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

OUTCOMES DOCUMENT

The Commission for the Conservation and Management of
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SC18 OUTCOMES DOCUMENT

AGENDA ITEM 1 — OPENING OF THE MEETING

1.1 Welcome address

1.2 Meeting arrangements

1.3 Adoption of the agenda

1.4 Reporting arrangements

AGENDA ITEM 2 — DATA AND STATISTICS THEME

2.1 Data gaps of the Commission

2.1.1 Data gaps

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

2. 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."

3. 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

4. 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.

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[2]

3.1.1.2 Provision of scientific information

a. Status and trends

5. 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.

6. 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 (80th 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 (80th 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.

7. 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

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

[2] SC18-SA-WP-01 https://meetings.wcpfc.int/node/16242

(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 recruitments 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).

8. 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).

9. 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).

10. 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.

11. 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.

12. 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

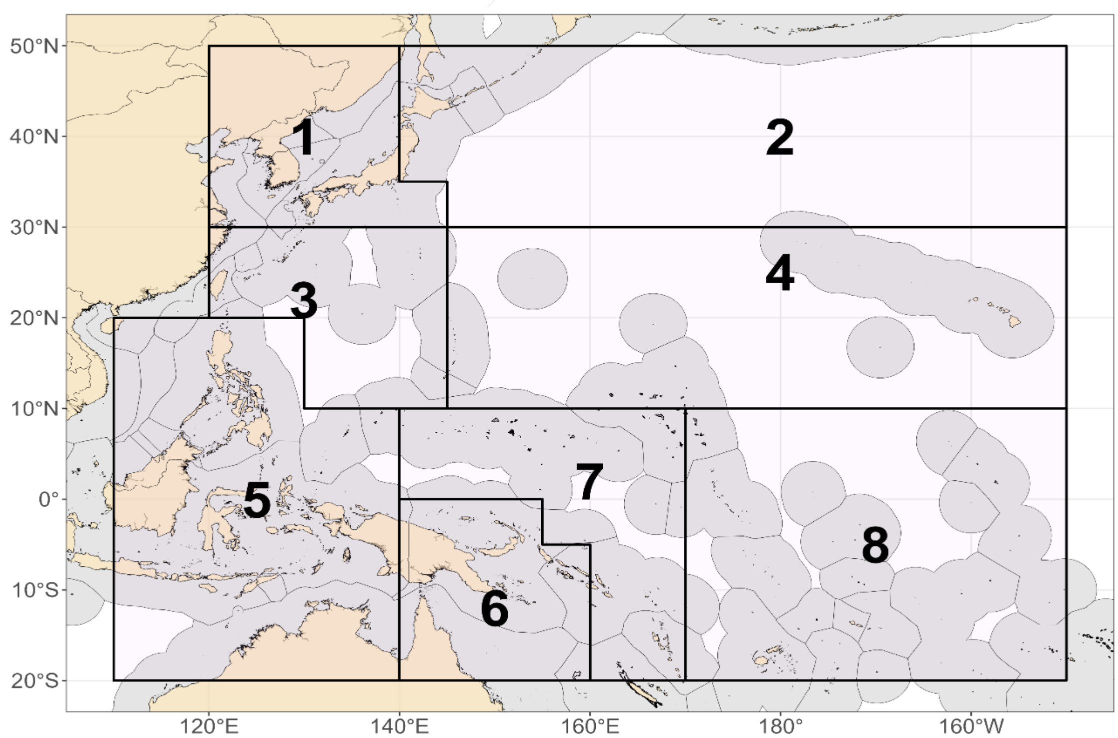

Figure SKJ-01. The geographical area covered by the stock assessment and the boundaries of the eight model regions used for 2022 WCPO skipjack assessment.

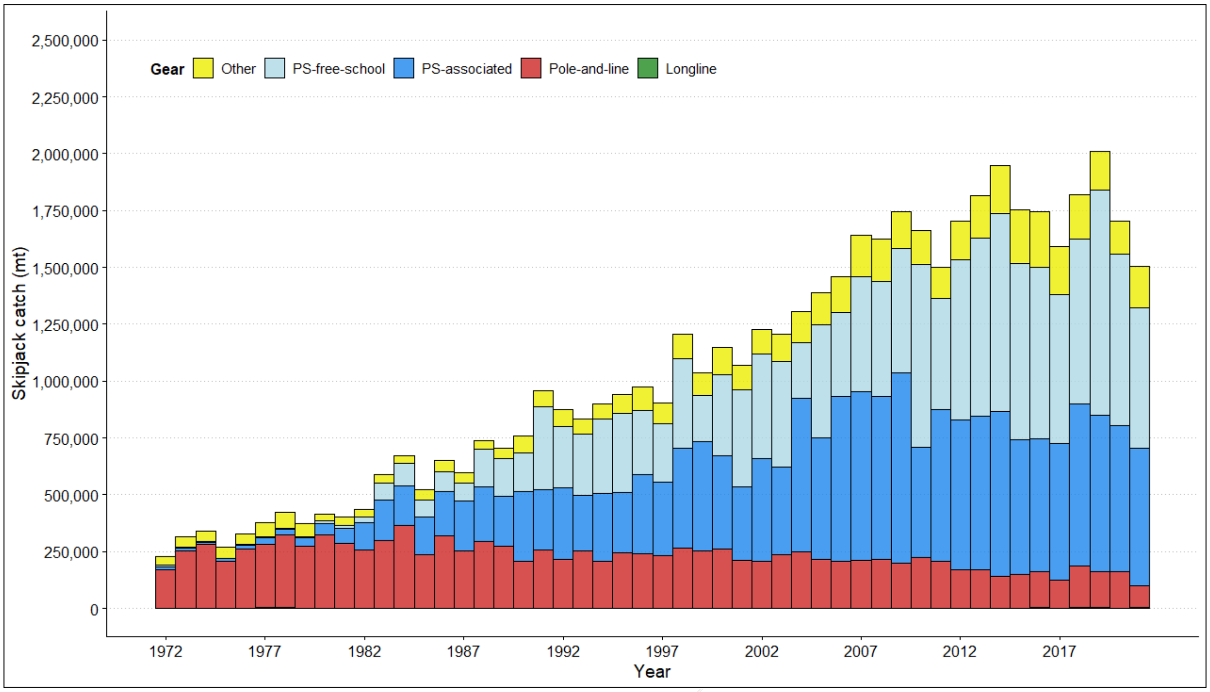

Figure SKJ-02. Annual catches of skipjack by gear type in the WCPO area covered by the assessment.

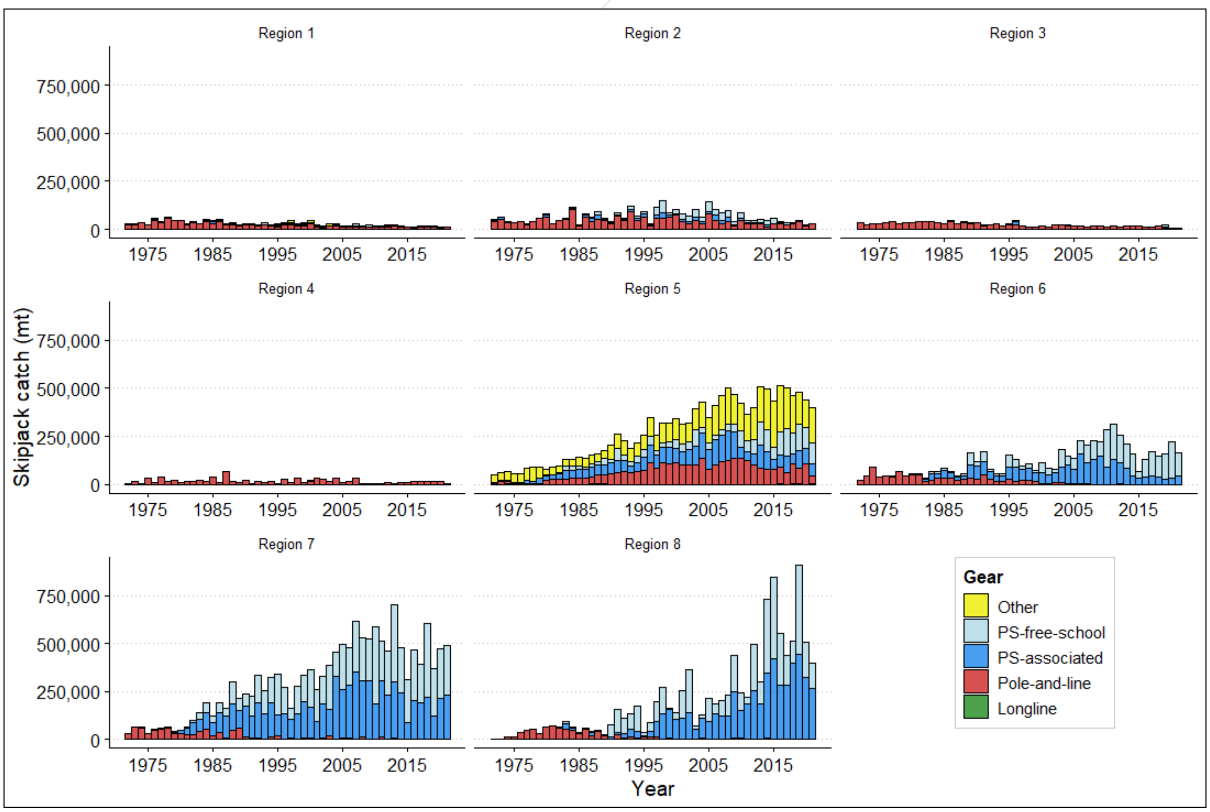

Figure SKJ-03. Annual catches of skipjack by gear type for each of the eight model regions.

