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

**Seventeenth Regular Session of the Scientific Committee**

**Electronic Meeting**
**11–19 August 2021**

# SUMMARY REPORT

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

**Scientific Committee**
**Seventeenth Regular Session**

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11 – 19 August 2021

# EXECUTIVE SUMMARY

## AGENDA ITEM 1 — OPENING OF THE MEETING

1. The Seventeenth Regular Session of the Scientific Committee of the Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean (SC17) took place for eight days during 11–19 August 2021 as an electronic meeting in response to the global coronavirus disease 2019 (COVID-19) pandemic. The meeting was chaired by the Vice-Chair Dr Tuikolongahau Halafihi (Tonga) as SC Chair Mr Matai'a Ueta Faasili Jr. (Samoa) was unable to attend.

2. The following WCPFC Members, Cooperating Non-members and Participating Territories (CCMs) attended SC17: Australia, Canada, China, Cook Islands, European Union (EU), Federated States of Micronesia (FSM), Fiji, Indonesia, Japan, Kiribati, Republic of Korea, Republic of Marshall Islands (RMI), Nauru, New Zealand, Niue, Palau, Papua New Guinea (PNG), Philippines, Samoa, Solomon Islands, Chinese Taipei, Tonga, Tuvalu, United States of America (USA), Vanuatu, American Samoa, French Polynesia, New Caledonia, Tokelau, Thailand and Vietnam.

3. Observers from the following inter-governmental organizations attended SC17: Inter-American Tropical Tuna Commission (IATTC), Pacific Islands Forum Fisheries Agency (FFA), Parties to the Nauru Agreement (PNA), the Pacific Community (SPC), the Secretariat of the Pacific Regional Environment Programme (SPREP), and The World Bank.

4. Observers from the following non-governmental organizations attended SC17: Australian National Centre for Ocean Resources and Security (ANCORS), Birdlife International, International Pole and Line Foundation (IPNLF), International Seafood Sustainability Foundation (ISSF), Marine Stewardship Council, Sustainable Fisheries Partnership (SFP) Foundation, The Nature Conservancy (TNC), The Ocean Foundation, The Pew Charitable Trusts (Pew), World Tuna Purse Seine Organisation (WTPO) and the World Wide Fund for Nature (WWF).

5. Mr Poasi Fale Ngaluafe (Tonga) gave the opening prayer. The WCPFC Chair Jung-re Riley Kim, the WCPFC Secretariat's Executive Director Feleti P Teo, OBE, and SC Vice-Chair Dr Tuikolongahau Halafihi (Tonga) delivered opening and welcome speeches.

6. The Conveners and their assigned theme sessions are listed below:

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

## AGEDNA ITEM 2 — DATA AND STATISTICS THEME

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

### 2.1 Data gaps of the Commission

#### 2.1.1 Data gaps

8. P. Williams (SPC) presented SC17-ST-WP-01 (*Scientific data available to the Western and Central Pacific Fisheries Commission*). Two additional papers (SC17-ST-IP-02 *Status of Observer Data Management* and SC17-ST-WP-03 *Draft Guidelines for the Voluntary Submission of Purse Seine Processor Data by CCMs to the Commission*) were noted.

**Recommendations**

9. **SC17 encouraged CCMs to resume observer coverage in their fisheries as soon as safe and logistically feasible to restore an important flow of scientific information to the Commission.**

10. **SC17 recommended the Scientific Services Provider (SSP) enhance the scientific data submission guidelines by preparing operational data field tables for longline, purse seine and pole and line operational data for SC18 review.**

11. **SC17 recommended publishing aggregated size data (data fields as listed in SC17-ST-WP-01, section 4.1) via the WCPFC Public Domain webpage, after CCMs have advised the SSP on which of their size data submissions should be excluded. In this regard, CCMs are requested to advise the SSP of the size data to be excluded before 31 December 2021, after which time the SSP will proceed to publish the WCPFC Public Domain size data based on this advice.**

12. **SC17 recommended that the SSP add a new annex to the data gaps paper to include a breakdown of the coverage levels for each operational data field by year and fleet.**

#### 2.1.2 Potential use of cannery data

**Recommendation**

13. **SC17 recommended the endorsement of the *Draft Guidelines for the Voluntary Submission of Purse Seine Processor Data by CCMs* to the Commission, and that the draft guidelines be forwarded to TCC17 and WCPFC18 for consideration. SC17 also recommended that TCC17 and WCPFC18 consider how to handle cannery data under the current WCPFC data rules, including updating the WCPFC data rules to include processor data as non-Public Domain (high risk classification) data.**

### 2.2 Other commercial fisheries for bigeye, yellowfin and skipjack tuna

14. P. Williams (SPC) presented SC17-ST-WP-02 (*An assessment of available information to address the WCPFC17 recommendation on the Tropical Tuna CMM para 51 (other commercial fisheries)*).

**Recommendations**

15. **SC17 reviewed information provided by Indonesia and the Philippines to inform a Commission discussion on the application of paragraph 51 of CMM 2020-01.**

a) **SC17 noted that paragraph 3 of CMM 2020-01 limits the measure to the high seas and EEZs, and based on the information presented recommended that paragraph 51 would not apply to the following fisheries which are restricted to territorial seas and archipelagic waters:**
   i) **Small-scale hook-and-line fisheries**
   ii) **Small-scale troll fisheries**
   iii) **Small-scale gillnet fisheries**
   iv) **Small-scale pole and line (funai – Indonesia)**
   v) **Pajeko (Indonesia mini-purse seine)**
   vi) **Bagnet, beach seine, artisanal longline and other artisanal gears with very minor tuna catch**
b) **SC17 recommended that paragraph 51 of CMM 2020-01 applies to the following fisheries:**
   i) **Indonesia pole and line fishery fishing outside archipelagic waters and territorial seas for vessels >30 GT, and**
   ii) **The "large-fish" handline fishery in Indonesia and the Philippines fishing outside archipelagic waters and territorial seas for vessels >30 GT.**
c) **SC17 recognized that sufficient data exist to determine a baseline and annual catches for the Indonesia pole-and-line fishery and the Philippines large-fish handline fishery**
d) **SC17 recognized that insufficient data exist to derive a baseline for the Indonesia large-fish handline, and suggests that WCPFC consider developing a baseline using years where data are available.**
e) **Although CMM 2020-01 is not applicable to archipelagic waters, SC17 encouraged Indonesia and the Philippines to provide data from fisheries that operate in those areas for scientific purposes.**

### 2.3 Consideration of SC17-ST-IP-06 and SC17-ST-IP-10

**Recommendations**

16. **SC17 recommended that Tables 6-9 on estimates of all purse seine bycatch (as presented in SC17-ST-IP-06) should be made publicly available in electronic format (EXCEL file on the WCPFC Public Domain Bycatch Data webpage) to facilitate extraction and use of data.**

17. **SC17 recommended that future analyses providing estimates of purse seine bycatch include estimates of marine mammal bycatch to the species level, where possible, to allow for additional monitoring of bycatch and bycatch rates of marine mammal species.**

## AGENDA ITEM 3 — STOCK ASSESSMENT THEME

18. Stock Assessment (SA) theme was convened by K. Bigelow (USA) and H. Minami (Japan).

### 3.1 WCPO Tunas

#### 3.1.1 South Pacific albacore tuna (*Thunnus alalunga*)

##### 3.1.1.1 Review of 2021 South Pacific albacore tuna stock assessment

19. Claudio Castillo Jordan (SPC-OFP) presented SC17-SA-WP-02 (*Stock assessment of South Pacific albacore*), which described the 2021 stock assessment of South Pacific albacore. An additional three years of data were available since the previous assessment in 2018 that included data to 2016. The new assessment

extends through to the end of 2019. New developments to the stock assessment include the expansion of the model region to include the entire South Pacific from the equator to 50ºS, incorporating the convention areas (CA) of the WCPFC and the IATTC. The previous assessment was restricted to the WCPFC-CA. The expanded geographical area of the assessment also included modification to the previous regional structure for the WCPFC-CA and inclusion of the fisheries in the IATTC-CA. A new growth model was included applying the recently developed approach to fractional ageing developed for the previous WCPFC yellowfin and bigeye tuna assessments and detailed in the supporting paper by Farley et al. 2021 (SC17-SA-IP-10). The assessment presents the estimated stock status results for entire South Pacific and the WCPFC-CA and IATTC-CA.

#### 3.1.1.2 Provision of scientific information

**a. Stock status and trends**

20. **The median values of relative recent (2016-2019) spawning biomass depletion ($SB_{recent}/SB_{F=0}$) and relative recent (2015-2018) fishing mortality ($F_{recent}/F_{MSY}$) over the uncertainty grid of 72 models (Table SPA-01) were used to define South Pacific albacore stock status. The values of the upper 90$^{th}$ and lower 10$^{th}$ percentiles of the empirical distributions of relative spawning biomass and relative fishing mortality from the uncertainty grid were used to characterize the probable range of stock status.**

21. **A description of the updated structural sensitivity grid used to characterize uncertainty in the assessment is illustrated in Table SPA-01. Tables SPA-02, SPA-03, and SPA-04 show reference points for South Pacific-wide, WCPFC-CA (Convention Area) and IATTC-CA, respectively, including the median values of relative 'recent' (2016-2019) and 'latest' (2019) spawning biomass depletion ($SB_{recent}/SB_{F=0}$) and relative recent (2015-2018) fishing mortality ($F_{recent}/F_{MSY}$) over the uncertainty grid of 72 models used to define stock status. These values are based on the uncertainty grid with the downweighted SEAPODYM (M2) movement hypothesis. The values of the upper 90$^{th}$ and lower 10$^{th}$ percentiles of the empirical distributions of relative spawning biomass and relative fishing mortality from the uncertainty grid were used to characterize the probable range of stock status.**

22. **The spatial structure used in the 2021 stock assessment is shown in Figure SPA-01. Time series of total annual catch by fishing gear over the full assessment period and by region are shown in Figure SPA-02. Estimated annual average recruitment, spawning potential, and total biomass by model region for the diagnostic case model are shown in Figure SPA-03. Estimated trends in spawning potential by region for the diagnostic case are shown in Figure SPA-04, and juvenile and adult fishing mortality rates from the diagnostic model are shown in Figure SPA-05. Time series of estimated spawning potential for the 72 models are shown in Figure SPA-06. Time-dynamic percentiles of depletion ($SB_t/SB_{t,F=0}$) for the 72 models are shown in Figure SPA-07. Majuro and Kobe plots summarizing the results for each of the 72 models in the weighted structural uncertainty grid are shown in Figures SPA-08 and SPA-09 for the 'recent' and 'latest' periods, respectively.**

23. **The most influential axis of uncertainty with respect to estimated stock status was movement, where assuming SEAPODYM derived movement resulted in more pessimistic outcomes.**

24. **SC17 noted that the median value of relative recent (2016-2019) spawning biomass depletion for South Pacific albacore ($SB_{2016-2019}/SB_{F=0}$) was 0.52 with a 10$^{th}$ to 90$^{th}$ percentile interval of 0.41 to 0.57.**

25. **SC17 further noted that there was 0% probability (0 out of 72 models) that the recent (2016-2019) spawning biomass had breached the adopted limit reference point (LRP).**

26. **SC17 noted that there has been a long-term increase in fishing mortality for adult South Pacific albacore, with a notable steep increase in fishing mortality since 2000.**

27. **SC17 noted that the median of relative recent fishing mortality for South Pacific albacore ($F_{2015\text{-}2018}/F_{MSY}$) was 0.24 with a 10th to 90th percentile interval of 0.15 to 0.37.**

28. **SC17 further noted that there was 0% probability (0 out of 72 models) that the recent (2015-2018) fishing mortality was above $F_{MSY}$.**

29. **SC17 noted the results of stochastic projections (based on the weighted grid, SC17-SA-WP-02a, Figures 1 and 2) from the 2021 assessment, which indicated the potential stock consequences of fishing at "status quo" conditions (2017–2019 or 2020 average catch or, separately, fishing effort) using the uncertainty framework approach endorsed by SC17. These results are provided for both South Pacific-wide and for the WCPFC Convention area only. All projections show a steep and rapid decline in biomass towards the LRP in the year 2021 followed by an increase in biomass thereafter.**

**Table SPA-01**. Description of the structural uncertainty grid used to characterize uncertainty in the management quantities derived from this assessment. Note that the M2-SEAPODYM hypothesis was downweighted by 50% by the SC17.

| Axis | 1 | 2 | 3 |
|---|---|---|---|
| **Steepness (S)** | 0.65 | **0.80** | 0.95 |
| **Movement (M)** | **M1-Estimated, age-dependent** | M2-SEAPODYM | |
| **Size data weight (D)** | Low (50) | **Medium (25)** | High (10) |
| **Recruitment distribution (R)** | **R1-SEAPODYM** | R2-Regions 3 and 4 | |
| **Growth/M (G/M)** | **Fixed otolith, Nat-M1** | Estimated from length frequency, Nat-M2 | |

**Table SPA-02**. South Pacific-wide (all regions) reference point estimates from the assessment based on the weighted grid.

| | Mean | Median | Min | 10% | 90% | Max |
|---|---|---|---|---|---|---|
| $C_{latest}$ | 87,184 | 86,827 | 83,519 | 85,092 | 87,633 | 130,936 |
| $F_{MSY}$ | 0.06 | 0.06 | 0.05 | 0.05 | 0.07 | 0.08 |
| $f_{mult}$ | 4.37 | 4.25 | 2.11 | 2.69 | 6.62 | 7.84 |
| $F_{recent} / F_{MSY}$ | 0.25 | 0.24 | 0.13 | 0.15 | 0.37 | 0.47 |
| $MSY$ | 115,661 | 120,020 | 68,200 | 75,584 | 158,600 | 166,240 |
| $SB_0$ | 623,542 | 660,200 | 361,800 | 392,590 | 845,100 | 929,300 |
| $SB_{F=0}$ | 675,861 | 678,345 | 524,886 | 537,740 | 824,855 | 873,278 |
| $SB_{latest} / SB_0$ | 0.41 | 0.41 | 0.34 | 0.37 | 0.46 | 0.48 |
| $SB_{latest} / SB_{F=0}$ | 0.37 | 0.40 | 0.25 | 0.27 | 0.45 | 0.46 |
| $SB_{latest} / SB_{MSY}$ | 2.50 | 2.33 | 1.45 | 1.69 | 3.921 | 4.28 |
| $SB_{MSY}$ | 109,710 | 104,100 | 48,040 | 61,497 | 157,500 | 190,000 |
| $SB_{MSY} / SB_0$ | 0.18 | 0.18 | 0.11 | 0.11 | 0.22 | 0.23 |
| $SB_{MSY} / SB_{F=0}$ | 0.16 | 0.16 | 0.09 | 0.11 | 0.22 | 0.23 |
| $SB_{recent} / SB_{F=0}$ | 0.50 | 0.52 | 0.37 | 0.41 | 0.57 | 0.59 |
| $SB_{recent} / SB_{MSY}$ | 3.34 | 3.22 | 2.07 | 2.24 | 5.18 | 5.33 |
| $Y F_{recent}$ | 81,998 | 85,020 | 58,440 | 63,656 | 94,720 | 101,400 |

**Table SPA-03**. WCPFC-CA reference point estimates from the assessment based on the weighted grid.

| | Mean | Median | Min | 10% | 90% | Max |
|---|---|---|---|---|---|---|
| $C_{latest}$ | 78,788 | 78,455 | 75,673 | 76,959 | 79,126 | 118,706 |
| $SB_{F=0}$ | 459,648 | 463,424 | 415,746 | 431,617 | 491,092 | 501,602 |
| $SB_{latest} / SB_{F=0}$ | 0.37 | 0.39 | 0.26 | 0.28 | 0.43 | 0.45 |
| $SB_{recent} / SB_{F=0}$ | 0.51 | 0.52 | 0.39 | 0.42 | 0.58 | 0.61 |

**Table SPA-04**. IATTC-CA reference point estimates from the assessment based on the weighted grid.

| | Mean | Median | Min | 10% | 90% | Max |
|---|---|---|---|---|---|---|
| $C_{latest}$ | 8,396 | 8,242 | 7,845 | 8,074 | 8,760 | 12,229 |
| $SB_{F=0}$ | 216,213 | 233,755 | 92,190 | 98,063 | 356,491 | 379,718 |
| $SB_{latest} / SB_{F=0}$ | 0.38 | 0.42 | 0.22 | 0.25 | 0.46 | 0.48 |
| $SB_{recent} / SB_{F=0}$ | 0.47 | 0.52 | 0.28 | 0.32 | 0.56 | 0.57 |

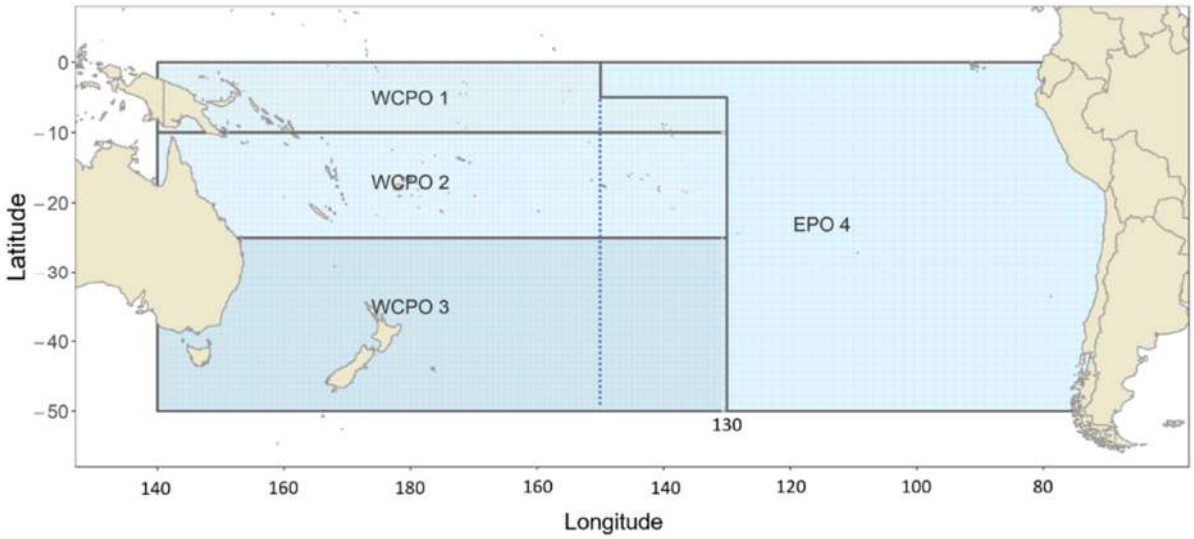


**Figure SPA-01**. The geographical area covered by the stock assessment and the boundaries of the four model regions used for South Pacific-wide 2021 albacore assessment. The overlap region between the WCPFC and IATTC convention areas is the area between 130º - 150º west demarcated by the dashed line. The catch from the 'overlap' area is included within the WCPFC-CA for this assessment.

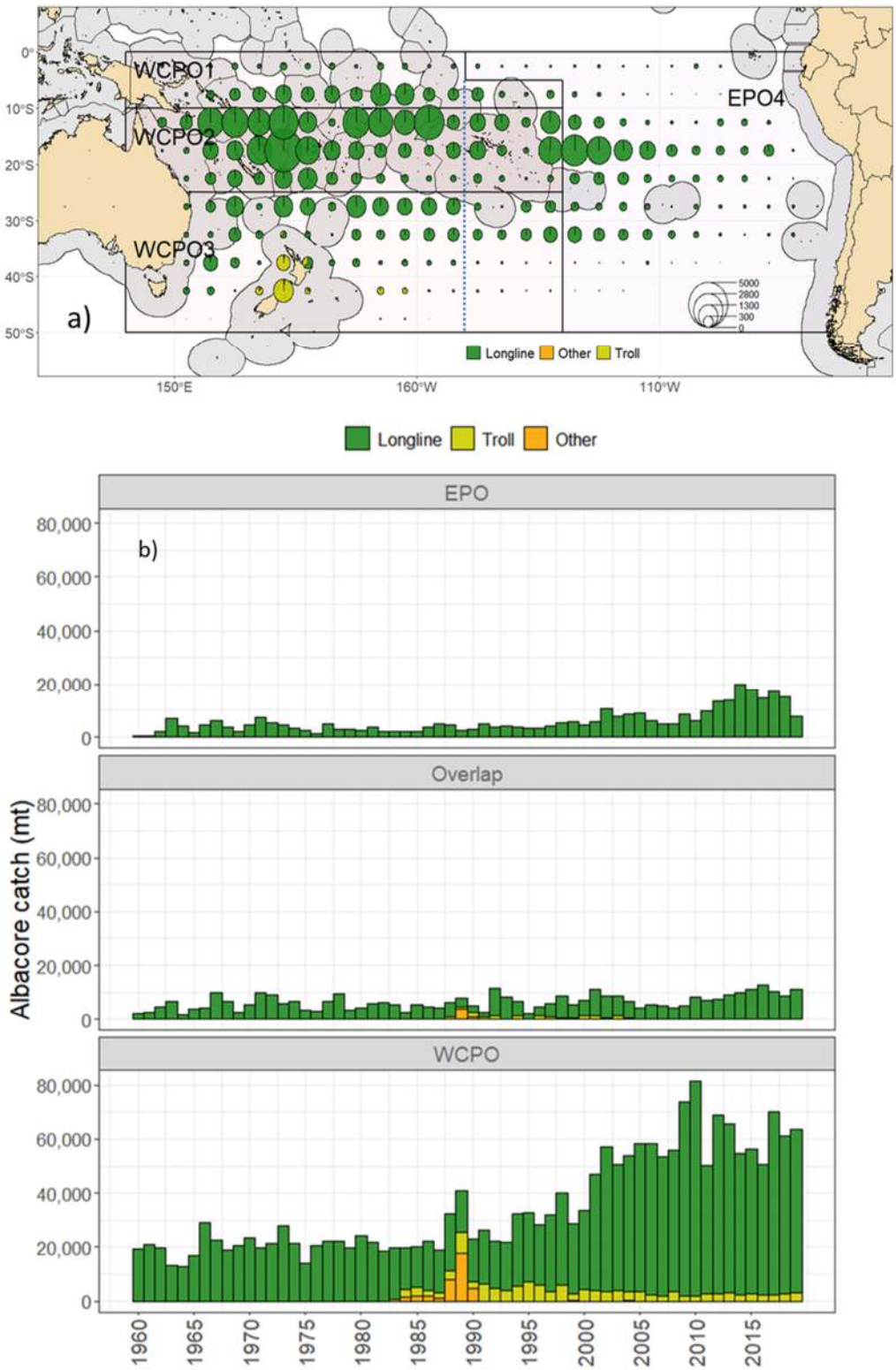


**Figure SPA-02**. a) Spatial pattern of albacore catch by gear type over the last decade, and b) historical catches of albacore across the model region from 1952-2019 by gear type.

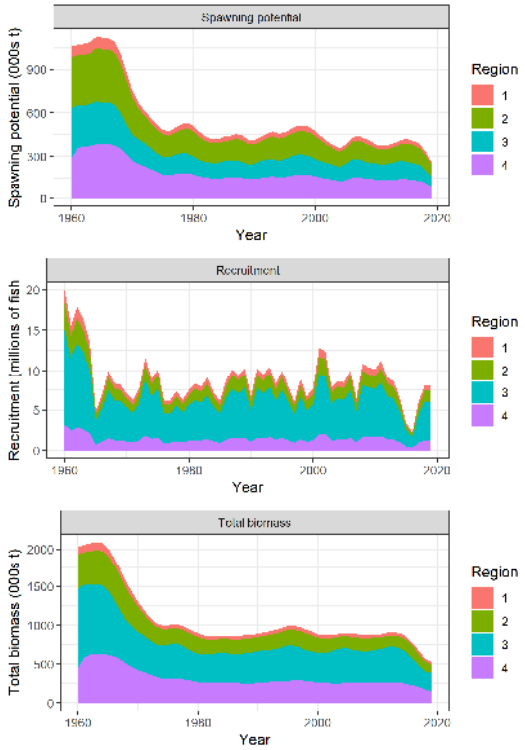


**Figure SPA-03**. Estimated annual average a) spawning potential, b) recruitment, and c) total biomass by model region for the diagnostic case model, showing the relative levels among regions.

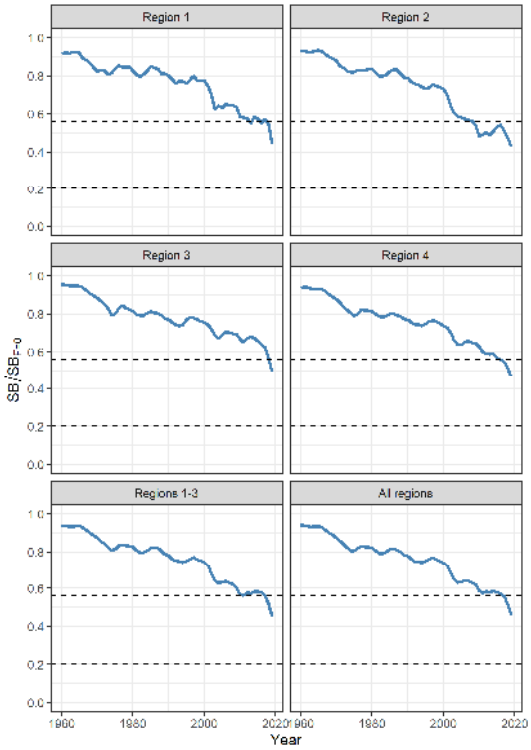


**Figure SPA-04**. Estimated temporal spawning potential by model region, grouped by region (WCPFC-CA, EPO) and South Pacific as a whole for the diagnostic case model. The dotted lines are included to indicate the $SB/SB_{F=0}$ interim target reference point (iTRP)=0.56 and the LRP=0.2 for the WCPFC-CA albacore fishery. Regions 1-3 represent the WCPFC-CA (including the "overlap"), Region 4 is the IATTC-CA.

