **Category V. The surface and subsurface parts of the FAD contain nonbiodegradable materials.**

384. **SC18 noted that these categories are preliminary and will be further examined by the FADMO-IWG, SC, TCC for Commission's consideration.**

385. **SC18 further recommended to the Commission that the FADMO-IWG continues its work on exploring a timeline for the stepwise introduction of biodegradable FADs, potential gaps/needs and any other relevant information for Commission's consideration. SC18 noted that the FADMO-IWG may seek advice from SC and TCC.**

AGENDA ITEM 6 — OTHER RESEARCH PROJECTS

6.1 Pacific Marine Specimen Bank (PMSB, Project 35b)

386. **SC18 endorsed the recommendations made by the PMSB Steering Committee in the *Project 35b Report* (SC18-RP-P35b-01), and:**

- **noted its continued support for initiatives to increase rates of observer biological sampling, noting that this contribution is essential to the ongoing success of the WCPFC's work;**
- **incorporated the identified Project 35b budget into SC's proposed 2023 budget and the 2024-25 indicative budgets, as development of the WCPFC PMSB is intended to be ongoing and is considered essential;**
- **supported efforts to obtain further super-cold storage capacity to ensure longevity of PMSB samples; and**
- **endorsed that the work plan in Section 4 of SC18-RP-P35b-02 should be pursued by the Scientific Services Provider, in addition to standard duties associated with maintenance and operation of the WCPFC PMSB in 2022-2023, and noting that detailed terms of reference for Project 35b are available in SC18-GN-IP-07.**

6.2 Pacific Tuna Tagging Project (Project 42)

387. **SC18 noted the ongoing progress in implementing the PTTP, as detailed in SC18-RP-PTTP-01, and:**

- **noted the successful 2021 CP15 tagging voyage, despite the unfolding COVID-19 pandemic;**
- **noted the critical importance of effective tag seeding to informing stock assessment, and supported an urgent increase (when feasible) in deployment and fleet coverage of tag seeding experiments and assistance in developing alternative approaches to understand the flow of tags through tuna product networks;**
- **noted the need for continued CCM participation and support in tag reporting;**
- **supported the 2023 tagging programme and associated budget;**

- **supported the 2024-2025 tagging programme and associated indicative budget; and**
- **considered and supported the PTTP Workplan for 2022-2025.**

6.3 WPEA Project Update

388. **SC18 noted the WPEA-ITM Project Update (SC18-RP-WPEA-01) and:**

a) recommended extending the initiative into 2024 at "no cost" due to current allocated budget underspend, which will mean most, if not all, of the WPEA-ITM activities will be completed; and

b) recommended development of a new project proposal for the next phase of WPEA work that is relevant to the WCPFC, to begin immediately after the current WPEA-ITM project expires.

AGENDA ITEM 7— FUTURE WORKPLAN AND BUDGET

7.1 Development of the 2023 work programme and budget, and projection of 2024-2025 provisional work programme and indicative budget

a. **Review of 2021 SC Projects and the results of the SC17 Online Discussion Forum**

389. **There were no objections raised regarding the progress and results of 2022 SC projects through the ODF, as detailed in SC18-ODF-01 (*Summary of Online Discussion Forum*).**

b. **Review of proposed projects for 2023 – 2025**

390. The Science Manager provided an overview of SC18-GN-IP-07a (*SC Work Program and Budget for 2023 – 2025*), and introduced the process by which SC would rank project proposals and develop a recommended proposed work program and budget for 2023, and indicative budget for 2024-2025, for consideration by the Commission at WCPFC19.

391. PNA and Tokelau addressed the intent of the SC ranking process and how it should be applied when the projects are considered at the WCPFC Finance and Administration Committee (FAC). They stated that at WCPFC18 the FAC changed the SC project ranking somewhat arbitrarily, through decisions that were not based on science but rather on the financial priorities of some CCMs. They stated that in their view, the SC project rankings and FAC decision process should follow these steps:

(i) first, the SC ranks the projects according to their priorities;
(ii) FAC sets the SC budget;
(iii) if the projects fit within that budget no further grooming of projects is required;
(iv) if the project budget exceeds the FAC SC budget, then the lowest-priority projects should be dropped sequentially until the project budget fits within the FAC budget.

They noted that the FAC should not re-prioritise the SC projects, but rather simply consider the budget, as is their role. PNA and Tokelau further noted the suggestion to split shark assessments over two years, as recommended in three separate papers to the SA and EB Themes, and voiced their support for this approach, as the recent assessments have demonstrated that the underlying data for these assessments are complex and require much additional work. This process would allow the data characterisation, CPUE analysis and catch reconstruction work to be carried out and completed for review at the SPC Pre-assessment Workshop, prior to the assessment commencing. They stated that they see this as a good step toward improving these assessments.

392. Several CCMs noted that the approach used for the scoring system should be changed so that overall

averages are shared rather than details regarding each CCM's rankings. Several CCMs also indicated they had not provided rankings for projects that had no budgetary implication for the Secretariat in 2023.

393. Scientific Services Provider provided the following list as the 2023 priority work:

- WCPO yellowfin tuna assessment (incorporating key recommendations from the yellowfin review in 2022);
- WCPO bigeye assessment (incorporating key relevant recommendations from the yellowfin review in 2022);
- Initial work following up on skipjack assessment recommendations (and review of implications arising from 2022 yellowfin review);
- Analytical support to tropical tuna CMM discussions in 2023;
- Ongoing work on assessment diagnostics based upon SC18 and SC19 discussions;
- Development of the requested SC19 paper on timelines for WCPO stock assessment outputs; and
- Input into the early 2023 CAPAM[34] tuna conference.

Recommendations

394. **SC18 recommended the proposed work program and budget for 2023 and indicative budget for 2024 – 2025 together with CCM's priority scores to the budgeted projects in Table WP-01 to the Commission.**

Table WP-01. Recommended Future Work Program and Budget for 2023 – 2025. Average score is based on Table WP-01 (SC project scoring table) of the SC17 Summary Report, with priority rankings: 6&9 = High; 3&4 = Medium; 1&2 = Low. 'No. CCMs' represent the number of CCMs which provided scores on that project.

Project Title	2023	2024	2025	Notes	Avg. Score	No. CCMs
Sub-item 1. Scientific services						
SPC-OFP scientific services	981,112	1,000,734	1,020,749	Budget: 2% ann. increase	essential	
Sub-item 2. Scientific research						
SPC Additional resourcing	176,670	180,204	183,808	Budget: 2% ann. increase TOR: MFCL work	essential	
P35b. WCPFC Pacific Marine Specimen Bank	105,268	107,373	109,520	Budget: 2% ann. increase	essential	
P42. Pacific Tuna Tagging Program	730,000	730,000	730,000	Responsibility: SPC	essential	
P60. Purse seine species composition				Responsibility: SPC Carry over 2021 budget of $40K to 2023		
P65. Peer review of yellowfin modeling				Responsibility: SPC (On-going)		
P68. Seabird mortality	25,000	40,000		Responsibility: SPC Indicative budget approved at WCPFC18	4.5	22
P90. Length weight conversion (WCPFC17 endorsed the extension of P90 to 57 months until Sep. 2023)				Responsibility: SPC (On-going)		
P100c (=P17X3). Preparing WCP tuna fisheries for application of CKMR methods to resolve key SA uncertainties. (Duration: 2023 - 2025)				Responsibility: SPC Funding: WCPFC, SPC, EU, IATTC and CSIRO Budget (matching fund) approved at WCPFC18		
P108. WCPO silky shark assessment	50,000	50,000		Indicative budget approved	6.2	23

[34] Center for the Advancement of Population Assessment Methodology

				at WCPFC18		
P109 - Training observers for elasmobranch sampling				Responsibility: SPC (On-going)		
P18X1 (=P17X1). Billfish Research Plan 2023 - 2027	55000			Responsibility: SPC Indicative budget approved at WCPFC18	7.0	22
P18X2 (=P17X4). Further development of ensemble model approaches for presenting SA uncertainty	30,000			Responsibility: SPC Indicative budget of $20K approved at WCPFC18	7.9	21
P18X3. Improved coverage of cannery receipt data for WCPFC scientific work	35,000	60,000	35,000	Responsibility: SPC	7.4	22
P18X4. Exploring evidence and mechanisms for a long-term increasing trend in recruitment of skipjack tuna in the equatorial Pacific and the development and modelling of defensible effort creep scenarios	20,000			Responsibility: SPC	7.6	21
P18X5. Ecosystem and Climate Indicators	0			Budget to be requested for 2024 and beyond	7.2	19
P18X6. Pacific silky shark assessment (inclusion in the Project 108)	0	30,000		Project 108: WCPO Project 18X6: Pacific-wide	4.5	22
P18X7. Pacific whale shark assessment	85,000				3.0	22
P18X8. Shark Research Plan midterm review	30,000				6.2	22

Table WP-02. Provisional assessment schedules for 2023-2026. Tunas are scheduled for assessment every 3 years; swordfish every 4 years; and sharks and other billfish every 5 years.

Species	Stock	Last assessment	2022	2023	2024	2025	2026
Bigeye tuna	WCPO	2020		X			X
	Pacific	2015					
Skipjack tuna	WCPO	2022	X			X	
Yellowfin tuna	WCPO	2020		X			X
Albacore	S Pacific	2021			X		
	N Pacific	2020		X			
Pacific bluefin	N Pacific	2022	X		X		
Striped marlin	SW Pacific	2019			X		
	N Pacific	2019		X			
Swordfish	SW Pacific	2017				X	
	N Pacific	2018		X			
Pacific blue marlin	Pacific						X
Silky Shark	WCPO	2018			X		
	Pacific	2018			X		
Oceanic whitetip shark	WCPO	2019				X	
Blue shark	SW Pacific	2021/2022	X				
	N Pacific	2022	X				
Mako	SW Pacific	2022	X				
	N Pacific	2018					

Bigeye thresher	Pacific	2017					
Porbeagle	S Pacific	2017					
Whale Shark	Pacific	2018					

AGENDA ITEM 8 — ADMINISTRATIVE MATTERS

8.1 Election of officers of the Scientific Committee

395. **SC18 made no nominations to fill the vacancies for SC Vice-Chair, Management Issues Theme Co-Convener, and Ecosystem and Bycatch Mitigation Theme Co-Convener. Nominations for these positions would remain open until WCPFC19.**

8.2 Next meeting

396. **SC18 recommended to the Commission that SC19 would be held from August 16 – 24 August 2023, and that Palau would confirm to the Commission at WCPFC19 whether it was able to host SC19.**

AGENDA ITEM 9 — OTHER MATTERS

9.1 Review of online discussion forum outputs

397. RMI, on behalf of the PNA and Tokelau, proposed that the ODF be used in the future, whether meetings are held in person or online, as this had proven to be a useful forum for advancing discussions on a number of issues.

9.2 Implications of low observer coverage on the upcoming bigeye and yellowfin tuna stock assessments

398. SPC noted that the impact of reduced observer coverage on purse seine species catch estimates was addressed in Section 2.2 in SC18-ST-WP 01. The largest impact will be on the bigeye and yellowfin stock assessments, which use data from 2021; in 2020 observer coverage was about 50% of that in 2019, and in 2021 it was about 10% of the 2019 level. SC18-ST-IP-03 presents a detailed analysis of the impact on the precision of tuna catch estimates; the lack of data will increase the CVs by 90% to 250% in some regional and fishery data sets. Bigeye will be most significantly impacted by the lack of observer sampling. Cannery data will be of help, while SC Project18X3 (*Improved coverage of cannery receipt data for WCPFC scientific work*, although not yet in place) may be of help with such problems in the future. Lack of observer coverage may result in some size sampling gaps for some fleets. The implications will depend on CPUE signals in the longline fleet, where there may be COVID-19 impacts, and there could be some conflict at the end of the time signals. SPC stated it would look into ways to address this in the stock assessments, perhaps through some specific sensitivity analyses on the overall stock advice. Use of depletion ratios and use of SB_{recent} in place of SB_{latest} may help. But recent fishing mortality (up to 2020) will possibly be more impacted than the depletions.