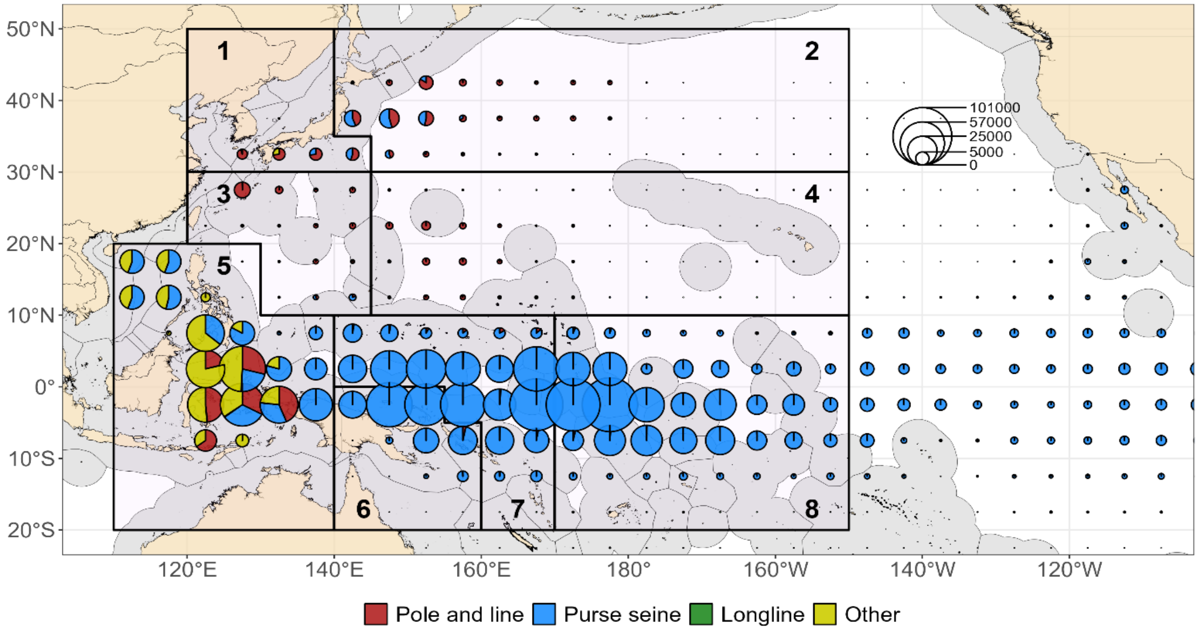

Figure SKJ-04. Distribution and magnitude of skipjack catches (mt) by gear type summed over the last 10 years (2012-2021) for 5 x 5 degree cells.

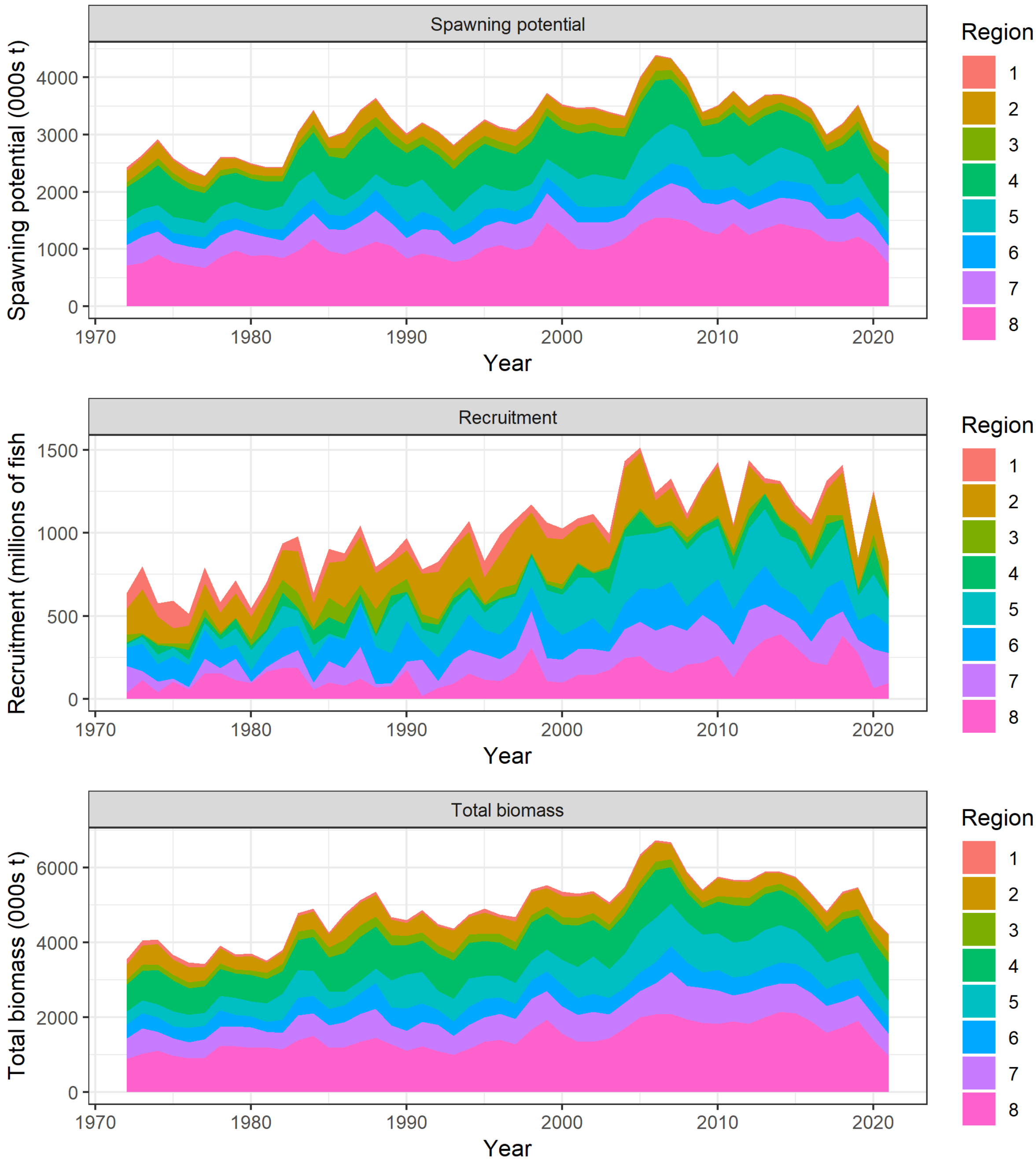

Figure SKJ-05. Estimated average quarterly recruitment, spawning potential and total biomass by model region from 1972-2021 for the 2022 skipjack diagnostic model, showing the relative proportions among regions.

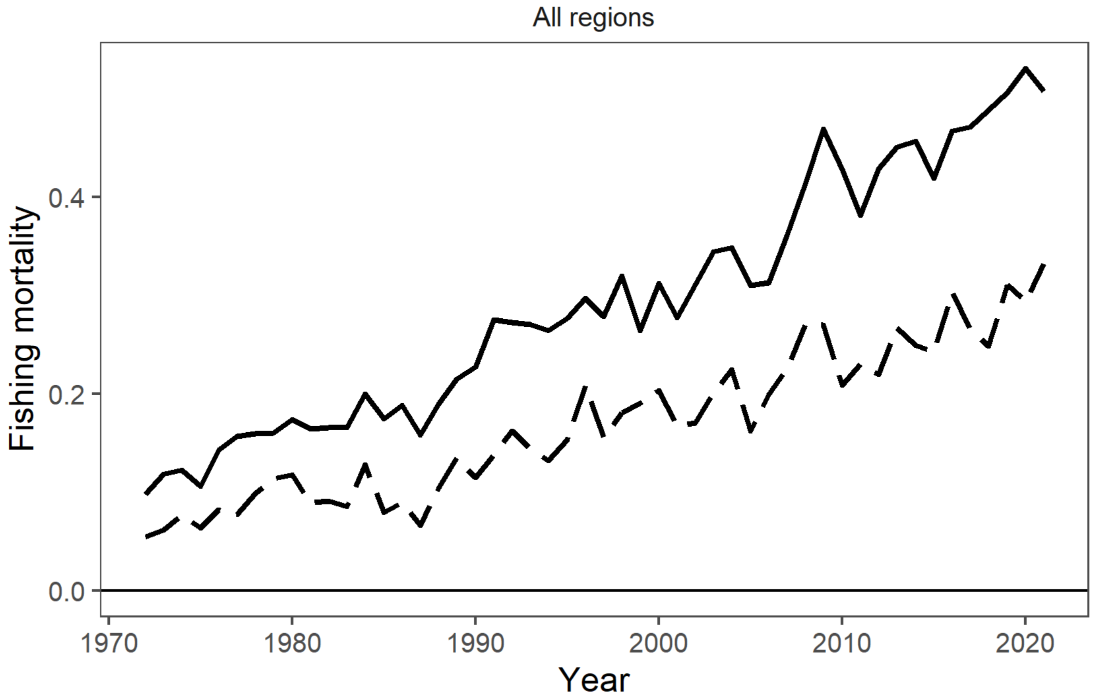

Figure SKJ-06. Estimated average quarterly adult (solid line) and juvenile (dashed line) fishing mortality for the diagnostic model from 1972-2021.