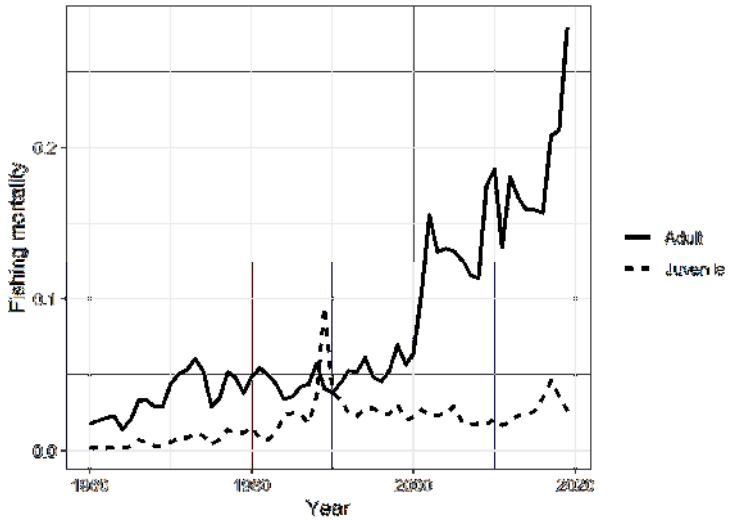


**Figure SPA-05**. Estimated annual average juvenile and adult fishing mortality for the diagnostic case model.

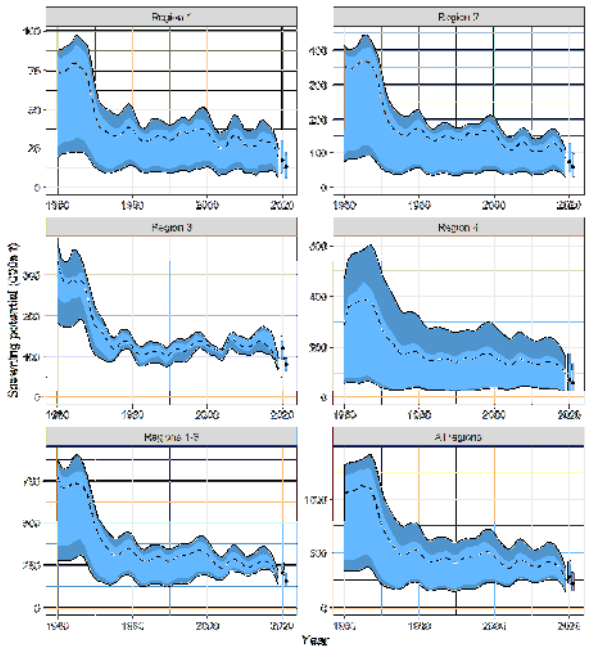

**Figure SPA-06**. Estimated spawning potential across all models in the structural uncertainty grid over the period 1960-2019. The dashed line represents the median. The darker band shows the 10th-90th percentile, and the lighter band shows the 25th-75th percentile of the model estimates. Regions 1-3 represent the WCPFC-CA (including the "overlap"), Region 4 is the IATTC-CA. The bars at right in each plot are the median values (points) and percentiles for recent (left) and latest (right) spawning potential.

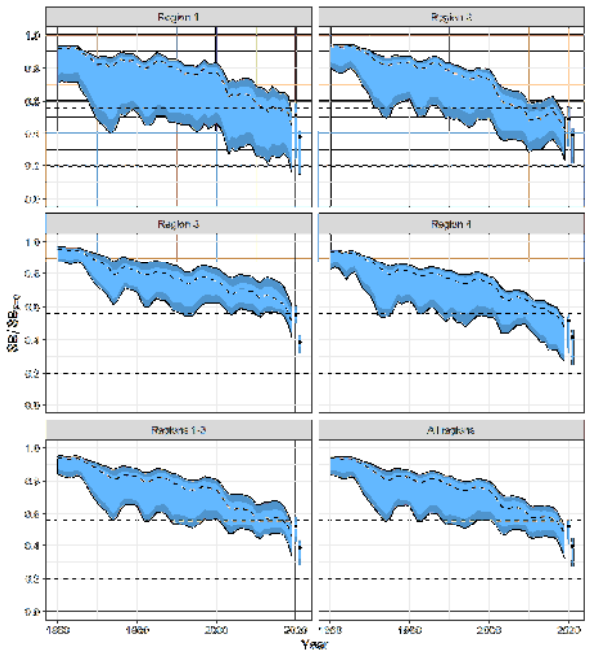

**Figure SPA-07**. Estimated spawning depletion across all models in the structural uncertainty grid over the period 1960-2019. The dashed line represents the median. The darker band shows the 10th-90th percentile, and the lighter band shows the 25th-75th percentile of the model estimates. Regions 1-3 represent the WCPFC-CA (including the "overlap"), Region 4 is the IATTC-CA. The dashed horizontal lines indicate the depletion LRP (0.2) and the WCPFC-CA TRP for $SB/SB_{F=0}$ (0.56). The bars at right in each plot are the median values (points) and percentiles for $SB_{recent}/SB_{F=0}$ (left) and $SB_{latest}/SB_{F=0}$ (right)

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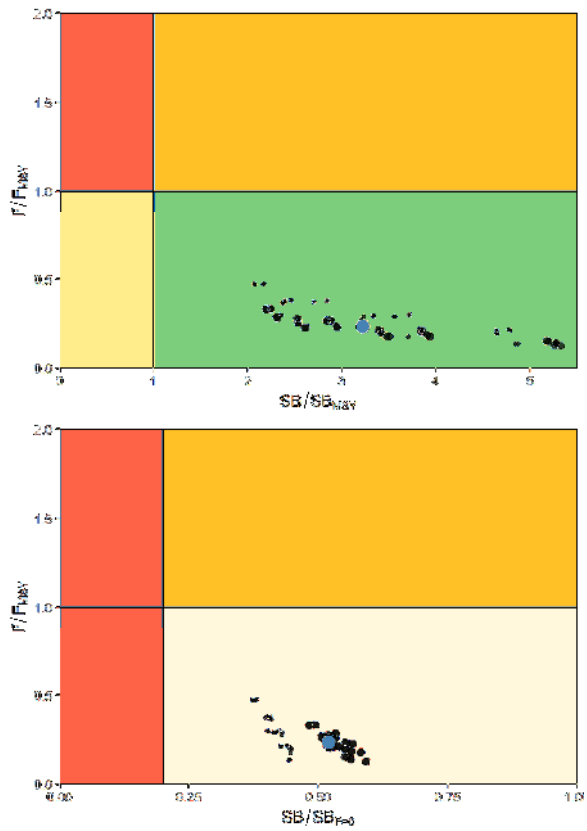

**Figure SPA-08**. Majuro (bottom) and Kobe (top) plots summarizing the Pacific-wide results for each of the models in the structural uncertainty grid for the 'recent' (2016-2019) period. The blue point is the median value based on the weighted grid models, with the more heavily weight models indicated by the larger black dots.

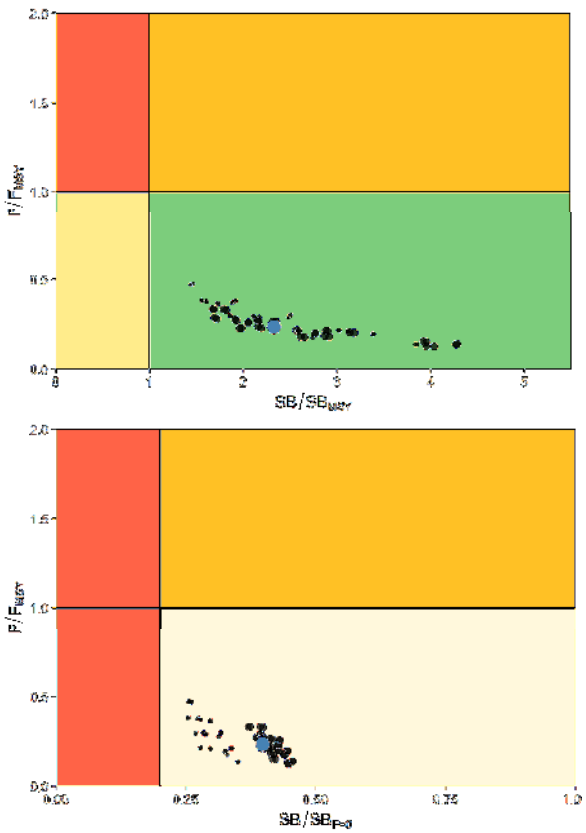

**Figure SPA-09**. Majuro (bottom) and Kobe (top) plots summarizing the Pacific-wide results for each of the models in the structural uncertainty grid for the 'latest' (2019) period. The blue point is the median value based on the weighted grid models, with the more heavily weighted models indicated by the larger black dots.

**b. Management advice and implications**

30. **Annual catch estimates for albacore in the South Pacific peaked at 93,835 mt (all gears) in 2017 (SC17-SA-IP-04). Catch by longliners represented 93% of the catch weight in 2020 at 64,963 mt and represented a 21% decrease from 2019 despite a shift of effort from the tropical to the southern longline fishery in 2020. By comparison, the 2020 total albacore catch within the southern part of the WCPFC-CA was 61,778 mt and the longline catch was 57,006 mt.**

31. **The 2021 South Pacific albacore stock assessment provided results consistent with the 2018 assessment. The addition of the EPO region into the current entire South Pacific assessment did not notably alter the main assessment outcomes, and similar trajectories and terminal depletion were estimated in both RFMO regions.**

32. **The spawning stock biomass has become more depleted across the model period (1960-2019), with a notable increase in depletion in the most recent years. Based on the set of models in the SC endorsed structural uncertainty grid, the South Pacific albacore assessment indicates the stock is not overfished, and there was zero estimated risk of the stock being below the Limit Reference Point of 20%$SB_{F=0}$. However, the decline in the latest estimated $SB_{latest}/SB_{F=0}$ (year 2019; median 0.40; 10$^{th}$ and**

**90th percentiles 0.27 - 0.45) is notably more pessimistic than those of $SB_{recent}/SB_{F=0}$ (years 2016-2019; median 0.52; 10th and 90th percentiles 0.41 - 0.57) indicating that there has been a substantial decline in stock status estimated over the last three years. The general trends are consistent for estimates across all regions of the South Pacific stock, and for the WCPFC-CA only.**

33. **For the WCPFC-CA region, the 'recent' and 'latest' SB estimates are on average both below the interim TRP of 0.56. Further, 86% of models (62 out of 72 models) in the structural uncertainty grid endorsed by SC17 estimated that $SB_{recent}/SB_{F=0}$ was below the interim TRP. In relation to management objectives for the WCPFC-CA longline fishery, this assessment estimated that the median `latest' (2019) and `recent' (2016-2019) longline vulnerable biomass for the WCPFC-CA are 56% and 76% of the 2013+8% target level that defined the interim TRP.**

34. **SC17 noted CPUE declines in many domestic longline fisheries in the southern portion of the WCPFC-CA.**

35. **SC17 noted that depletion is greatest in regions north of 25ºS, specifically in assessment Regions 1 and 2 where most domestic Pacific Island Countries and Territories (PICTs) fleets operate, including Small Island Developing States (SIDS) and Participating Territories that may have no high seas access. These are areas mostly unaffected by current management measure for South Pacific albacore (CMM 2015-02), which prescribe effort controls and reporting provisions south of 20ºS.**

36. **SC17 expressed great concern with the projected status of South Pacific albacore if recent catch or effort levels are maintained (SC17-SA-WP-02a REV2). Projections indicated that South Pacific albacore stock has a greater than 20% risk of falling below the LRP in 2021 under both catch and effort scenarios. These projections indicate an extended period where biomass is below the current interim TRP and in most cases the TRP is not achieved within the 30-year projection period.**

37. **Recalling its previous advice from SC11, SC12, and SC13, SC17 recommended that longline catch be reduced to avoid further and extended declines in the vulnerable biomass so that economically viable catch rates can be maintained, especially for longline catch of adult albacore.**

38. **SC17 recommended a recalibration of the interim TRP for review at WCPFC18 in accordance with the process agreed at WCPFC15 (WCPFC15 Summary Report, para 207). Further, SC17 recommended projections be undertaken to estimate the constant catch levels that would achieve that TRP on average over the long-term. SC17 recommended that these analyses be provided to WCPFC18 to guide its consideration of reductions in longline fishing mortality that will be required to return the vulnerable biomass to the 2013 +8% level as agreed.**

**c. Future research recommendations**

39. **SC17 noted with concern that the standardized CPUE indices do not show linear contrast with catches over the past 20 years when the catch has increased by 2 to 3-fold and also that the fit to the indices show a residual pattern over time. SC17 supported the assessment scientist's suggestion to consider split indices in future assessments, which might allow for the incorporation of more informative catchability and density covariates during the contemporary period, which is more important for estimates of recent status.**

40. **SC17 noted a possible nonlinear relationship between catch and effort or a time-varying relationship with changing fishing power and catchability. The next assessment could investigate such nonlinear relationships and explore alternative effort metrics.**

41. **SC17 noted with concern that the standardized CPUE model with hooks between floats (HBF) did not converge. The time-series is almost 70 years with substantial shifts to deploy more HBF though time. These gear changes have probably altered South Pacific albacore catchability and require additional research. HBF is one characteristic of longline gear that could affect catchability; operational longline data are largely absent of detailed vessel and gear characteristics that could be valuable in a standardization model. Reliably collecting additional gear characteristics will better inform these models on variability in catchability among vessels and fleets and over time and these data enhancements could be achieved by revisiting the minimum logsheet data standards, increasing observer coverage, or expanding electronic monitoring applications. Without this additional information the large uncertainties associated with the use of standardised-CPUE in assessments will remain unresolved and continue to impact on future assessments.**

42. **SC17 noted the need to both recalibrate the interim TRP according to the procedure agreed at WCPFC15 (WCPFC15 Summary Report, para 207) and estimate the constant catch levels that would achieve that TRP on average over the long-term. Specifically, based upon the SC-agreed 2021 South Pacific albacore stock assessment:**

- **a) re-calibrate the WCPFC interim TRP (the median depletion in the WCPFC-CA, $SB/SB_{F=0}$) that would on average achieve the agreed objective of an 8 % increase in vulnerable biomass (CPUE proxy) for the southern longline fishery as compared to 2013 levels.**
- **b) undertake projections to estimate the constant catch levels that would achieve the recalibrated TRP, on average, over the long-term.**
- **c) within that projection-based analysis, WCPFC-CA longline and troll fisheries should be modelled based upon catch, and fishing levels within the EPO should be adjusted in the same way as the WCPO for one scenario and fixed at recent catch levels for another scenario. Future recruitment should be sampled from the long-term recruitment pattern.**

43. **A number of key research needs were identified in undertaking the assessment that should be investigated either internally or through directed research.**

44. **As with the previous South Pacific albacore assessment, the fishery dependent CPUE-based indices of abundance lacked contrast to inform population responses to increased fishing pressure. This continues to be a significant concern for the reliability of estimates of population size. The CPUE analysis has been a major focus of preparatory work for this and previous assessments, and despite the attempts of various scientists, application of new approaches including attempts at splitting time series and testing various covariates, the CPUE continues to lack contrast. It is recommended that alternative fishery independent estimates of population size be explored, especially the genetic method of Close-Kin Mark-Recapture (CKMR).**

45. **The implications of uncertainty in movement were clearly evident in this year's assessment, with this being the most influential uncertainty for management advice. In the absence of strong empirical data to inform decisions on alternative movement hypotheses and based on the quality of fits to the data, the SC decided to downweight one of the two movement hypothesis for provision of management advice. This is an unsatisfactory situation and there is a clear need to improve understanding of connectivity among albacore populations across the South Pacific, and, in particular, the fishery regions in the WCPFC and IATTC convention areas. This is particularly critical if South Pacific-wide assessments are to continue. The CKMR method as a by-product can also address this uncertainty.**

46. **Despite applying the new growth data to this assessment, the modal structure in the New Zealand troll fishery size composition was still not fit adequately. Further work on growth modelling**

**is required. It should also be noted that otolith-based growth data being used is mostly derived for otolith samples collected in 2009 -2010. Further, to update the growth information for albacore, samples from the IATTC-CA are needed. Again, samples required to address this issue could be collected as part of a CKMR project that would also include a component to develop (tissue-based) epigenetic ageing methods and sex determination. This would be a major advance in including more contemporary growth information in tuna assessments.**

47. **Follow-up studies to assess the reliability of size composition data for providing information on recruitment and population trends, and if necessary, develop better stratification methods to improve the representativeness of size composition data should be considered.**

48. **Finally, the current model is highly parameterized, and reducing model parameters and complexity should be considered to improve model fits and diagnostics. One key advancement would be the application of the "catch conditioned" approach that will be available in MULTIFAN-CL for the next assessment.**

### 3.2 WCPO sharks

#### 3.2.1 Southwest Pacific blue shark (*Prionace glauca*)

##### 3.2.1.1 Review of 2021 Southwest Pacific blue shark stock assessment (Project 107)

49. P. Neubauer (Dragonfly Data Science) presented SC17-SA-WP-03 *Stock assessment of Southwest Pacific blue shark*.

##### 3.2.1.2 Provision of scientific information

*Provision of information about indicators*

50. SC17 noted that in 2021, the three major CPUE time series (high-latitude fisheries around New Zealand and South-East Australia; mid-latitude EU-Spain fishery; and the high latitude and high seas Japan fishery) for blue shark in the Southwest Pacific from 1995 to 2020 indicated a consistent trend of increasing CPUE in the recent decade.

51. SC17 noted that the CPUE of low latitude/high seas Japanese fishery suggested a declining trend in biomass from relatively high values of CPUE in the 1990s, reflecting increasing effort during that time, followed by a steady increase of biomass since around 2010 as effort plateaued and discard rates increased, and returned to biomass levels estimated at the beginning of the assessment period.

52. SC17 noted that blue sharks are relatively productive with fast growth and high fecundity compared to other sharks. In addition, the population is structured spatially with smaller fish in the higher latitudes.

**a. Stock status and trends**

53. **SC17 noted that WCPFC has not yet agreed on any reference points for Southwest Pacific blue shark.**

54. **SC17 noted that Southwest Pacific blue shark assessment was undertaken using the Stock Synthesis model framework and the structural uncertainty grid approach with 9 structural uncertainties (Catch, Discard, Initial-F, Rec. dev., High latitude CPUE, Low latitude CPUE, Natural**

**mortality, survival function, growth) resulting in 3,888 models. In addition, a surplus production model was run. SC17 noted that both assessment methods produced similar results.**

55. **SC17 agreed that the assessment was an improvement on the 2016 assessment. In particular, the catch reconstruction, CPUE time series, and re-parameterization of biological parameters using combined information from south and north Pacific assessments.**

56. **SC17 noted that 90% of model runs indicated that $F_{2020}$ was below $F_{MSY}$ and 96% of model runs shows that $SB_{2020}$ was above $SB_{MSY}$. However, the model grid was not adopted by SC17 due to the views of some CCMs that a more thorough investigation of diagnostics across the grid of models was required. These CCMs recommended that residual pattern and retrospective analysis, among other approaches, would be informative, and a deeper investigation into the grid model selection and uncertainty was advised.**

57. **SC17 noted that fishing mortality has likely declined over the last decade and is currently relatively low due to the fact that most sharks are released upon capture in most longline fleets.**

58. **SC17 requested several diagnostics (i.e., CPUE's residuals, retrospective analysis, jitter analysis, and recruitment deviations) for the diagnostic case.**

59. **These diagnostics showed that the model convergence was reasonable for the models in the uncertainty grid with low maximum gradient and positive definite of hessian matrix, but the model fitting of the CPUEs and recruitment deviations were contended by some members of the SC.**

**b. Management advice and implications**

60. **SC17 noted, based on the above information, that stock biomass is likely increasing, and fishing pressure has declined through the recent decade. The results indicate that, if assessed against conventional reference points, it is likely that the stock will not be found to be overfished nor would overfishing be occurring.**

61. **SC17 recommended improving the manner in which the grid was selected before approving the results for providing management advice and proposed developing objective criteria for evaluating the plausibility of the grid. It was suggested that an attempt be made to use diagnostic tests as criteria for determining the final grid of results to inform management advice and uncertainty in the assessment. The performance of each model would be assessed against the following four criteria.**

1) **Model convergence and stability: the analysis should assess the final gradient (the final gradient should be relatively small; $<1e^{4}$), and check that the Hessian matrix is definite. Apply the jitter procedure to verify the stability of the model to evaluate whether the model has converged to a global solution rather than a local minimum.**
2) **Goodness-of-fit: evaluate whether residuals patterns of the CPUE and length-frequency distributions were normally distributed or/and had temporal trends.**
3) **Model consistency: retrospective analysis to check the consistency of model estimates, for example, the invariance in SB and F as the model is updated with new data in retrospect.**
4) **Prediction skill: hindcasting analysis could be done to evaluate the model prediction skill of the CPUE. When conducting hindcasting, a model is fitted to the first part of a time series and then projected over the period omitted in the original fit. Prediction skill can then be evaluated by comparing the predictions from the projection with the observations.**

**c. Future research recommendations**

62. **SC17 recommended that:**

1) **increased effort be made to re-construct catch histories for sharks (and other bycatch species) from a range of sources;**
2) **dynamic/non-equilibrium reference points, such as $SB_{F=0}$ be investigated for shark stock status, as they may be more appropriate for fisheries with uncertain early exploitation history and strong environmental influences;**
3) **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;**
4) **additional growth studies from a range of locations be undertaken to help build a better understanding of typical growth, as well as regional growth differences;**
5) **genetic/genomic studies be undertaken to augment the tagging work to help resolve these stock/sub-stock structure patterns;**
6) **aggregated data for key sharks are submitted as by ocean area not simply as WCPO and, where possible, these data should be retrospectively corrected; and**
7) **observers (or the vessel) should record number of shark lines deployed per set or the number of floats with shark lines.**

## 3.3 WCPO billfishes

### 3.3.1 Southwest Pacific swordfish (*Xiphias gladius*)

#### 3.3.1.1 Structural Uncertainty Grids and Projections

63. N. Ducharme-Barth presented SC17-SA-WP-05 (*Focusing on the front end: A framework for incorporating uncertainty in biological parameters in model ensembles of integrated stock assessments*).

#### 3.3.1.2 Review of 2021 Southwest Pacific swordfish stock assessment

64. Nicholas Ducharme-Barth (SPC-OFP) presented SC17-SA-WP-04 (*Stock assessment of Southwest Pacific swordfish*), which described the 2021 stock assessment of Southwest Pacific Ocean swordfish *Xiphias gladius*.