Recommendation

399. **SC18 noted the information provided by SPC regarding the impact of reduced observer coverage on purse seine species catch estimates and the resultant impact on its scientific work.**

9.3 Absence of consensus

400. **SC18 noted that it could not reach consensus on the management advice for skipjack tuna. While there was general agreement on the stock assessment outputs, several CCMs wanted to note their view that depletion in the equatorial region was greater than in other areas. However, several other CCMs considered this pertained to the stock status section and did not agree on its inclusion under management advice. Despite the advice of the Commission's legal advisor that the WCPFC convention states that differences in views can be expressed in the report of the Scientific Committee, the recommendation from the legal advisor did not ultimately solve this issue. SC18 sought guidance from the Commission on how to proceed in the future when consensus cannot be reached and how lack of consensus should be reflected in the SC's report.**

AGENDA ITEM 10 — ADOPTION OF THE SC18 SUMMARY REPORT

401. **SC18 adopted the recommendations of the Eighteenth Regular Session of the Scientific Committee.**

402. **SC agreed that the SC18 Summary Report would be adopted intersessionally according to the following indicative schedule:**

Tentative Schedule	Actions to be taken
18 August	Close of SC18
By 27 August	Secretariat will receive Draft Summary Report from the rapporteur.
By 29 August	SC18 Outcomes Document distributed to all CCMs and observers (within 7 working days, Rules of Procedure).
By 3 September	Secretariat will clear the Draft report, and distribute the cleaned report to all Theme Convenors for review.
By 10 September	Theme conveners will review the report and return it back to the Secretariat
By 15 September	The Secretariat will post/distribute the draft Summary Report to all for CCMs' and Observers' review
By 26 October	Deadline for the submission of comments from CCMs and Observers

AGENDA ITEM 11 — CLOSE OF MEETING

403. The Commission Chair thanked the SC Chair and Theme Conveners, ISC chair, SPC, the Executive Director, the Science Manager and the rest of the Secretariat staff, and members and participants for their contributions to the discussions. She noted that SC18 addressed a number of important issues, including harvest strategy models for MSE and candidate MPs, and stated that SC18's recommendations and advice would assist WCPFC19 in its deliberations, as well as setting the stage for the upcoming SMD01.

404. The Executive Director expressed his thanks to the SC Chair and Theme Co-Conveners for completing the work of SC18. He noted that despite the directive to streamline the agenda the discussion remained very substantial and technical, with a high standard of presentations and discussions. He thanked to SPC for their contribution to the meeting and the large volume of presentations and documentation, and acknowledged the participation of observer organizations, including IATTC and ISC, as well as NGOs. He thanked his team at the Secretariat, and in particular the Science Manager and Assistant Science Manager; the Secretariat's IT team; and the Lead Rapporteur. He noted the upcoming SMD01, stating he hoped it

would add value to the Commission's efforts to enhance management of WPFC stocks, and stated he was hopeful that WCPFC19 would be able to meet in Vietnam in late November.

405. The SC Chair stated that he wished to add his thanks and appreciation to that voiced by the Commission Chair and Executive Director. He also acknowledged and commended those participants who live far from the Pacific but managed to participate constructively, and those who overcame technical difficulties in connecting to a virtual meeting. He noted that this marked the close of the 3rd consecutive virtual SC meeting, and praised everyone for working together in a spirit of mutual cooperation and collaboration. He thanked all contributors, and in particular the Theme Conveners, SPC and ISC colleagues, the Executive Director and his staff, the Legal Advisor, and rapporteurs.

406. Poi Okesene (Niue) offered the closing prayer.

407. The SC Chair closed SC18 at 12:30 Pohnpei time on 18 August 2022.

Attachment A

The Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean
Scientific Committee
Eighteenth Regular Session
Electronic Meeting
10 – 18 August 2022

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Attachment B

The Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean
Scientific Committee
Eighteenth Regular Session
Electronic Meeting
10 – 18 August 2022

Opening Remarks by the WCPFC Chair Ms. Jung-re Riley Kim

Dr. Tuikolongahau Halafihi, the Chair of the Scientific Committee, CCM Delegates and Observers, Mr. Feleti Teo, the ED and his team, especially our Science Manager Dr. Soh, Dr. Graham Piling and his team at the SPC, The Theme Convenors,

It is a great pleasure and honor for me to address the 18th Regular Session of the Scientific Committee of the Western and Central Pacific Fisheries Commission. Given the very limited time available for the SC sessions online, I will keep my remarks brief.

The WCPFC is one of the most reputable fisheries management organizations, and I believe it is mainly thanks to the robust science that has been supporting informed management decisions. SC18 this year again has a full plate of important issues that are reflected in the long list of agenda items.

Having read SC18 documents, I find it very encouraging and inspiring that the stocks that have recently been assessed, including skipjack and North Pacific blue shark, are maintaining a healthy status and the Pacific Bluefin tuna stock is showing signs of improvement.

One of the issues I would like to highlight as the Chair of the Commission is Harvest Strategy-related works: The Harvest Strategy Work Plan updated last year commits the Commission to developing and adopting Management Procedures as well as Management Strategy Evaluation for skipjack and South Pacific albacore at the 19th Session of the Commission this year. To this end, the Scientific Committee is tasked to come up with agreed operating models for MSE and also will be providing advice on performance of candidate management procedures for the two stocks for the Commission's consideration.

Some of the issues will be followed up by the 1st Science-Management Dialogue to be held next week, and I hope that the series of discussions at the Scientific Committee and the Science-Management Dialogue can come to fruition in December.

Turning to the conservation and management of bycatch and related ecosystems, CCM scientists will review bycatch reduction measures for silky and oceanic whitetip sharks, as well as FAD management options, focusing on biodegradable FADs, which I believe will feed into Commission's work on implementing the ecosystem-based approach and improving FAD management.

I would like to take this opportunity to thank our SC Chair and Theme Conveners for your hard work and outstanding leadership, and the Secretariat and the Science Provider for your excellent support.

Before closing, I would like to wish everyone of you good health and safety in these challenging times that are still lingering on. Thank you.

Attachment C

The Commission for the Conservation and Management of
Highly Migratory Fish Stocks in the Western and Central Pacific Ocean
Scientific Committee
Eighteenth Regular Session
Electronic Meeting
10 – 18 August 2022

Opening Remarks by the WCPFC Secretariat's Executive Director, Feleti P Teo, OBE

Good day, one and all and special greetings from your Secretariat office in Pohnpei, FSM.

Thank you Dr Tuikolongahau Halafihi, Chair of the Scientific Committee and the Chief Executive Officer at the Ministry of Fisheries of the Government of the Kingdom of Tonga.

Thank you Chair for permitting me to make some remarks at this opening session of the 18th Regular Session of the Scientific Committee of the WCPFC.

And like the Commission Chair, I am highly mindful of the time constraint of virtual meetings and the very substantial agenda that the Committee needs to get through. So, I will be brief. But, let me at the outset join you Chair and the Commission Chair, Madame Riley Kim in welcoming all delegates and observers to the Scientific Committee meeting for this year. Despite our best wishes and aspirations for a physical meeting this year, we once again meet virtually for a third time in a row for the Scientific Committee.

Although we have witnessed a massive improvement to the global responses to the pandemic and the lifting of many border closures and the relaxation of restrictions on international travel, we are not quite there yet to safely convene physically the Scientific Committee meeting this month and the Technical and Compliance Committee meeting next month here in Pohnpei, FSM as agreed by the Commission at WCPFC18 in December of last year.

Chair and distinguished delegates.

The Secretariat staff in Pohnpei, FSM have been very fortunate for we had remained virus free all this time until last month when community transmission of the virus in Pohnpei was detected for the first time and now spreading at a relatively high rate. Fortunately, all the staff in Pohnpei were fully vaccinated and most boosted and I am pleased to report to the Committee that most staff that were infected experienced only minor symptoms and most have recovered and are back at work. And because of the high level of infection and community transmission in Pohnpei we had to close the office and required staff who are able, to work from home. The situation experienced is what we have prepared and readied ourselves for some time now. We also have several senior staff stranded abroad and are servicing this meeting from their respective home stations.

With this our third year operating virtually, I would like to think that we are much better equipped to engage more effectively and efficiently using the Zoom virtual platform. However, there is no denying that there are still serious constraints and inhibitions to what virtual meetings can offer compared to face-to-face meetings, more so for the Scientific Committee given the highly technical nature of the issues to be deliberated.

As will be explained by the SC Chair, we have retained basically the same format and structure for the Scientific Committee as from previous years. The main plenary will utilize once again the Zoom virtual

platform using its videoconferencing facility and because of the necessity to streamline and abbreviate the agenda for the plenary to essential issues requiring formal decisions, several other routine issues were placed as in previous years as topics for the Online Discussion Forum (ODF) for delegates to exchange views prior to the plenary and in the first few days of the meeting. I understand arrangements agreed to at the Heads of Delegation meeting yesterday was to have the Online Discussion Forum closed on this coming Saturday, the 13th of August. The key outcome of those exchanges will be shared with the plenary towards the end of the meeting under Agenda item 9 on Other Matters.

Despite efforts to streamline and abbreviate the agenda for the meeting plenary, the agenda remains very substantial and extensive in coverage indicating the heavy workload placed on the Scientific Committee. The workload, Chair, is made doubly more difficult by the virtual nature of the deliberations. As earlier alluded to by the Commission Chair, some of the key issues expected out of this Scientific Committee that the Commission await advice and information include advice on further ways to close the data gaps of the Commission; progressing the work on stock assessment including that of skipjack, Pacific bluefin and the peer review of yellowfin amongst others; progressing some of the difficult harvest strategy issues including target reference point for the tropical tuna stock and South Pacific albacore, and work on management procedure for skipjack and South Pacific albacore which will be the core considerations for the first Science Management Dialogue to be convened immediately after this meeting; advice on additional bycatch mitigation measures to reduce the impact of fishing on non-target and bycatch species; and more information on guidance on the impacts of climate change on the WCPO fisheries.

As known, these are substantial issues that require a lot of research work and a lot of time spent on them. The extent of the work that was invested on this issue is reflected by the extensive documentation that have been posted and provided to facilitate discussions on them by the Committee. I understand from a quick count that there are around 150 meeting papers that have been posted for this meeting, which is a lot of documentation to work through, let alone to comprehend.

Chair and distinguished delegates.

As we know the bulk of these documentations is normally provided by the Commission Scientific Services Provider, the Oceanic Fisheries Programme of the Pacific Community whom I cannot thank them enough on the Commission's behalf for the high quality and the high standard of the work they produced year in and year out for the Committee and for the Commission. So, allow me once again to acknowledge with much appreciation for the continuing enormous contributions of Dr Graham Pilling and team SPC-OFP to the preparation and documentation for this meeting.

As we also know, the officers of the Scientific Committee, the Chair and your various Theme Conveners and co-Conveners play a lead role in coordinating and managing the preparation for and conduct of this meeting. These are non-paying officials that volunteer their own time and resources to support the work of the Scientific Committee especially under prevailing, difficult, and very challenging conditions. And I would also like to acknowledge with appreciations and high commendations of their contributions, dedications and sacrifice.

Chair, before I end my comments, allow me to also acknowledge with appreciation the contributions of my own Secretariat's staff for the planning and preparations of this meeting under the able leadership of the Science Manager, Dr SungKwon Soh who is servicing this meeting from his home city of Seoul, South Korea and the rest of the staff including our tireless ICT team comprising of Tim Jones and Samuel Rikin. Chair, the Secretariat as always stands ready to support the deliberations of the Scientific Committee over the next seven or so days. I wish you and the Committee well and best wishes for fruitful deliberations.

I thank you, Chair.

Attachment D

The Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean
Scientific Committee
Eighteenth Regular Session
Electronic Meeting
10 – 18 August 2022

Opening remarks by the SC Chair Dr. Tuikolongahau Halafihi

Malo e lelei!

Chair of the Commission Ms Riley Kim, the Executive Director Mr Feleti Teo, distinguished delegates, ladies and gentlemen…good morning, good afternoon, and good evening wherever you are. I also recognize that for some delegates, this will be very early in the morning or outside your usual office hours.

With the continuing COVID-19 pandemic conditions, it is still fortunate for all of us to be able to convene this virtual meeting in order to continue the work of the Commission's science, and I sincerely appreciate the efforts of the Executive Director and his staff for organizing this meeting.

This is the 3rd year that the Commission has agreed to convene an electronic meeting of the Scientific Committee with an abbreviated agenda consisting of essential items necessary to progress the scientific work of the Commission in 2022. The abbreviated agenda was developed by the Secretariat, in collaboration with all SC officers and the Scientific Services Provider, SPC-OFP. On behalf of the SC, I sincerely appreciate the work done so far.

As noted in our SC18 streamlined agenda, we will cover four key themes that will discuss key issues ranging from data gaps; stock assessments of six species; progress of developing the Commission's harvest strategy framework, i; and ecosystem and by-catch concerns to name a few.

I am also glad that the SC continued to utilize the Online Discussion Forum website to facilitate the progress of SC projects and other key topics that were omitted from the abbreviated agenda. This platform is a direct communication channel between authors and participants. The results of the Online Discussion Forum will be briefly covered under Agenda 7 (Future Work Program and Budget) and Agenda 9 (Other Matters) as needed. I encourage participants to make use of the Online Discussion Forum to efficiently progress other topics outside of the plenary agenda.

On behalf of all SC participants, I sincerely appreciate all Theme Conveners, for your commitment, expertise, and kind contribution to the work of the Scientific Committee. I appreciate Dr Graham Pilling and all his colleagues at SPC-OFP for your hard work to support the Commission's science, and also appreciate the Chair of the ISC Dr John Holmes and its members for providing valuable scientific information for our review.

With the limited time frame of this virtual meeting, I am asking all participants to fully cooperate, in a constructive manner, with us to produce successful outcomes.

Thank you very much and always stay safe. Malo!