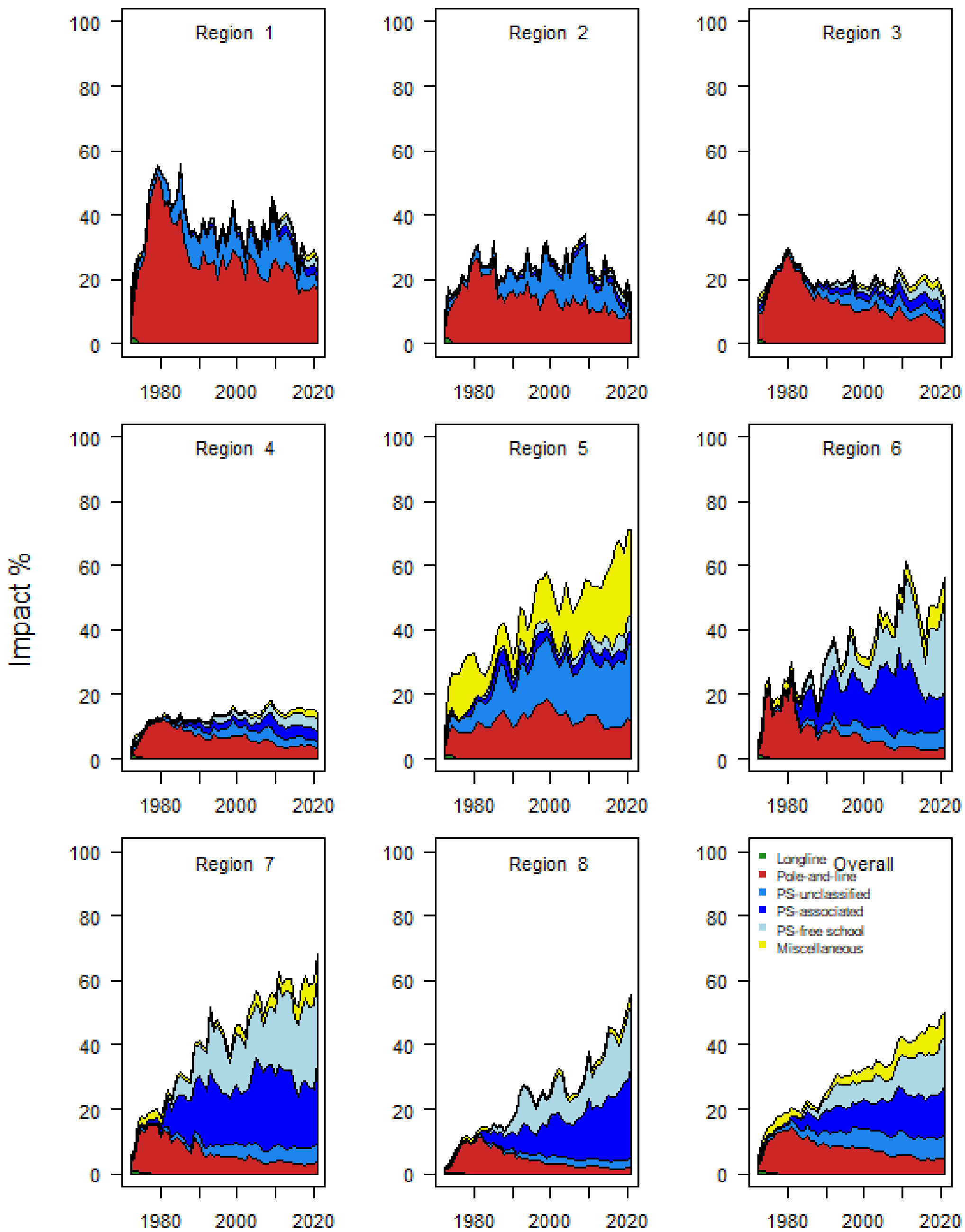

Figure SKJ-07. Estimates of reduction in spawning potential due to fishing (Fishery Impact = 1–$SB_{latest}/SB_{F=0}$) by region, and over all regions (lower right panel), attributed to various fishery groups for the diagnostic model.

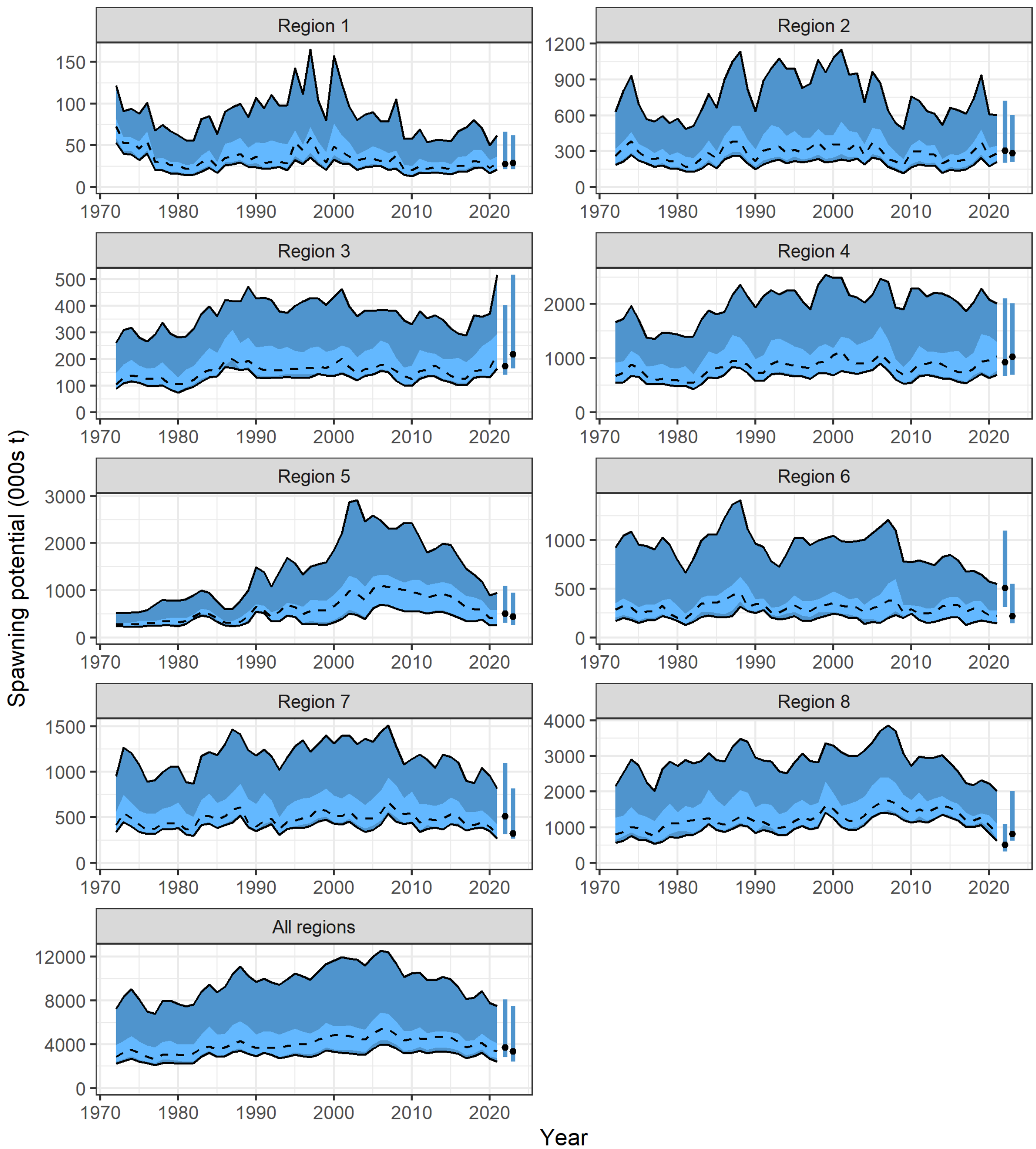

Figure SKJ-08. Trajectories of spawning potential (SB) across all models in the structural uncertainty grid over the period 1972-2021. The dashed line represents the median. The lighter band shows the 50th percentile, and the dark band shows the 80th percentile of the model estimates. The bars at the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

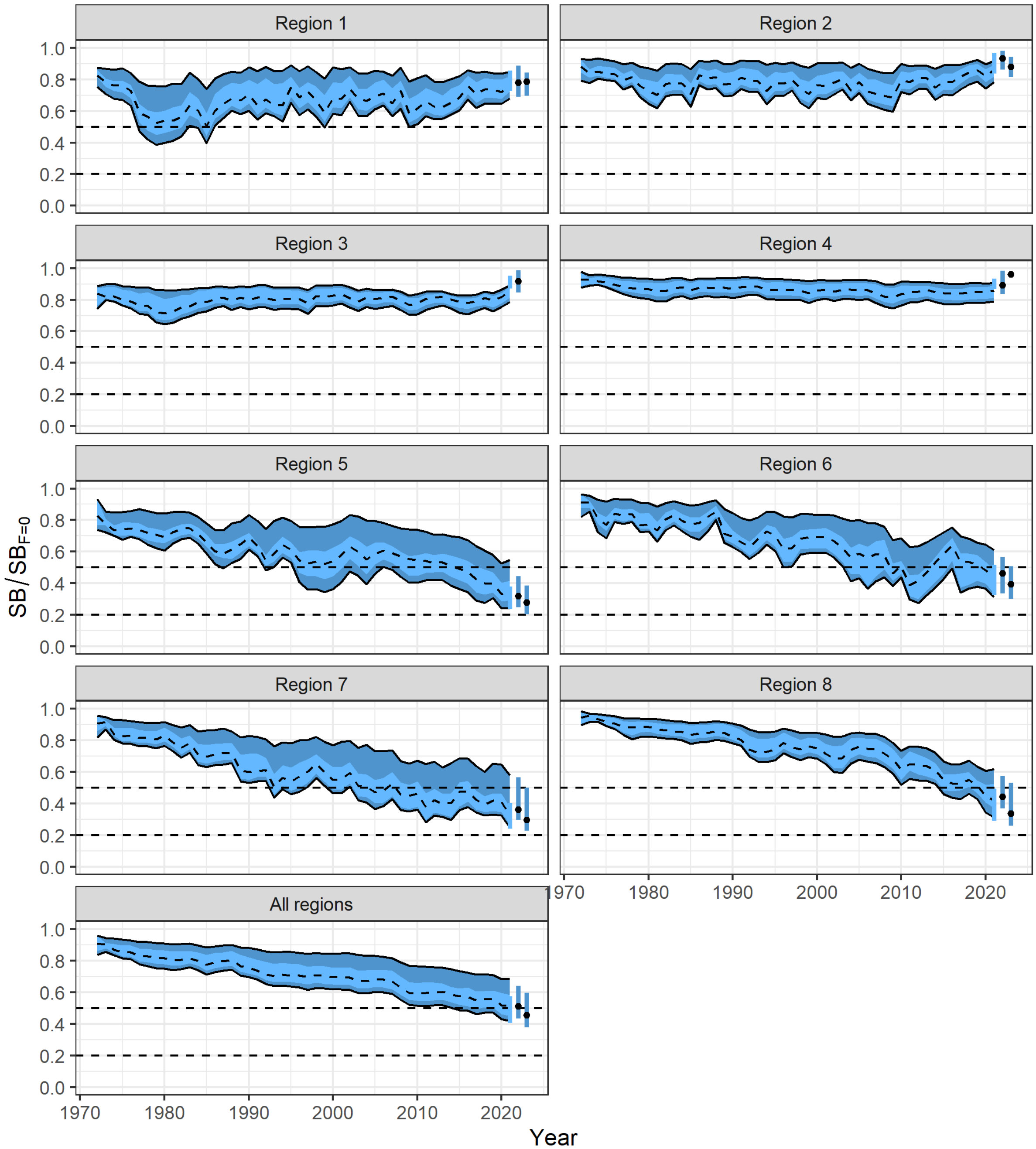

Figure SKJ-09. Trajectories of spawning potential depletion across all models in the structural uncertainty grid over the period 1972-2021. The dashed line represents the median. The lighter band shows the 50th percentile, and the dark band shows the 80th percentile of the model estimates. The bars at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