#### 3.3.1.3 Provision of scientific information

**a. Stock status and trends**

65. **The median values of relative latest (2019) spawning potential depletion ($SB_{latest}/SB_{F=0}$), spawning potential relative to MSY ($SB_{latest}/SB_{MSY}$) and relative recent (2015-2018) fishing mortality ($F_{recent}/F_{MSY}$) over the 25-model ensemble (Table SWO-03) were used to define Southwest Pacific swordfish stock status. The values of the upper 90$^{th}$ and lower 10$^{th}$ percentiles of the empirical distributions of relative spawning potential depletion, spawning potential relative to MSY and relative fishing mortality from the uncertainty ensemble (that included both structure and estimation uncertainty) were used to characterize the probable range of stock status.**

66. **A description of the model ensemble used to characterize uncertainty in the assessment is illustrated in Tables SWO-01 and SWO-02. Table SWO-03 shows reference points for Southwest Pacific swordfish, including the median values of relative 'latest' (2019) spawning biomass depletion ($SB_{latest}/SB_{F=0}$), spawning potential relative to spawning potential at MSY ($SB_{latest}/SB_{MSY}$), and relative**

**recent (2015-2018) fishing mortality ($F_{recent}/F_{MSY}$) over the final 25-model ensemble used to define stock status. These values present a more holistic view of uncertainty, accounting for both model (structural) and estimation (statistical) uncertainty.**

67. **The spatial structure used in the 2021 stock assessment is shown in Figure SWO-01. Time series of total annual catch by fishing gear over the full assessment period and by regions is shown in Figure SWO-02. Estimated annual average recruitment, spawning potential, and total biomass by model region for the diagnostic case model are shown in Figure SWO-03. Estimated trends in fishing mortality rates by age and region from the diagnostic model are shown in Figure SWO-04. Time-dynamic median and percentiles of depletion ($SB_t/SB_{t,F=0}$) for the 25 models are shown in Figure SWO-05. Majuro and Kobe plots summarizing the results for each of the 25 models in the ensemble are shown in Figures SWO-06 and SWO-07, respectively.**

68. **Estimated stock status was most impacted by the uncertainties in movement and natural mortality. Low natural mortality and higher rates of movement from Region 1 into Region 2 resulted in more pessimistic stock status.**

69. **SC17 noted that the stock is estimated to have gradually declined from the 1950s to the mid-1990s before rapidly declining to an overall low point near 2010. Current stock status is estimated to be at a similar level as the overall low with a declining trend in the terminal 4 years of the model.**

70. **SC17 noted that latest spawning potential depletion levels estimated by this assessment ($SB_{latest}/SB_{F=0}$) indicated a median of 0.39 ($10^{th}$ and $90^{th}$ percentiles 0.18 - 0.79).**

71. **SC17 noted that there was 13% risk that the latest (2019) spawning potential was lower than 20% $SB/SB_{F=0}$ when considering structural + estimation uncertainty. Omitting the estimation uncertainty as was done in the previous assessment, although this is known to exist, would have resulted in an 8% risk.**

72. **SC17 noted that the stock is estimated to have spawning potential above the MSY level ($SB_{latest}/SB_{MSY}$ median 2.95; $10^{th}$ and $90^{th}$ percentiles 0.99 – 6.78) and $SB_{recent}/SB_{MSY}$ has a median value of 3.61, $10^{th}$ and $90^{th}$ percentiles 1.23–7.39.**

73. **SC17 noted that there was 10% risk that $SB_{latest}/SB_{MSY} < 1$ when considering model and estimation uncertainty. Using only model-based uncertainty would have resulted in an 4% risk.**

74. **SC17 noted that fishing mortality is predicted to have increased gradually across the assessment region through the mid-1990s. Fishing mortality is estimated to have sharply increased in the early-2000s and appears to have stabilized at high levels in the last decade.**

75. **SC17 noted that the median of relative recent fishing mortality for Southwest Pacific swordfish $F_{recent}/F_{MSY}$ is 0.47 and $10^{th}$ and $90^{th}$ percentiles are 0.25 – 1.29.**

76. **SC17 noted that there was 20% risk that $F/F_{MSY} > 1$ when considering structural + estimation uncertainty. Omitting the estimation uncertainty, as was done in the previous assessment, although this is known to exit, would not have changed the level of risk.**

**Table SWO-01**. Summary of fixed assumptions made in the final model ensemble. The minimum, maximum, median and 10th and 90th percentiles are given for the ensemble parameters.

| | Mean | Median | Min | 10 | 90 | Max |
|---|---|---|---|---|---|---|
| $\sigma_{Age}$ | 29.51 | 28.50 | 25.76 | 26.13 | 34.10 | 40.66 |
| $\sigma_{Length}$ | 0.39 | 0.37 | 0.18 | 0.24 | 0.60 | 0.85 |
| Steepness | 0.89 | 0.90 | 0.71 | 0.85 | 0.94 | 0.98 |
| $\alpha_{LW}$ | 0.0000130 | 0.0000131 | 0.0000117 | 0.0000121 | 0.0000139 | 0.0000154 |
| $\beta_{LW}$ | 3.00 | 3.00 | 2.97 | 2.98 | 3.01 | 3.02 |
| $k$ | 0.20 | 0.19 | 0.16 | 0.17 | 0.22 | 0.26 |
| $L_\infty$ | 241.13 | 242.02 | 228.62 | 235.17 | 248.09 | 250.59 |
| $t_0$ | -2.07 | -2.12 | -2.60 | -2.39 | -1.74 | -1.15 |
| Average $M$ | 0.27 | 0.27 | 0.11 | 0.17 | 0.35 | 0.39 |
| $L_{50}$ Female maturity | 179.85 | 179.90 | 176.78 | 177.81 | 181.62 | 182.55 |
| $Region\ 1 \rightarrow\ 2$ | 0.036 | 0.036 | 0.008 | 0.011 | 0.065 | 0.096 |
| $Region\ 2 \rightarrow\ 1$ | 0.017 | 0.015 | 0.002 | 0.006 | 0.034 | 0.044 |
| LF scalar | 33.04 | 32.00 | 20.00 | 22.00 | 46.60 | 49.00 |
| WF scalar | 30.24 | 30.00 | 11.24 | 13.40 | 45.20 | 47.76 |
| Recruitment CV | 0.52 | 0.50 | 0.29 | 0.29 | 0.71 | 0.71 |
| AU index CV | 0.46 | 0.37 | 0.11 | 0.13 | 0.78 | 0.80 |
| NZ index CV | 0.43 | 0.42 | 0.11 | 0.19 | 0.71 | 0.78 |

**Table SWO-02**. Percentage of models remaining across the ensemble (Aggregate) and for each factorial level following each post-hoc filtration step.

| | Aggregate | DWFN - EU | DWFN - JP | DWFN - TW | DWFN - None | BH CV - 0.7 | BH CV - 0.5 | BH CV - 0.3 | $t_0$ prior - Uninformative | $t_0$ prior- Informative | M prior - VB | M prior - max Age |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 40% | 32% | 46% | 40% | 41% | 44% | 36% | 39% | 33% | 46% | 40% | 40% |
| 2 | 29% | 31% | 18% | 25% | 41% | 30% | 26% | 30% | 24% | 33% | 30% | 28% |
| 3 | 28% | 31% | 18% | 24% | 41% | 30% | 26% | 30% | 24% | 32% | 30% | 27% |
| 4 | 27% | 31% | 18% | 21% | 40% | 29% | 25% | 28% | 23% | 31% | 29% | 26% |
| 5 | 14% | 20% | 5% | 5% | 27% | 16% | 14% | 13% | 18% | 11% | 15% | 14% |
| 6 | 11% | 18% | 3% | 4% | 18% | 11% | 11% | 10% | 18% | 4% | 11% | 10% |
| 7 | 7% | 13% | 2% | 2% | 9% | 9% | 4% | 7% | 12% | 1% | 6% | 7% |

**Table SWO-03**. Summary of reference points (measures of central tendency, min, max and relevant percentiles, 10th and 90th) including model and estimation uncertainty from the 25 models in the final ensemble. Models were equally weighted in the ensemble. The quantity of $SB_{recent}/SB_{F=0}$ was not available from the current MFCL version due to the inclusion of both model and statistical uncertainty.

| | Mean | Median | Min | 10 | 90 | Max |
|---|---|---|---|---|---|---|
| $C_{latest}$ | 7,772 | 7,723 | 7,364 | 7,524 | 8,259 | 8,453 |
| $Y\ F_{recent}$ | 6,558 | 6,608 | 3,351 | 4,964 | 8,106 | 9,347 |
| $MSY$ | 9,922 | 9,543 | 3,869 | 5,470 | 14,738 | 22,278 |
| $F_{recent}/F_{MSY}$ | 0.67 | 0.47 | 0.16 | 0.25 | 1.29 | 2.34 |
| $SB_0$ | 83,853 | 69,390 | 16,491 | 31,472 | 145,944 | 334,518 |
| $SB_{latest}$ | 38,287 | 31,517 | 10,588 | 16,096 | 69,370 | 125,681 |
| $SB_{recent}$ | 41,916 | 38,106 | 14,975 | 18,956 | 68,550 | 99,304 |
| $SB_{MSY}$ | 12,507 | 11,480 | 2,427 | 5,212 | 21,722 | 29,297 |
| $SB_{latest}/SB_{MSY}$ | 3.7 | 2.95 | 0.44 | 0.99 | 6.78 | 18 |
| $SB_{recent}/SB_{MSY}$ | 4.1 | 3.61 | 0.64 | 1.23 | 7.39 | 16 |
| $SB_{latest}/SB_0$ | 0.59 | 0.46 | 0.1 | 0.2 | 1.09 | 2.49 |
| $SB_{latest}/SB_{F=0}$ | 0.45 | 0.39 | 0.08 | 0.18 | 0.79 | 1.42 |

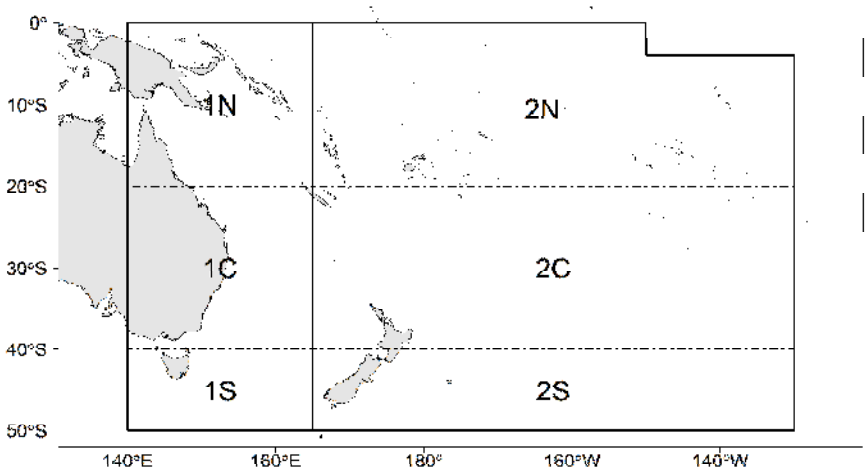


**Figure SWO-01**. Spatial structure for the 2021 Southwest Pacific swordfish stock assessment. Sub-regions used to differentiate fisheries are shown with the dotted lines.

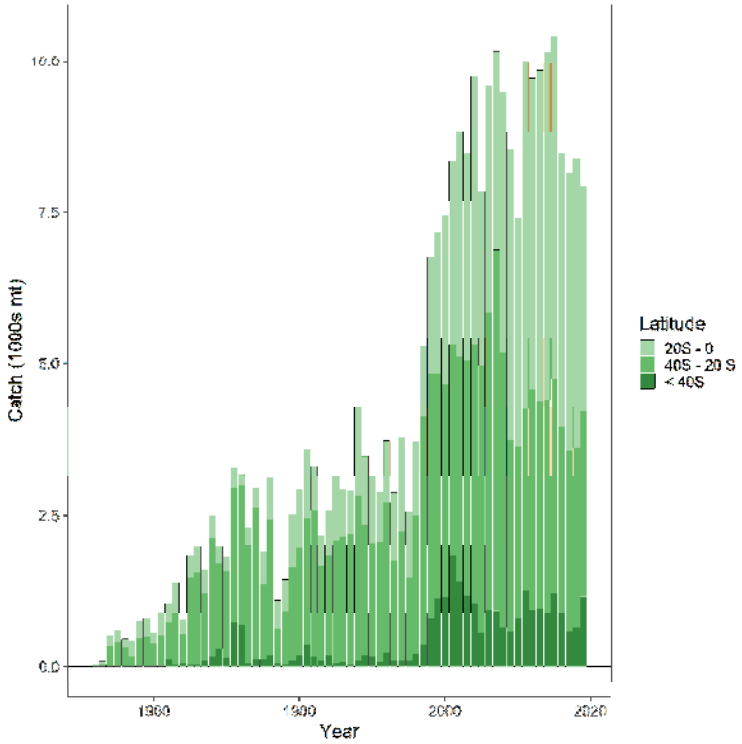


**Figure SWO-02.** Annual catch (mt) where the colors indicate latitudinal location of the catch.

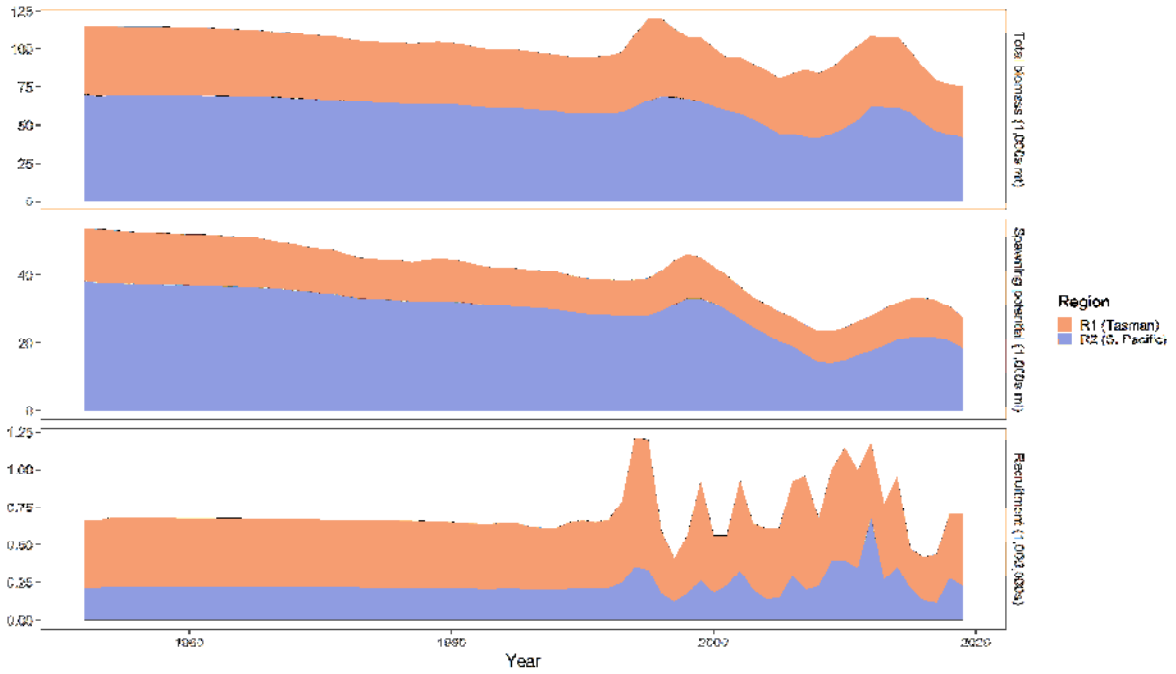


**Figure SWO-03**. Estimated total biomass (top panel), spawning potential (middle panel), and recruitment (lower panel) for the diagnostic case model. Color indicates the model region: Region 1 (orange) and Region 2 (blue).

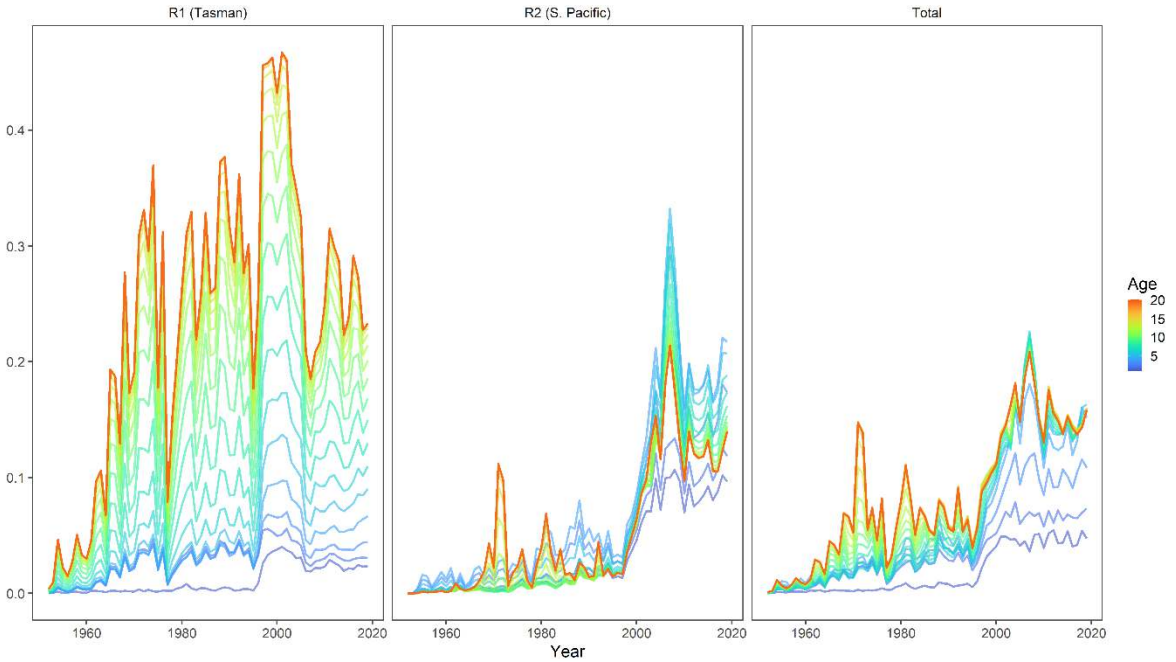


**Figure SWO-04**. Annual fishing mortality by age (color) and region (panel: Region 1 - left, Region 2 - center, and total - right).

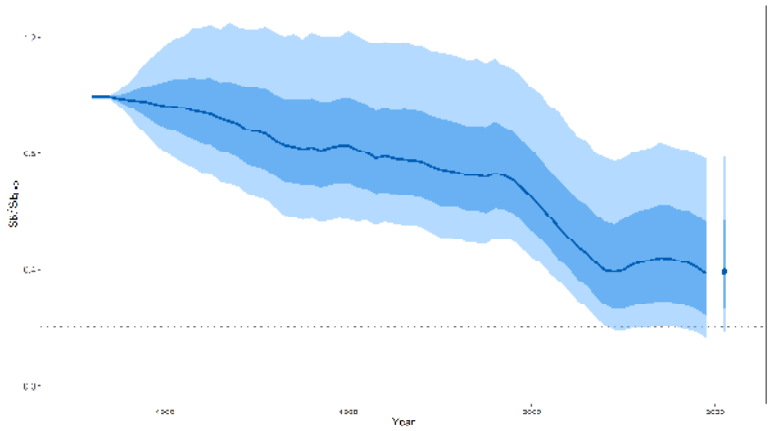


**Figure SWO-05**. Uncertainty in depletion where uncertainty is characterized as structural + estimation uncertainty. The median is showed by the dark line, the 25th-75th percentiles shown by the dark band, and the 10th-90th percentiles by the light band. The median and percentiles for total $SB_{latest}/SB_{F=0}$ are shown to the right of the Figure. For reference, the WCPFC tropical tuna LRP 20%$SB_{F=0}$ is shown with the dotted line.

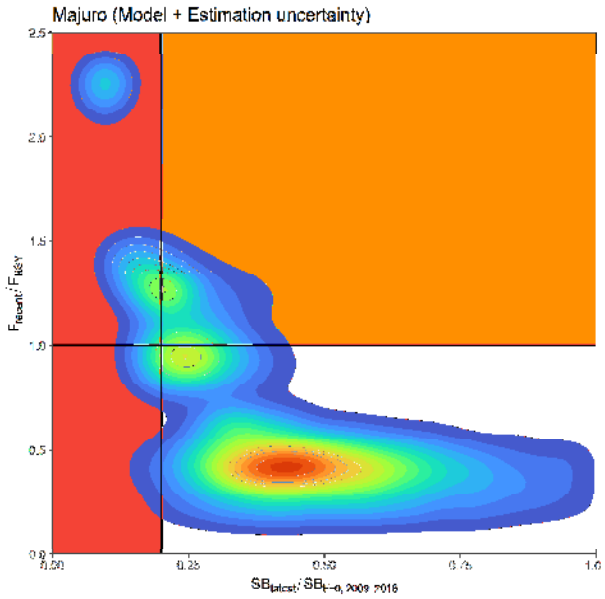


**Figure SWO-06**. Uncertainty in terminal stock status, based on the 12,500 bootstrap samples characterizing the structural + estimation uncertainty. Warmer colors indicate a greater density of samples, while cooler colors show the fringe of the distribution.

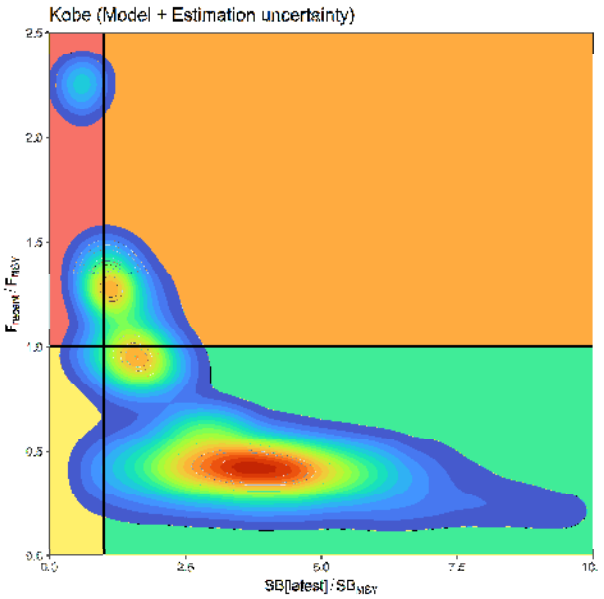


**Figure SWO-07**. Uncertainty in terminal stock status, based on the 12,500 bootstrap samples characterizing the structural + estimation uncertainty. Warmer colors indicate a greater density of samples, while cooler colors show the fringe of the distribution.

## b. Management advice and implications

77. **Annual catch estimates for Southwest Pacific swordfish peaked at 11,128 mt in 2012 (SC17-ST-IP-01). Catch by longline vessels in 2020 was 5,373 mt compared to 5,812 mt in 2019, a decline of 7.6%.**

78. **SC17 supported the new model ensemble approach for developing management advice for this stock, noting that this approach, including the process for review of priors and decisions on post-hoc filtering rules, would continue to be refined and improved in future. SC17 also noted this new approach may result in significant changes in the level of uncertainty assumed so far. This may have implications in the perception of risks, particularly when applied to species with adopted LRPs.**

79. **The outcomes of the assessment are on average more optimistic in relation to the 2017 assessment, but the estimated uncertainty has increased. Noting that a LRP for Southwest Pacific swordfish has not yet been adopted by WCPFC, SC17 noted that the median latest Southwest Pacific swordfish spawning biomass is above both $SB_{MSY}$ and the LRP $20\%SB_{F=0}$ applied to tunas, and recent fishing mortality is below $F_{MSY}$. The stock is likely not experiencing overfishing (80% probability $F<F_{MSY}$ and 20% probability $F>F_{MSY}$) and is likely not in an overfished condition (13% probability that $SB_{latest}/SB_{MSY} < 1$ and a 10% probability that $SB_{latest}/SB_{F=0}<0.2$).**

80. **SC17 noted that the levels of fishing mortality and depletion in the diagnostic case differ between the two model regions, with fishing mortality higher in Region 1 but spawning biomass depletion greater (more depleted) in Region 2. SC17 noted that over the past two decades, the majority of catch has been taken by a combination of swordfish targeting fleets (in the area south of 20°S; 42% of catches) and fleets taking swordfish as a bycatch on the high seas (in particular in the eastern stock area north of 20°S; 34% of catches).**

81. **While SC17 advocated for the adoption of the new ensemble approach, it is nevertheless important that the Commission understand the implications of the new approach and that additional work is required to refine this approach.**

82. **SC17 noted the significant unresolved uncertainties in the assessment relating to the reliability of CPUE indices, longitudinal movements, spatial connectivity and absolute population size. These uncertainties, combined with the need to further refine and review the new ensemble approach, suggest additional caution may be appropriate when interpreting the current assessment outcomes to guide management decisions. SC17 recommended that research priorities for this stock include directed longitudinal tagging of swordfish and a feasibility study on the utility of Close Kin Mark Recapture (CKMR).**

83. **SC17 noted the current measure (CMM 2009-03) for this stock does not contain provisions to limit total fishing mortality on the stock and emphasized the continued importance of WCPFC to develop a revised and strengthened CMM that will ensure the ongoing future sustainability of the Southwest Pacific swordfish. SC17 noted that the suite of catch projections requested by WCPFC16, which are to be undertaken by the SSP post-SC17 and prior to WCPFC18, are intended to test the future likely state of the stock under a range of potential future catch or effort scenarios. This information will inform the revision of the future measure.**

84. **SC17 recommended that a number of additional projection runs be explored alongside the WCPFC16 requested projections to be presented for consideration at WCPFC18:**

1) **No change to recent catch and effort levels.**
2) **10% and 20%reduction in total swordfish catch.**

85. **SC17 noted that the current CMM does not cover catches north of 20°S. SC17 recommends that the Commission take note of the swordfish projections in framing any future CMM.**

**c. Future research recommendations**

86. **Contingent on the collection of comprehensive sex-specific catch and size composition data, SC17 recommended to continue progress on developing a sex-disaggregated model to better account for the significant differences in life history between male and female swordfish. Implementation of a sex-disaggregated model applied to comprehensive sex-specific data could reduce bias in the model results. The Scientific Services Provider however did note that lack of sex specific size composition data was a major limitation to a sex disaggregate approach that would need to be improved.**

87. **The SPC investigated the application of a length-weight relationship bias correction factor during SC17. The analysis concluded that applying the bias-correction factor would not qualitatively change the management advice in this instance as it resulted in a 2-3% reduction in the risks to both the SW swordfish stock undergoing overfishing and being overfished. The Co-Convener advocated not to change the assessment runs for SC17 and to consider the correction for the next assessment.**

88. **The following three key research needs were identified in undertaking the assessment that should be investigated either internally or through directed research.**

1) **Directed longitudinal tagging of swordfish to reduce the uncertainty in movement rates, and a feasibility study to explore applying CKMR techniques to Southwest Pacific swordfish are the two most critical research items.**
2) **Development of a statistically robust sampling plan for the collection of fisheries dependent biological samples (by sex), including but not limited to age, catch, size frequency data, and genetic samples.**
3) **In order to improve quality of abundance indices there is a need to expand minimum reporting requirements for longline operational characteristics to include: *a priori* target species, light stick use, bait type, setting time (or fraction of night-time soak), and gear settings that influence fishing depth (e.g., hooks between floats, branch line length, float line length, and/or line setting speed).**

### 3.3.2 Pacific blue marlin (*Makaira nigricans*)

#### 3.3.2.1 Review of 2021 Pacific blue marlin stock assessment

89. H. Ijima (Japan) presented SC17-SA-WP-08 (*Stock assessment report for Pacific blue marlin (Makaira Nigricans) through 2019*). The ISC Billfish working group, IATTC, and SPC scientists conducted the current benchmark stock assessment.

#### 3.3.2.2 Provision of scientific information

**a. Stock status and trends**

90. **SC17 noted that ISC[1] provided the following conclusions on the stock status of Pacific blue marlin**:

> Stock status, biomass trends, and recruitment of Pacific blue marlin for both models in the ensemble had equal weights and similar trends, although the estimates of initial conditions are different. All reported results are the model-averaged estimates from the ensemble model unless otherwise noted.

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

Estimates of population biomass declined until the mid-2000s, increased again until 2019, and were relatively flat until the present. The minimum spawning stock biomass is estimated to be 17,592 mt (95% C.I. 14,512-20,703 mt) in 2006 which corresponds to 5% above $SB_{MSY}$, the spawning stock biomass to produce MSY, (i.e., $SB/SB_{MSY} = 1.05$; 95% C.I. 0.70-1.01, Figure PBUM-1). In 2019, SB = 24,272 mt and the relative $SB/SB_{MSY} = 1.17$ (95% C.I. 0.87-1.51).

Combined median fishing mortality on the stock (average F on ages 1-10) is currently below $F_{MSY}$ (Figure PBUM-1). It averaged roughly F = 0.13 during 2017-2019, or 40% below $F_{MSY}$, and in 2019, F=0.11 with a relative fishing mortality of $F/F_{MSY} = 0.50$ (95% C.I. 0.37-0.69). Median fishing mortality has been below $F_{MSY}$ in all years except the period 2003 to 2006.

The predicted value of the spawning potential ratio (SPR, the predicted spawning output at current *F* as a fraction of unfished spawning output) is currently $SPR_{2017-2019} = 31\%$ for the average of the ensemble model, which is above the SPR required to produce MSY (17%). Recruitment was relatively consistent throughout the assessment time horizon, with occasional pulses in recruitment, but no notable periods of below-average recruitment.