Attachment E

The Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean
Scientific Committee
Eighteenth Regular Session
Electronic Meeting
10 – 18 August 2022

Agenda

WCPFC-SC18-2022/02 (Rev.04)
9 August 2022

AGENDA ITEM 1 OPENING OF THE MEETING

1.1 Welcome address
1.2 Meeting arrangements
1.3 Adoption of agenda
1.4 Reporting arrangements

AGENDA ITEM 2 DATA AND STATISTICS THEME

2.1 Data gaps of the Commission
2.1.1 Data gaps
2.2 Other commercial fisheries for bigeye, yellowfin and skipjack tuna

AGENDA ITEM 3 STOCK ASSESSMENT THEME

3.1 WCPO tunas
3.1.1 Skipjack tuna (*Katsuwonus pelamis*)
3.1.1.1 Review of 2022 skipjack tuna stock assessment
3.1.1.2 Provision of scientific information
- a. Status and trends
- b. Management advice and implications

3.1.2 Pacific Bluefin Tuna *(Thunnus orientalis)*
3.1.2.1 Review of 2022 Pacific bluefin tuna stock assessment
3.1.2.2 Provision of scientific information
- a. Status and trends
- b. Management advice and implications

3.2 WCPO sharks
3.2.1 Southwest Pacific blue shark (*Prionace glauca*)
3.2.1.1 Towards providing scientific advice for Southwest Pacific blue shark (Project 107b)
3.2.1.2 Provision of scientific information
- a. Status and trends
- b. Management advice and implications

3.2.2 Southwest Pacific shortfin mako shark (*Isurus oxyrinchus)*
3.2.2.1 Review of 2022 Southwest Pacific shortfin mako shark stock assessment (Project 111)
3.2.2.2 Provision of scientific information
- a. Status and trends
- b. Management advice and implications

3.2.3 North Pacific blue shark (*Prionace glauca*)

3.2.3.1 Review of 2022 North Pacific blue shark stock assessment

3.2.3.2 Provision of scientific information

a. Status and trends
b. Management advice and implications

3.3 WCPO billfishes

3.3.1 North Pacific striped marlin (*Kajikia audax*)

3.3.1.1 Review of 2022 North Pacific striped marlin stock assessment

3.3.1.2 Provision of scientific information

a. Status and trends
b. Management advice and implications

3.4 Peer review

3.4.1 Progress of the peer review (Project 65)

3.4.2 Characterization of stock assessment uncertainty

AGENDA ITEM 4 MANAGEMENT ISSUES THEME

4.1 Development of the Harvest Strategy Framework for key tuna species

4.1.1 Skipjack tuna

4.1.1.1 Skipjack tuna TRP analyses

4.1.1.2 Skipjack operating models

4.1.1.3 Skipjack management procedure (MP) and evaluations

4.1.1.4 Skipjack MP implementation

4.1.2 South Pacific albacore tuna

4.1.2.1 South Pacific Albacore TRP

4.1.2.2 SP Albacore operating models

4.1.2.3 SP Albacore management procedures

4.1.3 Mixed fishery MSE framework

4.1.3.1 Bigeye and yellowfin tuna TRP analyses

4.1.3.2 Mixed fishery update

4.1.3.3 Mixed fishery performance indicators

4.1.4 Review of the WCPFC Harvest Strategy Workplan

4.2 South Pacific Swordfish Conservation and Management Measure

4.3 Limit Reference Points for Species Other than Tuna

4.3.1 Limit reference points for elasmobranchs

4.3.2 Review of appropriate LRPs for SWP striped marlin and other billfish (Project 104)

AGENDA ITEM 5 ECOSYSTEM AND BYCATCH MITIGATION THEME

5.1 Ecosystem and climate indicators

5.2 Review of potential mitigation measures to reduce fishing-related mortality on silky and oceanic whitetip sharks (Project 101)

5.3 Seabird bycatch mitigation

5.3.1 Seabird bycatch mitigation methods

5.3.2 ACAP advice on seabird mitigation

5.4 Issues arising from the Online Discussion Forum

5.4.1 Graphics associated with the Best Handling Practices for the Safe Handling and Release of Cetaceans

5.4.2 FAD Management Options IWG issues

AGENDA ITEM 6 OTHER RESEARCH PROJECTS

6.1 Pacific Marine Specimen Bank (Project 35b)
6.2 Pacific Tuna Tagging Project (Project 42)
6.3 WPEA Project Update

AGENDA ITEM 7 FUTURE WORK PROGRAM AND BUDGET

7.1 Development of the 2023 work programme and budget, and projection of 2024-2025 provisional work programme and indicative budget

AGENDA ITEM 8 ADMINISTRATIVE MATTERS

8.1 Election of officers of the Scientific Committee
8.2 Next meeting

AGENDA ITEM 9 OTHER MATTERS

9.1 Review of online discussion forum outputs
9.2 Implications of low observer coverage on stock assessments

AGENDA ITEM 10 ADOPTION OF THE SUMMARY REPORT

AGENDA ITEM 11 CLOSE OF MEETING

Attachment F

The Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean

Scientific Committee
Eighteenth Regular Session

Electronic Meeting
10 – 18 August 2022

SUMMARY OF THE SC18 ONLINE DISCUSSION FORUM

WCPFC-SC18-2022/ODF-01

INTRODUCTION

1. The Eighteenth Regular Session of the Scientific Committee (SC18) was held online with an abbreviated agenda as a result of the ongoing coronavirus disease (COVID-19) pandemic. As was the case for the two previous online meetings (SC16 and SC17), SC18 made use of an Online Discussion Forum (ODF) to facilitate consideration of discussions on 2022 SC projects and other items omitted from the abbreviated SC18 agenda. The ODF was opened on 25 July and closed on 13 August 2022, during SC18, to allow the outcomes of the ODF discussions to be considered by CCMs at SC18.

2. For reference during the SC18 Work Program and Budget discussions, the table below summarizes the input provided by SC participants on ODF Topics related to WCPFC projects. The full comments are presented in this paper under each Topic.

SUMMARY OF INPUT FROM SC18 ON SC PROJECTS

Topic No.	Subject	Comments
3	**Project 60 —** Progress towards achieving SC17 recommendations	**PNA and Tokelau** support: • current High priority for paired grab-spill sample trips (funding carried over from 2020 Budget) • in principle High priority for the proposed collaboration with members to support the Project 60 workplan, request further information • maintaining the video-based work at Medium priority • proposed Project to collect cannery data, consider it High priority. **ISSF:** offers to contribute $10,000 annually for a project to improve the submission of cannery data
4	**Project 90 —** Better data on fish weights and lengths for scientific analyses	**PNA and Tokelau** supports**:** • the program and its ongoing data collection efforts • the proposed workplan for 2022-2023

Topic No.	Subject	Comments
5	**Project 109 —** Training observers for elasmobranch biological sampling	**The USA:** supports the work and agreed with the recommendation for a no-cost extension
15	**Project 105** Progress report on bomb radiocarbon age validation for yellowfin and bigeye tunas in the WCPO (Project 105) - 2022	**PNA and Tokelau:** welcomed the progress on the analysis, hoped this work and the subsequent growth curve development using these otolith interpretations can be used for the next bigeye and yellowfin stock assessments.
18	**Project 110** —Non-entangling and biodegradable FAD trial in the WCPO	**PNA and Tokelau:** support a no-cost extension. **ISSF:** as a donor to the project supports a no-cost extension. **IWC:** suggests cetacean bycatch also be recorded during project trials
23	**Graphics for Best Practices for the Safe Handling and Release of Cetaceans**	**PNA and Tokelau:** support the work, and producing the guidelines in various languages targeting vessels crews **USA**: supports adoption of the graphics and translation into various languages, and suggested any surplus funds from its 2021 voluntary contribution for graphics could be used for translation **IWC**: suggests modifications to text and graphics
28	**WPEA-ITM Project Update**	**Philippines and Indonesia**: support a no-cost extension of the project to 2024, and development of a new project proposal for the next phase of WPEA work that is relevant to the WCPFC

TOPIC 1. Overview of tuna fisheries in the WCPO, including economic conditions – 2021

1.1 Background

- **Introduction**: The paper provides a broad description of the major fisheries in the WCPFC Statistical Area highlighting activities during the most recent calendar year (2021) and covering the most recent summary of catch estimates by gear and species.
- **Responsibility:** Pacific Community (SPC)

1.2 Relevant Documents

SC18-GN-IP-01	P. Williams and T. Ruaia. **Overview of tuna fisheries in the Western and Central Pacific Ocean, including economic conditions – 2021**

1.3 Key Questions and Comments

3. **Nauru, on behalf of PNA and Tokelau,** thanked SPC and the Forum Fisheries Agency (FFA) for their excellent paper. They stated that the PNA and Tokelau appreciate the effort made by all involved in the purse seine fishery to keep that fishery operating through the COVID-19 pandemic at only slightly below recent levels, as shown by the paper. The PNA and Tokelau also thanked SPC for including the reference to Figure A.1 in the discussion; it shows (and the paper notes) that "over 85% of the WCP–CA tuna catch occurs in the waters of the coastal states." They stated that this is a defining feature of the WCPFC

compared to other tuna regional fisheries management organisations (RFMOS), where catches are largely taken in the high seas, and it is valuable to have this information presented prominently in the paper.

(i) **Question:** The authors noted, regarding purse seine catch per unit effort (CPUE), that Figure 3.5.1 seems to show outstanding increases in skipjack CPUE for one of the major fleets. In light of the analysis in SC18-MI-IP-02 (*Examining Indicators of Effort Creep in the WCPO Purse Seine Fishery*), the PNA and Tokelau asked whether is it possible that this increase in CPUE is a result of misreporting rather than real increases in fishing power?

- **Reply: SPC** thanked the PNA and Tokelau for this important comment and question. It Noted the following:
  - (a) Paper SC18-GN-IP-01 includes the following caveat in the presentation of nominal CPUE figures for the purse seine fishery …
    "*Recent reviews of the available logsheet data used to determine nominal CPUE highlight an apparent change in reporting behaviour, with a clear increase in the reporting of transit days (over days searching); since transit days are not included as purse seine effort (and days searching is included), this change will inevitably result in a positive bias in the nominal CPUE data presented herein.*"
  - (b) Paper **SC18-MI-IP-02** provides an in-depth review of the potential issues involved…
    "The effort creep is difficult to quantify with certainty because it is a multi-faceted and complex phenomenon, often lacking the full complement of data to precisely assess. Overall, the effort creep indicators within and outside the PNA waters have generally shown no trends over the period of VDS implementation, but most show interannual variation. We note that this conclusion differs substantially from the previous effort creep papers, where the use of logsheet fishing days with the recent bias had the effect of artificially generating recent increasing trends in the indicators for nominal effort rates and daily catch rates."… which suggests that the increase in nominal CPUE is more a result of the misreporting rather than real increases in fishing power.
  - (c) SPC also noted the potential recommendation that the WCPFC should consider a review of the operational data requirements to improve the accuracy of logbook reporting of vessel activities and correct the historic logbook data for biases due to misreporting of vessel activities.

4. **SPC**, in response to a query from the Pew Charitable Trust, noted that the table on purse seine tuna catch and effort by set type and species (Table A.3) that was formerly contained in the appendix of this overview paper was moved (as of SC17) to the regular MI Theme paper on "Catch and Effort data summaries to support discussions on the tropical tuna CMMs" in response to a request. The most recent version of this table is in **SC18-MI-IP08** (Table 4).

TOPIC 2. The Tuna Fishery in the Eastern Pacific Ocean in 2021

2.1 Background

- **Introduction:** The document summarizes the catches and effort of the fisheries for species covered by the IATTC's Antigua Convention ("tunas and tuna-like species and other species of fish taken by vessels fishing for tunas and tuna-like species") in the eastern Pacific Ocean (EPO) in 2021.
- **Responsibility**: Inter-American Tropical Tuna Commission (IATTC)

2.2 Relevant Documents

SC18-GN-IP-02	IATTC. **The Tuna Fishery in the Eastern Pacific Ocean in 2020**

2.3 Key Questions and Comments

5. There were no comments or questions.

TOPIC 3. Project 60 – Progress towards achieving SC17 recommendations

3.1 Background

- **Introduction:** The objective of Project 60 is to improve the accuracy and precision of species composition data for tuna (skipjack, yellowfin and bigeye) caught by purse-seine fisheries in the WCPO, in order to improve species-specific catch histories and size compositions that are used in the stock assessments of these key target species in the WCPO. The project history is provided in Appendix A of the report.
- **Responsibility**: SPC

3.2 Relevant Documents

SC18-ST-IP-03	SPC-OFP. **Scientific data available to WCPFC (Section 4.2)**

3.3 Key Questions and Comments

6. **The PNA and Tokelau** thanked SPC and all those involved for their efforts to maintain progress in Project 60 toward achieving the recommendations from SC.

(i) **Priorities:** (in Table 2 of the paper) On priorities within Project 60, PNA and Tokelau sated they:

- support the current High priority for paired grab-spill sample trips, noting that there is funding for this activity to be carried over from the 2020 Budget;
- support in principle High priority for the proposed collaboration with members to support the Project 60 workplan but request further information on the proposed Project, including the budget; and
- support maintaining the video-based work at Medium priority
    - **Reply (SPC):** SPC thanked PNA and Tokelau for their support for the proposed work plan for Project 60, and their comments and questions. Regarding the proposed collaborative work with CCMs, SPC envisaged that this would involve analyses similar to those in **SC13-ST-WP-03** and **SC16-ST-IP-05**, i.e. comparisons of catch compositions from different data sources and at varying resolutions. These comparisons could enable reviewing and refining the thresholds used to determine when species composition estimates are sample based vs. model based. However, the specifics of the work, and the budget required, are dependent on interest from members and the range of available data sources.