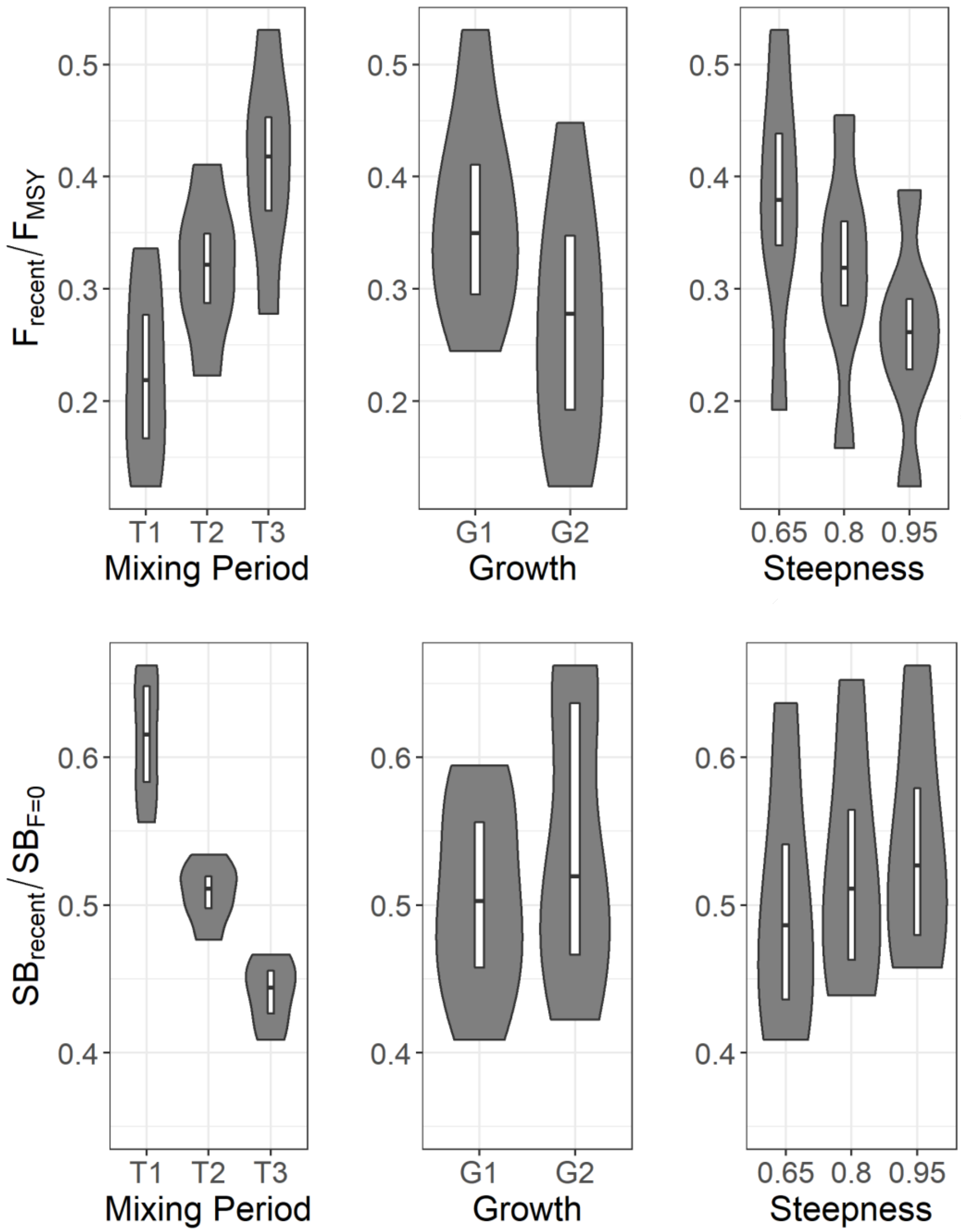

Figure SKJ-10. Box and violin plots summarizing (Top) the estimated F_{recent}/F_{MSY} and (Bottom) $SB_{recent}/SB_{F=0}$ for each of the models in the structural uncertainty grid grouped by uncertainty axes (growth, tag mixing and steepness). The line in the white box is the median of the estimates,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

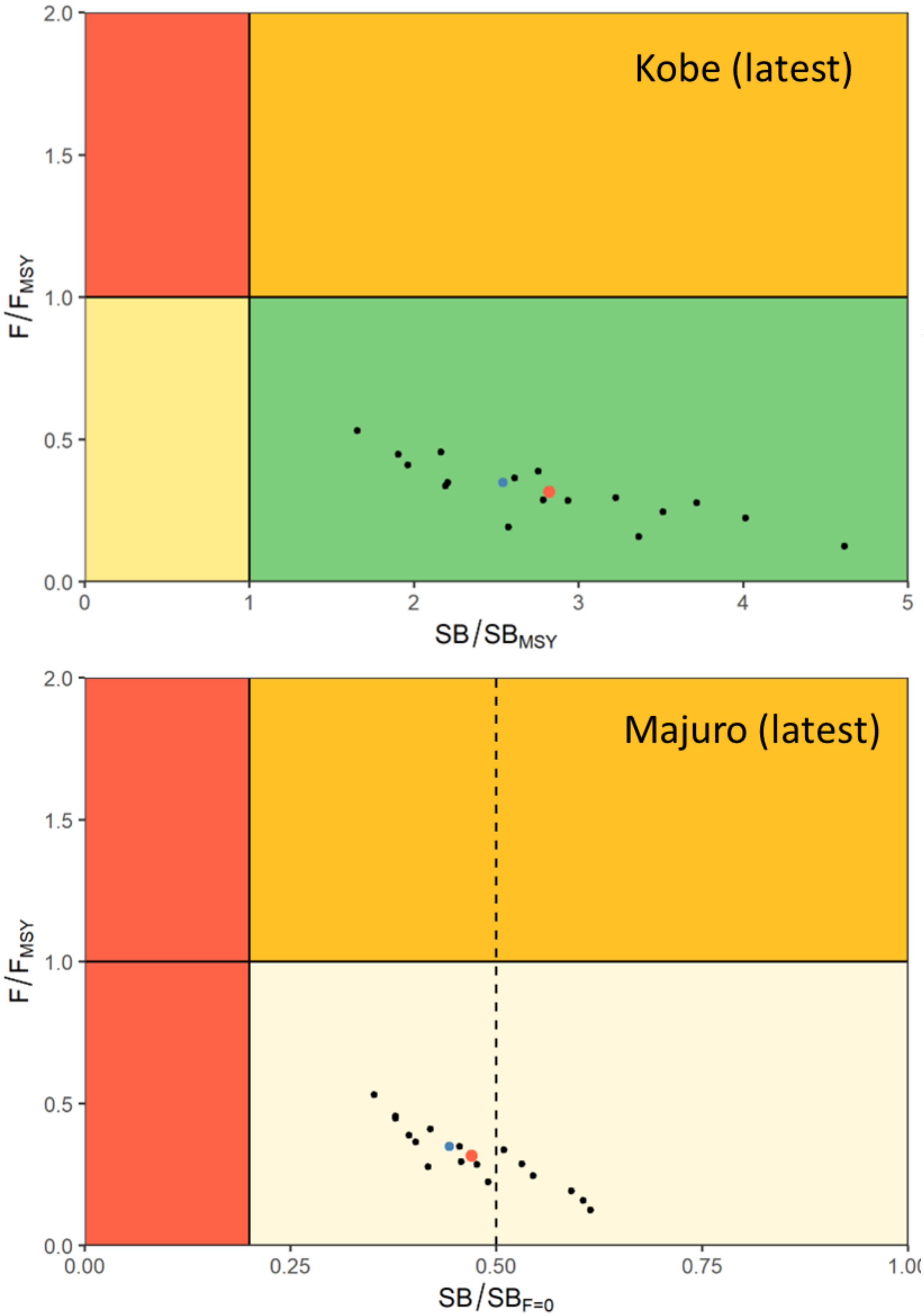

Figure SKJ-11. Kobe (top) and Majuro (bottom) plots summarising the results for each of the models in the structural uncertainty grid for the 'latest' (2021) period. The vertical dotted line on the Majuro plot is included to indicate the interim TRP of $0.50SB_{F=0}$ for the WCPFC-CA skipjack stock as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