No target or limit reference points have been established for Pacific blue marlin under the auspices of the WCPFC. Blue marlin is expected to be highly productive due to its rapid growth and high resilience to reductions in spawning potential. Although fishing mortality has approached $F_{MSY}$ and exceeded MSY from 2003 to 2006, the biomass of the stock has remained above $SB_{MSY}$ since this time. With continued decreases in fishing effort and associated catches of Pacific blue marlin, the stock is expected to remain within MSY limits. When the status of blue marlin is evaluated relative to MSY-based reference points, the 2019 spawning stock biomass of 24,272 mt is 17% above $SB_{MSY}$ (20,677 mt, 95% C.I. -13% to +50%) and the 2017-2019 fishing mortality is 50% of $F_{MSY}$ (95% C.I. 37% to 69%). Therefore, relative to MSY-based reference points, overfishing was very likely not occurring (>90% probability) and Pacific blue marlin is likely not overfished (81% probability, Figure PBUM-2).

Deterministic stock projections were conducted with Stock Synthesis to evaluate the impact of alternative future levels of harvest intensity on female spawning stock biomass, fishing mortality, and yield for Pacific blue marlin. Future recruitment was predicted based on the stock- recruitment curve. These projections used all the multi-fleet, multi-season, size- and age- selectivity, and complexity in the assessment model to produce consistent results. The stock projections started in 2020 and continued through 2029 (10 years) under 4 levels of constant fishing mortality: (1) constant fishing mortality equal to the 2003-2005 average ($F_{2003-2005}$); (2) constant fishing mortality equal to $F_{MSY}$; (3) constant fishing mortality equal to the 2016-2018 average defined as current; and (4) constant fishing mortality equal to F30% (F30% corresponds to the fishing mortality that produces 30% of the spawning potential ratio). Stock projections for each F scenario were run for both growth models in the ensemble and combined using the multivariate lognormal method. Using the deterministic projection result, the multivariate lognormal approximation was applied to generate 10,000 trajectories of SSB and F to calculate the model-averaged results of the new and old growth models. Results showing the projected female spawning stock biomasses, fishing mortality, and the catch biomasses under each of the combined scenarios are provided in Table PBUM-3 and Figure PBUM-3.

91. SC17 noted the following stock status from ISC:

Based on these findings, the following information on the status of the WCNPO blue marlin stock is provided:

1. No target or limit reference points have been established for Pacific blue marlin by the WCPFC;
2. Female spawning stock biomass was estimated to be 24,241 mt in 2019, or about 17% above $SSB_{MSY}$ and 17% above $20\%SSB_0$.
3. Fishing mortality on the stock (average F, ages 1 to 10) averaged roughly F = 0.13 during 2016-2019, or about 40% below $F_{MSY}$ and 28% below $F_{20\%SSB0}$.
4. Blue marlin stock status from the ensemble model indicates that relative to MSY-based reference points, overfishing was very likely not occurring (>90% probability) and Pacific blue marlin is likely not overfished (81% probability, Figure PBUM-2).

92. SC17 noted that this result is predicated on the use of the Japanese and Taiwanese longline CPUE indices in the assessment, and the exclusion of the Hawaii longline CPUE index, which shows a somewhat different trend (declining by about 50% from 1995-2005, then flat) to the Taiwanese CPUE index in particular. The ISC Billfish Working Group (BILLWG) doesn't believe that the Hawaii longline CPUE index was representative of the Pacific-wide relative abundance of Pacific blue marlin due to the small area it represents, rather a measure of local density. In addition, the CPUE index was in conflict with both Taiwanese and Japanese indices over the same time period. Further, the decision to remove the Hawaii longline CPUE index was consistent with the model decisions made for the 2016 assessment.

**b. Management advice and implications**

93. **SC17 noted the following conservation information from ISC**:

The Pacific blue marlin stock has produced annual yields of around 18,800 mt per year since 2015, or about 90% of the MSY catch (Table PBUM-1). Blue marlin stock status from the ensemble model indicates that the current median spawning biomass is above $SSB_{MSY}$ and that the current median fishing mortality is below $F_{MSY}$. However, uncertainty in the stock status indicates a 19% chance of Pacific blue marlin being overfished relative to $SSB_{MSY}$. Both the old and new growth models show evidence of spawning biomass being above $SSB_{MSY}$ and fishing mortality being below $F_{MSY}$ during the last 5 years. Catch biomass has been declining for the last 5 years, and therefore the stock has a low risk of experiencing overfishing or being overfished unless fishing mortality increases to above $F_{MSY}$ based upon stock projections (Table PBUM-3 and Figure PBUM-3). However, it is also important to note that retrospective analyses show that the assessment model tends to overestimate biomass and underestimate fishing mortality in recent years, in part due to rapid changes in longline CPUE.

Based on these findings, the following conservation information is provided:

1. There is no evidence of excess fishing mortality above $F_{MSY}$ ($F_{2016\text{-}2019}$ is 40% of $F_{MSY}$) or substantial depletion of spawning potential ($SSB_{2019}$ is 17% above $SSB_{MSY}$);
2. It is important to note that retrospective analyses show that the assessment model tends to overestimate spawning stock biomass in recent years; and
3. The results show that projected female spawning biomass is expected to increase under the $F_{status\ quo}$ and $F_{30\%}$ harvest scenarios and decline to $SSB_{MSY}$ under the High F and $F_{MSY}$ harvest scenarios. The probability that the stock is overfished or overfishing occurring by 2029 under each harvest scenario is low.

Special Comments

1. Uncertainty regarding the choice of BUM growth curve led to the ensemble model approach for this assessment. The BILLWG recognized that there is considerable uncertainty in input CPUE data in the recent years and life history parameters, especially

growth. The BILLWG considered an extensive suite of model formulations and associated diagnostics for developing the assessment models. Overall, the BILLWG found issues with both the new growth and old growth model diagnostics and sensitivity runs that are consistent with the presence of data conflicts, but none of the model diagnostics show that the results of either model were invalid. It is recommended model development work to reduce data conflicts and modeling uncertainties continue and that input assessment data be reevaluated to improve the time series.

2. It is recommended that biological sampling to improve life history parameter estimates continue to be collected and ISC countries participate in the BILLWG International Biological Sampling program to improve those estimates.

**Table PBUM-1.** Reported catch (mt) used in the stock assessment along with annual model-averaged estimates of female spawning biomass (mt), relative female spawning biomass ($SSB/SSB_{MSY}$), recruitment (thousands of age-0 fish), fishing mortality (average F, ages 1 – 10), relative fishing mortality ($F/F_{MSY}$), and spawning potential ratio (SPR) of Pacific blue marlin.

| Year | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | Mean[1] | Min[1] | Max[1] |
|---|---|---|---|---|---|---|---|---|---|---|
| **Reported Catch** | 22,166 | 23,741 | 21,861 | 22,644 | 14,443 | 18,589 | 16,503 | 18,873 | 10,882 | 26,138 |
| **Spawning Biomass** | 27,707 | 26,321 | 25,476 | 23,693 | 22,942 | 23,222 | 24,279 | 35,007 | 17,601 | 69,331 |
| **Relative Spawning Biomass** | 1.33 | 1.26 | 1.22 | 1.15 | 1.11 | 1.12 | 1.18 | 1.70 | 0.84 | 3.51 |
| **Recruitment (thousands of age 0 fish)** | 960 | 785 | 608 | 862 | 870 | 1,399 | 876 | 895 | 502 | 1,399 |
| **Fishing Mortality** | 0.18 | 0.19 | 0.19 | 0.21 | 0.13 | 0.16 | 0.11 | 0.16 | 0.08 | 0.25 |
| **Relative Fishing Mortality** | 0.81 | 0.85 | 0.83 | 0.95 | 0.58 | 0.71 | 0.50 | 0.71 | 0.35 | 1.11 |
| **Spawning Potential Ratio** | 0.26 | 0.24 | 0.25 | 0.22 | 0.33 | 0.27 | 0.34 | 0.33 | 0.17 | 0.60 |

[1]During 1971-2019

**Table PBUM-2**. Estimates of biological reference points along with estimates of fishing mortality (F), spawning stock biomass (SSB), recent average yield (C), and spawning potential ratio (SPR) of Pacific blue marlin, derived from the assessment ensemble model, where "MSY" indicates reference points based on maximum sustainable yield.

| Reference Point | Estimate |
|---|---|
| $F_{MSY}$ (age 1-10) | 0.23 |
| $F_{2019}$ (age 1-10) | 0.11 |
| $F_{20\%SSB0}$ | 0.18 |
| $SSB_{MSY}$ | 20,677 mt |
| $SSB_{2019}$ | 24,241 mt |
| $SSB_{20\%SSB0}$ | 20,729 mt |
| MSY | 24,600 mt |
| $C_{2017\text{-}2019}$ | 16,512 mt |
| $SPR_{MSY}$ | 17% |
| $SPR_{2019}$ | 34% |
| $SPR_{20\%SSB0}$ | 23% |

**Table PBUM-3**. Projected median values of Pacific blue marlin spawning stock biomass (SSB, mt) and catch (mt) under four constant fishing mortality rate (F) scenarios during 2020-2029.

| Year | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Scenario 1: $F = F_{2003-2005}$** | | | | | | | | | | |
| SSB | 25,459 | 23,462 | 21,752 | 20,498 | 19,262 | 18,689 | 18,252 | 17,835 | 17,583 | 17,475 |
| Catch | 33,111 | 30,527 | 28,638 | 27,331 | 26,431 | 25,806 | 25,363 | 25,044 | 24,811 | 24,641 |
| **Scenario 2: $F = F_{MSY}$** | | | | | | | | | | |
| SSB | 25,318 | 23,351 | 21,583 | 20,255 | 19,216 | 18,405 | 18,186 | 17,809 | 17,513 | 17,466 |
| Catch | 32,875 | 30,436 | 28,662 | 27,439 | 26,606 | 26,037 | 25,645 | 25,370 | 25,177 | 25,039 |
| **Scenario 3: $F = F_{2016-2018}$** | | | | | | | | | | |
| SSB | 26,930 | 28,182 | 28,764 | 28,675 | 28,428 | 28,731 | 28,052 | 28,142 | 27,861 | 28,081 |
| Catch | 23,321 | 23,546 | 23,591 | 23,561 | 23,513 | 23,472 | 23,443 | 23,422 | 23,407 | 23,397 |
| **Scenario 4: $F = F_{30\%}$** | | | | | | | | | | |
| SSB | 27,757 | 30,064 | 30,624 | 30,976 | 31,072 | 31,624 | 31,415 | 31,800 | 31,753 | 32,132 |
| Catch | 20,828 | 21,404 | 21,764 | 22,001 | 22,167 | 22,294 | 22,393 | 22,471 | 22,532 | 22,580 |

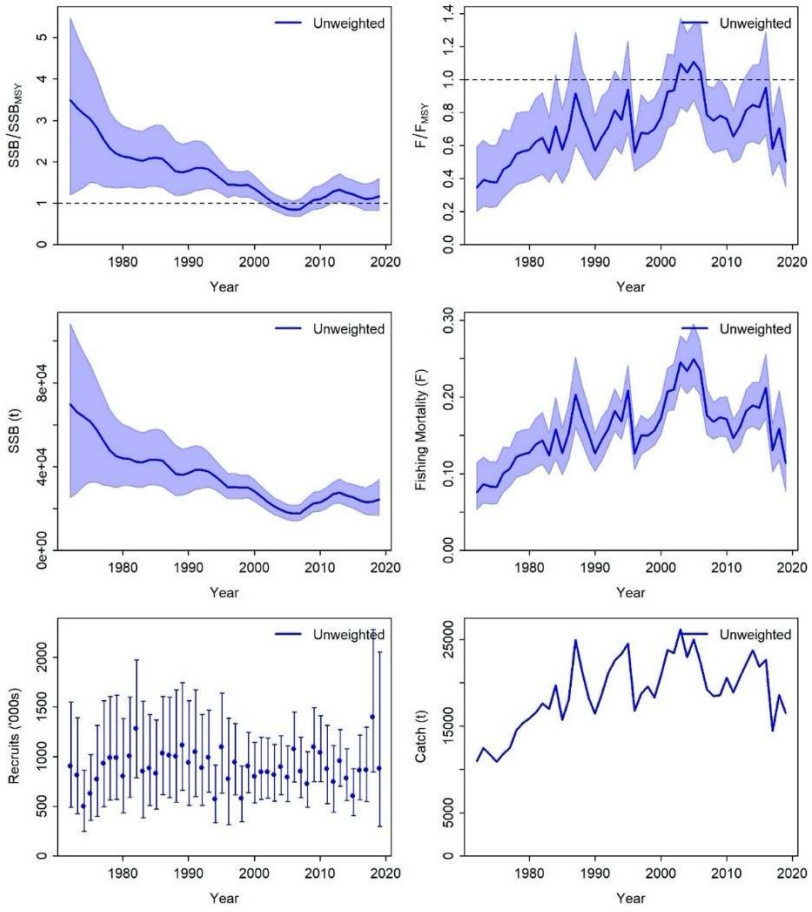


**Figure PBUM-1**. Time series of estimates of female spawning stock biomass over female spawning stock biomass at MSY (top left), fishing mortality overfishing mortality at MSY (top right), spawning stock biomass (center left), instantaneous fishing mortality (ages 1-10 year$^{-1}$, center right), recruitment (age-0 fish, bottom left), and catch (bottom right) for Pacific blue marlin (*Makaira nigricans*) derived from the 2021 stock assessment model ensemble. Lines (or points for recruitment) indicate the median value estimated from the joint multivariate delta-lognormal estimation, shaded areas (or error bars for recruitment) indicate the 95% confidence intervals. Unweighted indicates that both models have equal weights in the ensemble.

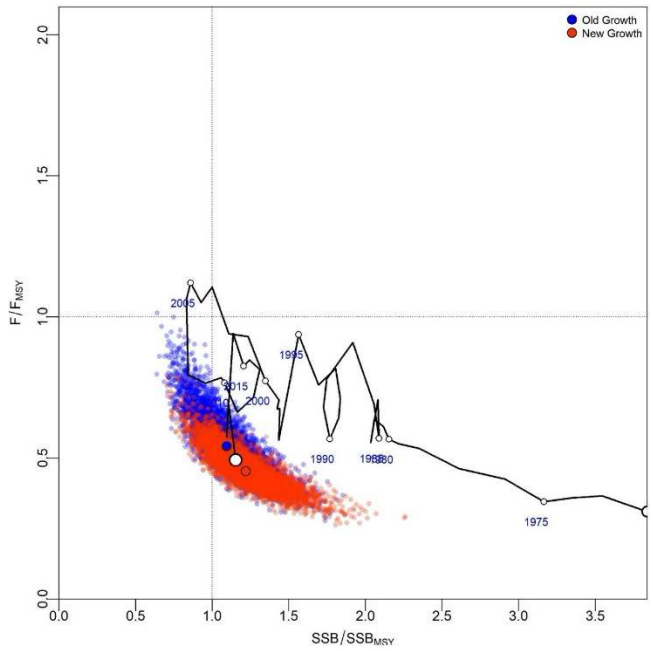


**Figure PBUM-2**. Kobe plot of the time series of estimates of relative fishing mortality (average of age 1-10) and relative spawning stock biomass of Pacific blue marlin (*Makaira nigricans*) during 1971-2019. The white circle denotes the delta-lognormal multivariate estimate of the combined models in 2019, blue dots indicate the final year stock status of the old growth model with the 10,000 multivariate draws, and red dots indicate the final year stock status of the new growth model with the 10,000 multivariate draws.

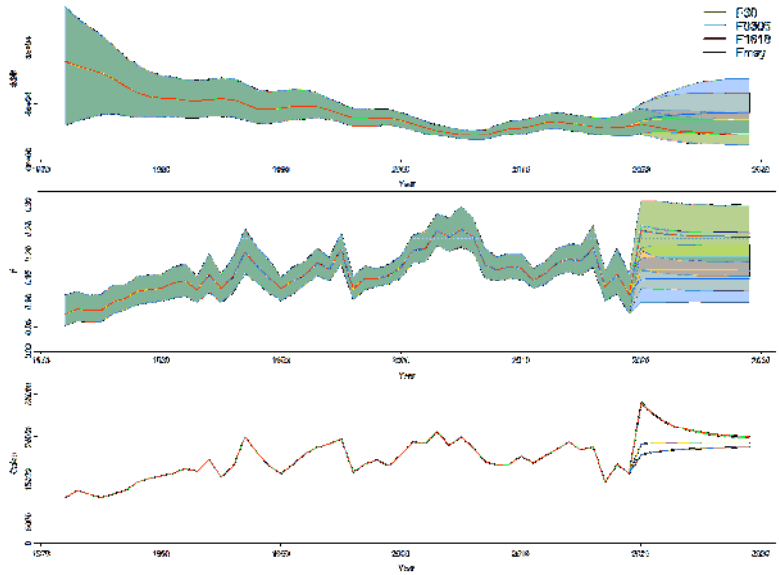

**Figure PBUM-3**. Historical and projected trajectories of spawning biomass and total catch from the Pacific blue marlin combined models based upon the four F scenarios: projected spawning biomass, dotted line indicates $SSB_{MSY}$, shading indicates 95% confidence intervals (top); projected instantaneous fishing mortality (ages 1-10 $year^{-1}$), dotted line indicates $F_{MSY}$, shading indicates 95% confidence intervals (center); and projected catch (mt. bottom). Green indicates scenario 1, $F_{2003\text{-}2005;}$ red indicates scenario 2, $F_{MSY}$; yellow indicates scenario 3, $F_{2016\text{-}2018}$; and blue indicates scenario 4, $F_{30\%}$. The list of projection scenarios can be found in Table 3.

### 3.4 Peer Review

94. Paul Hamer (SPC) introduced SC17-SA-WPO-06 (*Draft terms of reference for an independent peer review of the 2020 WCPO yellowfin tuna assessment*), and updated SC17 on the arrangements to conduct the review.

## AGENDA ITEM 4 — MANAGEMENT ISSUES THEME

95. The Management Issues (MI) theme was convened by R. Campbell (Australia), who stated that the MI Theme has two major agenda items to consider: i) development of the harvest strategy framework for key tuna species (which includes consideration of TRPs), and ii) LRPs for sharks and billfish. These topics are covered in 7 working papers and 14 information papers (4 of which were posted on the ODF).

### 4.1 Development of the Harvest Strategy Framework for key tuna species

#### 4.1.1 Overview on the progress and updates to the harvest strategy workplan

#### 4.1.2 Target reference points (TRPs)

##### 4.1.2.1 Bigeye and yellowfin tuna TRP analyses

96. Steven Hare (SPC) presented SC17-MI-WP-01 **(***Updated WCPO bigeye and yellowfin TRP evaluations*).

**Recommendations**

97. **Noting the request from WCPFC17 to review any updated information on TRPs for bigeye and yellowfin tuna, SC17 reviewed SC17-MI-WP-01 (*Updated WCPO bigeye and yellowfin TRP evaluations*).**

98. **SC17 noted that these analyses 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.**

99. **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.**

100. **SC17 noted that the analyses will greatly aid in considering candidate TRPs for bigeye and yellowfin tuna.**

101. **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.**

102. **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.**

103. **SC17 noted that South Pacific albacore had not been included in the TRP evaluations and asked the Scientific Services Provider (SSP) to update this report to include South Pacific albacore in future evaluations.**

#### 4.1.2.2 Skipjack tuna TRP analyses

104. G. Pilling (SPC) presented SC17-MI-WP-02 (*Further updates to WCPO skipjack tuna projected stock status to inform consideration of an updated target reference point*).

**Recommendations**

105. **Noting the request from WCPFC17 to review the updated information provided by the SSP on the performance of candidate TRPs and provide advice to the Commission for its potential update of the skipjack TRP, SC17 reviewed SC17-MI-WP-02 (*Further updates to WCPO skipjack tuna projected stock status to inform consideration of an updated target reference point*).**

106. **SC17 noted the challenges outlined in the paper on interpreting future fishing mortality and several CCMs proposed that additional analyses should be undertaken to consider how the fishing mortality estimated within the analysis is driven by the assumptions, particularly the contributions of the different gear types to the catch in Region 5. To better understand the importance of each sector one CCM also requested yield or spawning biomass per-recruit curves by fishing sector be added to the paper.**

107. **SC17 recommended forwarding this working paper, and any updates, to the Commission and that the results be taken into account at the next Tropical Tuna Measure Workshop (TTMW2).**

### 4.1.3 Review of the overall harvest strategy work

**Recommendations**

108. **Noting the revised work plan for the adoption of the WCPFC Harvest Strategy under CMM 2014-06 (Attachment H, WCPFC17 Summary Report), SC17 reviewed the overall progress to date in the development of the harvest strategy covered by this workplan as outlined in SC17-MI-WP-03 (*Recent progress in the technical development of harvest strategies for WCPFC stocks and fisheries*).**

109. **SC17 noted several difficulties with the use of CPUE to inform a management procedure for South Pacific albacore and supported the continuing investigation of simple model-based alternatives. Incorporation of the new treatment of uncertainty (as included in the updated assessment for Southwest Pacific swordfish reviewed by SC17) should also be investigated.**

110. **SC17 continued to encourage a focus on capacity building workshops, particularly for SIDS and developing states, on understanding of harvest strategy functioning and implications. Building such capacity will assist all CCMs to participate fully in this complex process and have the confidence in the harvest strategy development process and its outcomes when implemented. It will also assist the effective participation of all CCMs in any future Science-Management Dialogue.**

111. **SC17 endorsed the work outlined in SC17-MI-WP-03 and to progress the Harvest Strategy Workplan recommends that the Commission take note of this work and provide advice on the following issues:**

- **Definition of fisheries and fishery controls within the harvest strategy.**

- **Procedures for identifying, selecting, and implementing the 'best' management procedure.**

112. **Finally, SC17 noted that while the current Harvest Strategy Workplan only goes through 2022, the funding support from New Zealand for the associated project (Pacific Tuna Management Strategy Evaluation) has been extended to the beginning of 2024. SC17 noted that the current timeline for completing the harvest strategy is ambitious.**

### 4.1.4 Skipjack MSE framework

113. R. Scott (SPC) presented SC17-MI-WP-04 (*Skipjack Management Procedure evaluations*), the latest information on the MSE framework for WCPO skipjack tuna. The results of all evaluations are available online at https://ofp-sam.shinyapps.io/pimple/.

**Recommendations**

114. **Noting the planned schedule of adopting the management procedure for skipjack tuna in 2022, SC17 reviewed the progress on analysing the performance of candidate management procedures outlined in SC17-MI-WP-04 (*Evaluations of candidate management procedures for skipjack tuna in the WCPO*).**

115. **SC17 noted the SC14 recommendation to retain the full list of performance indicators for skipjack even for those that may be difficult to estimate. SC17 also noted that a scenario which assumes an annual 3% effort creep in the purse-seine fishery will be included in the robustness set for skipjack.**

116. **SC17 also noted that current candidate Management Procedures are developed using a single schedule applicable for both effort-controlled fisheries (PS) and catch-controlled (non-PS) fisheries, resulting in different projected yield patterns between two types of fisheries. For PS, the catch will increase if stock increases even if the effort is kept constant, while for non-PS fisheries catch will be kept constant even if the stock increases. This could cause problems as this may be seen as unequitable among stakeholders.**

117. **SC17 also commended the SSP for the PIMPLE app as it has served an important role in enhancing understanding of Management Procedures (MPs) and encouraged its use with managers in providing advice on the scientific aspects of candidate MPs. SC17 noted there are some MSY indicators presented within the PIMPLE software as this tool now includes both Kobe and Majuro plots.**

118. **SC17 noted that evaluations of candidate management procedures for skipjack tuna were based on a grid of operating models that was initially proposed at SC15 and subsequently revised at SC16. However, no formal agreement on the range of OMs to be used has been made by the SC. SC17 further noted that the details of the OMs including model diagnostics were available for inspection online at https://ofp-sam.shinyapps.io/hierophant but more detailed presentation and discussion are warranted at SC18.**

119. **SC17 noted the continuing high quality of the work on a skipjack MSE framework.**

120. **To progress the development of harvest strategies for skipjack, SC17 recommends that the Commission take note of the analyses outlined in SC17-MI-WP-04 and requests the Commission to provide advice on the following issues:**

- **Multispecies impacts on other tropical tuna related harvest strategies;**
- **Definition of fisheries and fishery controls within the harvest strategy;**
- **Input into candidate MP designs;**
- **Feedback on presentational approaches to enhance decision making;**
- **Procedures for selecting the 'best performing' MP.**

121. **SC17 saw much value in presenting this work to managers and other stakeholders, and to achieve this and help address the requests made above a Science-Management Dialogue to be held in 2022 was strongly supported.**

### 4.1.5 Mixed fisheries

122. Finley Scott presented SC17-MI-WP-05 (*Mixed fishery harvest strategy developments*). The paper focuses on a simplified management strategy evaluation framework that includes WCPO skipjack, bigeye and yellowfin tuna.