(ii) **Request**: On Recommendation 4, PNA and Tokelau requested that para 4 i)

The SSP or WCPFC Contractor to work with relevant CCM port and flag states to obtain purse seine processor data not yet provided, using the guidelines to ensure data confidentiality

include working with relevant coastal states, since some coastal states already have requirements for vessels to provide unloading data, and coastal states have access to Commission data relating to vessels operating in their waters, including non-Public Data Domain data such as cannery/processor data.

- **Reply:** SPC thanked PNA and Tokelau for their request to include relevant coastal states in the project on improving cannery data, and noted they updated the draft project proposal (**SC18-ST-IP-11-rev1**) to include the involvement of relevant coastal states.

(iii) **Comment**: In addition, PNA and Tokelau supported the proposed project to collect cannery data and consider it should be High priority.

7. **Chinese Taipei** noted the following regarding Recommendation 4, which also relates to the background of the draft proposal for the Project to improve the coverage of cannery receipt data. Chinese Taipei stated its understanding that in usual practice and without sampling procedure, the composition of purse seine catch can't be verified until the catch is processed in the cannery, even when they are loaded in ports. In this regard, it recognized that cannery data is considered as an important source to verify purse seine tuna catch. However, it also noted that the Guidelines for the Voluntary Submission of Purse Seine Processor data by CCMs to the Commission was only adopted by the Commission in 2021.

(i) **Question:** How many cannery data have been received by SPC-OFP during the preceding year (by trip, by received time, or by the CCMs who provided the data), and what procedure was used after receiving those data to verify the catch composition data;

- **Reply:** SPC stated that Table 3 of **SC18-ST-IP-03** (rev 1) provides a summary of cannery data provided by year, including coverage and comparisons to other data sources (i.e. logbook and observer trips). The coverage of cannery data is currently too low to consider verifying catch composition data for all fleets except one purse seine fleet. In past SC papers on cannery data submissions, SPC has noted generally good consistency when comparing species composition determined from observer data to the species composition from cannery data from this particular fleet that has adequate coverage of cannery data. Improving coverage of cannery receipt data would therefore assist the SSP extend the catch composition verification to other fleets.

(ii) **Question:** Chinese Taipei inquired regarding SPC's assessment of the effectiveness in terms of collecting the cannery data to improve the composition data, in parallel with the current sampling procedure under the project 60. In other words, if cannery data and sampling data are both available to the data processing process, by what proportion or under what process will the catch composition estimation process be taken?

- **Reply:** SPC stated that if there is adequate coverage of cannery receipt data, it would attempt to compare tuna species composition estimated from the observer data with the species composition from the cannery data, at the trip level but mostly at more aggregated levels. This verification could potentially be extended to the set type level where possible, for example, trips which are on unassociated/free-swimming schools only during the FAD closure.
- **SPC** further stated it updated the draft proposal (**SC18-ST-IP-11 rev1**) based on Chinese Taipei's suggestions. It noted that where differences are identified, further specific review of both the observer data and cannery review data would be required to identify why there are differences and may identify enhancements required in the data collection and/or estimation processes.

8. **ISSF** stated it supports the proposal for a project to improve the submission of cannery data and offers to contribute $10,000 annually as cofinancing for the project.

- **Reply (SPC):** SPC thanked ISSF for their continued generous support to the scientific work of the WCPFC.

TOPIC 4. Project 90 Update – Better data on fish weights and lengths for scientific analyses

4.1 Background

- **Introduction:** Project 90 developed from discussions at SC13 around the need for accurate 'conversion factor' data for targeted and bycatch fish species captured across the WCPO.

SC18-ST-IP-04 updates SC18 on activities occurring during the 12 months to 23 July 2022, and outlines planned actions for the coming year.

- **Responsibility:** SPC

4.2 Relevant Documents

SC18-ST-IP-04	SPC. **Project 90 update: Better data on fish weights and lengths for scientific analyses**

4.3 Key Questions and Comments

9. **The PNA and Tokelau** stated that they support this program and its ongoing data collection efforts, noting the utility of the data presented on the SPC and WCPFC websites.

(i) **Question:** There are data gaps for some species of special interest such as mantas that are important to PNA and Tokelau; is there a plan to try and fill these in the future?

- **Reply:** SPC thanked the PNA and Tokelau for their comments and continuing support for this programme of work. Activity 1.3 under Project 90 specifically addresses the conversion factor data gap for species of special interest (SSIs), including mantas, Mobulid rays and marine mammals. The latest update under this Activity is detailed in ANNEX 1, Table A1 in the Project 90 SC17 report [**WCPFC-SC17-2021/ST-IP-05**]; SPC referred CCMs to this and previous papers to see the evolution of this and other activities within the project. In brief, discussion has continued on avenues for obtaining measurements on these SSIs; however, no implementation has occurred in the previous 12 months. This remains a priority area of work for the project, and SPC stated it hopes that with COVID-19 travel restrictions easing across the region, the roll out of trials using newly-purchased motion compensating scales to obtain accurate weight measurements on board fishing vessels will provide further opportunities for observer-based conversion factor data collection on SSIs in the coming 12 months.

(ii) **Comment:** PNA and Tokelau noted that in the final paper a series of figures and conversion equations should be presented as a useful point of reference.

- **Reply:** SPC stated that the comment was well noted, and highlighted that the 2022-2023 workplan (under point 6 in **SC18-ST-IP-04**) includes the development of a web-based tool for plotting conversion factor relationships for target and bycatch species that links to SPC's conversion factor database, and that this tool will be made available on the WCPFC web site. They noted also that an online tool is currently available for accessing information within SPC's conversion factor database, in particular, the range of species-specific equations available.
- The tool (www.spc.int/ofp/preview/login.php?redirect=species_conv_factor.php) is accessible via a login.

(iii) **Comment:** PNA and Tokelau supported the proposed workplan for 2022-2023.

- **Reply**: SPC thanked the PNA and Tokelau for their support on the proposed 2022-2023 workplan.

TOPIC 5. Project 109 – Training observers for elasmobranch biological sampling

5.1 Background

- **Introduction:** SC18-ST-IP-05 details the activities undertaken on Project 109 since SC17. The paper requests that a no-cost extension to the project period to the end August 2023 be considered to reflect the challenges in undertaking project activities during the COVID-19

global health crisis and anticipated return to normal observer operations, and to allow reporting to SC19.

- **Responsibility:** SPC

5.2 Relevant Documents

SC18-ST-IP-05	T. Park. **Project 90 update: Better data on fish weights and lengths for scientific analyses**

5.3 Key Questions and Comments

10. **The USA** stated it fully supports the work and agrees with the recommendation to allow a no-cost extension. The USA noted its efforts taken domestically to improve data collection for mobulid rays in its longline and purse seine fisheries in the region, including through genetic sampling and tagging efforts. The USA has also developed a shark ID guide for fishers and observers, with plans to develop a similar ID guide for mobulid rays in 2023. The USA stated it would be happy to collaborate with SPC to share any relevant training materials and ID guides that have been developed.

- **Reply**: SPC stated it produced a shark and ray ID guide in 2019 with a key to improve ID by observers and crew, and would be happy to work with the US to share and improve training materials. [SPC's guide is available online].

TOPIC 6. Designing EM reviewing rates for WCPFC fisheries

6.1 Background

- **Introduction:** Electronic Monitoring/Observation of tuna fisheries in the WCPO is currently undergoing various trials throughout the region to ascertain how it can best complement existing at-sea observer programs. This paper describes investigation of a general sampling scheme involving the random sampling of vessels, trips, and sets. The primary data were the observer and logbook data for the years 2016-2019 inclusive. Analytical equations were developed for the variance and coefficient of variation (CV) of an unbiased estimator of total catch for a given species, area, and timeframe.
- **Responsibility: SPC**

6.2 Relevant Documents

SC18-ST-IP-06	SPC. **Designing EM reviewing rates for WCPFC fisheries**

6.3 Key Questions and Comments

11. **BirdLife International** stated it was pleased to see electronic monitoring (EM) review rates in the discussions of SC18, and suggested that SC should seek to implement a minimum of 20% EM review rate by 2024, and review this rate biannually thereafter with a view to increasing review rates in steps as data analysis tools, such as artificial intelligence (AI), evolves, in order to reduce the burden on human reviewers and the need for data storage. Birdlife International noted this is a pragmatic and achievable goal, and that some CCMs are already close to achieving this rate of observer coverage. EM will reduce costs and challenges of achieving representative spatial coverage on smaller vessels, and for longer trips, which have been consistently underrepresented in observer data. BirdLife emphasized that the required level of observer coverage has remained at just 5% for over 14 years, severely impeding the ability to measure progress and achieve the goals agreed to by CCMs (some of which fail to meet even this minimum requirement). At below 5% observer coverage is statistically meaningless for evaluating fisheries management and for assessing compliance objectives that CCMs have agreed to in the WCPF Convention.

Of note, the requirements under this MOU that relate to having a statistically informative EM review rate include:

- *collect and share, in a timely manner, complete and accurate data concerning fishing activities on, inter alia, vessel position, catch of target and non-target species and fishing effort, as well as information from national and international research programs*
- *obtain for its consideration the best scientific information available from the Scientific Committee through review of research results, encouraging and promoting cooperation in scientific research and assessing status of target or non-target stocks of interest*

Birdlife International acknowledged that not all data required to manage the fishery can be obtained with EM, and that human observers remain a critical component of managing WCPO fisheries, but noted that uncertainty due to a lack of data is continually cited in the WCPFC process as a reason for inaction, while the improved certainty offered by higher rates of observer coverage is consistently rejected, and stressed that the inaction has been unacceptable for too long. The COVID-19 pandemic has further demonstrated the need to supplement human observers with EM, or the WCPFC will continue to fail to meet its data reporting obligations.

12. **The USA** commented as follows:

(i) Comments on practical aspects of the three sampling designs considered in the working paper.
The three sampling designs in the working paper are:

(1) Sampling sets: a proportion of the sets on every trip by every vessel are sampled randomly within trip
(2) Sampling trips: a proportion of the trips across all vessels are sampled randomly and every set on a selected trip is sampled
(3) Sampling trips within vessel: a proportion of the trips by each vessel are sampled randomly and every set on a selected trip is sampled.

For the 1st and 3rd design, the sampling design resembles a stratified sample with simple random sampling without replacement (SRSWOR) within each stratum (the working paper does not specify a SRSWOR within stratum but it appears this is what the authors are assuming). For the 1st design, the strata are the trips, and for the 3rd design, the strata are the vessels. For the 2nd design, the sampling design appears to be a SRSWOR of trips. For both of these designs, the authors were able to compute the finite population variance within each stratum because they created the catch values for the finite population. In practice, one would not know the population variance within each stratum and would need to estimate it. For both of these proposed sampling designs, for some fisheries, there would likely be several strata with only one sample. As the common estimator of the variance requires more than one sample per stratum, the common estimator of variance would not be applicable. The working paper does not propose an alternate way to estimate the variance and then show that the proposed estimator performs well. If a reasonable estimate of the standard error is desired then the 1st and 3rd design may not be satisfactory until a reasonable estimator of the variance is identified.
For the 2nd and 3rd sampling designs, the sampling frame for drawing the SRSWOR would not be available until after the year. There is no discussion how such a sample could be drawn without a sampling frame that covers the whole population such that unwanted bias is not introduced if assuming a SRSWOR.

(ii) Comments on the theoretical development of the three designs.
At the working paper defines μ and $\sigma 2$ as the population mean and variance, the working paper

appears to be taking the approach that the estimators of the total and variance are based on randomization theory (sample-based) and not model-based (with model-based, μ and σ2 represent unknown infinite population parameters and one should define the model being assumed). Under randomization theory, the catch (X) are considered fixed but unknown; that is, they are not considered random variables. The randomization variable used in randomization theory inference indicates which population units are in the sample. For example, a common way to develop randomization theory is to define the random variable Zi equal to 1 if the unit i is in the sample and 0 otherwise. Under randomization theory, E(Xi)=Xi and Var(Xi)=0 as Xi is fixed and not a random variable. Hence, the proofs and theoretical development's in this paper are incorrect because they assumes Xi is a random variable and that E(Xi)= μ and Var(Xi)= σ2. Under the sample-based approach, the estimators of total for the three designs are unbiased and a proof of this can be found in most books on sampling theory. The variance of the estimator of total for all three designs is not the variance commonly used for these designs. There is no explanation for this and the proofs of the estimators of variance in this paper are incorrect as they assume that Xi is a random variable and disregard the randomization variable. If the equations for the variance of the estimators are incorrect then the CVs are incorrect. I did not check the formulas for the other estimators for the other sampling designs considered but they should be checked as well as the formulation of the expected number of sets sampled for the difference sampling designs.