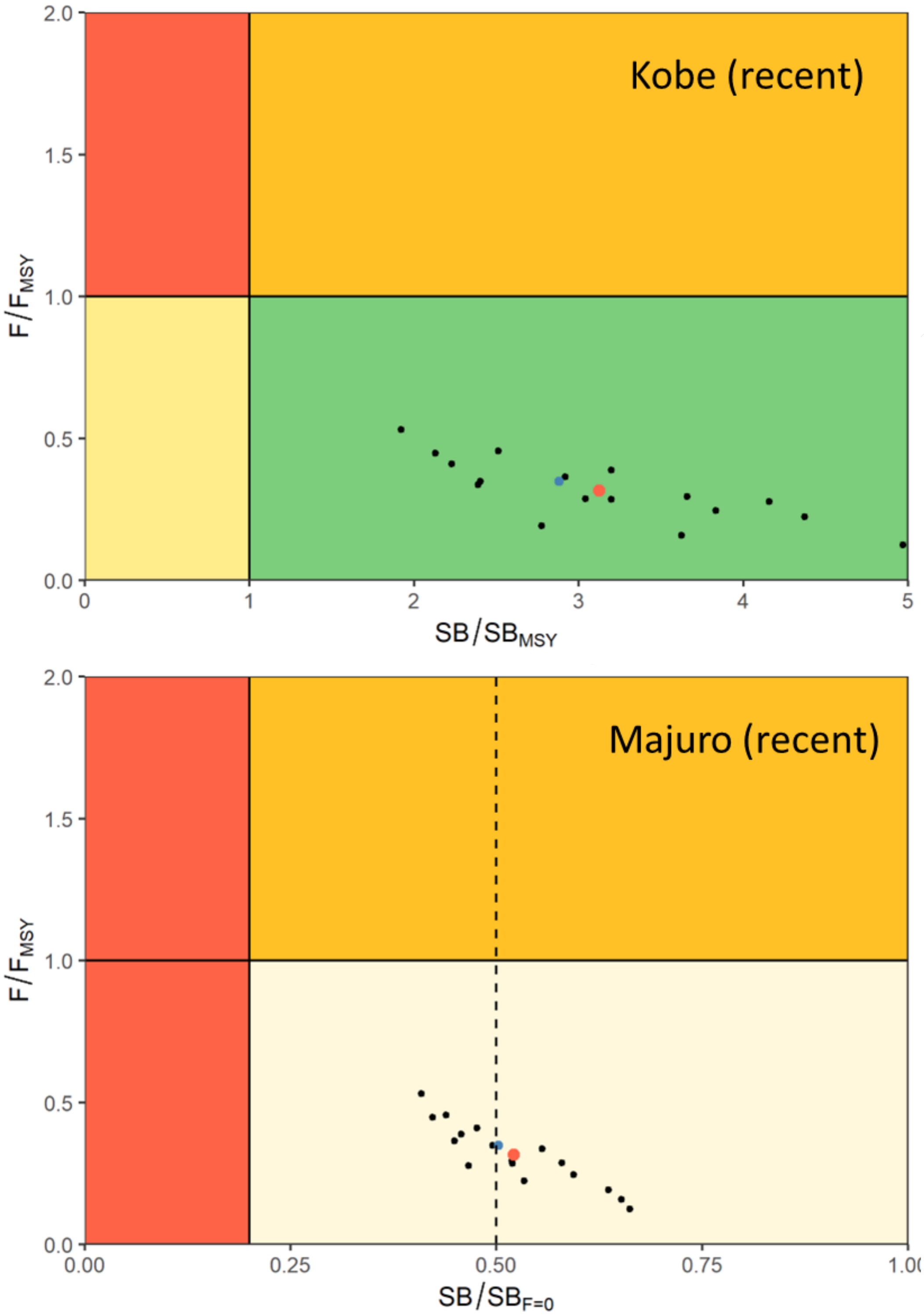

Figure SKJ-12. Kobe (top) and Majuro (bottom) plots summarising the results for each of the models in the structural uncertainty grid for the 'recent' (2018-2021) period. The vertical dotted line on the Majuro plot is included to indicate the interim TRP of $0.50SB_{F=0}$ for the WCPFC-CA skipjack stock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

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

14. 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.

15. 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

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

(ii) General recommendations for WCPFC stock assessments

17. 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

18. 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.

19. 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[3] 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);

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[3] 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/

- For key input analyses, such as the preparation of standardized indices of abundance, the 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

20. 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 a set of diagnostic criteria that 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.

21. SC18 noted the terms of reference (TOR) for Project 18X2a and b (*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 scenario*s) in SC18-GN-IP-07[4], which would address further issues of importance.

22. 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.

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[4] 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.

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

3.1.2 Pacific Bluefin Tuna *(Thunnus orientalis)*

3.1.2.1 Review of 2022 Pacific bluefin tuna stock assessment[5]

3.1.2.2 Provision of scientific information

a. Status and trends

24. 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%.

25. 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.

26. 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.

27. 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

[5] SC18-SA-WP-05 https://meetings.wcpfc.int/node/16246

28. 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.

29. 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.

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

31. 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. $F_{xx\%SPR}$: F that produces given % of the unfished spawning potential (biomass) under equilibrium condition.

Reference Period	Fmax	F0.1	Fmed	(1-SPR)/(1/SPR$_{xx\%}$)				Estimated SSB for terminal year of each period (ton)	Depletion rate for terminal year of each period (%)
				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.

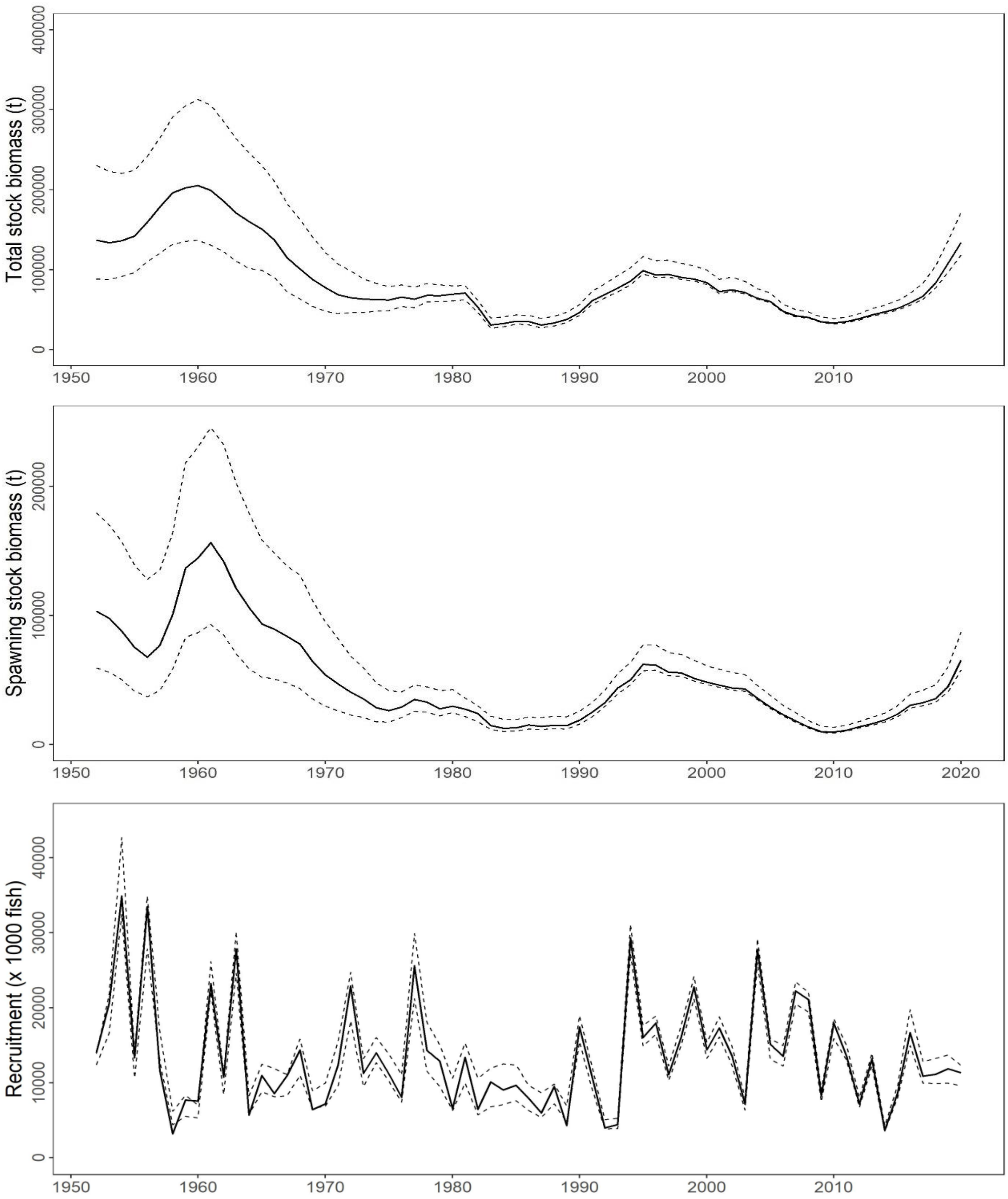


Figure PBF-1. Total stock biomass (top), spawning stock biomass (middle), and recruitment (bottom) of Pacific bluefin tuna (*Thunnus orientalis*) (1952-2020) estimated from the base-case model. The solid line is the point estimate and dashed lines delineate the 90% confidence interval.