**Recommendations**

123. **Noting the initial work presented to SC16 in developing a multi-species modelling framework for mixed fishery interactions when developing and testing harvest strategies for the four main WCPO tuna stocks, SC17 reviewed an update on the development of this framework outlined in SC17-MI-WP-05 (*Mixed-fishery harvest strategy developments*).**

124. **SC17 noted that in the present 'proof of concept' analyses there are differences between the reference year used for the archipelagic waters (2012) whereas the tropical and southern longline fisheries are held to the average of 2016-2018. There will need to be agreement on various assumptions that underpin these simulations noting that as the mixed fishery framework develops, the tropical and southern longline fisheries will not be held constant but will be managed through management procedures.**

125. **SC17 also noted that while there is agreement on the hierarchical approach, the order of the hierarchy (i.e., the order in which the species-specific management procedures are implemented) has not yet been agreed and that a process to get such an agreement is required.**

126. **SC17 welcomed the initial work and results of SC17-MI-WP-05 as demonstrating the 'proof of concept' and supported continued work by the SSP to further develop this modelling framework as it is critical to the future management of the key tuna stocks in the WCPO.**

127. **SC17 endorsed the work outlined in SC17-MI-WP-05 and noted the next steps to progress this work, including i) building a full suite of OMs for bigeye and yellowfin, ii) developing candidate MPs for bigeye for the tropical longline fishery, iii) the inclusion of South Pacific albacore in the modelling framework, and iv) agreeing multi-species performance indicators.**

128. **SC17 recommends that the Commission take note of the progress on the development of a mixed fishery MSE framework and provide advice on the issues listed in the previous paragraph.**

### 4.1.6 Review of future progress of the WCPFC Harvest Strategy Workplan

**Recommendations**

129. **SC17 noted the request from the Commission to review the steps required to further progress the Harvest Strategy Workplan and highlight issues for further guidance by the Commission, including how decisions on Management Procedures can be made and what the role of the SC might be in this process. This includes continuing to consider options to convene a Science-Management Dialogue to assist this process.**

130. **SC17 noted that while substantial progress has been made on the technical work to support harvest strategies according to the workplan, the workplan does not currently extend beyond 2022 and that it will require amendment to encompass future technical work and decision making, particularly on bigeye, yellowfin and the multispecies framework. Toward this end SC17 noted Australia's intention to again take a leading role in amending the Harvest Strategy Workplan to reflect decisions made, progress to date, and to cover the work and decisions for years 2023 and beyond for the consideration of the Commission this year.**

131. **While SC17 noted that the technical work by the SSP has generally kept pace with the Harvest Strategy Workplan, it was also noted that capacity-building initiatives, as well as WCPFC consideration, engagement and decision-making has perhaps not kept pace. SC17 noted that greater input from WCPFC bodies in general, but particularly commissioners, managers and stakeholders, will be vital over the coming years to inform the testing of candidate management procedures for skipjack and South Pacific albacore in the WCPO, and in the iterative process of their review and refinement prior to formal adoption.**

132. **Finally, noting that the development of the WCPFC harvest strategy framework is reaching a mature stage, and the increasing number of issues that require the attention of, and feedback from, managers in order to progress the Harvest Strategy Workplan (as noted in several recommendations above). SC17 again reiterates its previous recommendations for a Science-Management Dialogue to be convened in 2022. In addition, SC17 calls attention to the importance of such a dialogue to ensure the input of managers and stakeholders to the MSE process and to ensure timely execution of the Commission's harvest strategies workplan.**

133. **SC17 also recommended that greater priority should be given during 2022 to Harvest Strategy work within the Commission Workplan.**

### 4.2 Limit Reference Points for Species other than Tuna

#### 4.2.1 Limit reference points for elasmobranchs

134. S. Zhou presented SC17-MI-WP-07 (*Appropriate reference points for WCPO elasmobranchs – Project 103*), which summarized major sections from the previous project.

**Recommendations**

135. **Noting the request from WCPFC16 to identity appropriate LRPs for elasmobranchs in the WCPO, SC17 reviewed the outcomes of Project 103 outlined in SC17-MI-WP-07 (*Appropriate Limit Reference Points for WCPO Elasmobranchs*).**

136. **SC17 noted the comprehensive scope of the project report and that this work had built on the results of several other reports previously reviewed by the SC (SC10-MI-WP-07; SC11-EB-IP-13; SC14-MI-WP-07).**

137. **SC17 noted and discussed the recommendations made in SC17-MI-WP-07 and conveyed the following conclusions to the Commission:**

- **SC17 continued to support the tier-based approach first recommended by SC10:**
  - **For stocks assessed using a stock assessment model (i.e., data-rich stocks), reference points estimated in the same stock-assessment should be adopted.**
  - **For stock without a stock assessment (i.e., data-poor stocks), or when the results are not robust, risk-based RPs should be used.**
- **SC17 noted that the data rich approach might not necessarily have lower uncertainty than the data poor approach.**
- **While an LRP for WCPO elasmobranchs equivalent to $B_{lim}=0.25B_o$ (consistent with $20\%SB_{unfished}$ for target species) and the corresponding $F_{lim}=1.5F_{MSY}$ was supported by a number of CCMs, several other CCMs did not support the use of this LRP, instead suggesting that a broader range of reference points should be appraised (such as outlined in Table 7 of SC17-MI-WP-08) to assess their applicability to WCPO elasmobranchs, and that these be considered under a broader banner of reference points for non-tuna species. However, there was some concern expressed that such a review of other metrics had already been undertaken by earlier reports (e.g., SC10-MI-WP-07).**
- **The use of a constant percentage of SPR (spawning potential ratio) such as $F_{60\%}SPR$ (i.e., F that produces an SPR of 60% of unfished) as a reference point for all stocks was not supported.**
- **It was noted that continued fishing at or above $F_{crash}$ would lead to stock collapse. In the long term, an LRP should constrain fishing mortality to below this level.**
- **Finally, SC17 noted that it is important to continue research to provide or improve estimates of life-history parameters and gear selectivity to improve the determination of risk-based reference points.**
- **SC17 noted that a management strategy evaluation approach could be helpful in determining what LRPs would work best when there is uncertainty in the input assessment data, population dynamics, model structure and other dynamic features of the WCPO fishery system.**

138. **SC17 agreed that Project 103, and the other projects that had preceded it, had provided a good framework for progressing the development and identification of appropriate LRP for WCPO elasmobranchs. However, SC17 expressed disappointment that after such lengthy consideration that the SC was at this time unable to make a final recommendation on appropriate LRPs to the Commission.**

139. **SC17 recommended that the Commission take note of the work and recommendations outlined in SC17-MI-WP-07 together with the conclusions reached by SC17 and the need for further work as noted above.**

### 4.2.2 Review of appropriate LRPs for Southwest Pacific striped marlin and other billfish (Project 104)

140. Stephen Brouwer (Saggitus Limited) presented SC17-MI-WP-08 (*Appropriate limit reference points for Southwest Pacific Ocean striped marlin and other billfish – Project 104*).

**Recommendations**

141. **Noting the agreed outcome from WCPFC16 to revisit the identification of an appropriate limit reference point for South Pacific Striped marlin, SC17 reviewed the outcomes of Project 104**

**outlined in SC17-MI-WP-08 (*Appropriate LRPs for Southwest Pacific Ocean Striped Marlin and Other Billfish*).**

142. **SC17 noted the comprehensive scope of the project report and discussed the nine recommendations made in SC17-MI-WP-08 and while broadly supporting these recommendations conveys the following conclusions to the Commission:**

- **The WCPFC should develop interim objectives for Southwest Pacific striped marlin to guide the appropriate levels for any agreed LRP and the associated maximum risk levels for breaching this LRP.**
- **While an LRP equivalent to 20% $SB/SB_{F=0}$ for Southwest Pacific striped marlin was supported by several CCMs (consistent with the logic behind the application to key tuna stocks), several other CCMs pointed out that the life-history of billfish are substantially different to key tuna species and therefore did not support this LRP. Several CCMs also noted that in adopting the tuna LRPs, in their view the Commission took into account factors such as the risk of greater fluctuations in recruitment and smaller fish sizes and values as biomass declined, and these factors may not be as applicable to setting LRPs for billfish.**
- **Several CCMs supported the development of billfish LRPs based on MSY criteria with appropriate risk choices.**
- **For WCPO billfish species the identification of appropriate LRPs should be guided by developing management objectives for different species divided into the following groups: target species (swordfish); data-rich bycatch species (striped and blue marlin); medium information bycatch species with levels of catch (black marlin); and data-poor low-catch bycatch species (shortbilled spearfish and sailfish). Having agreed objectives would help clarify which approach to use and inform selection of the acceptable risk of breaching the LRP.**
- **Each billfish species should initially be assessed against the potential LRPs listed in Table MI-1. The SC should also work towards developing a minimum list of metrics that should appear in any future billfish assessment reports and a preferred metric for each WCPO billfish stock. For example, several CCMs suggested the addition of $F_{MSY}$ and $SB_{MSY}$-related values, as it is related to the spirit of the Convention in their view and is the reference point used by other RFMOs for billfish species. In the interim SC agreed to retain Table MI-1 as an interim list of candidate LRPs for billfish.**
- **The applicability of LRPs should be evaluated, whenever possible, at the stock level. Some CCMs noted that for some species, like the south Pacific swordfish, the adopted LRP for tropical tuna species ($20\%SB_{F=0}$) is significantly above $SB_{MSY}$.**
- **There was support for the proposed additions to the hierarchical approach, originally endorsed by WCPFC8 for key target species and SC10 for elasmobranchs, to cater for empirical and risk-based reference points of medium and low data stocks. The updated table is presented in Table MI-2.**
- **These decisions should be incorporated into the Billfish Research Plan that is scheduled to be developed in 2022 and focus that work on developing objectives, assessing LRPs for each species, and determining if a pathway to a higher level of information and knowledge should be developed. This Plan should also consider a request that the SSP compile a table based on existing assessments of billfish and sharks that shows $SB_{MSY}$, $SB_0$ and $SB_{F=0}$ levels and the percentage of $SB_{MSY}$ relative to the other two metrics, with associated uncertainty.**
- **The risk-based fishing mortality benchmarks should be defined as dependent variables in the two main assessment platforms used (Stock Synthesis and MFCL) so that statistical uncertainty of the estimates can be calculated.**

143. **SC17 agreed that Project 104 had developed a good framework for progressing the development and identification of appropriate LRP for WCPO billfish and recommends that the Commission take note of the above conclusions reached by SC17 and the need for further work as outlined above.**

**Table MI-1**. Proposed list of potential limit reference points for consideration for WCPFC billfish, categorized as Target and Bycatch and by assessment type. Gray shading is simply for easy separation of LRP groups.

| LRP | Group | Assessment type | Comments |
|---|---|---|---|
| x% $F/F_{MSY}$ | Target & Bycatch | Data rich | Choose the level of x based on an evaluation. |
| x% $SB/SB_{F=0}$ | Target & Bycatch | Data rich | Choose the level of x based on an evaluation. |
| x% $SB_0$ | Target & Bycatch | Data rich | Choose the level of x based on an evaluation. |
| SPR x% $SB_{F=0}$ | Bycatch | Medium data or data poor | Choose the level of x based on an evaluation. |
| x% $CPUE_0$ | Target & Bycatch | Data rich or medium data | Choose the start of a reliable CPUE series and the level of x. |
| $SB/SB_{F=0, t1-t2}$ | Target & Bycatch | Data rich | Choose a time period where the stock was considered in an undesirable state (and should be avoided in future) but recovered back to suitable levels. |
| $SB_{t1-t2}$ | Target & Bycatch | Data rich | Choose a time period where the stock was considered in an undesirable state (and should be avoided in future) but recovered back to suitable levels. |
| $CPUE_{t1-t2}$ | Target & Bycatch | Data rich or medium data | Choose a time period where the stock was considered in an undesirable state (and should be avoided in future) but recovered back to suitable levels. |
| $SB/SB_{F=0}$_ low | Target & Bycatch | Data rich | Choose a low year where the stock was considered in an undesirable state (and should be avoided in future) but recovered back to suitable levels. |
| SB_low | Target & Bycatch | Data rich | Choose a low year where the stock was considered in an undesirable state (and should be avoided in future) but recovered back to suitable levels. |
| CPUE_low | Target & Bycatch | Data rich or medium data | Choose a low year where the stock was considered in an undesirable state (and should be avoided in future) but recovered back to suitable levels. Note CPUEt1 − t2 is more precautionary. |
| $F/F_{lim}$ >1 | Bycatch | Data poor | Use as an interim LRP until a more reliable metric can be generated. |
| $F/F_{crash}$ >1 | Bycatch | Data poor | Use as an interim LRP until a more reliable metric can be generated. |

**Table MI-2**. The 5-level hierarchical approach for defining LRPs for bycatch species modified from that endorsed by WCPFC8.

| Level | Condition | LRP metrics |
|---|---|---|
| Level 1 | A reliable estimate of steepness is available. | $F_{MSY}$ and $B_{MSY}$ |
| Level 2 | Steepness is not known well, if at all, but the key biological (natural mortality, maturity) and fishery (selectivity) variables are reasonably well estimated. | $Fx\%_{SPR\_F=0}$ and either x% $SB_0$ or x% $SB_{current,F=0}$ |
| Level 3 | The key biological and fishery variables are not well estimated or understood. | x% $SB_0$ or x% $SB_{current,F=0}$ |
| Level 4 | Poor biological information, fishery data sparse or patchy with no ability to estimate parameters noted above, or other | $CPUE_{t1-t2}$ or CPUE_low |

| | | |
|---|---|---|
| | metrics considered important. But a reliable CPUE index is available. | |
| Level 5 | The key biological variables (age, reproduction, intrinsic rate of increase and carrying capacity) are reliably estimated. | $F/F_{crash}$ >1 or $F/F_{lim}$ >1 |

## AGENDA ITEM 5 — ECOSYSTEM AND BYCATCH MITIGATION THEME

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

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

145. The Ecosystem and Bycatch Mitigation (EB) theme was convened by Y. Swimmer (USA). K. Bigelow (USA) presented SC17-EB-WP-01 (*Review of potential mitigation measures to reduce fishing-related mortality on silky and oceanic whitetip sharks – Project 101*).

**Recommendations**

146. **SC17 recommends that the Project 101 be continued with the following modifications:**

- **Relevant CCMs should consider authorizing the release of their non-ROP longline data (facilitated through SPC) for this study, specifically to provide more complete gear configurations by flag, or collaborating to conduct such an analysis for their flagged vessels, and allow analyses similar to Caneco et al. (2014)[2] to estimate factors affecting shark catchability and condition on longline retrieval to be conducted using a more complete dataset;**
- **Conduct the Monte Carlo analyses with inputs on catchability, condition on longline retrieval and gear configurations by flag;**
- **Conduct updated projections with inputs on the impact of banning shark lines and wire leaders or both and estimates of the probability of post release mortalities of silky and oceanic whitetip sharks (as based on Hutchinson et al. 2021 or other new information);**

**Additionally, results of the analyses should be shared to CCMs that made contributions to those analyses for their review and comments in advance of SC18.**

147. **SC17 also noted the result contained in SC17-EB-WP-01 and recommends that the Commission to be alerted to them, including:**

- **Banning shark lines has the potential to reduce fishing mortality by 2.6% and 5.4% for silky shark and oceanic whitetip shark, respectively. These percentages are lower than predicted estimates from Harley et al. (2015) which may be explained by a decrease in use of shark lines in more recent observer data; and]**
- **Banning branchline wire leaders has the potential to reduce fishing mortality by 28.2% and 35.8% for silky shark and oceanic whitetip shark, respectively. These percentages are higher than estimates from Harley et al. (2015) and are due to a better representation of wire leader use in distant water fisheries.**

148. **Shark conservation and management measure (CMM 2019-04 paragraph 14) contains the option to either ban the carrying and use of wire leaders as branchlines or ban the use of branchlines**

[2] SC10-EB-WP-10: https://meetings.wcpfc.int/node/8758

**directly off the longline floats or drop lines, known as shark lines, is currently in effect in many CCMs.**

### 5.2 Best handling practices for the release of cetaceans

149. Emily Crigler introduced SC17-EB-WP-02 (*Draft Best Handling Practices for the Safe Handling and Release of Cetaceans*), which includes guidelines for purse seine gear and longline gear.

**Recommendations**

150. **SC17 recommends the *Draft Best Handling Practices for the Safe Handling and Release of Cetaceans* be forwarded to TCC17 and WCPFC18 for consideration.**

151. **SC17 further recommends that the Commission develop graphics to be included with the *Best Handling Practices for the Safe Handling and Release of Cetaceans* for consideration at WCPFC19.**

### 5.3 Other issues

#### 5.3.1 Review of the ODF outputs on seabird mitigation measures

152. E. Crigler (USA) introduced SC17-EB-IP-15 (*Seabird Mitigation Measures on Small-Scale Longline Vessels North of 23° North*) on mitigation measure for seabirds.

**Recommendations**

153. **SC17 recommends that Commission CCMs with small-scale longline vessels (< 24m) operating north of 23° North provide the SC with information, such as the results of scientific research or EM-based commercial vessel survey, as well as the specific mitigation measures used by those vessels and the associated seabird interaction rates for each mitigation measure, if available, including streamer-less tori lines, and that SC18 review such information, to make findings and recommendations with respect to the effectiveness of the streamer-less tori line designs to inform the Commission's review under CMM 2015-03 (and its successor measures).**

154. **SC17 encourages further experimental investigation of 'strategic' offal discharge and blue-dyed bait to determine the relative efficacy of these seabird bycatch mitigation methods.**

## AGENDA ITEM 6 — FUTURE WORK PROGRAM AND BUDGET

### 6.1 Development of the 2022 work programme and budget, and projection of 2023-2024 provisional work programme and indicative budget

#### a. Review of *Scoring of the Proposed Scientific Committee Projects* (SC17-GN-WP-01)

**Recommendation**

155. **SC17 agreed that Table WP-01 be used to score and then rank SC projects. SC agreed to implement this approach at SC17 and thereafter. Ranking is derived from the average of the scores allocated by CCMs.**

**Table WP-01**. SC project scoring table. Colours represent priority rankings (6,9 = High; 3,4 = Medium; 1,2 = Low):

| | | Importance to WCPFC Management Outcomes or to the functioning of the SC | | |
|---|---|---|---|---|
| | Rank | Low | Moderate | High |
| Feasibility: Likelihood of Success | Low | 1 | 2 | 3 |
| | Moderate | 2 | 4 | 6 |
| | High | 3 | 6 | 9 |

Notes:
**Importance criteria** evaluate the significance of the outcomes of the proposal in contributing to the successful management of the WCPFC stocks or the functioning of the SC (e.g. is the proposal aligned with the WCPFC research and/or management priorities; does the proposal contribute to the effective planning and functioning of the SC; are the intended outputs/benefits well-defined and relevant; what is the level of impact and likelihood that the proposal outputs will be adopted; is the proposal cost effective). High= Essential; Moderate=Important but not essential; Low=Not Important.

**Feasibility criteria** evaluate the proposal's potential for success i.e., how likely is the proposal to achieve its stated objectives (e.g., are the objectives clearly stated, is the methodology sound, are the project objectives realistic and likely to be achieved, does the research team [if identified] have the ability, capacity and track record to deliver the outputs).

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

156. SC17 noted the progress of 2021 project outputs detailed in SC17-GN-IP-06 (*Intersessional activities of the Scientific Committee*). SC17 also noted that there were no objections raised regarding the results of 2021 projects through the Online Discussion Forum, as detailed in SC17-ODF-01 (*Summary of Online Discussion Forum*).

**c. Review of *SPC assessment-related activities under the SSP standard SPC and additional resourcing budget* (SC17-GN-WP-02)**

157. SPC addressed SC17-GN-WP-02 (*SPC assessment-related activities under the Scientific Services Provider standard budget and additional resourcing budget*). SPC highlighted that SC could choose 3 items in Table WP-02 (with a maximum of two from Column 1) to be funded by the SSP standard budget and additional resourcing budget.

**Table WP-02.** Assessment-related activities under the SSP standard and additional resourcing budgets.

| Priority | Column 1 | Column 2 |
|---|---|---|
| 1 | SKJ assessment | Continue to develop the new ensemble approach – applicable approaches across species? |
| 2 | YFT peer review and additional analysis | Additional SWO projections (this would be expected by Dec. 2021) |
| 3 | SWP mako assessment | Revision of SP albacore TRP (this also expected by Dec. 2021) and Consequences for SP albacore of BET/YFT TRP levels (timeline to be defined) |

158. **SC17 agreed that the Commission's 2022 scientific services from SPC would comprise (i) the skipjack stock assessment; (ii) the YFT peer review and additional analyses; and (iii) continuing work to develop the new ensemble approach. Other additional priority work areas beyond the current agreed 2021 scientific services were identified for the remainder of 2021, including the requested**

**stock projections for Southwest Pacific swordfish, and requested analyses related to the South Pacific albacore TRP and implications of the work presented in SC17-MI-WP-01 for that stock.**

### d. Review of proposed projects for 2022 – 2024

159. **SC17 recommended the proposed work program and budget for 2022 and indicative budget for 2023 – 2024 in Table WP-03 to the Commission.**

**Table WP-03**. Recommended Future Work Program and Budget for 2022 – 2024, ordered by CCM's averaged score. (Essential projects are highlighted in gray; P17Xy represents a new project)

| Project Title | TOR | 2022 (SC18) | 2023 (SC19) | 2024 (SC20) | Responsibility | Avg. score | # CCMs |
|---|---|---|---|---|---|---|---|
| SPC-OFP scientific services[3] | | 961,874 | 981,112 | 1,000,734 | SPC | **8.8** | 18 |
| SPC Additional resourcing[2] | MFCL work | 173,206 | 176,670 | 180,204 | SPC | **8.2** | 18 |
| P35b. WCPFC Tissue Bank[2] | SC15-Att.G | 103,204 | 105,268 | 107,373 | SPC | **8.7** | 19 |
| P42. Pacific Tuna Tagging Program | SC15-Att.G | 730,000 | 730,000 | 730,000 | SPC | **8.9** | 19 |
| P65. Peer review | SC17-GN-IP-07 | 50,000 | | | SPC | **9.0** | 20 |
| P17X4. Further development of ensemble model approaches for presenting SA uncertainty | TOR - TBC | | 20,000 | | SPC | **7.9** | 20 |
| P17X1. Billfish Research Plan 2023 - 2027 | SC17-GN-IP-07 | 55,000 | | | SPC | **7.8** | 20 |
| P90. Length weight conversion | SC16-GN-IP-08 | 75,000 | | | SPC | **7.6** | 20 |
| P17X3. Preparing WCP tuna fisheries for application of CKMR methods to resolve key SA uncertainties. | SC17-GN-IP-07 | 40,000 | | | SPC; Contingent on EU support | **6.9** | 20 |
| P17X2. SWP mako shark SA | SC17-GN-IP-07 | 105,000 | | | SPC | **6.5** | 20 |
| P17X5. Scientific Advice for Southwest Pacific blue shark | SC17-GN-IP-07 | 40,000 | | | SPC | **6.2** | 20 |
| P108. WCPO silky shark assessment | SC17-GN-IP-07 | 50,000 | 50,000 | | SPC; Report to SC19 | **5.6** | 14 |
| P68. Seabird mortality | SC17-GN-IP-07 | 25,000 | 40,000 | 10,000 | SPC | **5.2** | 20 |
| P60. PS Species Composition (Carry over 2000 budget to 2022) | SC15-Att.G | | | | SPC | **N/A** | |
| **Total Project Budget** | | **1,446,410** | **1,121,938** | **1,027,577** | | | |
| **Total Project Budget + (SPC-OFP)** | | **2,408,284** | **2,103,050** | **2,028,311** | | | |

## AGENDA ITEM 7 — ADMINISTRATIVE MATTERS

### 7.1 Election of officers of the Scientific Committee

160. No nominations for a SC Chair and Vice-Chair for SC18 were made at SC17. The Executive Director advised that nominations for these positions would remain open until WCPFC18.

[3] Budget – 2% annual increase

### 7.2 Next meeting

161. **SC17 recommended to the Commission that SC18 would be held from 10–18 August 2022, and that it had not identified a host country for the meeting if held in person. Tonga offered to host SC19 in 2023.**

## AGENDA ITEM 8 — OTHER MATTERS

### 8.1 Review of Online Discussion Forum outputs

162. **SC17 noted the results of the Online Discussion Forum (SC17-ODF-01, *Summary of Online Discussion Forum*).**

### 8.2 Consideration of SC17-ST-IP-06 and SC17-ST-IP-10

163. Addressed under Agenda Item 2.3.

## AGENDA ITEM 9 — ADOPTION OF THE SUMMARY REPORT OF THE SEVENTEENTH REGULAR SESSION OF THE SCIENTIFIC COMMITTEE

164. **SC17 adopted the recommendations of the Seventeenth Regular Session of the Scientific Committee.**

165. **SC agreed that the SC17 Summary Report would be adopted intersessionally according to the following schedule:**

| Tentative Schedule | Actions to be taken |
|---|---|
| **19 August** | Close of SC17.<br>By 30 August, ***SC17 Outcomes Document*** will be distributed to all CCMs and observers (within 7 working days, Rules of Procedure). |
| **26 Aug – 6 Sep** | Secretariat will receive Draft Summary Report from the lead rapporteur and review the Draft Report |
| **6-14 September** | Secretariat will distribute the Report to all Theme Conveners for review. |
| **14-21 September** | Secretariat will clear the Report for posting and distribution |
| **21 Sep -30 Oct** | The Secretariat will post/distribute the draft Summary Report to all for CCMs and Observers for their review. Deadline for submission of comments by 30 October |
| **Early November** | Intersessional process for the adoption of the **SC17 Summary Report** |

## AGEDNA ITEM 10 — CLOSE OF MEETING

166. The Vice-Chair closed SC17 at 12:10 Pohnpei time on Thursday, 19 August 2021.

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

**Scientific Committee**
**Seventeenth Regular Session**

**Electronic Meeting**
11 – 19 August 2021

# SUMMARY REPORT

## AGENDA ITEM 1 — OPENING OF THE MEETING

1. The Seventeenth Regular Session of the Scientific Committee of the Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean (SC17) took place for eight days during 11–19 August 2021 as an electronic meeting in response to the global coronavirus disease 2019 (COVID-19) pandemic. The meeting was chaired by the Vice-Chair Dr Tuikolongahau Halafihi (Tonga) as SC Chair Mr Matai'a Ueta Faasili Jr. (Samoa) was unable to attend.

2. The following WCPFC Members, Cooperating Non-members and Participating Territories (CCMs) attended SC17: Australia, Canada, China, Cook Islands, European Union (EU), Federated States of Micronesia (FSM), Fiji, Indonesia, Japan, Kiribati, Republic of Korea, Republic of Marshall Islands (RMI), Nauru, New Zealand, Niue, Palau, Papua New Guinea (PNG), Philippines, Samoa, Solomon Islands, Chinese Taipei, Tonga, Tuvalu, United States of America (USA), Vanuatu, American Samoa, French Polynesia, New Caledonia, Tokelau, Thailand and Vietnam.

3. Observers from the following inter-governmental organizations attended SC17: Inter-American Tropical Tuna Commission (IATTC), Pacific Islands Forum Fisheries Agency (FFA), Parties to the Nauru Agreement (PNA), the Pacific Community (SPC), the Secretariat of the Pacific Regional Environment Programme (SPREP), and The World Bank.