(iii) Comment on species that are very rarely caught.

For species that are very rarely caught, there are model-based estimators that can be used. These estimators will provide a measure of uncertainty around the point estimate even when all sampled units have a catch of 0.Comments on approximation of CV on page 10 of working paper I'm concerned about this approximation as it assumes that p is constant or nearly constant. For the 1st design, the probabilities for a set being included in the sample will likely be unequal since there is variability in the number of sets within a trip. Under the description in this working paper concerning how the sample size within a stratum would be determine, the probabilities could vary from 1 and to less than .1 if targeting a p=.1.

- **Reply:** SPC thanked the USA for its comments, and stated they were unsure they understand the comments in the context of the sampling scheme described in the paper. SPC noted that if they interpreted the comments correctly, these assert that SPC has treated known constants (estimated from the observer and logbook data) as random variables. This is not the case. SPC referred the USA to the description of methods (pp. 5-10 in SC18-ST-IP-06) for an explanation of the sampling scheme applied (and associated assumptions). SPC noted the lack of time to engage on this issue prior to close of the ODF, and offered to continue the discussion with the USA via email, if required.

TOPIC 7. FAD Minimum Data Fields to be Recorded by WCPFC Purse Seine Vessel Operators

7.1 Background

- **Introduction:** The PNA and Tokelau have developed requirements for provision of data on FAD design and construction and FAD activity by purse seine vessel operators that are being applied for licensed vessels from 1 January 2022. The information is critical for scientific analyses to guide management of FADs in the waters of the PNA and WCPO, as well as to monitor compliance. The main differences between the fields of FAD data now required to be provided by vessel operators and the current ROP minimum data fields for FAD data are: (i) requirements for quantitative and measurable information where the WCPFC ROP

data fields require provision of qualitative information and descriptions; (ii) more details including in data fields regarding the buoy and materials for each component; and (iii) more details related to SSI entanglement.

- **Responsibility:** Paper authors

7.2 Relevant Documents

SC18-ST-IP-09	PNA and Tokelau. **FAD Minimum Data Fields to be Recorded by WCPFC Purse Seine Vessel Operators**

7.3 Key Questions and Comments

13. **ISSF** congratulated PNA and Tokelau for this initiative, noting that the proposed FAD logsheet is very complete. However, ISSF suggested that other designs be considered in Annexes 2 and 3. Specifically, the "jelly-FAD" which uses a biodegradable cubic drogue. This design is already being tested by various fisheries in the WCPO and will be also used in Project 110, as explained in document **SC18-2022/EB-IP-01**.

14. **The American Tunaboat Association** (ATA) stated that from an industry perspective, it is supportive of the intent behind these minimum data fields. However, it requested flexibility in the method of sharing the data, given the limitations of submitting it through the onboard iFIMs app:

(i) The ATA suggested that any WCPFC requirements consider flexibilities for some of the FAD data fields, particularly on information related to the buoy inventory and buoy signal loss, as some of this information may be more efficiently uploaded from the vessel manager to the iFIMs web page or provided by buoy providers, rather than requiring entry by the vessel operator itself.

(ii) Annex 1 Table A1 #13a-e, implies that vessels should report on buoy signal loss through iFIMs. This information could more easily be provided through automatic reporting from buoy providers themselves

(iii) Annex 1 Table A2, #1 and #2 appear to be redundant with 5a-b? Additionally, if FAD origin data is collected during the initial deployment of a FAD from the vessel doing the plant, it seems redundant to receive FAD origin data repeatedly during each subsequent visit. Furthermore, vessels are unlikely to have perfect records on the origin of FADs planted by other vessels, so information in that field from each additional visit will be prone to error.

- **Reply:** The PNA Office thanked the ISSF and ATA for their comments, and stated they would look carefully at the suggestions.

TOPIC 8. A compendium of fisheries indicators for target tuna stocks in the WCPFC Convention Area

8.1 Background

- **Introduction**: The paper provides empirical information on recent patterns in fisheries for SC's consideration, including fishery indicators for all 'key' target tuna species (skipjack, bigeye, yellowfin and South Pacific albacore tuna).
- **Responsibility**: SPC

8.2 Relevant Documents

SC18-SA-IP-01	S. Hare, G. Pilling and P. Williams. **A compendium of fisheries indicators for target tuna stocks in the WCPFC Convention Area**

8.3 Key Questions and Comments

15. **FFA members** thanked SPC for the comprehensive work that undertaken again to compile these fishery indicators. FFA members stated they find these indicators very useful as they provide empirical information on recent patterns in fisheries for all `key' target tuna species for those years when a stock assessment is not conducted. Along with short-term stochastic projections, this helps members to assess potential stock status until such time as a full stock assessment is undertaken. For instance, FFA members noted that the catch of all key stocks fell in 2021 with the exception of bigeye, which increased by 9%. Of the stocks where the catch fell in 2021, by far the largest decline was observed in South Pacific albacore, decreasing 24% from 2020 and 28% from the 2016-2020 average.

TOPIC 9. Updated draft research plan for 'key' tuna species in the WCPO, 2022-2025

9.1 Background

- **Introduction**: The paper updates the draft 2021 SC research plan for improving the stock assessments of 'key' WCPO tuna stocks: WCPO skipjack, bigeye and yellowfin and South Pacific albacore (SC17-SA-IP-05).
- **Responsibility**: SPC-OFP

9.2 Relevant Documents

SC18-SA-IP-04	SPC. **Updated draft research plan for 'key' tuna species in the WCPO, 2022-2025.**

9.3 Key Questions and Comments

16. **The PNA and Tokelau** stated they believe that research planning is an integral part of delivering a successful and coordinated suite of information to support stock assessment work. They also noted that the shark research plan has helped to focus work on elasmobranchs within the SC and is proving to be a useful exercise, and that noted that research planning for both tuna and billfish would also be constructive.

(i) **Comment:** PNA and Tokelau noted that a project ranking urgent and important matrix is a useful way to prioritise the workload, but stated it is unclear if CCMs will be asked to rank all projects or just those that are currently not resourced. They stated that in their view only currently unfunded work should be ranked, but that this could be more thoroughly discussed through a small working group at the next in-person meeting.
   - Reply: SPC supported the approach of ranking currently unfunded work.

(ii) **Comment:** PNA and Tokelau stated that a summary of ongoing and completed work as well as commentary around projects that were planned but not started/completed would be a useful addition to the document to assist SC in tracking the work program.
   - Reply: SPC stated that completed work could be moved to a separate table within the document, and where appropriate the corresponding report to SC referenced in that table. SPC supported discussing these further at the next in-person meeting.

TOPIC 10. Review and new analyses of skipjack growth in the WCPO

10.1 Background

- **Introduction:** The paper addresses three growth curves produced as possible alternatives for use in the 2022 WCPFC skipjack assessment.
- **Responsibility**: Authors

10.2 Relevant documents

SC18-SA-IP-06	J. Macdonald, J. Day, A. Magnusson, M. Maunder, Y. Aoki, N. Matsubara, Y. Tsuda, S. McKechnie, T. Teears, B. Leroy, C. Castillo-Jordán, J. Hampton, and P. Hamer. **Review and new analyses of skipjack growth in the WCPO**

10.3 Key Questions and Comments

17. **The PNA and Tokelau** thanked the authors for this work and note the progress that has been made. They acknowledged that this represents a step forward in the WCPFC's understanding of skipjack tuna age and growth. They expressed concern about the VBtag.oto model, in that:

> (a). This model ignores the possibility that growth can be suppressed in tagged fish. There is some evidence in the paper that this may be the case, as in the length-at-age plots the tag estimates are almost always smaller at length than the otolith-aged fish.
> (b) They noted that daily aging is challenging for fish over 1 year old, so no otolith-aged fish are included for older fish.
> (c) There are no recaptures of very large fish from which to get tag growth estimates.

The result is a lifting of the growth curve for young ages and depression of the asymptote, suggesting fairly flat growth. This would suggest a lower level of productivity than previously estimated for skipjack tuna. PNA and Tokelau stated that it believes that more work is needed and endorsed the improvements suggested. In particular, they stated work should be put into getting otoliths from large longline-caught fish, and very small fish, as well as otolith samples more broadly from across the region. In addition, otolith age validation work should be prioritized. They also suggested that tag effects on growth should be explicitly incorporated into any future models.

18. **The USA** thanked the authors for a detailed analysis that applied meta-analytic approaches and analyzed the limited available tag-increment and daily otolith data in an attempt to define an alternative growth curve to use in the skipjack tuna stock assessment. While they acknowledged that the data available for this analysis was quite sparse and opportunistically collected, it is a concern that the proposed growth curve does not appear to be able to account for known observations of small and large individuals. As noted by the authors, this is likely a product of fitting to data without observations of the smallest and largest individuals seen in the fishery length composition data. The analysis attempts to make the most of the available data by combining samples from spatially disparate regions. However, this could result in a biased population level growth curve if growth rates are not spatially homogeneous. The USA stated it concurs with the authors' conclusions that the analysis could be improved with the collection of additional samples from a structured sampling program, improvements to aging methods, and the inclusion of length composition data in the estimation model.

- **Reply:** SPC thanked the PNA and Tokelau and the US for their interest in and insightful comments on the growth analysis of skipjack in the WCPO. Regarding the specific comment (a) by PNA and Tokelau, while studies on other species have demonstrated the potential for growth suppression by external tagging activities, particularly through the application of electronic tags, we feel that the most plausible scenario explaining the difference in growth rates observed between our otolith and tag-recapture datasets stems from the potential for spatial (and/or temporal) variation in growth rates. While there is undoubtedly some conflict between the different data sources used in our analysis, we also note that the otoliths were collected from a restricted area, whereas the tag release and returns were spread more broadly, both spatially and temporally. We also note there appears to be no data available on the effect of tagging on growth for skipjack. However, given the fact that skipjack are fast growing and robust and that the tagging is conducted quickly and efficiently on pole and line vessels, with fish returned to

the water quickly and in excellent condition, we think that the growth retardation for tagged fish would be minor. This is very different to tagging programs for other species where fish may have been on a long line hook for some hours prior to tagging, and/or where fish can be brought to the surface prior to tagging from considerable depths. Given the known problems associated with ageing skipjack older than about a year, the authors deliberately chose a daily aged otolith dataset covering only young individuals, so that potentially inaccurate or biased age readings from older fish were not included in the growth estimates. Undoubtedly recaptures of larger tagged fish would be very valuable for informing growth on the older fish – but the authors consider that the estimate of L_infinity was biologically plausible given the length data observed, noting that there is considerable variation between individual fish in terms of length-at-age. Given the larger estimated size for younger fish, and vice versa for older fish, it is not clear that the alternative growth curve will result in a lower level of productivity than the growth curve estimated in the assessment. The analysis does not attempt to fit to length composition data from the catches, and given the spatial and temporal scales that this data is collected on, it is not surprising that the new growth curve does not fit this length frequency data very well. Considering the geographical range of skipjack and the different environmental conditions throughout this geographical range, it may be better to consider a model which allows for estimation of different growth rates in different regions. However, the authors stated they believe that there is insufficient data available to reliably estimate such spatial variation in growth. They agreed that additional work would be useful, including making use of length frequency data. However, priority work includes advances in epigenetic ageing and on validated ageing of skipjack otoliths, especially for large fish, so that otolith data from larger fish could be used in modelling approaches such as ours. Validated ageing of otoliths could also result in the production of conditional age-at-length data, which would be very useful data for future work estimating skipjack growth, either externally or internally within an integrated assessment framework.

19. **Australia** noted that growth estimation continues to be a challenge for skipjack, and thanked the authors for their work fitting integrated growth models to otolith and tag-recapture data. The VBtag.oto model results show some discrepancies between the two age-length datasets, particularly for small fish. Australia stated that more flexible growth models could be explored, such as a two-stanza growth model. It agreed that skipjack otoliths are not suitable for daily ageing adults. Annual age estimation of skipjack remains difficult but recent preliminary work in the Indian Ocean using otoliths and fin spines has shown some promise, and there is also similar collaborative work underway in Indonesia. This approach could be considered in the Pacific Ocean, with appropriate age validation. Australia also supported epigenetic ageing for skipjack in the long-term, but stated it is important to note that a set of validated length-at-age estimates is a prerequisite for calibrating epigenetic age estimation models. If this calibration can be done and is successful, then it may be possible for age information to be estimated from routine tissue sample collection by observers and port sampling.

TOPIC 11. Draft TOR for an independent peer review of treatment of uncertainty characterisation including ensemble model approach

11.1 Background

- **Responsibility**: SPC

11.2 Relevant documents

SC18-SA-IP-09	SPC. **Draft TOR for an independent peer review of treatment of uncertainty characterisation including ensemble model approach**

11.3 Key Questions and Comments

20. There were no questions or comments.

TOPIC 12. Progress towards a Close-Kin-Mark-Recapture application to South Pacific albacore

12.1 Background

- **Responsibility**: SPC-OFP

12.2 Relevant documents

SC18-SA-IP-10	SPC-OFP. **Progress towards a Close-Kin-Mark-Recapture application to South Pacific albacore**

12.3 Key Questions and Comments:

21. **The Nature Conservancy** noted that SPC-OFP and the US troll albacore supported group — the American Fishermen's Research Foundation (AFRF) — are developing a collaborative effort to sample South Pacific albacore in support of the CKMR project. Participating vessels that fish the South Pacific albacore stock and processors affiliated with AFRF have been identified with sampling proposed to begin in the 2022-2023 austral summer season.