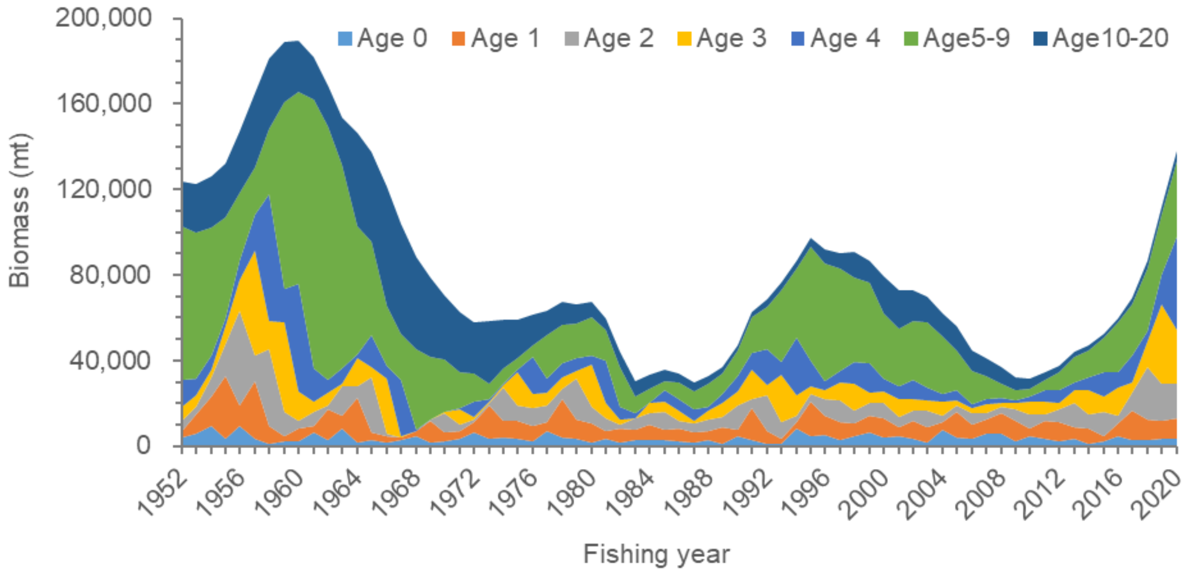
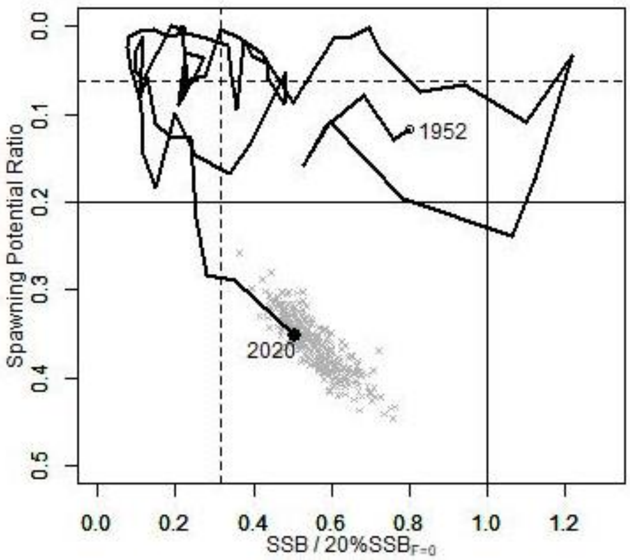


Figure PBF-2. Total biomass (tonnes) by age of Pacific bluefin tuna (*Thunnus orientalis*) estimated from the base-case model (1952-2020).



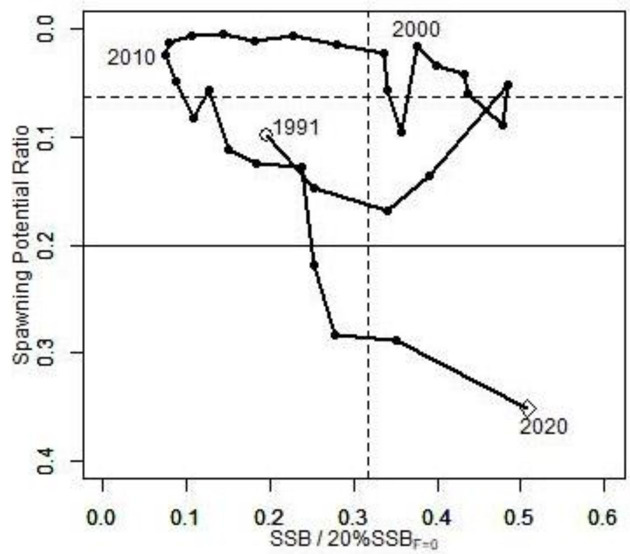


Figure PBF-3. Kobe plots for Pacific bluefin tuna (*Thunnus orientalis*) estimated from the base-case model. The X-axis shows the annual SSB relative to 20%SSB_0 and the Y-axis shows the spawning potential ratio (SPR) as a measure of fishing mortality. Vertical and horizontal solid lines in the left 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.

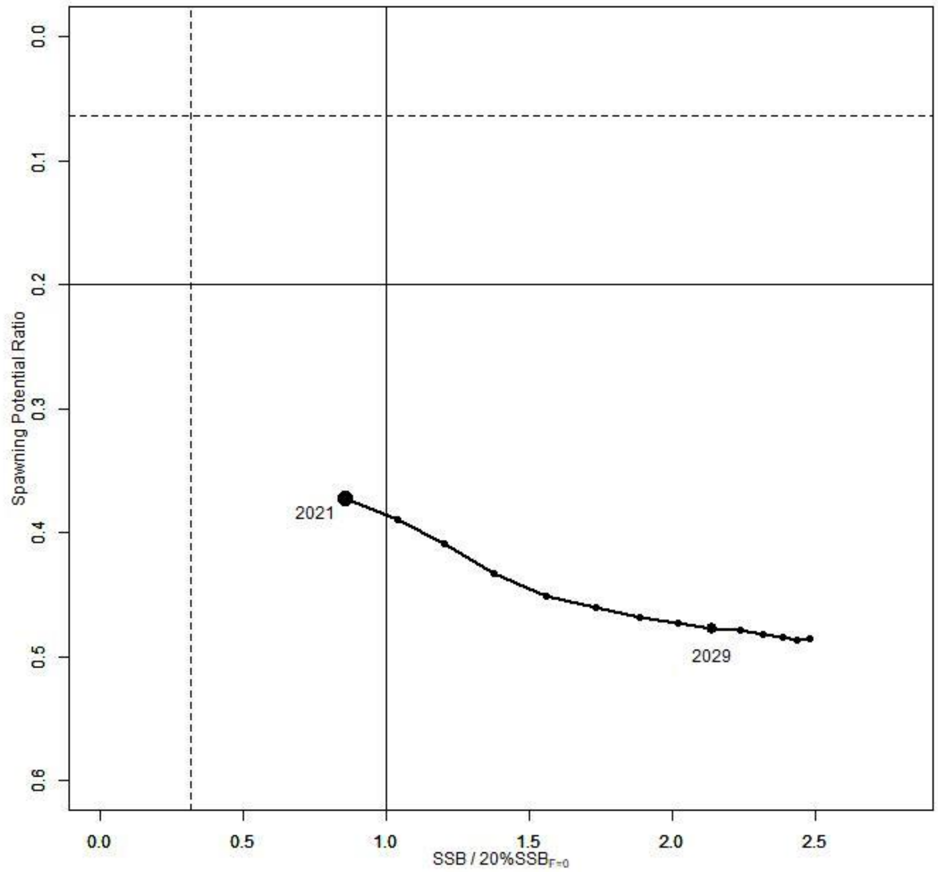


Figure PBF-4. "Future Kobe Plot" of projection results for Pacific bluefin tuna (*Thunnus orientalis*) from Scenario 1 from Table PBF-3.

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)[6]

3.2.1.2 Provision of scientific information

a. Status and trends

32. 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.

33. 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.

[6] SC18-SA-WP-03 https://meetings.wcpfc.int/node/16244

34. 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.

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

36. SC18 noted that the median value of $SB_{2017\text{-}2020}/SB_{MSY}$ was 1.64 (90^{th} 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}.

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

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

	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

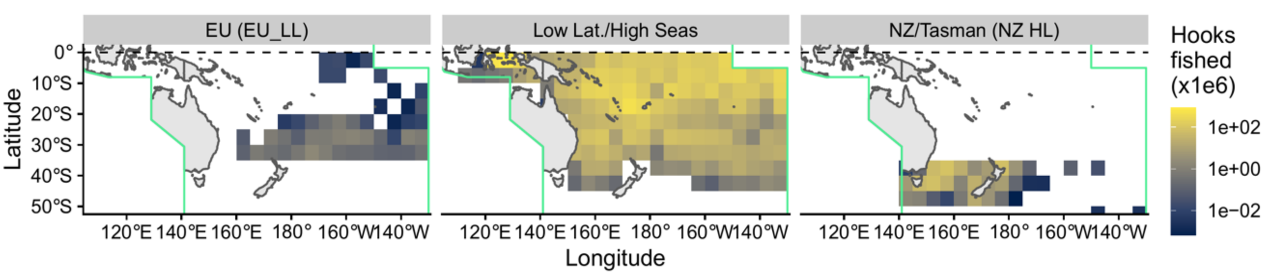


Figure SBSH-1. Spatial structure used in the 2022 stock assessment model.