4. Observers from the following non-governmental organizations attended SC17: Australian National Centre for Ocean Resources and Security (ANCORS), Birdlife International, International Pole and Line Foundation (IPNLF), International Seafood Sustainability Foundation (ISSF), Marine Stewardship Council, Sustainable Fisheries Partnership (SFP) Foundation, The Nature Conservancy (TNC), The Ocean Foundation, The Pew Charitable Trusts (Pew), World Tuna Purse Seine Organisation (WTPO) and the World Wide Fund for Nature (WWF).

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

### 1.1 Welcome address

6. Mr Poasi Fale Ngaluafe (Tonga) gave the opening prayer.

7. Ms. Jung-re Riley Kim, Chair of the WCPFC, welcomed delegates, observers, the SC Vice-Chair, the WCPFC Executive Director and his staff, and the staff of SPC to SC17. She stated it was a pleasure and honour to address SC17. She noted that the COVID-19 pandemic has dragged on longer than many expected

and expressed thanks to everyone involved in SC for their efforts to ensure the essential science-related work of the Commission continued. She observed how crucial the work of SC is to Commission decisions, and particularly in 2021 because of the need of approve a new tropical tuna measure. She noted the work SC17 would address included updates on TRPs as an outcome from the first Tropical Tuna Workshop (TTMW1) and issues related to the harvest strategy framework. Her full remarks are appended as **Attachment B.**

8. WCPFC Secretariat Executive Director, Feleti P Teo, OBE, welcomed delegates to SC17. He stated that the global COVID-19 pandemic continued to impact lives and health globally and left the Commission no choice but to hold a virtual SC meeting in 2021. He observed that experience over the previous year with virtual meetings meant the Secretariat was well prepared for SC17, but also well aware of the serious constraints of virtual compared to face-to-face meetings. He noted that the need to streamline the meeting agenda meant a number of routine issues were covered in the Online Discussion Forum (ODF); in addition, the meeting period was extended to 8 days to ensure all business could be completed. He noted the upcoming Tropical Tuna Measure Workshop 2 (TTMW2) in September, and voiced his expectation that some discussions at SC17 related to tropical tuna stocks would inform those later discussions. He acknowledged the enormous contribution of SPC's scientists in preparing for SC17 and TTMW2, and acknowledged the work of the SC officers and Theme Conveners who all serve voluntarily. He noted the need for nominations for SC Chair and Vice-Chair, for several Theme Co-Conveners. He also acknowledged the efforts of the Commission staff, under the leadership of the Science Manager, Dr SungKwon Soh, and the Commission's IT Team, led by Tim Jones. He stated the Commission stood ready to support SC's deliberations over next 8 days. His full remarks are appended as **Attachment C.**

9. The SC Vice-Chair Dr Tuikolongahau Halafihi welcomed the WCPFC Chair, Executive Director, and all delegates and observers. He stated that the Commission was fortunate in that it was possible to convene the virtual SC17 meeting, and stated his sincere appreciation for the efforts of the Commission in organising the meeting. He stated that the agenda was developed in collaboration with the SC officers and SPC, and stated his sincere appreciation for the work done. He also noted the Online Discussion Forum (ODF), which would remain open for several more days, and encouraged CCMs to continue to make use of it. He closed by welcoming the full cooperation of all participants in ensuring the success of the SC17 meeting. His full remarks are appended as **Attachment D.**

### 1.2 Meeting arrangements

10. The Vice-Chair outlined procedural matters. The IT Manager reviewed the virtual meeting protocols (WCPFC-SC17-2020-05). The Vice-Chair provided an overview of the meeting schedule (WCPFC-SC17-2021-06), administrative arrangements, and the list of Theme Conveners. The Conveners and their assigned theme were:

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

11. The Vice-Chair noted that nominations for a new SC Chair and Vice-Chair were needed, as well as new Co-Conveners for the Management Issues and Ecosystem and Bycatch Mitigation themes.

### 1.3 Adoption of the agenda

12. The Vice-Chair noted that the Provisional Agenda for the electronic SC17 meeting was finalized among the Secretariat, SC Chair, Vice-Chair, Theme Conveners and SPC, and initially posted on 04 June 2021. The Vice-Chair also noted that the US requested the ability to comment on two additional information papers within the Data and Statistics Theme, which were covered under Agenda 8 (Other Matters).

13. In response to a query from the Vice-Chair regarding whether CCMs wished to propose additional items for consideration under Agenda Item 8 (Other Matters), Birdlife International (speaking also on behalf of WWF, PEW, The Ocean Foundation, and SPREP) requested that the Secretariat and CCMs allocate time under Agenda Item 8 to propose and assess the impact of the ongoing loss of data resulting from the continued suspension of the Regional Observer Program (ROP) on the ability of the SC to provide robust advice; noting SC17-ST-IP-17 on electronic monitoring (EM) for improved accountability, they recommended that the Commission, with guidance from TCC, expedite alternative data collection measures to minimise the impact of this ongoing data loss. They noted with concern with the ongoing suspension of the ROP and its impact on the collection of a variety of critical data for fisheries management, including bycatch of endangered and threatened shark species and seabird bycatch mitigation compliance. They acknowledged that there are serious human health concerns related to the ongoing pandemic and the risk to crew, observers and port-based workers; despite a vaccine having been developed, there are delays in reaching many people, and restrictions to travel are likely to continue into the foreseeable future. With this in mind, they agree with the PNA's recent recommendations that fisheries workers, including observers, across the Pacific be prioritised for vaccination as essential workers; most importantly, they stated it is critical that the WCPFC and CCMs develop an immediate contingency plan for the collection of critical onboard data to manage the stocks and ecologically related species under WCPFC purview. Furthermore, the current situation emphasises the importance of data collected by observers and represents an important opportunity to progress the development of guidelines on EM, which are critical to improving data collection quality and coverage across the fishery. They stated that the COVID-19 pandemic has highlighted the importance of taking urgent action to implement EM broadly in the fleets operating in the WCPFC Convention Area.

14. The Vice-Chair stated that the Secretariat indicated it would liaise with Birdlife International on best way to facilitate their request, and had posted SC17-GN-IP-08 *COVID-19 related Intercessional Decisions* (also posted as WCPFC-TCC17-2021-14) on the impacts of the COVID-19 decisions related issues, which addresses the issues raised by Birdlife International.

15. The SC17 agenda was adopted **(Attachment E).**

### 1.4 Reporting arrangements

16. The Science Manager reviewed the reporting arrangements and noted that in accordance with the Rule 33 of the Commission's Rules of Procedure, the text of all decisions adopted by the SC17 would be distributed in the form of the Outcomes Document to all members, participating territories and observers within seven (7) working days following their adoption. The SC17 Summary Report, including an Executive Summary, would be adopted intersessionally. The Executive Summary includes a brief overview of the meeting, all theme recommendations adopted during the meeting, including a synopsis of stock status and management advice, and any other initiatives arising from SC17.

## AGEDNA ITEM 2 — DATA AND STATISTICS THEME

17. The Data and Statistics (ST) theme was convened by V. Post (USA). The Convener outlined the theme session structure and noted that there were 3 working papers and 11 information papers. She also noted that the USA requested time to consider two additional information papers, which were presented under Agenda Item 8.

### 2.1 Data gaps of the Commission

#### 2.1.1 Data gaps

18. P. Williams (SPC) presented SC17-ST-WP-01 (*Scientific data available to the Western and Central Pacific Fisheries Commission*). Two additional papers (SC17-ST-IP-02 *Status of Observer Data Management* and SC17-ST-WP-03 *Draft Guidelines for the Voluntary Submission of Purse Seine Processor Data by CCMs to the Commission*) were noted. SC17-ST-WP-01 reports on the major developments over the prior year with regards to filling gaps in the provision of scientific data to the Commission.

19. The review of gaps in 2019 and 2020 scientific data provisions includes the assignment of a tier-scoring evaluation level. There have not been any significant developments in some categories of the main data gaps over the past five years and readers have therefore been referred to the relevant sections in past data-gap papers. All CCMs with fleets active in the WCPFC Convention Area provided 2020 annual catch estimates by the deadline of the 30th April 2021. The issues previously reported in annual catch estimates have been further reduced and the lack of any estimates for key shark species remains the main gap for some CCMs, particularly in years before 2017. Aggregate catch/effort data for 2020 were provided by the deadline of 30th April 2021 for all fleets. The quality of aggregate data provided continues to improve with a reduction in the number of data-gap notes assigned to the aggregate data in recent years. The other main data gap concerns the low coverage of operational data available to generate aggregate data for the Indonesian and Vietnam fleets, and the anticipated under-reporting of key shark species in general. Most CCMs with active fleets provided operational catch/effort data for 2020, with the main gaps being

(i) the low coverage in the data provided for the Indonesian and Vietnam fleets;
(ii) the non-provision of certain required fields in the Indonesian operational data, and
(iii) catches of key shark species are not included in the Indonesian fleet data.

20. However, there was some progress in the operational catch/effort data gaps reported for Indonesia and Vietnam in the past year, in resolving the non-provision of some of the required data fields. The coverage of 2020 operational data for some fleets is not complete (100%), although there was some improvement in coverage compared to the 2019 data.

21. Several proposals for SC17 consideration were provided in the paper and the presentation.

(i) SC17 consider the outcomes of an initial study into the impacts of the COVID-19 affected reduced observer coverage in the purse seine fishery on the precision of tuna catch estimates (Peatman et al., 2021). The outcomes suggest that, *inter alia*, reduced observer coverage significantly effects the precision of the purse seine bigeye tuna catch estimates in the aggregate data used for the assessments, so a return to 100% purse seine observer coverage is strongly recommended as soon as it is safe and logistically feasible.
(ii) SC17 review the draft *Guidelines for the Voluntary Submission of Purse Seine Processor Data by* CCMs *to the Commission* (Annex in SC17-ST-WP-03) and consider endorsement for forwarding to TCC17 and WCPFC18.
(iii) SC17 note the benefits of an additional table structure for operational longline catch and effort data fields in the "*Scientific Data to be Provided to the Commission*" and recommend

further work to include the purse seine and pole-and-line operational catch effort data fields, for review by SC18 and TCC18.

(iv) SC17 review the proposal to establish a WCPFC Public Domain size data set for publication on the WCPFC website and advise on a way forward, including a potential recommendation for TCC17 and WCPFC18.

(v) SC17 review the latest version of the ACE Tables and provide comments and advice on the latest updates and any changes, as required.

**Discussion**

22. Palau, on behalf of PNA members, thanked SPC for its paper and supported the proposals it contains, noting the following:

- PNA members support the call for a return to 100% purse seine observer coverage as soon as it is safe and logistically feasible, both to ensure the flow of data that is needed, and to restore the livelihoods of observers. The PNA are already planning to resume full observer coverage, and encourage other CCMs to explore all opportunities for maintaining some level of observer coverage until the ROP requirements are reapplied.
- PNA members also support the enhanced scientific data submission guidelines and establishment of a WCPFC Public Domain size-data set for publication on the WCPFC web site. PNA members think the revised guidelines are clearer and will make it easier to revise the data requirements as the needs change.
- PNA members welcome the preparation of the expanded ACE tables online and support the adoption of the ACE Tables as an alternative to reporting this data in Part 1 Reports.

23. The USA stated that for scientific reasons, it supports a return to observer coverage generally (purse seine and longline) as soon as it is safe and logistically feasible, noting that SC17-ST-IP-04 shows greater resolution for purse seine estimates with increasing observer coverage. The USA also supported

- endorsement by SC17 of the *Draft Guidelines for the Voluntary Submission of Purse Seine Processor Data by CCMs to the Commission*;
- the proposal to enhance scientific data submission guidelines by clearly indicating which requirements are binding and non-binding; and
- either option for release of Public Domain size data, but with a slight preference for the second option (where all data are available unless otherwise advised by individual CCMs), as long as there are appropriate caveats stated.

24. Australia made several observations with related questions:

(i) Australia noted that the *Standards for the Provision of Operational Level Catch and Effort Data* (Annex 1 in the *Scientific Data to be provided to the Commission*) list the data that needs to be provided to the Commission. Apart from some other data fields, the fields related to gear settings are: Date of start of set, Time of start of set, Position of start of set, Number of hooks per set, and Number of branch lines between floats. Australia stated that from the tables in Annex 2 in the SC17-ST-WP-01, it appears that provision of these data fields is binding, but that evaluations regarding provision of operational catch and effort data in Tables 5 and 6 in the SC17-ST-WP-01 is based on whether the field is included in a data submission, rather than on an evaluation of data quality or completeness. Australia inquired whether a coverage figure of 100% in the last column of Tables 5 and 6 indicates that complete sets of data for all gear-related fields were provided for all (100% of) sets and if not, what the 100% relates to. Australia stated that it would be good to get a better understanding of the percentage of longline sets for which the gear data is provided – by year and fleet – and noted its understanding that the "Time of start of set" has been included

as a minimum data requirement since around 2005 but continues to be a field for which there is insufficient data to include in the CPUE standardisation analyses. It suggested that if this data is missing then perhaps gaps can be identified and attempts made to recover this data. SPC replied that at present the data provision requirement is satisfied if data is provided, and no assessment of data quality is made. SPC stated that it would be possible to add an annex that provides more information regarding the coverage of the fields at the data field level, and by year and fleet, and indicated that SPC would seek to include such an annex for SC18.

(ii) Australia observed that in Table 6 in the SC17-ST-WP-01 (*Provision of 2020 Operational catch and Effort data*) the last column lists the coverage score for each country. Of the around 50 fleets listed, 18 have a coverage level less than 100%. However, in Table 8 (*Overall compliance evaluation for the provision of 2020 scientific data*), only two countries have a coverage for operational catch and effort data of less than 100%, and asked for an explanation of the discrepancy. SPC stated that in Table 6 the column for coverage is non-binding and is there for information purposes; it is not taken into account in the calculation for Table 8, which is purely related to the TCC requirement. SPC further clarified that the coverage data in the last column of Table 6 relates to the coverage of the data provided, not the fields. Thus, a figure of 80% indicates that data have been provided on 80% of the trips.

(iii) Australia stated that over time SC was continuing to request better information on gear settings from the stock assessment analysts to inform the standardisation of CPUE indices in the stock assessments, and suggested there is a strong need to re-assess the minimum data requirements for operational data.

25. PNG stated that processing data is linked to business operations of the canneries and plants that operate in PNG, and that it was therefore concerned about the recommendations in the paper. PNG noted that connecting the receipts from canneries and the actual landing at the facility is not covered by the data rules. Because of the sensitivity of the data PNG stated its preference that a time lag be included of at least 3-5 years before release of size data into the Public Domain. The Theme Convener noted that release of cannery data is voluntary, and acknowledged a preference to include a lag time for when size data could be published in the Public Domain.

26. Chinese Taipei noted that there were discrepancies between the data in SC17-ST-IP-01 and that listed on WCPFC website. SPC noted the website was in the process of being updated, and that this should be complete during SC17.

27. PNG, on behalf of FFA members, noted the highlights of key gaps in the Commission's data holdings, particularly the impacts of COVID-19 on observer coverage and the data that they collect. FFA members supported the proposal put forward by SPC to enhance the scientific data submission guidelines. FFA members also acknowledged the improvements that have been made by Indonesia, Philippines and Vietnam, working together with SPC in recent years on the submissions of operational data. They noted the remaining missing aggregate/effort data as mentioned in the report and encouraged the responsible countries to address these gaps.

28. The EU supported the actions suggested by SPC and detailed in the recommendations. Regarding size data, the EU stated it would prefer the 2nd option (where all data are available unless otherwise advised by individual CCMs).

29. Nauru, on behalf of FFA members, thanked SPC for their work and acknowledged CCMs for contributing to the guidelines for voluntary submission of purse seine processor data. FFA members stated

their support for the guidelines. FFA members encouraged CCMs to make voluntary submissions of purse seine processor data.

30. Kiribati stated that they agree with proposal 1 in working paper SC17-ST-WP-01, and also want observers to return to sea as soon as possible to avoid losing trained expertise. It also stressed the need to avoid introducing COVID-19 – particularly the more infectious delta variant – to uninfected Pacific islands, and to prioritise inoculation of seafarers. Another problem is repatriation of observers after trips, and rather than require vessels themselves to return observers to their home ports, Kiribati stated it wanted observers to be designated as key workers so their transit travel can be expedited; it is pursuing these initiatives through various channels, and noted this was a major item of discussion at the FFC Ministerial meeting in the week preceding SC17.

31. PNG supported the comments from the USA and EU, provided that the timeframe be guided by the parties involved.

32. Indonesia stated that its provision of operational data was improving but complicated by COVID-19, which postponed several key activities (e.g., a shark data workshop); efforts were under way to proceed with these, possibly online. Regarding release of size data as Public Domain, Indonesia stated it wanted discuss the timeframe and mechanism to have notification and permission from the relevant countries. Indonesia also noted that provision of operational data would also be subject to impacts from COVID-19, which was reducing the available funding for data collection monitoring and research.

**Recommendations**

33. **SC17 encouraged CCMs to resume observer coverage in their fisheries as soon as safe and logistically feasible to restore an important flow of scientific information to the Commission.**

34. **SC17 recommended the Scientific Services Provider (SSP) enhance the scientific data submission guidelines by preparing operational data field tables for longline, purse seine and pole and line operational data for SC18 review.**

35. **SC17 recommended publishing aggregated size data (data fields as listed in SC17-ST-WP-01, section 4.1) via the WCPFC Public Domain webpage, after CCMs have advised the SSP on which of their size data submissions should be excluded. In this regard, CCMs are requested to advise the SSP of the size data to be excluded before 31 December 2021, after which time the SSP will proceed to publish the WCPFC Public Domain size data based on this advice.**

36. **SC17 recommended that the SSP add a new annex to the data gaps paper to include a breakdown of the coverage levels for each operational data field by year and fleet.**

### 2.1.2 Potential use of cannery data

37. ISSF commented on the voluntary submission of cannery data, as outlined in observing that reduced catch data as a result of reduced observer coverage will impact scientific analyses, particularly for bigeye. ISSF suggested that if all canneries that process bigeye and other tuna species submit data the uncertainty would be much lower. ISSF noted that this was voluntary, and encouraged SC to endorse this.

**Recommendation**

38. **SC17 recommended the endorsement of the *Draft Guidelines for the Voluntary Submission of Purse Seine Processor Data by CCMs* to the Commission, and that the draft guidelines be forwarded**

**to TCC17 and WCPFC18 for consideration. SC17 also recommended that TCC17 and WCPFC18 consider how to handle cannery data under the current WCPFC data rules, including updating the WCPFC data rules to include processor data as non-Public Domain (high risk classification) data.**

### 2.2 Other commercial fisheries for bigeye, yellowfin and skipjack tuna

39. P. Williams (SPC) presented SC17-ST-WP-02 (*An assessment of available information to address the WCPFC17 recommendation on the Tropical Tuna CMM para 51 (other commercial fisheries)*). The paper provides an assessment of available information in response to the following WCPFC17 recommendation on paragraph 51 of the tropical tuna conservation and management measure (CMM 2018-01 and CMM 2020-01):

> *198. CMM 2018-01, TCC16 had recognized the difficulty of the application of this paragraph in terms of the scope of "other commercial fisheries" in Indonesia and the Philippines.*
> *199. The Commission noted that Indonesia and the Philippines had submitted delegation papers to SC16, TCC16 and WCPFC17 (WCPFC17-2020-DP04 and WCPFC17-2020-DP05) in response to the request from TCC15 to inform a Commission discussion on the application of paragraph 51 of CMM 2018-01. However, the virtual format of these meetings made it difficult to consider these papers at SC16 and TCC16.*
> *200. The Commission agreed to task SC17 and TCC17 to review these papers and provide advice to the Commission to facilitate a decision by WCPFC18 on the application of paragraph 51 of CMM 2018-01.*

40. The paper used information provided in the following papers SC17 information papers, and data submitted to the WCPFC Scientific Services Provider (SSP) by Indonesia and Philippines:

- SC17-ST IP-08 *Estimates of annual catches of tropical tuna by the Philippines relevant to WCPFC CMM on Tropical Tunas [other commercial fisheries]*
- SC17-ST-IP-09 *Availability of Catch Estimates from the Other Commercial Fisheries in Indonesia*
- Indonesia tuna landings and port sampling fishery data.
- Philippines National Stock Assessment Project (NSAP) landings and port sampling data.

41. Based on the assessment, five recommendations were proposed. The paper also reiterated the importance of the ongoing (and enhanced) data collection in the comprehensive and complex small-scale, artisanal fisheries of Indonesia and the Philippines for the scientific work of the Commission.

**Discussion**

42. Tonga, on behalf of FFA members, noted the six recommendations provided by SPC regarding the response to the WCPFC17 recommendation on "other commercial fisheries". FFA members supported the recommendations and thanked Indonesia and the Philippines for their papers on the application of paragraph 51 of the tropical tuna measure. They welcomed the effort that these CCMs put into the papers in an effort to provide clarity on this important issue.

43. The Philippines thanked SPC for its assistance in gathering the needed data, and stated it was committed to supplying the data for the purposes of scientific analysis.

44. Indonesia also thanked SPC for its assistance, and noted the importance gathering information on these fisheries, including for Indonesia's harvest strategy for tropical tuna, and to ensure the sustainability of its fishery in the future.

**Recommendations**

45. **SC17 reviewed information provided by Indonesia and the Philippines to inform a Commission discussion on the application of paragraph 51 of CMM 2020-01.**

- **a) SC17 noted that paragraph 3 of CMM 2020-01 limits the measure to the high seas and EEZs, and based on the information presented recommended that paragraph 51 would not apply to the following fisheries which are restricted to territorial seas and archipelagic waters:**
  - **i) Small-scale hook-and-line fisheries**
  - **ii) Small-scale troll fisheries**
  - **iii) Small-scale gillnet fisheries**
  - **iv) Small-scale pole and line (funai – Indonesia)**
  - **v) Pajeko (Indonesia mini-purse seine)**
  - **vi) Bagnet, beach seine, artisanal longline and other artisanal gears with very minor tuna catch**
- **b) SC17 recommended that paragraph 51 of CMM 2020-01 applies to the following fisheries:**
  - **i) Indonesia pole and line fishery fishing outside archipelagic waters and territorial seas for vessels >30 GT, and**
  - **ii) The "large-fish" handline fishery in Indonesia and the Philippines fishing outside archipelagic waters and territorial seas for vessels >30 GT.**
- **c) SC17 recognized that sufficient data exist to determine a baseline and annual catches for the Indonesia pole-and-line fishery and the Philippines large-fish handline fishery**
- **d) SC17 recognized that insufficient data exist to derive a baseline for the Indonesia large-fish handline, and suggests that WCPFC consider developing a baseline using years where data are available.**
- **e) Although CMM 2020-01 is not applicable to archipelagic waters, SC17 encouraged Indonesia and the Philippines to provide data from fisheries that operate in those areas for scientific purposes.**

**2.3 Consideration of SC17-ST-IP-06 and SC17-ST-IP-10**

46. The ST Theme Convener opened comments on SC17-ST-IP-06 (*Updated Purse Seine Bycatch Estimates in the WCPO*).

47. The USA noted that the findings in the paper indicate bycatch of sharks and marine mammals has been underreported in previous years. Given this the USA stated it is pleased with the Commission's recent adoption of safe handling guidelines for sharks, and encouraged the adoption of new guidelines for the safe handling of cetaceans. The USA also supported making estimates of the purse seine bycatch publicly available in electronic form for use by CCMs and other organizations, as noted in the paper. The USA proposed recommendations for SC's consideration.

48. FSM, on behalf of PNA members, thanked the authors for their updated paper, stating that the paper provides valuable bycatch estimates. PNA noted from the paper that these estimates should be interpreted as the catch that would have been observed if observer data were available for all fishing events, and noted the comments regarding the underestimates of shark observations. PNA members inquired whether it is correct to interpret these as underestimates for most small to medium-sized species, but that the data are probably a truer reflection of a minimum estimate of the actual catch for large species such as cetaceans, whale sharks and manta rays. PNA members stated the results are of value and have utility in identifying species of potential concern that may warrant more detailed investigation. The PNA members also supported making the data presented as tables in this report publicly available in electronic format as spreadsheets and/or R data objects, to facilitate use of these data. These data extracts could be housed on

the WCPFC website alongside the tuna yearbook data. Along similar lines PNA members stated that that the data extract presented in SC14-ST-WP-03 should also be made available for the longline bycatch estimates. In addition, the PNA members stated that would like to see future work aimed at explicitly modelling the spatial distribution of these species, and continued to support the SC14 recommendation that SPC provide updates of purse seine and longline bycatch estimates every 2-3 years. SPC stated it could support the requests from the PNA, while noting that CCMs shouldn't necessarily assume that the underreporting from shark species applies to all similar sized animals. That result largely stems from a secondary study on that examines overall underestimation. The confidence intervals are included to give the range of plausibility with regard to uncertainty. For WCPFC this is driven in large part by the observer coverage.

49. In response to a query from Japan it was clarified that the Excel-format files referred to were simply the data from Tables 6-9 in SC17-ST-IP-06, and as such the data were already in the Public Domain.

50. The Theme Convener noted SC17-EB-IP-18 (*Assessing and addressing cetacean bycatch in tuna fisheries –A collaborative project proposed to Common Oceans ABNJ Tuna Phase II*) authored by the International Whaling Commission (IWC) Secretariat that sets forth a project that could fund analyses similar to that conducted for SC17-ST-IP-10 with respect to cetacean interactions in tuna fisheries.

51. Japan stated that it did not agree to engaging in collaborative work with the IWC.

52. The ST Theme Convener opened comments on SC17-ST-IP-10 (*An update on available data on cetacean interactions in the WCPFC longline and purse seine fisheries*).

53. The USA supported the idea proposed in SC17-ST-IP-10 to estimate marine mammal bycatch with finer taxonomic resolution, at the species level.

54. SPREP welcomed SC17-ST-IP-10 and supported the USA's proposal to continue to have analyses provided on purse seine bycatch to species level where possible. SPREP also recommended an analysis that may be useful in understanding the extent of the problem and ways to mitigate. SPREP stated that SPC have helpfully provided a column in tables on cetacean interactions for purse seine and longline where comments have been provided by observers. These were used by SPC to investigate whether cetaceans were interacting with the gear or not and enabled some changes to be made as a result. Given the extent of comments available for interactions there may be some further insights into the interactions that can be gauged from the observer comments to assist with further understanding the problem.