TOPIC 13. No Population Structure of Bigeye Tunas (*Thunnus obesus*) in the Western and Central Pacific Ocean Indicated by Single Nucleotide Polymorphisms

13.1 Background

- **Responsibility**: Paper authors

13.2 Relevant documents

SC18-SA-IP-11	J. Natasha, B. L. Stockwell, A. D. Marie, J. Hampton, N. Smith, S. Nicol and C. Rico. **No Population Structure of Bigeye Tunas (*Thunnus obesus*) in the Western and Central Pacific Ocean Indicated by Single Nucleotide Polymorphisms**

13.3 Key Questions and Comments

22. **The PNA and Tokelau** thanked the authors for the work and noted the progress made. They acknowledged that this represents a step forward in the understanding of bigeye structure in the WCPO that is essential for the proper management of the resource. They also noted that the data indicate that the current understanding of a single WCPO bigeye tuna stock remains likely, and that this premise should be retained within the next bigeye assessment.

TOPIC 14. Estimating post-release mortality of longline caught tropical tunas in the Pacific Ocean

14.1 Background

- **Introduction:** Post-release mortality experiments were undertaken on bigeye and yellowfin tuna to assess potential post-release survival probabilities of conventional tagging on such individuals during commercial longline operations.
- **Responsibility**: Paper authors

14.2 Relevant documents

SC18-SA-IP-12	J. Muir, R. Barker, M. Hutchinson, B. Leroy, S. Nicol and J. Scutt Phillips. **Estimating post-release mortality of longline caught tropical tunas in the Pacific Ocean**

14.3 Key Questions and Comments

23. There were no questions or comments.

TOPIC 15. Progress report on bomb radiocarbon age validation for yellowfin and bigeye tunas in the WCPO (Project 105) - 2022

15.1 Background

- **Introduction**: The paper describes the progress made under Project 105 aimed at using bomb radiocarbon (14C) dating to test estimates of age from purported annual growth zones in otolith sections of WCPO yellowfin and bigeye tuna.
- **Responsibility**: Authors.

15.2 Relevant documents

SC18-SA-IP-14	A. Andrews, K. Okamoto, K. Satoh, F. Roupsard, C. Welte, and J. Farley. **Progress report on bomb radiocarbon age validation for yellowfin and bigeye tunas in the WCPO (Project 105) - 2022**

15.3 Key Questions and Comments

24. **The PNA and Tokelau** welcomed the progress on the analysis, commended the authors on a very good piece of work, and stated they are encouraged by the results that suggest the age estimates being used appear to be an accurate reflection of the real fish age. While noting that more work is planned, they stated it appears that future age and growth analyses on bigeye and yellowfin should use these recommended otolith age interpretations. They stated their hope that this work and the subsequent growth curve development using these otolith interpretations can be used for the next bigeye and yellowfin stock assessments.

TOPIC 16. Examining Indicators of Effort Creep in the WCPO Purse Seine Fishery

16.1 Background

- The paper updates and summarizes information available to SPC (as of February 2022) on catch and effort levels and any observed or potential increase in average nominal fishing effort per day and capture effectiveness per set since the introduction of the VDS management framework.
- **Responsibility**: Authors

16.2 Relevant documents

SC18-MI-IP-02	SPC and the PNAO. **Examining Indicators of Effort Creep in the WCPO Purse Seine Fishery**

16.3 Key Questions and Comments

25. **Pew Charitable Trusts** thanked the authors for the effort creep analysis, stating this is a very important element in understanding fishery dynamics. The use of VMS data in the analysis is a good step

forward in avoiding the potential bias associated with the logbook data.

(i) **Question** (for consideration in future iterations of the report): Given that a fishing day can be defined as "days when searching is conducted but a net is not necessarily deployed", should every day at sea (with available hold capacity) be defined as a fishing day in non FAD-closure periods, given that modern FAD buoys are monitoring for fish 24/7 and vessels effectively know if fish are associated with their FADs at any time (i.e., they are "searching" at all times)? In other words, should a vessel day currently defined as "in transit" to a fishing ground be defined as a fishing day if it knows it is travelling to a productive FAD? Obviously, during the FAD closure period, vessels travelling from port to a fishing ground should be classed as "in transit" as they will theoretically not be searching until they arrive.

- **Reply:** SPC stated that for this analysis using VMS days the approach counts every day that a vessel is within a PNA EEZ as a fishing day, transit days are when a vessel is travelling at speed to and from a port to a fishing ground in EEZ. Hence, the estimates of fishing days are a bit higher than those counted as fishing days in the VDS system as SPC has not adjusted for non-fishing days claims. Ideally, SPC stated it would not include days where the vessels are incapacitated and can't fish, but it doesn't get this information, so if anything, the VMS approach that is used overestimates the actual fishing/searching days. SPC stated its doesn't think a transit day from port to a fishing ground is a fishing day – vessels move at speed from a port to the fishing ground in an EEZ where they have a right to fish, once they enter the EEZ, they are immediately fishing as far as SPC's VMS analyses is concerned. SPC suggested Pew might be referring mostly to high seas effort? As to the influence of FADs and sonar technology – this has no doubt allowed vessels to target their movements between FADs more effectively, but they can still only do one FAD set a day. It was the expectation under the VDS that vessels would start doing additional sets on free schools to get more from their purchased days (i.e., increase the nominal fishing effort), but the new analysis using VMS days provided no real indication that this has happened, a bit surprising. One would expect the use of FADs with sonar and 24/7 monitoring would allow vessels to target FADs within travel range that have signals suggesting they have more associated biomass, but other factors will play into decisions to target a particular FAD – irrespective of the sonar signal, and these sonar signals are still not overly reliable apparently. SPC stated it would have expected to see increasing trends in catch per set, but that is not evident either. It noted one major caveat that is difficult to adequately address – the lack of trends in catch rates per set may actually be due to increased effectiveness of purse seine FAD sets (i.e., using sonar data effectively to target higher biomass FADs) thus compensating for underlying declines in the abundance. This is a key part of the reason SPC has decided not to use FADs in CPUE indices for stock assessment.

TOPIC 17. Key decisions for the WCPFC Commission and Scientific Committee under the harvest strategy approach for WCPO tuna stocks and fisheries (UPDATE to SC14-MI-WP-05)

17.1 Background

- **Introduction**: **SC14-MI-WP-05** highlighted areas of decision-making focus for managers and scientists during the development of harvest strategy approaches for WCPO fisheries and stocks. **SC18-MI-IP-03** updates that paper and highlights key decision areas that i) regional fishery managers and stakeholders (through the Commission and Science Management Dialogue), and ii) scientists (through the Scientific Committee and Science Management Dialogue) will need to consider during the WCPFC's process.
- **Responsibility**: SPC

17.2 Relevant Documents

SC18-MI-IP-03	G. Pilling, R. Scott, P. Hamer, J. Hampton, F. Scott, and N. Yao. **Key decisions for the WCPFC Commission and Scientific Committee under the harvest strategy approach for WCPO tuna stocks and fisheries (UPDATE to SC14-MI-WP-05)**
SC14-MI-WP-05	SPC. **Key decisions for managers and scientists under the harvest strategy approach for WCPO tuna stocks and fisheries**

17.3 Key Questions and Comments

26. **The PNA and Tokelau** stated that SC18 needs to undertake the tasks necessary to make it possible for the Commission to adopt a skipjack management procedure at WCPFC19. They made the following comments and requests:

(i) **Comment:** PNA and Tokelau see the priorities relating to a skipjack management procedure for SC18 as
   (a) Formulating a request to SPC for a revised analysis on candidate skipjack TRPs following the new skipjack assessment
   (b) Adoption of the skipjack operating model
   (c) Adoption of skipjack estimation model settings
   (d) Adoption of the MSE framework
   (e) Advice on the data collection programme
   (f) Advice on a monitoring strategy
   (g) Advice on the future role of the SC
   (h) Advice on exceptional circumstances

(ii) **Request**: PNA and Tokelau request that SPC suggest for consideration by SC18 a draft data collection programme and monitoring strategy to be included in the skipjack MP

(iii) **Comment**: To provide a basis for discussion on (g) and (h) above, PNA and Tokelau suggested the following language:

- Role of SC in a skipjack MP:
  The Scientific Committee (SC) shall regularly review the performance and outputs of the MP and provide advice to the Commission on the MP, including advice to the Commission on exceptional circumstances in accordance with ……
- Exceptional Circumstances
  Exceptional circumstances are defined as the occurrence of events that are outside the range of scenarios considered for testing the management procedure. In the case of such events, it may be necessary to re-evaluate the management procedure or, in severe cases where there is considered to be a risk to the stock, take remedial action. Meta-rules for exceptional circumstances are not a mechanism for making regular, small adjustments to the MP, but rather should be invoked where, through an agreed process, the operation of the MP has been demonstrated to be highly risky or inappropriate. This text provides guidance on the process for determining whether exceptional circumstances exist and the necessary actions but does not provide firm definitions of all possible exceptional circumstances.
  - Process to determine if exceptional circumstances exist

  SC to implement and conduct a monitoring strategy and to advise the Commission on the occurrence of exceptional circumstances based on the results of:
    - *Routine annual evaluation of potential exceptional circumstances based on information presented to and reviewed by SC.*
    - *Detailed evaluation of potential exceptional circumstances every 3 years coincident with the stock assessment.*
  - Examples of what might constitute exceptional circumstances include, but are not limited

to:

- *Persistent low recruitment outside the range for which the MP was tested.*
- *Substantial improvements in knowledge, or new knowledge, concerning the dynamics of the population which would have an appreciable effect on the operating models used to test the MP.*
- *Non-availability of important input data resulting in an inability to run the MP.*
- *Stock assessment biomass estimates that are substantially outside the range of simulated stock trajectories considered in the MP evaluations, calculated under the reference set of operating models.*
- *Persistent or strong negative outcome in key objective indicators*

o Process for action in the event of exceptional circumstances

Having determined that there is evidence for exceptional circumstances, the SC will, in the same year, provide advice to the Commission including, but not limited to:

- *the nature and considered severity of the exceptional circumstances*
- *the necessary action required*
  - *where the severity is considered to be high, the recommendation may be for a change to the catch/effort limits*
  - *where the severity is considered to be low, the recommendation may be that SC review the MP earlier than scheduled.*

(iv) PNA and Tokelau welcomed comments on these proposals.

TOPIC 18. Report of Project 110: Non-entangling and biodegradable FAD trial in the Western and Central Pacific Ocean

18.1 Background

- **Introduction**: The paper updates SC on WCPFC Project 110, which will conduct trials of non-entangling and biodegradable drifting FADs in the WCPO
- **Responsibility**: Authors

18.2 Relevant Documents

SC18-EB-IP-01	L. Escalle, G. Moreno, S. Hare and P. Hamer. **Report of Project 110: Non-entangling and biodegradable FAD trial in the Western and Central Pacific Ocean**

18.3 Key Questions and Comments

27. **The PNA and Tokelau** thanked the team working on Project 110 and noted the progress made; they expressed support for a no-cost extension.

28. **ISSF** stated that as a donor to this project, ISSF supports a no-cost extension.

29. **The International Whaling Commission** (IWC) welcomed the advances of this project, particularly the literature review with the listing the designs and materials that have already been used globally, including details of previous initiatives. It stated that the IWC's Scientific and Conservation Committees have been gathering information to assess the impacts of FADs on cetaceans. The Commission has issued recommendations with respect to FADs and the topic has also been addressed in two recent workshops. These discussions underscore concern at the rapid development of FADs in many parts of the world and the links with entanglement and ingestion by cetaceans, particularly young animals. Indeed, the IWC recently received a report of a humpback whale entangled in a local FAD off Niue. SC18-EB-IP-07 makes note of the entanglement risk of FADs to cetaceans in the Pacific Islands Region. The IWC stated it

welcomes efforts of this project to improve the design and test the performance of non-entangling and biodegradable FADs, and encourages that the bycatch of cetaceans is also recorded in the trials of this project.

TOPIC 19. Preliminarily analyses of the regional database of stranded drifting FADs in the Pacific Ocean

19.1 Background

- **Introduction**: Drifting FADs are reaching coastal areas where they can become stranded, adding to pollution and/or causing environmental damage. To quantify these events and their impacts, CCMs, in collaboration with the SPC and international NGOs have started programmes to collect in-situ data. These data collection programs on stranded and lost drifting Fads are fully implemented in seven jurisdictions to date (Cook Islands, Wallis and Futuna, the FSM, RMI, French Polynesia, Palmyra, and Hawai'i), and are starting in 2022 year in New Caledonia and Tuvalu.
- **Responsibility**: Authors

19.2 Relevant Documents

SC18-EB-IP-03	Escalle L., Mourot J., Bigler B., Jaugeon B., Kutan M., Lynch J.M., Nicholas T.R., Pollock K., Prioul F., Royer S.J., Thellier T., Wichman J., Jon Lopez, the PNA Office, Hare S., and Hamer P. **Preliminarily analyses of the regional database of stranded drifting FADs in the Pacific Ocean**

19.3 Key Questions and Comments

30. **PNA and Tokelau** thanked the other authors for their contributions and stated they were pleased to be able to support the work with use of data from the PNA FAD Buoy Tracking Programme. They stated that the PNA FAD Buoy Tracking Programme will be strengthened from January 1, 2023 as it moves from being a trial to being a mandatory requirement; in particular, this should substantially improve the data for the purpose of analysing beaching impacts by removing most of the current geo-fencing problem with the data, and stopping buoys from being deactivated/turned off while they are drifting in the tropical WCPO.