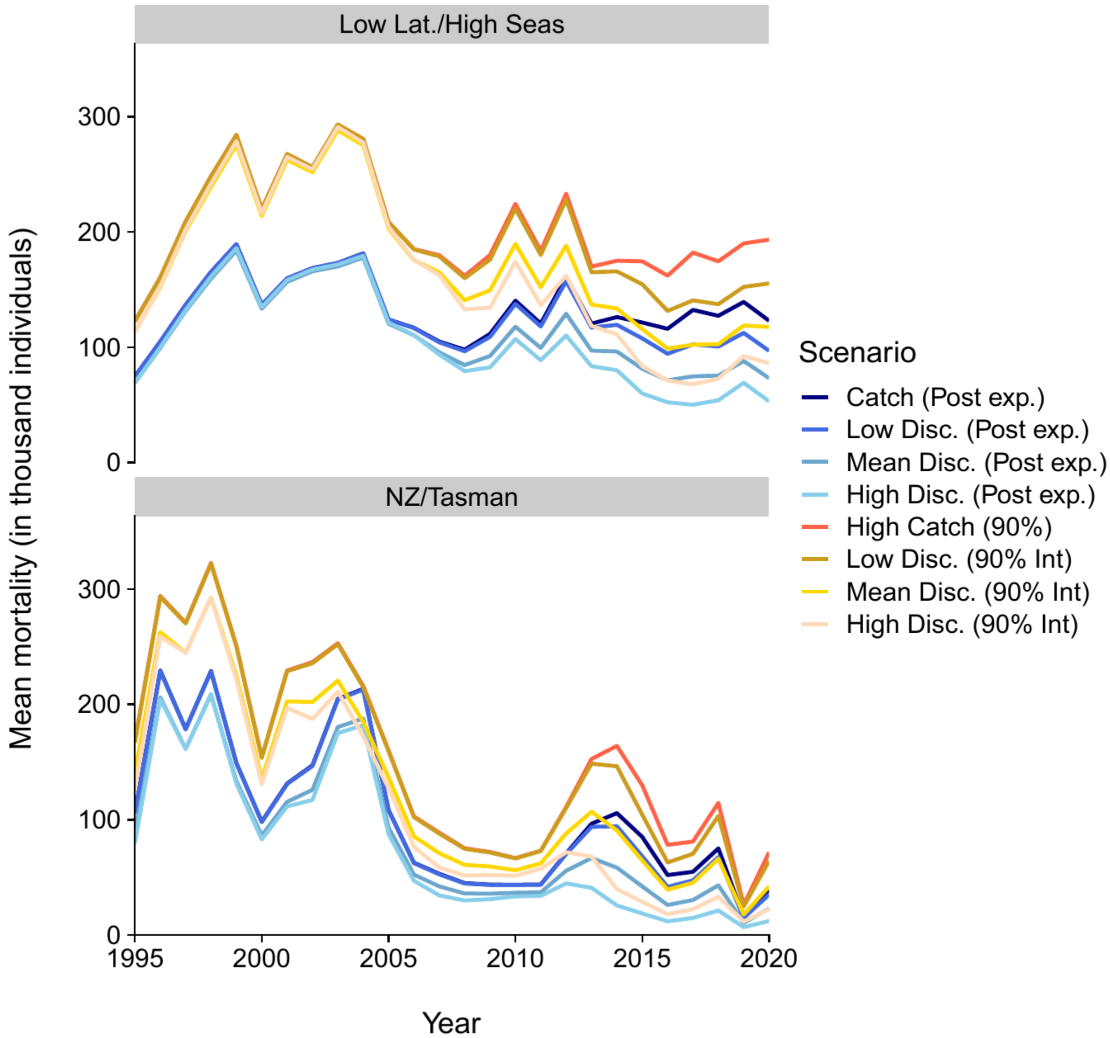


Figure SBSH-2. Top panel: Time series of total reported annual Southwest Pacific BSH catch for the EU-SP fleet (mt), Bottom panels: Predicted total fishing related mortality by latitudinal stratum (high [≥35 degree South] and low latitude [< 35 degree South]), including 17% post release mortality for 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.

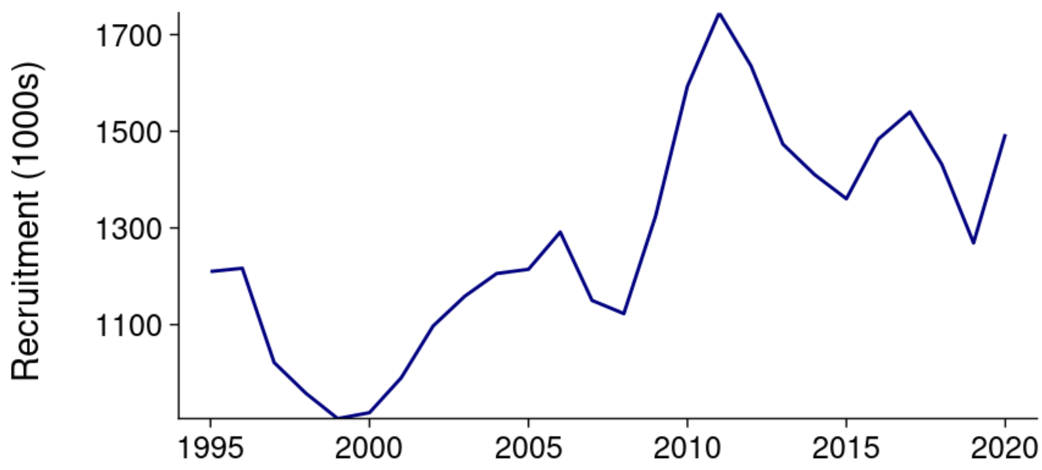


Figure SBSH-3. Estimated annual recruitment for the diagnostic case model

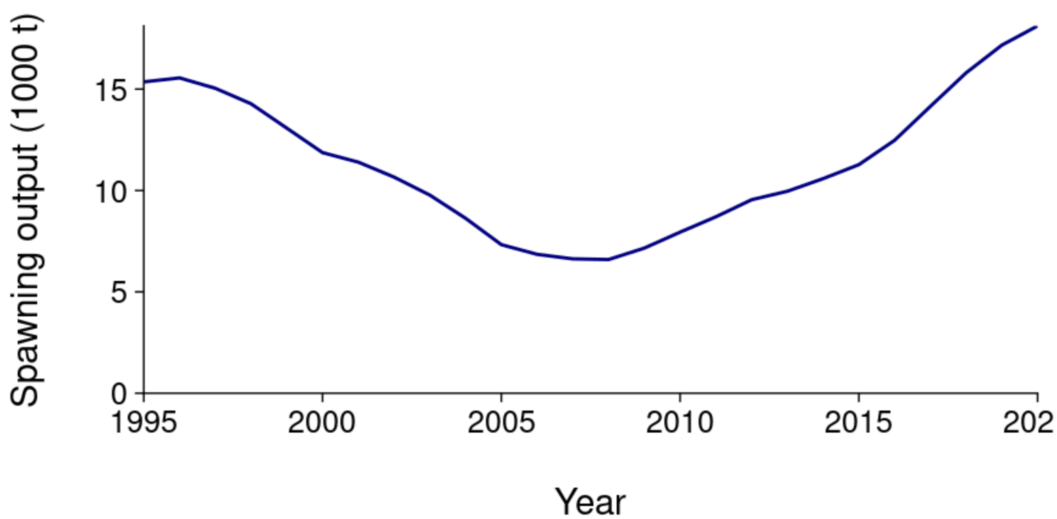


Figure SBSH-4. Estimated annual spawning potential by model region for diagnostic case model