55. Tuvalu, on behalf of PNA members and Tokelau, noted that numerous interactions between longline gear and cetaceans have occurred, but that, given the high number of longline vessels operating in the WCPO, the interaction rates are relatively low. They stated that the detailed tables and figures presented in SC17-ST-IP-10 provide enough information for the Commission to decide how CMM 2011-03 could be updated. At TCC16, PNA supported the moves to include the longline fishery into an updated CMM 2011-03, and this paper provides the data supporting that decision. While the PNA believe that there is enough data to support discussions on an updated CMM, they stated that additional analyses could provide a better understanding of the trends in the interactions. In particular, the PNA and Tokelau think that a deeper review of interaction trends over time would be valuable and suggested that additional plots of interaction types, fate and condition and mortality through time be included in future reports. SPC stated that provision of trends in the interactions over time was dependent on observer coverage; this is more feasible for purse seine since 2010, but that is a short time series. SPC divided the table data by time blocks to illustrate the trends.

56. USA stated in reference to SC17-ST-IP-10 that it is important to understand trends, and it would welcome efforts by SPC to do that. It stated that at SC16 the USA requested that the paper be updated to include normalized data, and asked if that was possible for future versions. SPC stated that was probably easier with the purse seine fishery, but posed challenges with the longline fishery. SPC noted some overlap with the work underlying SC17-ST-IP-06, to estimate the purse seine bycatch; SC17-ST-IP-06 is done every few years, while SC17-ST-IP-10 is prepared annually. SPC stated that it might be feasible to enhance SC17-ST-IP-10, and include an examination of observer coverage rates. SPC also addressed the issue of sample size; species have been grouped to increase the sample size, and it would be best to disaggregate the data and see what level of information loss results when looking at species trends; SC could then assess whether it prefers trends by species or an aggregated approach. SPC suggested another analysis looking at the comments made by observers could be useful; SPREP offered to work with SPC on this.

**Recommendations**

57. **SC17 recommended that Tables 6-9 on estimates of all purse seine bycatch (as presented in SC17-ST-IP-06) should be made publicly available in electronic format (EXCEL file on the WCPFC Public Domain Bycatch Data webpage) to facilitate extraction and use of data.**

58. **SC17 recommended that future analyses providing estimates of purse seine bycatch include estimates of marine mammal bycatch to the species level, where possible, to allow for additional monitoring of bycatch and bycatch rates of marine mammal species.**

## AGENDA ITEM 3 — STOCK ASSESSMENT THEME

59. K. Bigelow (USA) and H. Minami (Japan), Stock Assessment (SA) Theme Co-Conveners, reviewed the proposed report format for the stock assessment theme, and outlined there were 6 working papers that would be addressed in presentations, as well as 21 information papers that would serve as background for the discussions, and indicated what input was sought from CCM delegations regarding the stock assessments.

### 3.1 WCPO Tunas

#### 3.1.1 South Pacific albacore tuna (*Thunnus alalunga*)

##### 3.1.1.1 Review of 2021 South Pacific albacore tuna stock assessment

60. Claudio Castillo Jordan (SPC-OFP) presented SC17-SA-WP-02 (*Stock assessment of South Pacific albacore*), which described the 2021 stock assessment of South Pacific albacore. An additional three years of data were available since the previous assessment in 2018 that included data to 2016. The new assessment extends through to the end of 2019. New developments to the stock assessment include the expansion of the model region to include the entire South Pacific from the equator to 50ºS, incorporating the convention areas (CA) of the WCPFC and the IATTC. The previous assessment was restricted to the WCPFC-CA. The expanded geographical area of the assessment also included modification to the previous regional structure for the WCPFC-CA and inclusion of the fisheries in the IATTC-CA. A new growth model was included applying the recently developed approach to fractional ageing developed for the previous WCPFC yellowfin and bigeye tuna assessments and detailed in the supporting paper by Farley et al. 2021 (SC17-SA-IP-10). The assessment presents the estimated stock status results for entire South Pacific and the WCPFC-CA and IATTC-CA.

61. Changes made in the progression from the 2018 to 2021 diagnostic case models were as follows:

- Update of 2018 diagnostic case model with the newest MULTIFAN-CL (MFCL) executable (2.0.8.0);
- Apply new growth parameters (as external fixed values) from the age-length re-analyses by Farley et al. 2021 (SC17-SA-IP-10);
- Apply revised CPUE indices as described in Vidal et al. 2021 (SC17-SA-IP-03);
- Exclude the tagging data from 2018 diagnostic case model;
- Include the New Zealand troll fishery data by month, and apply the new region and fleet structure for the WCPFC-CA with data up until 2016;
- Update all data until 2019 for the WCPFC-CA region model; and
- Add the new regions/fisheries (EPO – Region 4) and include data up until 2019, this step resulted in the diagnostic case model for 2021.

62. The assessment provides management advice on stock status from a structural uncertainty grid of 72 models (Table SPA-01). The uncertainty grid included axis for movement hypotheses (x2), size composition data weighting (x3), steepness (x3), combined growth/natural mortality (x2), and recruitment distribution (x2).

63. The initial uncertainty grid was modified by the SC17 by downweighting one of the movement hypotheses (the SEAPODYM M2 hypothesis) by 50%. The results for the structural uncertainty grid presented in this summary are based on the revised weighted grid. The original results are available in the stock assessment paper by Castillo Jordan et al. 2021 (SC17-SA-WP-02_rev2).

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

(i) *Spawning Potential*: Spawning potential for the South Pacific albacore stock declined from 1960 until the early 1980s after which it stabilised for a period, before declining more gradually as catches increased from the 1990s until 2010. A notable decline in spawning potential is estimated to have occurred since 2015.

(ii) *Depletion ($SB/SB_{F=0}$)*: The terminal depletion levels estimated by this assessment for the South Pacific stock as a whole are the most pessimistic across the model time period with $SB_{recent}/SB_{F=0}$ median of 0.52 (0.41 - 0.57, 10th and 90th percentiles) and $SB_{latest}/SB_{F=0}$ median of 0.40 (0.27 - 0.45, 10th and 90th percentiles). None of the 72 models breached the WCPFC limit reference point (LRP) of 20% $SB_{F=0}$. There is no defined target reference point applied for the South Pacific albacore stock at the scale of the entire South Pacific.

(iii) *Fishing Mortality*: A steady increase in the South Pacific-wide fishing mortality on adult age-classes is estimated to have occurred over most of the assessment period, accelerating since the 1990s, with a rapid increase in the last five years. Juvenile fishing mortality increased until around 1990 and has remained stable at a comparatively low level since that time. Recent fishing mortality is estimated to be below $F_{MSY}$ ($F_{recent}/F_{MSY}$ median 0.24; 0.15 - 0.37, 10th and 90th percentiles) and none of the 72 models had $F_{recent}$ exceeding $F_{MSY}$.

(iv) *WCPFC-CA*: For the WCPFC-CA (Regions 1-3), estimated spawning biomass had become more depleted since the end of the previous assessment (i.e., data to 2016). Median estimates of depletion are below the interim TRP of $0.56SB_{F=0}$ ($SB_{recent}/SB_{F=0}$ median = 0.52; 0.42 - 0.58, 10th and 90th percentiles, and $SB_{latest}/SB_{F=0}$ median = 0.39; 0.28 - 0.43, 10th and 90th percentiles), but no models estimated the stock to be below the LRP of $20\%SB_{F=0}$. In relation to management objectives for the WCPFC-CA southern longline fishery, this assessment estimated that the median 'latest' (2019) and 'recent' (2016-2019) longline vulnerable biomass for the WCPFC-CA are at 56% and 76%, respectively, of the 2013+8% target level that defined the interim TRP.

(v) IATTC-CA: For the IATTC-CA (Region 4), estimated spawning biomass had become more *depleted* since the end of the previous assessment. Depletion was estimated to be the

lowest for the model time series, $SB_{recent}/SB_{F=0}$ median = 0.52; 0.32 - 0.55, 10th and 90th percentiles, and $SB_{latest}/SB_{F=0}$ median = 0.42; 0.25 - 0.46, 10th and 90th percentiles, with no models estimating that the stock was below 20% $SB_{F=0}$.

(vi) The model estimates of stock status were most sensitive to the assumptions on movement *probabilities* among the four model regions. Two movement scenarios were modelled; one where movement was estimated internal to the model and the alternative where movement probabilities were fixed according to predictions from a SEAPODYM model of albacore spatial population dynamics in the South Pacific.[4] The latter scenario estimated lower rates of movement between the WCPFC-CA and the IATTC-CA, lower spawning potential and a more depleted stock status.

(vii) A low period of recruitment was estimated to have occurred from 2015-2017, and appeared responsible for a recent decline in spawning potential and the most depleted (median) stock status *estimated* across the assessment time series. The main data informing the estimates of poor recruitment were the size composition data from the longline and troll fisheries in Region 3. Concern was expressed by some members of the SC as to the reliability of the information obtained by fitting to thesesize composition data, and therefore the reliability of the recent recruitment estimates and associated stock decline.

(viii) A number of key research needs were identified in undertaking the assessment that should be investigated either internally or through directed research.

(ix) As with previous South Pacific albacore assessment the fishery dependent CPUE based indices of *abundance* lacked contrast to inform population responses to increased fishing pressure. This continues to be a significant concern for the reliability of estimates of population size. The CPUE analysis has been a major focus of preparatory work for this and previous assessments, and despite the attempts of various scientists, application of new approaches including attempts at splitting time series and testing various covariates, the CPUE continues to lack contrast. It is recommended that alternative fishery independent estimates of population size be explored, especially the genetic method of close-kin mark-recapture (CKMR).

(x) The implications of uncertainty in movement were evident in this year's assessment, with this being the most influential uncertainty for management advice. In the absence of strong *empirical* data to inform decisions on alternative movement hypotheses, the SC decided to downweight one of the two movement hypothesis for provision of management advice. This is an unsatisfactory situation and there is a clear need to improve understanding of connectivity among albacore populations across the South Pacific, and, in particular, the fishery regions in the WCPFC and IATTC convention areas. This is particularly critical if South Pacific-wide assessments are to continue. With careful design, CKMR is capable of establishing measures of connectivity and thereby could address this uncertainty..

(xi) Despite applying the new growth data to this assessment, the modal structure in the New Zealand *troll* fishery size composition was still not fit adequately. Further work on growth modelling is required. It should also be noted that the otolith-based age data being used to determine growth curves is mostly derived from otolith samples collected in 2009 – 2010. Updated growth information for albacore, including samples from the IATTC-CA, is needed. Samples required to address this issue could be collected as part of a CKMR project that would also include a component to develop epigenetic (tissue based) ageing methods and sex determination. This would be a major advance for including more contemporary growth information in tuna assessments.

[4] Senina, I. N., Lehodey, P., Hampton, J., and Sibert, J. (2020). Quantitative modelling of the spatial dynamics of South Pacific and Atlantic albacore tuna populations. *Deep Sea Research Part II: Topical Studies in Oceanography*, 175:104667

(xii) Follow-up studies to assess the reliability of size composition data for providing information on recruitment and population trends, and if necessary, develop better stratification methods to improve the representativeness of size composition data should be considered.

(xiii) Finally, the current model is highly parameterized, and reducing model parameters and *complexity* should be considered to improve model fits and diagnostics. A key advancement would the application of the "catch conditioned" approach that will be available in MFCL for the next assessment.

**Discussion**

**a. Discussion on technical aspects of the assessment**

65. Samoa, on behalf of FFA members, stated that the stock assessment report was a major undertaking covering the entire South Pacific Ocean, which is important for understanding the status of the entire South Pacific albacore stock. They noted that South Pacific albacore is not yet overfished nor is overfishing occurring according to $F_{MSY}$ reference points, but that it is concerning that the spawning potential of the stock continues to decline, and welcomed further work undertaken by SPC to explore the causes for this apparent trend. They stated that another very concerning factor is the recruitment variability and its potential impacts on future biomass, particularly the recent period of very low recruitment during 2015–2016 as shown by Figure 33 in SC17-SA-WP-02. FFA members also noted that catches from north of the $20^0$ S high seas pockets and the high seas continue to increase with high peaks in recent times. They also noted that in 2020, changes in market conditions triggered a shift in effort out of the tropical fishery, and into the southern longline fishery. FFA members stated that current management arrangements are incapable of preventing these concerning trends, and that this needs to be addressed and/or stopped.

66. Australia remarked on the importance of standardised CPUE indices as an input to all assessments and made several observations and inquiries:

(i) The *clustering* algorithm used in the CPUE analysis was applied to the full data set simultaneously, as opposed to the index regions separately as done in the previous assessment. Australia inquired whether doing this assumes that the density distribution of all four species is relatively homogeneous across the entire assessment region so that the change in catch composition reflects a change in targeting. Australia noted that the density distributions of all four species are not homogeneous with, for example, the density of yellowfin and bigeye being appreciably higher in the equatorial regions and the density of albacore being higher in the mid-latitudes. As such, a change in catch composition may be more responsive to the relative changes in the density of fish than to a change in targeting alone, and requested that SPC comment on this issue. SPC stated that these are good questions related to Australia's earlier remarks regarding minimum data standards. In the past the clustering algorithm had used species composition alone, but there were concerns that it was capturing density more than targeting practices, so in 2021 the algorithm also incorporated hooks between floats, hoping to get more at targeting behaviour as opposed to the resulting catch. These are important uncertainties, and SPC stated that the data to generate better results are not currently available.

(ii) The related information paper (SC17-SA-IP-03) states that "the updated regional indices from the 2018 model structure demonstrated notable departures from the original 2018 trends. These differences are likely due to the impact of updates to historical data" – can you please explain what these updates were. SPC stated they had tried to replicate the pattern Australia observed in the 2018 indices. There were some initial increases in some regions (Region 1 and 2) and then a subsequent decline. SPC has not been able to fully

identify the data elements creating the 2018 pattern; SPC used the updated data set, as it appears the best suited for the analysis, but remains unsure why the differences exist.

(iii) In Figure 12 showing the stepwise changes from the previous assessment, the result labelled "New CPUE" displays a marked changed in the spawning potential trend. The Std-CPUE indices for each region shown in Figure 7 display a steady decline in the first 20 years after which time they are reasonably flat. However, the spawning potential shown in Figure 12 for this model run indicates a very different trend – relatively flat for the first 20 years, then declining, and reaching a peak after 2000 that is higher than in the initial years, which seems rather strange. Australia also noted the trends in residuals noted in Figure 16, especially in the early years.

(iv) Before 1990, total catch was generally less than 30,000 tonnes, but since then catches have increased substantially and average around 80,000 tonnes over the past decade. However, the largest declines in CPUE are observed to have occurred in the first decade when catches were comparably low, and CPUE has remained relatively stable since 1990 when catches have increased substantially. Australia asked SPC to comment on this apparent inconsistency. SPC stated that CPUE is pretty flat over a long period of time, noting that this may be surprising in view of the increased catch over the last few decades. SPC stated that this is what the data indicate, and is one of the things that makes this stock assessment very hard to grapple with; further discussion can be had over how informative the fisheries data are regarding the dynamics of South Pacific albacore. SPC indicated that the model also estimates a fairly flat CPUE. This can be compared in the top panel of Figure 16 (observed and predicted CPUE from the index fisheries). The model does broadly predict the initial decline. This is broadly consistent with a long period of fairly stable CPUE. There are some departures in the fit, but there are many constraints in this model so it lacks the flexibility needed to fit the data perfectly.

67. New Zealand thanked SPC for completing and presenting a very complex new assessment for South Pacific albacore. New Zealand expressed concerns with the reliability of the severe spawning potential declines at the end of the time series. Estimates of recent recruitment (2015–2017) are the lowest in the time series, and it is important to understand their reliability. Recruitment estimates at the end of a time series are always uncertain because they are not informed by much data. New Zealand also noted a few years of retrospective pattern in the spawning potential decline (Appendix 5), which reduces confidence that it will be sustained when there are more data. The most likely cause of the decline appears to be the size data in Region 3. However, the Region 3 longline size data are very variable through time, and do not fit well in the assessment. The New Zealand troll size data are also highly variable, and do not seem to show signs of low recruitment. Given the unusually steep decline, and given that the data informing it are limited, variable and do not fit very well, New Zealand stated it doesn't have high confidence in the steeply declining trend; it stated it had conveyed its concerns to SPC and offered assistance in helping to resolve these issues. SPC noted it had performed some analyses that indicated recent low recruitment is driven mainly by recent length-frequency data, particularly New Zealand troll data. The index fishery CPUE data are likely not implicated. SPC noted that there are various ways to try and get to the bottom of this issue. SPC noted that there was a very strong El Nino event in late 2014-2015, which is broadly consistent with estimated recruitment decline period.

68. Japan stated that the SEAPODYM movement grid provides different results, and sought SPC's view on its plausibility, especially in terms of movement, noting the very low actual spawning potential, which seems implausible if examined regionally. SPC stated that the motivation for including a movement alternative was the recognition that the fishery data is not very informative about movement – given the very small amount of tagging data available for South Pacific albacore, this is an area of the stock dynamics where relying only on fishery data may not give biologically valid results. SPC examined work done by CLS on the SEAPODYM model for South Pacific albacore, which uses biological drivers (e.g.,

reproductive biology, where spawning occurs, the age at which spawning occurs) to predict stock dynamics. SPC used the SEAPODYM model in a simulation mode to estimate the probability of movement among the four areas of the stock assessment. Estimates from SEAPODYM and the estimates generated internally in the stock assessment model differ in many respects; those from the stock assessment model lack the links to the South Pacific albacore biology that the SEAPODYM model includes. SPC stated its view that the SEAPODYM results were plausible and should be included in the uncertainty grid to reflect two different scenarios for movement that will impact the stock assessment results. These do give quite different results when the SEAPODYM results are imposed on the model results. The two movement alternatives were the main area of departure in terms of stock assessment results when looking at the ensemble as a whole.

69. Chinese Taipei observed that the pattern of fishing in the WCPO vs. the EPO may be different, and that standardized CPUE is important for the stock assessment.

(i) Chinese Taipei inquired why only Japan's CPUE was used in the stock assessment for the EPO, noting that the Japanese CPUE may not have enough information in recent years to represent abundance trends. The IATTC stated that the EPO is not a spatially structured model, and without properly accounting for length variation among countries, impact is hard to standardize. Japanese length-composition data is reliable; data for other countries is very different, and for some fleets not reliable. Therefore, only Japanese catch and effort data were used for the CPUE standardization for the EPO. The IATTC acknowledged the decline in data for recent years, and suggested it was important to consider some spatial/temporal standardization so data for other countries can also be included.

(ii) Chinese Taipei inquired regarding differences in fishery impact by region, specifically in Region 4. SPC stated that the impact in Region 4 was quite substantial, and similar in magnitude to the impact in other regions, and explained that impact in one region can be affected by fishery activities in all other regions. Strong movement can transfer the impact between regions, and there is strong movement into Region 4 from the other regions.

70. The EU addressed two issues:

(i) The EU stated its understanding from the discussion in the SPC's Pre-assessment Workshop (PAW) report (SC17-SA-IP-02) that size data could be misleading if there are changes in selectivity or changes in the sampling methodology, and more focus should be placed on CPUE, but the presenter mentioned the lack of contrast in the standardized CPUE indices and the need for greater reliance on size composition to inform population scale. The EU observed that this seems to be an important issue that might be causing some of the potential artifacts discussed and inquired whether splitting the time series could overcome this apparently important limitation. SPC stated that splitting vs. not splitting the CPUE series made little difference. The PAW model had a split around the 1990s, which seemed logical, and included some oceanographic data, but there were no notable differences, and nothing that seemed to warrant a split in the time series. SPC agreed that some additional characteristics could be valuable in the future.

(ii) The EU indicated that one of the main outcomes of the assessment in relation to management advice may be with regard to longline vulnerable biomass. In this regard, the EU inquired to what extent the 60% reduction from 2013+8% levels compares to the nominal CPUE time series; they indicated this might also be a question for CCMs. SPC stated that the vulnerable biomass was calculated for all longline fleets for the southern convention area, as the median across the 72 models and across the regions. SPC stated it hasn't compared the standardized index in 2013 vs. the more recent period or the operational data raw CPUE. There are data in the albacore trends paper (SC17-SA-IP-04) that SPC stated it could examine if needed, but there is a need to be very specific about what is being considered, as the model itself is looking at multiple fleets with varying selectivity in the southern CA, rather than one specific flag fleet in term of the actual data.

SPC further commented that if looking at nominal CPUE for South Pacific albacore fleets, some have not changed much, others have declined by up to 66% relative to 2013+8%. There is much variation across fleets in the South Pacific.

71. The USA made several comments:

(i) The USA states its concern that the standardized CPUE indices do not show linear contrast over the past 20 years when the catch has increased by 2 to 3-fold and also that the fit to the indices show a residual pattern over time. It supported the authors' suggestion to consider split indices in future assessments, which might allow the data to be more informative during the contemporary period, which is more important. It questioned whether there is a nonlinear relationship between relative abundance and CPUE or a time-varying relationship with changing fishing power and catchability.

(ii) The USA also notes that SC14 discussed a conflict with size composition data with CPUE, and that this apparent conflict does not seem to have been resolved.

(iii) The USA stated its concern about the application of a pooled-sex population dynamics model to assess a resource that exhibits sexual dimorphism in growth and other life history parameters. The USA notes that there appear to be some important differences between the life history parameters used in the North and South Pacific albacore assessments. In particular, the Brody growth coefficient (also known as von Bertalanffy K parameter) for the pooled-sex model used in the South Pacific albacore assessment is about 10% higher for females and about 29% lower for males in the North Pacific albacore population. Further the instantaneous natural mortality rates used for the South Pacific albacore stock assessment are estimated to be lower for females and males in comparison to the North Pacific stock assessment (Figure 10 suggests an adult M on the order M=0.30 but M (male)=0.38/yr and M (female)=0.49/yr for the North Pacific stock as reported by the ISC). These differences in growth and natural mortality rates are substantial and if true, suggest that the South Pacific albacore stock has a much higher natural survival rate, for whatever reason, in comparison to the North Pacific stock. It is also not clear how the natural mortality rates were derived for South Pacific albacore resource assessment, noting that an unpublished method is cited,[5] but it is not clear how this method was applied to derive juvenile or adult mortality rates. Stock-recruitment steepness for South Pacific albacore is also treated as a major uncertainty with h=0.65, 0.8, or 0.95 with equal probability. The North Pacific albacore assessment uses a value of h=0.90, which is much different than the central tendency of h=0.8 or the lower resilience scenario of h=0.65. The USA stated that it is not clear why such substantial differences in stock-recruitment resilience and other parameters would exist between South and North Pacific populations, and asked for clarification. SPC stated that it appears they are different in growth. A CSIRO study provided the new growth parameters using a recognized technique, and PAW agreed to begin using this value. The June mortality workshop recommended avoiding the use of a fixed value for mortality (M); SPC now uses M at age, and using growth data for this species. SPC noted that linking growth and natural mortality is a sensible approach, leading to some impact of growth on natural mortality. Information was accessed from various meta-analyses. Regarding the lack of responsiveness of CPUE to substantial increases in catches in the last few decades can be seen as a surprising feature of the CPUE data, but there is a noticeable decline in the CPUE post-2000, which would be coincident with large increases in longline catch, and be more evident at a smaller scale.

[5] *A review of estimation methods for natural mortality and their performance* Mark N. Maunder, Hui-Hua Lee, Kevin R. Piner, Owen S. Hamel, Jason M. Cope, Andr´e E. Punt, James N. Ianelli, Richard D. Methot. Manuscript submitted to Fisheries Research.

72. Solomon Islands, on behalf of PNA members, thanked SPC for the assessment, and stated they are encouraged to see the developments to improve the modelling approach and the collections and analysis of biological material. They stated their concern with the strong influence of two poor recruitment years on the overall biomass in the recent period. FFA members inquired whether the assessment team could expand on this issue. One would expect a short-term recruitment fluctuation to have limited influence on the overall spawning biomass in a stock with highly asymptotic growth and with multiple age classes in the adult population. This raises the question why recruitment is so influential in reducing the spawning biomass in the recent period of this model, as this seems somewhat biologically implausible. SPC stated that this could be demonstrated with some additional work and graphics, but in brief, the spawning biomass is composed of age classes about from about annual age classes 6 to 12. The spawning biomass is dominated by the younger age classes, especially noting that take into account the sex ratio into the computation of the spawning biomass. The goal is for the spawning biomass to be representative of what we think the female spawning biomass will be. There is a fairly sharp decline in the sex ratio (% of females) in adult population for older age classes. Those older age classes have a declining contribution to the spawning biomass in the last few years. The spawning potential would be dominated by the younger age classes, and thus recruitment has an effect that is delayed by the entry of progressive age classes.

73. Australia made three comments:

(i) in reply to a question posed by the EU, Australia stated that the standardised CPUE index for South Pacific albacore for the Australian longline fishery shows only a small decline in recent years.

(ii) In relation to the analysis to std-CPUE in this assessment, Australia was surprised to read that the Std-CPUE model with hooks between floats (HBF) fitted did not converge! However, Figure 8 in this document displays substantial shifts to deploy more HBF over time in all regions which are very likely to have influenced CPUE. Indeed, in the domestic Australian fishery, shifts in the number of HBF account for large changes in CPUE for this fleet.

(iii) Finally, Australia was also surprised that the split time CPUE analysis did not result in changes in the indices. However, the paper notes that the operational longline data are largely absent of detailed vessel and gear characteristics that could be valuable in a standardization model. There appears to be a strong need to re-assess the minimum data requirements for operational data, especially for those fleets used in assessments such as this. Australia stressed that it would be useful to have this as a recommendation as stock assessments such as this one continue to be compromised by poor data in this regard.

74. China welcomed that for first time WCPFC and IATTC have conducted a joint stock assessment for South Pacific albacore, and stated its hope that this cooperation continues. It supported the suggestion by SPC to continue analyses and study to reduce uncertainty. It stated it was not surprised by the conclusion that available biomass is continuing to decline, and encouraged the Commission to establish comprehensive management measures to reduce the pressure on the stock.