TOPIC 20. Can Stomach Content and Microbiomes of Tuna Provide Near Real-Time Detection of Ecosystem Composition in the Pacific Ocean?

20.1 Background

- **Introduction**: This preliminary study used DNA metabarcoding to test whether the stomach content and gut microbiome of tuna could be a viable near real-time monitoring tool for detecting composition and change in oceanic ecosystems.
- **Responsibility**: Authors

20.2 Relevant Documents

SC18-EB-IP-05	A. Trujillo-Gonzalez, T. Li, J. Potts, S. Nicol, V. Allain, S. C. Godwin, E. Vourey, A. Portal, B. Kumasi, T. Usu, A. Rodrigo and D. Gleeson. **Can Stomach Content and Microbiomes of Tuna Provide Near Real-Time Detection of Ecosystem Composition in the Pacific Ocean?**

20.3 Key Questions and Comments

31. **PNA and Tokelau** thanked the authors for the interesting analysis. They suggested that if the work continues, the authors explore issues that are emerging as important management and stock assessment issues. Namely:

- the impact on FADs vs free-school on fish diet;
- the calorific content of the diet of these fish, as well as gut fullness, both of which may be more influential on fish growth and condition than the species diversity of the diet; and
- recording fish condition and comparing that to the above.

TOPIC 21. Outcomes of the FAD Management Options IWG: 1) Guidelines for non-entangling and biodegradable FADs, and 2) Preliminary Review of Available Information on Biodegradable FADs

21.1 Background

- **Responsibility**: FAD Management Options IWG

21.2 Relevant Documents

SC18-EB-IP-06	**Guidelines for Non-entangling and Biodegradable FAD Materials**
SC18-EB-IP-13	WCPFC FAD Management Options IWG. **Preliminary Review of Available Information on Biodegradable FADs**

21.3 Key Questions and Comments

32. **PNA and Tokelau** stated that they continue to attach importance to WCPFC's decision to consider the adoption of measures on the implementation of biodegradable material on FADs in 2023. At the same time, PNA and Tokelau stated that they are cautious about the implications of changes because of the economic dependence of some PNA Members on the FAD fishery in their waters. One area that PNA considers important is improving monitoring of the implementation of non-entangling and/or biodegradable FAD guidelines and requirements. They noted that this is an outstanding recommendation from the FAD Management Options IWG from 2021. PNA and Tokelau are implementing new requirements for FAD data to be provided by vessel operators; these are aimed at improving the quality of data on FADs and FAD buoys and allowing observers to focus on monitoring the use of FADs and the implementation of FAD-related measures. This will result in the need to revise the ROP minimum data fields for FAD data to remove some of the detailed technical fields now provided by observers and replacing these with data elements more specifically directed at monitoring the implementation of non-entangling and biodegradable FADs. PNA and Tokelau stated that this change can't be made until the quality of the data from vessel operators is assured, but encouraged CCMs to consider what the revised ROP data fields for FADs should include.

- **Reply:** The FADMO-IWG Chair stated that the non-entangling and biodegradable FAD guidelines may still be considered outstanding or work in progress as new information becomes available. WCPFC-SC18-EB-IP-01 for WCPFC Project 110 will include a review of non-entangling and biodegradable FAD trials that have been performed worldwide, as well as the potential biodegradable materials that could be used (Appendix 2, SC18-EB-IP-01). He stated that results from Project 110 should provide updated information to improve the guidelines for non-entangling and biodegradable FADs. Regarding improvement of FAD data quality and monitoring, FADMO-IWG has yet to reach this stage but the Chair stated he would consider incorporating this into the timeline for the stepwise approach noting this has been applied within the PNA, noting that it might be worthwhile if the DCC or TCC would revisit the ROP minimum data fields related to FADs, particularly monitoring of non-entangling and biodegradable FADs implementation in the future, to improve data quality in this area.

33. **ISSF** noted that SC18-EB-IP-17 presents information that is complementary to that in WCPFC-SC18-EB-IP-01. This biodegradable design is being tested in the WCPO, EPO and Atlantic and the results are very promising.

- **Reply:** The FADMO-IWG Chair thanked ISSF for the comment, and noted that para. 14 in EP-IP-13 has reflected most of the recommendations from the EP-IP-17, and stated he would also like to seek views, especially from the SC participants, on the recommendations in the EP-IP-17.

34. **The USA** stated it supports the WCPFC considering the definition and categories of biodegradable as developed and adopted by the IATTC this year.

- **Reply:** The FADMO-IWG Chair thanked the USA for its support on the IATTC definition and categories of biodegradable.

35. **SPREP** stated that it welcomes the ongoing work of the FAD Management Options IWG. One area of research that appears lacking is in relation to biodegradable FAD materials and ongoing impacts to the marine environment until the materials breakdown to their component parts. For example, entanglement by marine species could still occur even with biodegradable materials and release through breakdown of materials may not happen fast enough to reduce mortality. In this regard a focus on retrieval of FADs should continue to remain a priority.

36. **The IWC** welcomed the discussion at SC-18 of the topic of managing deployment, collecting data, and the development of non-entangling and biodegradable FADs. It stated this is a topic of great interest in the Pacific with the significant use of the FADs, and noted the IWC recently received a report of a humpback whale entangled in a local FAD off Niue. Paper EB-19-07 (Miller et al) makes note of the entanglement risk of FADs to cetaceans in the Pacific Islands Region. The IWC's Scientific and Conservation Committees have been gathering information to assess the impacts of FADs on cetaceans. The Commission has issued recommendations with respect to FADs and the topic has also been addressed in two recent workshops. These discussions underscore concern at the rapid development of FADs in many parts of the world and the links with entanglement and ingestion by cetaceans, particularly young animals. IWC stated it welcomes efforts to improve the design of FADs, and the tracking of their deployment (with unique identifiers) and retrieval. In addition to potential population-level impacts on cetaceans, interactions between fishery operations and cetaceans can cause damage and loss of fishing gear with economic impacts on the fishery sector.

TOPIC 22. Review of cetacean diversity, status and threats in the Pacific Islands region 2021

22.1 Background

- **Introduction:** The paper updates a review conducted by the same author in 2008 and provides an overview of the state of knowledge on threats to cetaceans (whales and dolphins) in the waters surrounding the Pacific Island Countries and Territories of the Pacific Islands region.
- **Responsibility**: SPREP

22.2 Relevant Documents

SC17-EB-IP-13	C. Miller (SPREP) **Review of cetacean diversity, status and threats in the Pacific Islands region 2021**

22.3 Key Comments and Questions

37. **SPREP** stated that it is eager to get some feedback on the recommendations in this paper (page 38) including

(i) a focus on increasing the quality and quantity of data collected in the regional observer programme (ii) improving general knowledge of cetacean diversity, distribution and populations in the region (iii) increasing data coverage, confidence and availability of data on key threats to cetaceans (iv) promoting targeted in-country funding, partnerships and support for cetacean related research and conservation for use by PICTs (v) mainstreaming cetacean issues in relevant national and regional environmental initiatives.

SPREP stated it was especially keen to get comments in relation to i) and iii), noting the recommendations on training and resources (p. 38) and reporting and recording of observations (p. 41).

38. **The USA** congratulated SPREP on the impressive document and supported the idea to increase the quality and quantity of data on cetacean bycatch in the WCPO, including through increased observer coverage in improved data collection (e.g. ID guides, cameras, updated species codes on collection forms, etc.). Given the USA's support for the recently adopted WCPFC cetacean safe handling and release guidelines, and the accompanying graphics (SC18 ODF Topic 23), the USA stated it is also supportive that these guidelines could be widely shared across the WCPO.

39. **The IWC** welcomed the publication of this important study documenting the diversity, status and threats to cetaceans in the Pacific Islands region. The IWC noted in particular the wide range of threats to these populations, and the evidence of population-level impacts on cetaceans from accidental interactions with fishing gear. The IWC stated it considers the recommendations proposed in the report (both on training and resources, and reporting and recording of observations) pertinent and highly relevant to increasing the understanding of cetacean diversity, distribution and threats in the Pacific islands. The IWC stated that whenever deemed necessary, it offers its expertise and mechanisms to support the continuation (or the initiation) of the efforts of different stakeholders to improve cetaceans knowledge as well as the assessment, monitoring and/or mitigation of its bycatch in the Pacific. The IWC noted it is launching a four-year study funded by FAO under the Common Oceans II tuna project that will work collaboratively with the relevant tuna RFMOs to find practical, workable solutions to monitor and mitigate cetacean bycatch while conducting viable fishery operations. This will involve field work with local fishing communities and partners (WCPFC, SPREP, and FFA as possible) and sharing of experiences across fisheries. With this important study, this Common Oceans II FAO project will already have a good baseline of information to design the initial plans for the research and field work, in collaboration with partners in the Pacific. The knowledge gaps identified in this study are a handy starting point for planning this work. The IWC stated it welcomes the engagement of WCPFC members and partners in IWC's Scientific and Conservation Committees meetings and processes.

TOPIC 23. Graphics for Best Practices for the Safe Handling and Release of Cetaceans

23.1 Background

- **Introduction:** WCPFC18 adopted Best Practices for the Safe Handling and Release of Cetaceans. This document presents a set of draft graphics produced to illustrate the guidelines, as recommended by SC17. SC18 is invited to consider the graphics and provide a recommendation for adoption by WCPFC19.
- **Responsibility**: Secretariat

23.2 Relevant Documents

SC18-EB-IP-12	Secretariat. **Graphics for Best Practices for the Safe Handling and Release of Cetaceans**

23.3 Key Comments and Questions

40. **PNA and Tokelau** thanked the Secretariat for the work to build on and translate a clear message of the guidelines that were recently adopted at WCPFC18 on the safe handling and release of Cetaceans. They supported the work and consider that it is as important to also produce these guidelines in various languages for vessels crews being the target audience, to easily understand, as most do not speak English.

41. **The United States** thanked the Secretariat for coordinating the work, and supported the adoption of the graphics for Best Practices for the Safe Handling and Release of Cetaceans. The USA suggested the following SC18 recommendation:

SC18 recommends the graphics for Best Practices for the Safe Handling and Release of Cetaceans be forwarded to TCC18 and WCPFC19 for consideration and adoption.

The USA also supported the suggestion from PNA and Tokelau regarding the translation of WCPFC guidelines into various languages, noting it had submitted a voluntary contribution in 2021 to support the development and distribution of graphics illustrating the cetacean guidelines. If there are remaining funds from that contribution, the USA suggested that they could be used to translate the guidelines.

42. **The IWC** welcomed the graphics as a tool to support the active use of the Safe Handling and Release Guidelines and noted it is preparing 'Fact Sheets' to support the use of the FAO's recently published Guidelines to prevent and reduce bycatch of marine mammals in capture fisheries. The graphics presented in the paper are well designed and provide a lot of basic, useful information for fishery operators. Based on the consensus of the "IWC best practices", the IWC requested that SC consider modifying the text and graphics shown (in both ANNEX I and ANNEX II) — regarding the admonition to NOT get into the water — as follows:

- For the text saying "2- Do not attempt to release large cetaceans by having crew in the water, to the extent possible", we suggest to remove "to the extent possible". If there needs to be replacement text, IWC suggest it could read "2- Do not attempt to release large cetaceans by having the crew in the water. Instead, use knives that are securely attached to long poles, from a small vessel alongside the animal."
- For the associated drawings, IWC suggest it to be modified so that it shows an individual in the water, next to a large cetacean with the internationally recognized slash for "NO" through it . This would be preferable to the current draft which seems to discourage the use of inflatable vessels. Please note that, entanglement response experts do in fact often work alongside entangled whales using inflatables because it is possible to observe with a dive mask by leading off the side of the boat, without getting into the water, and if the whale is bumped, the soft surface of the vessel is less likely to elicit a reaction than a hard metal boat.

TOPIC 24. Practicality and Efficacy of Tori Lines to Mitigate Albatross Interactions in the Hawaii Deep-set Longline Fishery

24.1 Background

- **Introduction:** In 2019, the Council, Hawaii Longline Association, NMFS Pacific Islands Fisheries Science Center and NMFS Pacific Islands Regional Office implemented a cooperative research project to conduct a tori line demonstration and experiment in the Hawaii deep-set longline fishery. The project assessed the practicality of alternative tori line designs, determined the effect of tori line use on albatross interaction risk, and developed recommendations for tori line minimum standards.
- **Responsibility:** Authors

24.2 Relevant Documents

SC18-EB-IP-14	E. Gilman et al. Practicality and Efficacy of Tori Lines to Mitigate Albatross Interactions in the Hawaii Deep-set Longline Fishery

24.3 Key Comments and Questions

43. **The USA** thanked the authors for this important work. They noted that there were a number of small longline vessels (<24 m) that participated in the study, and stated the research may provide a good example of effective tori line designs that could reasonably be implemented on vessels <24 m.