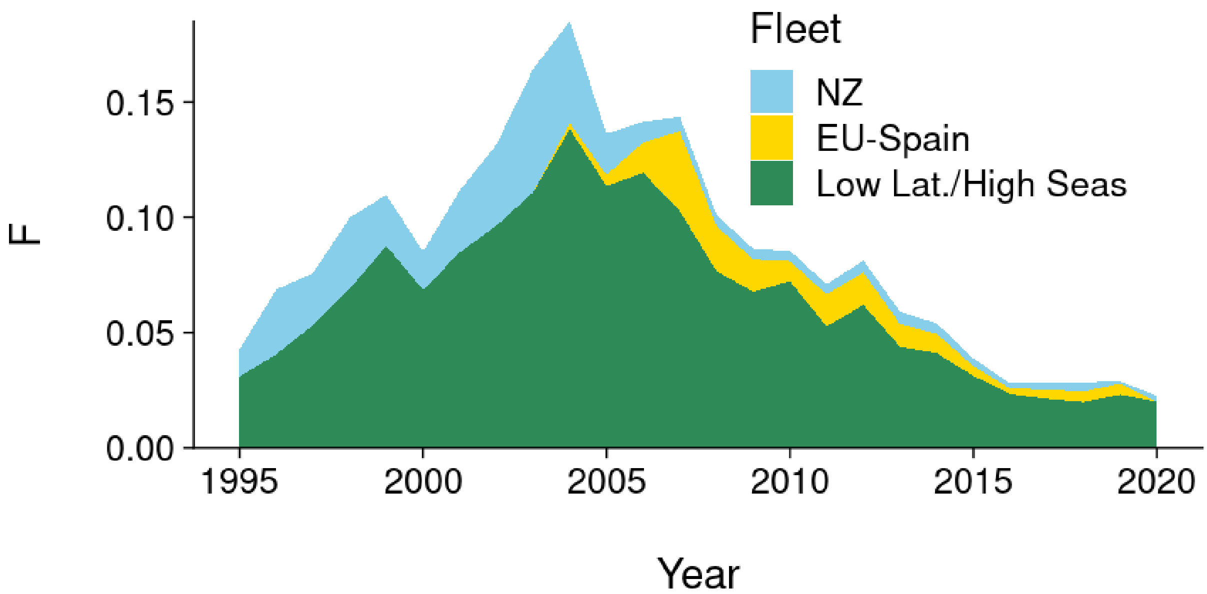


Figure SBSH-5. Estimated annual fishing mortality for the diagnostic case model

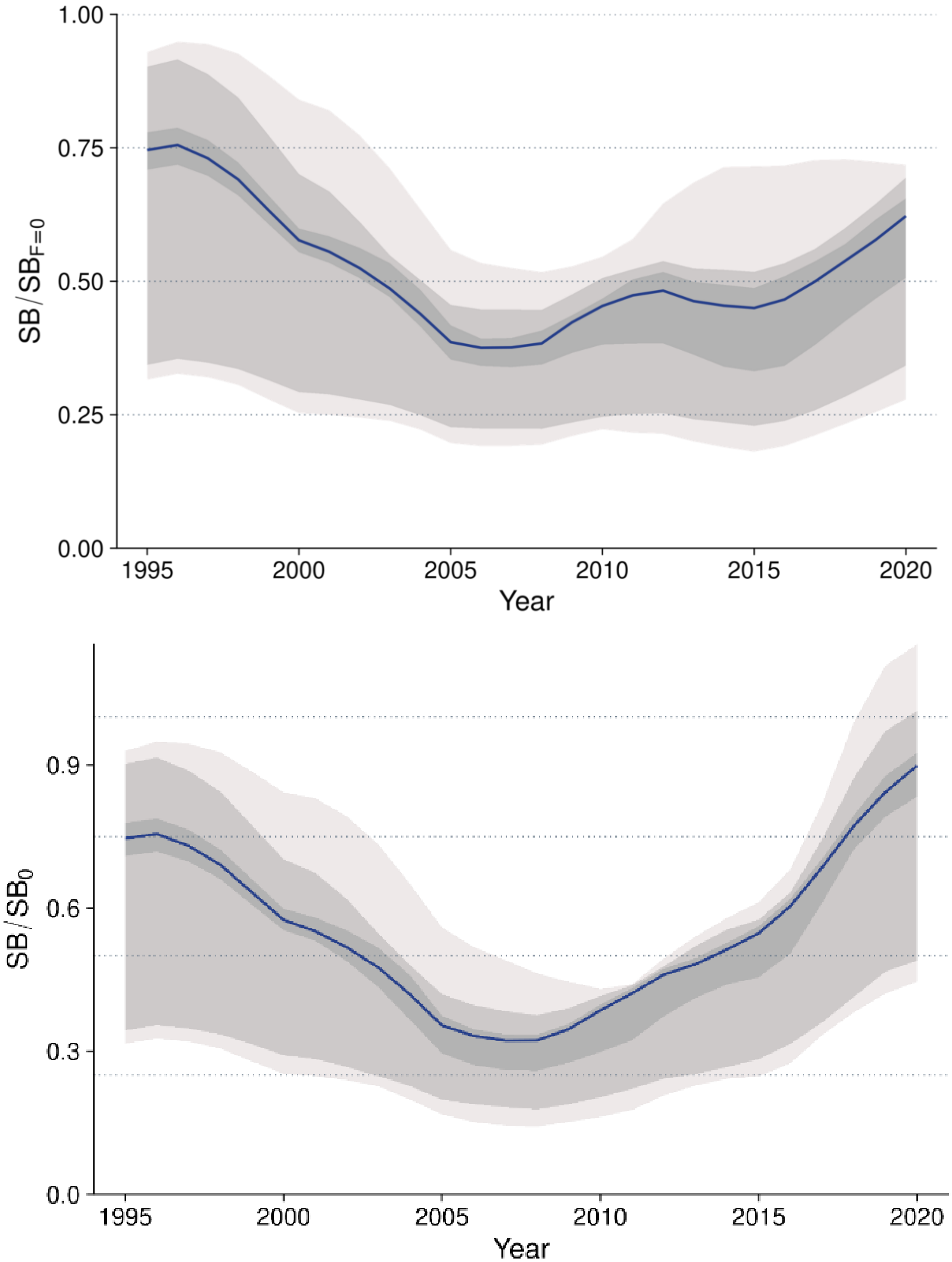


Figure SBSH-6. Plot showing the quantiles of trajectories of fishing depletion (of spawning potential) for the 228 model runs included in the structural uncertainty grid

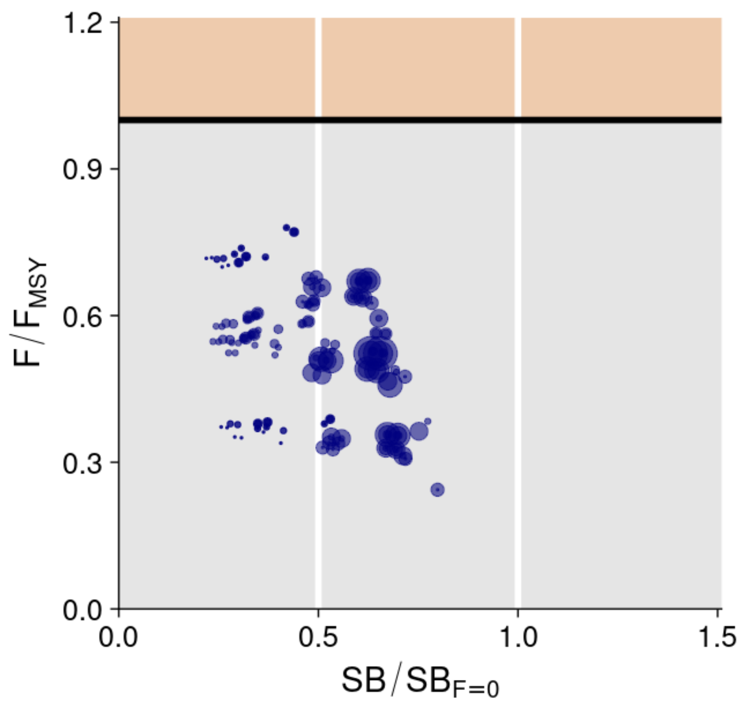


Figure SBSH-7. Majuro plot summarising the results for each of the models in the structural uncertainty grid. Size indicates weight of each model in the grid, darker shading indicates multiple models with similar outcomes.

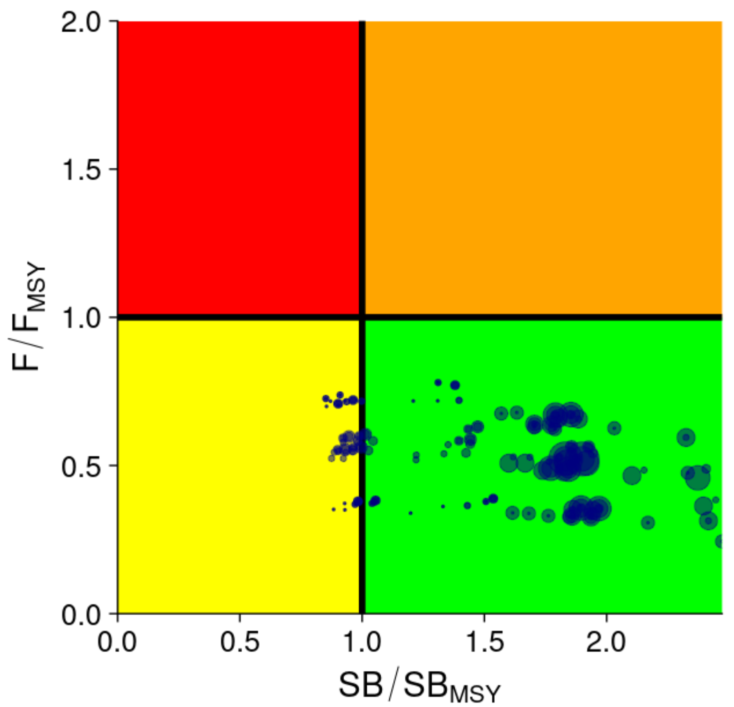


Figure SBSH-8. Kobe plot summarising the results for each of the models in the structural uncertainty grid. Size indicates weight of each model in the grid, darker shading indicates multiple models with similar outcomes.

b. Management advice and implications

39. 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.

40. 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

41. 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)[7]

3.2.2.2 Provision of scientific information

[7] SC18-SA-WP-02 https://meetings.wcpfc.int/node/16243

a. Status and trends

42. 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

43. SC18 did not regard the South Pacific mako shark assessment to be robust enough to provide management advice. As such, SC18 was unable to provide management advice and implications for South Pacific mako shark to the Commission. SC18 noted 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 encouraged 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

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

- Future assessments should spend increased effort to reconstruct spatio-temporal 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 March 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[8]

3.2.3.2 Provision of scientific information

a. Stock status and trends

45. 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} (80th 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 ($F_{2017\text{-}2019}$) 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

[8] SC18-SA-WP-06 https://meetings.wcpfc.int/node/16247

reference points.

46. 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

47. 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 E5).
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.

48. 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[9]

3.3.1.2 Provision of scientific information

a. Status and trends

49. 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

[9] SC18-SA-WP-07 https://meetings.wcpfc.int/node/16248

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

50. 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)

51. SC18 noted that the in-person peer review workshop for the 2020 WCPO yellowfin tuna stock assessment will occur from the 7-13th 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

52. 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

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

53. 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*).

54. 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.

55. 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.

56. 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.

57. 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.

58. 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

59. 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*).

60. 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.

61. 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.

62. 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.

63. 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.

64. 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.

65. 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

66. 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).*

67. 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).

68. 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.

69. 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.

70. 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.

71. 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.

72. 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.

73. 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

74. 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*).

75. 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.

76. 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.

77. 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.

78. 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.

79. 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

80. 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).*

81. 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.

82. 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.

83. 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

84. 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).*

85. 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.

86. 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.

87. 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).

88. 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 South Pacific albacore management procedures

89. 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).*

90. SC18 noted the progress on the development of MPs using model-based approaches (SPiCT[10]) for South Pacific albacore tuna and recommended that candidate HCRs for this species be adapted from those already considered for skipjack tuna.

91. 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.

[10] Stochastic Production model in Continuous Time

4.1.3 Mixed fishery framework

4.1.3.1 Bigeye and yellowfin tuna TRP analyses

92. 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 (subparas. 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 multi-species 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 and performance indicators

93. 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*).

94. 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.

95. 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.

96. 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.

97. 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.

98. 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

99. 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.

100. 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.

101. 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

102. 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*).

103. 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)*).

104. 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.

105. 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.

106. 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

107. 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.

108. 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)[11].

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

109. 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.

110. 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

5.1 Ecosystem and climate indicators

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

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

112. 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.

113. 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.

114. 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)

115. 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[12]) 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.

116. 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.

117. 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.

118. 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.

119. 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.

120. 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

[12] SC18-EB-WP-02 https://meetings.wcpfc.int/node/16316

5.3.1 Seabird bycatch mitigation methods

121. 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.

122. 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.

123. 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

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

124. SC18 noted the *Graphics for Best Practices for the Safe Handling and Release of Cetaceans*[13] and forwarded these to TCC18 and WCPFC19 for consideration and possible adoption.

5.4.2 FAD Management Options IWG issues

125. 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[14] and/or bio-based alternatives that are consistent with international standards[15] 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):

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

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

[15] 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.

126. SC18 noted that these categories are preliminary and will be further examined by the FADMO-IWG, SC, TCC for Commission’s consideration.

127. 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 POJECTS

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

128. 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 WCPFC-SC18-2022/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)

129. 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 Covid19 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

130. 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 WORK PROGRAM AND BUDGET

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

a. Review of 2022 SC Projects and the results of the SC18 Online Discussion Forum

131. 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

132. 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 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 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 mid-term review	30,000				6.2	22

AGENDA ITEM 8 — ADMINISTRATIVE MATTERS

8.1 Election of officers of the Scientific Committee

133. 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

134. SC18 recommended to the Commission that SC19 would be held from 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

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

135. 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

136. 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 SUMMARY REPORT OF THE EIGHTEENTH REGULAR SESSION OF THE SCIENTIFIC COMMITTEE

137. SC18 adopted the recommendations of the Eighteenth Regular Session of the Scientific Committee.

138. 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 29 August, SC18 Outcomes Document will be distributed to all CCMs and observers (within 7 working days, Rules of Procedure).
By 27 August	Secretariat will receive Draft Summary Report from the rapporteur.
By 3September	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

AGEDNA ITEM 11 — CLOSE OF MEETING

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