TOPIC 25. Could tori lines replace blue-dyed bait to reduce seabird bycatch risk in the Hawaii deep-set longline fishery?

25.1 Background

- **Introduction:** The comparative efficacy of tori lines and blue-dyed fish bait as seabird bycatch mitigation measures was assessed for the Hawaii deep-set tuna longline fishery.
- **Responsibility**: Authors

25.2 Relevant Documents

SC18-EB-IP-15	E. Gilman et al. **Could tori lines replace blue-dyed bait to reduce seabird bycatch risk in the Hawaii deep-set longline fishery?**

25.3 Key Comments and Questions

44. **Birdlife International** stated it is highly supportive of ongoing efforts to identify improved seabird bycatch mitigation measures in WCPFC fisheries, and is pleased the issue of blue dyed bait being replaced with tori lines will be discussed at SC18. It noted that, regarding blue-dyed bait, ACAP best practice advice states "*No experimental evidence of effectiveness in pelagic longline fisheries*." This advice is further supported by the evidence submitted to SC18 in paper SC18-EB-IP-14. Birdlife International stated it fully supports any proposal to update the seabird bycatch mitigation measures in the North Pacific as current measures have been demonstrated to be ineffective at reducing bycatch, noting this is evidenced by the reported seabird bycatch in the annual reports of CMMs who fish north of 23° N. Birdlife International stated it is grateful to SC for discussing this and hope to see action to amend CMM2018-03 as a result.

45. **SPREP** noted the work by Gilman et al showing the effectiveness of tori lines to reduce by-catch of seabirds. SPREP stated it supports science-based evidence to improve management measures for better protection of ETP species, and looks forward to discussions to review the CMM for seabirds to bring it into line with ACAP best practice guidelines.

46. **The USA** stated it supported a future review of the current CMM 2018-03 mitigation requirements, including the use of blue-dyed bait and offal discards as mitigation strategies. It noted that domestic research in the USA to explore the effectiveness of seabird mitigation measures in its Hawaii longline fleet is ongoing, and state it will further explore the effectiveness of blue dyed bait and offal discards.

47. **Japan** stated that its research group has reported on blue-dyed bait to SC7 (in SC7-EB-WP-09. *A comparison of two blue-dyed bait types for reducing incidental catch of seabirds in the experimental operations of the Japanese southern bluefin tuna longline*). The study concluded that blue bait is effective

in bycatch reduction, which appears to be at conflict with the results of the Hawaii study. However, Japan suggested it is not actually in conflict and that the effect of blue-dyed bait may be such that it is an additional assist to major mitigation measures such as tori-lines, weighted branchlines, and night setting. Japan stated there appears to be a need for more verification and discussion of the effect of blue-dyed bait among specialists of bycatch mitigation gears.

TOPIC 26. Proposed procedures in accordance with "Access to genetic resources and Benefit-Sharing" (ABS) concept for publishing scientific paper in the Western and Central Pacific Fisheries Commission

26.1 Background

- **Responsibility:** Authors

26.2 Related Documents

SC18-GN-IP-08	K. Satoh, Y. Tsuda, K. Okamoto, J. Matsubayashi and H. Minami. **Proposed procedures in accordance with "Access to genetic resources and Benefit-Sharing" (ABS) concept for publishing scientific paper in the Western and Central Pacific Fisheries Commission**

26.3 Key Comments and Questions

48. **PNA and Tokelau** stated they have some concern regarding the proposal in terms of ensuring the linkage between this process is consistent with the ongoing work relating to access to genetic resources and the fair and equitable sharing of benefits arising from their utilization in other international fora. They stated that they are also working through national mechanisms for utilization of marine resources through platforms such as the blue economy and marine spatial planning, and foresee a need to capture, through the consent process for sample collection, considerations such as the following:

(a) Is there a national repository to store copies of the scientific reports produced from offshore research?
(b) Are there requirements that fee-free access to any publications be made available to the coastal states whose waters samples are taken from?
(c) Do Parties have capacity for researchers, students, or observers to participate in research cruises conducted in the waters of a coastal state?
(d) Is there a requirement to have a national collaborative institution for the purpose of knowledge and technology sharing?

The PNA and Tokelau suggested the additional considerations as specified above be incorporated into the proposal through a consultative process.

- **Reply:** Japan replied that it appreciated the suggestions and questions for its proposal.

(a) and
(b) Regarding the first two questions, Japan stated that creating such a repository framework to share scientific reports is quite important to properly implement our proposals. Although a copyrighted content is difficult to open to the public in some cases, this problem cab be overcome by sharing authors' contact addresses in the framework. Japan doesn't currently have a specific repository related to the ABS matter in the WCPFC area. It recommended that parties including CCMs prepare a framework to readily share published scientific papers under the ABS concept in the WCPFC area. In addition, if the phrase "of the scientific reports" in the first question indicates the research cruise reports including raw data (e.g., position and number of specimens by sampling station), it is beyond of the scope of the original proposals. However, such cruise report including raw data can be shared using the framework if needed only within

the group (primary body of the research and counterpart), at least before publishing.

(c) Regarding the third question, an application to the relevant country for access to the coastal zone usually will be made before research cruises. It is expected to discuss possibility of boarding of researchers, students and observers from the relevant country through this application process. We would like to add this option to our proposal. In the case of a research cruise in coastal areas, it is recommended that parties, primary body of the research and counterpart, explore the possibility of having counterpart from coastal countries participate in research cruises.

(d) Regarding the last question, the benefit sharing in the ABS concept for genetic resources is assumed to be achieved thorough publishing scientific papers and sharing novel scientific knowledge, thus the approach for sharing knowledge and technology depends on the situation for each research and each country.

Japan further stated it had revised its proposal based on the suggestions from PNA and Tokelau, and invited SC18 to consider the revised proposal.

Revised proposals

(1) The objectives of the WCPFC Convention are compatible with the objectives of the Convention on Biological Diversity (CBD) and the Nagoya Protocol. The biological samples of tuna, tuna related species and bycatch species covered by the WCPFC Convention can be used for scientific purposes that contribute to the management of these species. The benefit sharing in the ABS concept for the genetic resources is assumed to be achieved thorough publishing scientific papers and sharing novel scientific knowledge which contribute to refine the stock assessments and management of the fishery resources.

(2) If the domestic laws related to the ABS procedure are in place, the procedures of domestic laws will be taken into consideration.

Additional new proposals

(3) It is recommended that parties including CCM prepare a framework to readily share published scientific papers under the ABS concept in the WCPFC area.

(4) In the case of a research cruise in coastal areas, it is recommended that primary body of the research and counterpart explore the possibility of having counterpart from coastal countries participate in research cruises.

TOPIC 27. Statistical and Monte Carlo Analysis of the Hawaii Deep-Set Longline Fishery with Emphasis on Take and Mortality of Oceanic Whitetip Shark

27.1 Background

- **Introduction:** The study developed a process model from pelagic observer data to describe the take and mortality of oceanic whitetip shark in the Hawaii deep-set longline fishery.
- **Responsibility:** Authors

27.2 Related Documents

SC18-EB-IP-18	K. Bigelow and F. Carvalho. **Statistical and Monte Carlo Analysis of the Hawaii Deep-Set Longline Fishery with Emphasis on Take and Mortality of Oceanic Whitetip Shark**

27.3 Key Comments and Questions

49. There were no comments or questions.

TOPIC 28. WPEA Project Update

28.1 Background

- **Responsibility:** Secretariat

28.2 Related Documents

SC18-RP-WPEA-01	L. Olsen. **WPEA Project Update**

28.3 Key Comments and Questions

50. **The Philippines** stated it fully supported the two recommendations in the WPEA report (regarding a no-cost extension to 2024, and development of a new project proposal for the next phase of WPEA work that is relevant to the WCPFC, to begin immediately after the current WPEA-ITM project expires). The Philippines stated that it is grateful to New Zealand for the funding support made to the WPEA-ITM Project for the last three years.

51. **Indonesia** supported the two recommendations in the WPEA report (a no-cost extension to 2024 and development of a new project proposal), given the importance of the activities, and the unavoidable postponement of some activities due to COVID-19. Indonesia expressed its appreciation and thanks to New Zealand for its ongoing support of the WPEA-ITM since 2019.

TOPIC 29. Consideration of the robustness set of operating models for skipjack tuna in the WCPO

29.1 Background

- **Responsibility:** SPC

29.2 Related Documents

SC18-MI-IP-12	R. Scott, F. Scott, N. Yao, P. Hamer, and G. Pilling. **Consideration of the robustness set of operating models for skipjack tuna in the WCPO**

29.3 Key Comments and Questions

52. There were no comments or questions.

TOPIC 30 An update on the options for a baseline of the "large fish" handline fishery fishing in Indonesia's EEZ (IEEZ) with vessels >30GT for the WCPFC Tropical Tuna Measure

30.1 Background

- **Introduction:** TCC17 considered the work conducted on the application of paragraph 51 of CMM 2020-01 to Indonesia's "Other Commercial" domestic fisheries, noting the following papers presented to SC17 and TCC17: SC17 ST-IP-09and SC17-ST-WP02. TCC17 and SC17 agreed on the recommendations provided in these papers but noted the difficulties in determining a baseline for the Indonesia large-fish Handline fishery (relevant to para 51 of CMM 2020-01). WCPFC18 considered the SC17 and TCC17 papers and recommendations, and WCPFC18-2021-24. At WCPFC18 CCMs agreed to refer the issue to SC18 and TCC18 for consideration prior to making any determinations regarding this issue in the context of the tropical tuna measure's other commercial fisheries.
- **Responsibility:** SPC

30.2 Related Documents

SC18-ST-WP-02	An update on the options for a baseline of the "large-fish" Handline fishery fishing in Indonesia's EEZ (IEEZ) with vessels >30GT for the WCPFC Tropical Tuna Measure.

29.3 Key Comments and Questions

53. **FFA members** noted that at WCPFC18 they expressed their concern that the information provided by Indonesia had not been considered by the SC and the TCC in the same way that the baselines for the other relevant fisheries covered by paragraph 47 had been. Furthermore, FFA members also maintained that this review is important, both for the purpose of ensuring due process, and also to ensure that the implications of the different baseline period can be considered. They noted that it is important that a precedence is not set where limits are set outside the period stipulated by a CMM. They requested SPC to provide guidance on possible implications of setting limits on a different baseline from that of 2001-2004 or 2004.

- **Reply:** SPC stated that the issue is complicated to explain because the catches of this fishery in the archipelagic waters (Aws) do not apply for the tropical tuna measure limit, but SPC does account for the total catches both inside and outside AWs in the scientific work of the WCPFC. As explained in previous papers, estimates for this particular fishery do not exist for the baseline period; in addition, Indonesia fishery estimates in general for years prior to the WPEA project have been acknowledged as unreliable and at least for the small-scale fisheries, under-reported. The main issue for setting limits using a different baseline period is that the limit might be higher than the original baseline-year catches (if these were known). SPC does not have any data for the tropical tuna baseline period of 2001-2004 other than the estimates for the "other fisheries" submitted by Indonesia. There appears to be some qualitative evidence that at least one of the main processing plants for the large-fish handline fishery existed during the baseline years. There were also considerable catches in the Philippines large-fish handline fishery in adjacent/overlapping waters during these baseline years. Annual catch estimates for the Indonesian large-fish handline fishery are only available for 2013-2016 (and not estimated after 2016). However, to ensure consistency when estimates for this fishery are used for WCPFC Scientific work, the catch levels for years 2014-2016 (when estimates were available) have been carried over for years 2017 through 2020. These (carry-over) catch estimates have been used in the recent WCPFC scientific work (e.g. yellowfin stock assessments and yellowfin projections), so at least the approximate level of catch proposed with this limit has been accounted for in recent scientific work. The main impact of a baseline is on stock projections. At present, for catch projections, SPC assumes future catches will be at the level of the 2016-2018 average - noting that for this fishery, we are using the catch estimates for 2016 provided for this fishery as shown in Table 1 of the paper and carried forward for 2017 and 2018. A changed baseline would not impact the stock assessment unless the level of catches currently estimated for that fishery were to be changed as the result of new information (for example, if estimates for 2017 and beyond for this fishery become available). As an indication, and referring to the 2020 yellowfin stock assessment, the proposed limit for large-fish handline represents about 10% of the total yellowfin catch for what is termed the "MISCELLANEOUS GEARS" for the Indonesia and Philippine fleets in Region 7 for recent years… noting that the fishery impacts by region are shown in Figure 58 of the yellowfin stock assessment paper. With these constraints noted and this brief response, hopefully there is enough information provided for SC18 to consider an appropriate baseline.