75. Japan stated that the objective as agreed four years ago was to maintain the longline vulnerable biomass 8% above 2013 level. Noting that the 56% of $SB_{F=0}$ was the result of the previous stock assessment, Japan asked the percentage of $SB_{F=0}$ equivalent to 2013 + 8% calculated based on the current stock assessment. SPC stated that the situation is similar to skipjack, where SPC re-evaluated the TRP based on the new stock assessment. Once SC defines the grid of models on which management advice can be agreed, SPC can do this for the Commission. But SC needs to make a decision on the models first.

**b. Discussion on the structural uncertainty grid**

76. Japan asked whether all 72 runs satisfy the standard required convergence. SPC confirmed that they did.

77. USA asked whether besides the gradient of the objective function being 0, was the estimate of the covariance matrix positive or negative. SPC agree this is an important point to consider. Need to recognize that have over 4,500 parameters. Did spend some time diagnosing issues around not being able to get a positive/negative Hessian. The negative values seem to be related to the estimated effort deviation coefficient, which are parameters in the model, and do not appear to be strongly correlated with any other parameters that SPC considers influential on the stock dynamics. SPC will seek to run a catch condition model and address this; it does not appear to be a major issue, at least in terms of the point estimates produced thus far.

78. Japan noted the Region 4 biomass trend, and the SEAPODYM uncertainty grid, which gives very low continuity; this is true for other regions as well. Looking at Kobe chart (Figure 46, righthand side): some runs give very large biomass, 4-5 times the current biomass, and 4-5 times $B_{MSY}$. This means that those with very high ratio against $B_{MSY}$ would have very large $B_{MSY}$ level. So current biomass is 4-5 times $B_{MSY}$. Japan inquired if this is this related to particular axes. SPC referenced Table 6, summary of reference points for the grid models, noting that $SB_{MSY}$ as a proportion of $SB_{F=0}$ is only about 0.15. Early in the time series one can expect large values of biomass in relation to $SB_{MSY.}$

79. Australia acknowledged the comments from Japan and suggested possibly down-weighting the SEAPODYM axis in the grid.

80. The USA raised two questions regarding the South Pacific albacore grid:

- What was the rationale for changing the size data weights to 50, 25, and 10 in this assessment from the higher values of 80, 50, and 20 used in the 2018 stock assessment?
- Why was the standardized CPUE not included as an axis of uncertainty in this assessment relative to the 2018 assessment?

SPC stated it would cross check back to the 2018 stock assessment for the reasons for the change, which may be related to the fact that these stock assessments include index fisheries that share the same source size data with the capture fisheries; SPC stated it recalled taking this into account in 2018 through data weighting coefficients. In this stock assessment it was addressed at the data level. Regarding the difference in the CPUE treatment in the current vs the 2018 stock assessments: 2018 was the first year the index fishery approach was used; all subsequent stock assessments have endorsed the use of the spatial temporal CPUE approach. The USA stated that it may be worthwhile in modelling this to have a split CPUE time series to account for some of the changes that seem to show up in the model.

81. NZ supported inclusion of SEAPODYM movement rates in the grid as the only alternative assumption available, given that there is considerable uncertainty about movement and given that the diagnostic case model estimates high movement rates based on limited information.

82. SPC stated that optimistic models with high current $SB/SB_{MSY}$ levels are those with high (0.95) steepness.

83. USA inquired regarding data weighting between the 2018 and 2021 stock assessments, noting the difference is apparent, but that it was not clear what needed to be changed to improve the overall modelling of stock status by adjusting the weights. It sought comments from SPC regarding the difference, and whether this was something that should be caried forward. SPC agreed that adopting increased consistency for all stock assessments for weighting size data would be beneficial, and welcomed guidance on this from SC. SPC stated that it is clear the more you down-weight the size data the more conservative the results are. There is implicit downweighting, because the data was in effect divided by 2 (in terms of sample size)

because it was used for both index and extractive fisheries. That is part of the rationale for not exploring downweighting beyond 50; in previous stock assessments that down-weighting of data did not occur, thus we used the 80 down-weighting option, but that is not necessary in the 2021 stock assessment because of the implicit down-weighting in the data. SPC welcomed guidance from CCMs.

84. The EU stated it does not have a strong view on the weighting of the different axes, and their initial preference is to weight all the levels equally, but that some CCMs had commented on their preference to down-weight the models using SEAPODYM movement estimates. The EU stated that while SEAPODYM movement estimates are not validated, they can potentially be more realistic from a biological perspective than those derived from the assessment model, where movement and recruitment can be confounded. In that regard, the EU sought comments on the rationale for down-weighting SEAPODYM movement estimates. The USA spoke in in response to the EU comment on application of SEAPODYM-derived movement rates. Noting that movement is a source of uncertainty for this stock assessment, the USA stated it is important to consider the availability of good tag information that can inform movement rates. SEAPODYM provides an external source of movement, dependent on the accuracy of the model assumptions. SPC clarified that regarding movement, in this stock assessment tagging data is not used. SPC found it made little difference when it was included. Also, tagging data is not available for Region 4, if used it is just for the WCPO.

85. Japan commented regarding steepness, and referenced Figures 35 and 36, where steepness makes little difference in reference point comparison. This is primarily because the prior stock assessment model has a huge *sigma r*; regardless of steepness value, past recruitment is freely estimated, and steepness doesn't change historical recruitment. This may produce a large difference in the Kobe chart, because it calculates a different level of $B_{MSY}$, but does not actually change the stock assessment model results, so is not really needed in a stock assessment with this type of structure. SPC confirmed the issues raised by Japan; by design SPC seeks to ensure assumptions about *sigma r* do not impact stock assessment recruitment estimates. This was suggested by the bigeye stock assessment review in 2011. However, SPC would be hesitant to remove steepness from the uncertainty grid. WCPFC continues to use MSY as the fishing mortality-based reference point in Kobe and Majuro plots so there would be somewhat more impact of steepness assumptions on $F_{MSY}$. If spawning biomass levels are closer to 20% then steepness assumptions may have an impact on absolute recruitment, and thus on absolute spawning biomass, and even depletion-based estimates of reference points would be impacted.

86. Australia noted the statement that tagging data didn't seem to change the result, but observed that because tagging data is limited to Region 3, data informing movement across boundaries is limited. Because there is no tagging data in the stock assessment model itself, movement is estimated by modal changes in the size and CPUE data, but there are issues with both sets of data. It is possible movement estimates by the model are just making up for the problems in those data sets, and may not be reflective of any actual movement. Australia questioned whether it would be useful to consider a no-movement model (i.e., a single area model), as was done for one sensitivity run for swordfish, and suggested this would be useful to include in future stock assessments. SPC stated they wanted to get to a single region model formulation for this stock assessments but had insufficient time. SPC stated it could follow up on this after SC17. It noted that a single region stock assessment says movement is rapid and instant across the entire region. Thus, this is not a non-movement scenario (to do that you need to maintain the spatial boundaries and set movement coefficients to 0). Rather than a no-movement scenario, it would be single area model.

87. NZ supported Australia's suggestion that applying a single area model would be useful, and this was the approach used in SP-ALB assessments from 2005-2012. NZ inquired regarding the fit of SEAPODYM model to size data given low movement, and if the fit to that model is sufficient to give it the same weight in the grid. SPC stated their recollection that size data likelihood was comparable across the MI and M2 movement hypotheses. The fit with the SEAPODYM movement was substantially degraded

with respect to the index data. The SEAPODYM movement model or the grid models that have SEAPODYM movement have a somewhat degraded fit to the model, which is to be expected.

88. Japan stated that if SEAPODYM is included then this will be the first occasion that movement has been incorporated in this manner, and it may have future implication if SC recognizes SEAPODYM input as equally valid as other input data. Japan stated it was not entirely confident, and suggested weighting SEAPODYM movement at 50%. Australia, New Zealand and the EU supported the proposal.

89. The USA noted it is positive to include more information on movement rather than less, and that SEAPODYM does provide some information. It noted the issue of directionality of bias on the use of one movement model rather than another.

90. SPC confirmed its understanding that it would down-weight the SEAPODYM runs (36) by 50%, and produce the management quantities based on that.

91. Japan addressed the provision by SPC of information against the reference point, which it had raised previously. The South Pacific albacore interim TRP is 56% of $SB_{F=0}$, but the spirit of that was to maintain 8% of vulnerable biomass above the 2013 level. Japan asked if SC should evaluate the status against the interim 56% or 8% over vulnerable biomass of 2013. It suggested the latter, because it is clearly specified.

92. The Theme Convener noted that this would need to be clearly articulated in the management advice and implications**.**

93. Australia offered the following comments on behalf of FFA members. It noted with great concern the results of projections presented in Appendix 6 of SC17-SA-WP-02. These show stock status for the South Pacific as a whole and for the WCPFC convention area under average catch levels during 2017–2019. FFA members noted with concern that South Pacific albacore within the WCPO is likely to fall below the LRP immediately following the stock assessment, and may in fact already be below the LRP. FFA members recognised the need for work to both recalibrate the TRP according to the procedure agreed at WCPFC15 (WCPFC15 Summary Report, para 207) and estimate the constant catch levels that would achieve that TRP on average over the long term. Based upon the SC-agreed 2021 South Pacific albacore stock assessment, FFA members proposed SPC be tasked to re-calibrate the WCPFC TRP (the median depletion in the WCPFC-CA, $SB/SB_{F=0}$) that would on average achieve the agreed objective of an 8% increase in vulnerable biomass (catch per unit of effort proxy) for the southern longline fishery as compared to 2013 levels. Within that projection-based analysis, WCPFC-CA longline and troll fisheries should be modelled based upon catch, and fishing levels within the EPO should be adjusted in the same way as the WCPO for one scenario and fixed at recent catch levels for another scenario. Future recruitment should be sampled from the long-term recruitment pattern.

94. Japan restated its interest in having SPC calculate the depletion ratio if based on a level of 8% over 2013 vulnerable biomass, to check if that level of vulnerable biomass still stands as what the Commission expects. Japan also inquired regarding whether in the MFCL South Pacific albacore model catchability was fixed or estimable, noting that the assumption seems to be that CPUE is linear to biomass. SPC replied that it would prepare the analysis of the depletion ratio prior to WCPFC18. Regrading catchability, SPC noted that for the index longline fisheries catchability is assumed to be constant over time. Thus, the CPUE is providing a standardized index of abundance.

95. The USA commented on the need to gather full information before proceeding on decisions on this aspect of the management system and to understand that the intent of any agreements is fulfilled, noting that some ambiguity remained.

**c. Discussion on the revised grid and recommendations**

96. Following recalculation by SPC of the results based on the 50% downweighting of the SEAPODYM-derived movement inputs, Japan inquired regarding the shift in the median with respect to the upper and lower bounds in the trend comparison for the grid with downweighted movement. SPC explained that while the lower bounds of the range don't change the median does, because of the downweighting.

97. Australia noted that a decision was taken to perform a South Pacific-wide assessment without a lot of discussion. While there are some advantages to a South Pacific-wide assessment, a number of substantial new uncertainties have arisen as a result of applying the Pacific-wide approach, and it also complicates SC's advice to the Commission. Australia advocated that SC needs to discuss and make a more active decision on this issue before the next assessment. Australia also noted the work underway toward scoping the application of the CKMR method to South Pacific albacore, which it indicated shows great promise for addressing a wide variety of uncertainties present in the current stock assessment, and was indeed a key research recommendation of the assessment. It strongly supported this work and proposed that SC17 similarly express support for this work, which will be reported to SC18.

98. Samoa, on behalf of FFA members, summarised the outcomes of the discussion on the South Pacific Albacore stock assessment, noting there appear to be two priority areas that need further research and development; the need for a better estimate of the absolute spawning biomass given the lack of signal in the CPUE derived index of abundance; and the degree of connectivity or movement between the regions. FFA members stated that SC15 and SC16 commenced discussions on the role that CKMR may play in resolving these types of uncertainties and that SC17-SA-IP-14 has commenced looking at the feasibility of this methodology for South Pacific albacore. They inquired if SPC could provide some comment on how this methodology could resolve these uncertainties and what would be the steps required to implement this approach for South Pacific albacore.

99. SPC stated that following SC16, CSIRO and SPC worked to look at the feasibility of using CKMR to scale absolute biomass for South Pacific albacore; that effort is well underway, and that it should be possible to report to SC18 regarding a full feasibility study on CKMR. SPC noted that they were examining the use of epigenetic aging techniques in addition to reliance on otolith based ages; if epigenetic aging calibration is feasible this would reduce costs. Another focus is on ensuring an efficient sampling program, and minimizing DNA degradation. SPC noted that they would have more information on feasibility by the end of 2021. SPC mentioned the need to undertake consultations between CCMs and the technical experts at CSIRO and SPC, to ensure that everyone understands what is being proposed and undertaken, and suggested intersessional consultations could be useful. SPC also noted the issue of movement and the interconnectivity between the eastern and western south Pacific, which can be addressed using the CKMR approach.

**d. Discussion on management advice**

100. Fiji, on behalf of FFA members, stated that the pessimistic outcome of the stock assessment is very concerning to FFA members and called on the Commission to prioritise urgent action to put in place effective measures for the sustainability of the South Pacific albacore stock and the fishery. They stated that management actions are urgently needed now not only to prevent further increases in effort, but to implement measures that will reduce mortality and return the vulnerable biomass to the 2013 +8% level as agreed. A trajectory to achieve the interim target reference point (iTRP) needs to be in place and implemented as soon as possible. FFA members understand that recalibrating the stock depletion value of the iTRP with respect to stock vulnerable biomass in accordance with the new stock assessment may be the

next step, but stated that this should not delay actions to reduce catches as soon as possible. FFA members urged the South Pacific albacore IWG to speed up this process, and present a clear set of recommendations for the Commission's consideration at WCPFC18.

101. Australia supported the intervention by Fiji on behalf of FFA members. It also supported expressing stock status and trends in the usual way, while noting the need to be clear as to whether this pertains to South Pacific wide or WCPFC-CA. It suggested prioritising information for the CA (or both CA and South Pacific-wide) as this may be most relevant to the Commission. This carries forward to the tables and Figures for South Pacific albacore. It stated its preference to provide these figures for the CA where appropriate and possible.

102. RMI, on behalf of PNA members, also noted the high catch on the high seas and echoed the concern of FFA members. They stated that better controls are needed for the longline fishery on the high seas that has low observer coverage and is largely uncontrolled. To address this, PNA members stated that the development of zone-based limits is required with compatible measures on the high seas, and increased independent observer coverage on vessels operating in the high seas.

103. The USA stated its concern about stock projections for South Pacific albacore, based on the original uncertainty grid, and noted it expects these concerns to also be valid for the agreed-upon model grid. These two projection concerns were:

- Projected biomass at equilibrium in future years in the WCPFC-CA is approaching the LRP under scenarios of 2017-2019 and 2020 catches, and
- Projected biomass within the WCPFC-CA with fishing at 2017-2019 and 2020 catch levels have 0% probability of reaching the interim TRP of 56% of $SB_{F=0}$.

104. Cook Islands stated that the outcome of the 2021 stock assessment of south Pacific albacore signals the urgent need for stronger management action of this stock to be taken by Commission. Although the stock is above the agreed LRP of 20% $SB/SB_{F=0}$ in the last year of the assessment, the projections suggest that may no longer be the case, with the stock in the WCPFC CA likely to have fallen below the LRP in 2020. Further to that, despite the downgrading of SEAPODYM in the updated assessment, the stock is at a lower status than the assessment in 2018 and appears to be further away from the agreed iTRP of 0.56 $SB/SB_{F=0}$. The current CMM for South Pacific albacore is clearly insufficient to achieve the iTRP, or even reverse the decline. The impact of movement of effort in 2020 from the tropical longline fishery into the southern fishery, driven by market changes, shows the current management arrangements in place are insufficient to prevent sudden increases in effort targeting albacore. Decreases in CPUE also strongly support the stock assessments conclusions that indicate the stock continues to be depleted, and it appears localised depletions are most likely occurring as a result of the very high additional effort that moved into the southern fishery in 2020. Stronger management measures need to promptly be put in place to prevent further depletion to the stock and prevent more effort flowing into the southern longline fishery. This is particularly the case in the high seas, which does not benefit from the stronger measures that many countries have implemented in their EEZs. There must be an immediate reduction in the already excessive levels of albacore catch and effort, specifically in the high seas.

105. New Caledonia stated that their future is linked to that of the South Pacific albacore stock, and noted that despite their own focus on ensuring their fishery is sustainable, and their low current fishing effort, the status of the stock is worsening. New Caledonia expressed concern that CPUE in the Melanesian region is declining, while catches are elevated, as noted in SC17-SA-IP15. New Caledonia also expressed concern about the increase in high seas pocket I7, which almost doubled as shown in SC17-SA-IP-04 Table A2-2. Increased effort in this region is of great concern because juveniles are more likely located there. New Caledonia called for more specific analysis regarding high seas fishing activities to inform the

decisions that the Commission will have to make. New Caledonia supported the research projects that were discussed by SPC.

106. The USA stated it is concerned that depletion is greatest in regions north of 25º S, specifically Regions 1 and 2, which are areas mostly outside of the effort control and reporting provisions for South Pacific Albacore (CMM-2015-02). Depletion of Region 2 is greatest, this is also where most PICT fleets operate, including American Samoa, where there is no high seas access. This depletion is a particular concern for American Samoa.

107. French Polynesia shared the concerns expressed regarding the state of South Pacific albacore stocks. It noted that its South Pacific albacore catch is essential for domestic food security, and that accurate information on the stocks is of vital importance. It agreed with New Caledonia regarding the need for information on fishing in the high seas, noting the presence of a high seas pocket adjacent to French Polynesia.

108. The United States encouraged the South Pacific Albacore Roadmap Working Group to prioritize discussion and consideration of including the regions of greatest depletion (i.e., Regions 1 and 2 north of 25ºS) into CMM 2015-02 for South Pacific albacore.

109. New Zealand commented that current stock status has not changed significantly since 2018, and that some wording used then could be applied.

#### 3.1.1.2 Provision of scientific information

**a. Stock status and trends**

110. **The median values of relative recent (2016-2019) spawning biomass depletion ($SB_{recent}/ SB_{F=0}$) and relative recent (2015-2018) fishing mortality ($F_{recent}/F_{MSY}$) over the uncertainty grid of 72 models (Table SPA-01) were used to define South Pacific albacore stock status. The values of the upper 90$^{th}$ and lower 10$^{th}$ percentiles of the empirical distributions of relative spawning biomass and relative fishing mortality from the uncertainty grid were used to characterize the probable range of stock status.**

111. **A description of the updated structural sensitivity grid used to characterize uncertainty in the assessment is illustrated in Table SPA-01. Tables SPA-02, SPA-03, and SPA-04 show reference points for South Pacific-wide, WCPFC-CA (Convention Area) and IATTC-CA, respectively, including the median values of relative 'recent' (2016-2019) and 'latest' (2019) spawning biomass depletion ($SB_{recent}/SB_{F=0}$) and relative recent (2015-2018) fishing mortality ($F_{recent}/F_{MSY}$) over the uncertainty grid of 72 models used to define stock status. These values are based on the uncertainty grid with the downweighted SEAPODYM (M2) movement hypothesis. The values of the upper 90$^{th}$ and lower 10$^{th}$ percentiles of the empirical distributions of relative spawning biomass and relative fishing mortality from the uncertainty grid were used to characterize the probable range of stock status.**

112. **The spatial structure used in the 2021 stock assessment is shown in Figure SPA-01. Time series of total annual catch by fishing gear over the full assessment period and by region are shown in Figure SPA-02. Estimated annual average recruitment, spawning potential, and total biomass by model region for the diagnostic case model are shown in Figure SPA-03. Estimated trends in spawning potential by region for the diagnostic case are shown in Figure SPA-04, and juvenile and adult fishing mortality rates from the diagnostic model are shown in Figure SPA-05. Time series of estimated spawning potential for the 72 models are shown in Figure SPA-06. Time-dynamic**

**percentiles of depletion ($SB_t/SB_{t,F=0}$) for the 72 models are shown in Figure SPA-07. Majuro and Kobe plots summarizing the results for each of the 72 models in the weighted structural uncertainty grid are shown in Figures SPA-08 and SPA-09 for the 'recent' and 'latest' periods, respectively.**

113. **The most influential axis of uncertainty with respect to estimated stock status was movement, where assuming SEAPODYM-derived movement resulted in more pessimistic outcomes.**

114. **SC17 noted that the median value of relative recent (2016-2019) spawning biomass depletion for South Pacific albacore ($SB_{2016-2019}/SB_{F=0}$) was 0.52 with a 10th to 90th percentile interval of 0.41 to 0.57.**

115. **SC17 further noted that there was 0% probability (0 out of 72 models) that the recent (2016-2019) spawning biomass had breached the adopted limit reference point (LRP).**

116. **SC17 noted that there has been a long-term increase in fishing mortality for adult South Pacific albacore, with a notable steep increase in fishing mortality since 2000.**

117. **SC17 noted that the median of relative recent fishing mortality for South Pacific albacore ($F_{2015-2018}/F_{MSY}$) was 0.24 with a 10th to 90th percentile interval of 0.15 to 0.37.**

118. **SC17 further noted that there was 0% probability (0 out of 72 models) that the recent (2015-2018) fishing mortality was above $F_{MSY}$.**

119. **SC17 noted the results of stochastic projections (based on the weighted grid, SC17-SA-WP-02a, Figures 1 and 2) from the 2021 assessment, which indicated the potential stock consequences of fishing at "status quo" conditions (2017–2019 or 2020 average catch or, separately, fishing effort) using the uncertainty framework approach endorsed by SC17. These results are provided for both South Pacific-wide and for the WCPFC Convention area only. All projections show a steep and rapid decline in biomass towards the LRP in the year 2021 followed by an increase in biomass thereafter.**

**Table SPA-01**. Description of the structural uncertainty grid used to characterize uncertainty in the management quantities derived from this assessment. Note that the M2-SEAPODYM hypothesis was downweighted by 50% by the SC17.

| Axis | 1 | 2 | 3 |
|---|---|---|---|
| **Steepness (S)** | 0.65 | **0.80** | 0.95 |
| **Movement (M)** | **M1-Estimated, age-dependent** | M2-SEAPODYM | |
| **Size data weight (D)** | Low (50) | **Medium (25)** | High (10) |
| **Recruitment distribution (R)** | **R1-SEAPODYM** | R2-Regions 3 and 4 | |
| **Growth/M (G/M)** | **Fixed otolith, Nat-M1** | Estimated from length frequency, Nat-M2 | |

**Table SPA-02**. South Pacific-wide (all regions) reference point estimates from the assessment based on the weighted grid.

| | Mean | Median | Min | 10% | 90% | Max |
|---|---|---|---|---|---|---|
| $C_{latest}$ | 87,184 | 86,827 | 83,519 | 85,092 | 87,633 | 130,936 |
| $F_{MSY}$ | 0.06 | 0.06 | 0.05 | 0.05 | 0.07 | 0.08 |
| $f_{mult}$ | 4.37 | 4.25 | 2.11 | 2.69 | 6.62 | 7.84 |
| $F_{recent} / F_{MSY}$ | 0.25 | 0.24 | 0.13 | 0.15 | 0.37 | 0.47 |
| $MSY$ | 115,661 | 120,020 | 68,200 | 75,584 | 158,600 | 166,240 |
| $SB_0$ | 623,542 | 660,200 | 361,800 | 392,590 | 845,100 | 929,300 |
| $SB_{F=0}$ | 675,861 | 678,345 | 524,886 | 537,740 | 824,855 | 873,278 |
| $SB_{latest} / SB_0$ | 0.41 | 0.41 | 0.34 | 0.37 | 0.46 | 0.48 |
| $SB_{latest} / SB_{F=0}$ | 0.37 | 0.40 | 0.25 | 0.27 | 0.45 | 0.46 |
| $SB_{latest} / SB_{MSY}$ | 2.50 | 2.33 | 1.45 | 1.69 | 3.921 | 4.28 |
| $SB_{MSY}$ | 109,710 | 104,100 | 48,040 | 61,497 | 157,500 | 190,000 |
| $SB_{MSY} / SB_0$ | 0.18 | 0.18 | 0.11 | 0.11 | 0.22 | 0.23 |
| $SB_{MSY} / SB_{F=0}$ | 0.16 | 0.16 | 0.09 | 0.11 | 0.22 | 0.23 |
| $SB_{recent} / SB_{F=0}$ | 0.50 | 0.52 | 0.37 | 0.41 | 0.57 | 0.59 |
| $SB_{recent} / SB_{MSY}$ | 3.34 | 3.22 | 2.07 | 2.24 | 5.18 | 5.33 |
| $Y F_{recent}$ | 81,998 | 85,020 | 58,440 | 63,656 | 94,720 | 101,400 |

**Table SPA-03**. WCPFC-CA reference point estimates from the assessment based on the weighted grid.

| | Mean | Median | Min | 10% | 90% | Max |
|---|---|---|---|---|---|---|
| $C_{latest}$ | 78,788 | 78,455 | 75,673 | 76,959 | 79,126 | 118,706 |
| $SB_{F=0}$ | 459,648 | 463,424 | 415,746 | 431,617 | 491,092 | 501,602 |
| $SB_{latest} / SB_{F=0}$ | 0.37 | 0.39 | 0.26 | 0.28 | 0.43 | 0.45 |
| $SB_{recent} / SB_{F=0}$ | 0.51 | 0.52 | 0.39 | 0.42 | 0.58 | 0.61 |

**Table SPA-04**. IATTC-CA reference point estimates from the assessment based on the weighted grid.

| | Mean | Median | Min | 10% | 90% | Max |
|---|---|---|---|---|---|---|
| $C_{latest}$ | 8,396 | 8,242 | 7,845 | 8,074 | 8,760 | 12,229 |
| $SB_{F=0}$ | 216,213 | 233,755 | 92,190 | 98,063 | 356,491 | 379,718 |
| $SB_{latest} / SB_{F=0}$ | 0.38 | 0.42 | 0.22 | 0.25 | 0.46 | 0.48 |
| $SB_{recent} / SB_{F=0}$ | 0.47 | 0.52 | 0.28 | 0.32 | 0.56 | 0.57 |

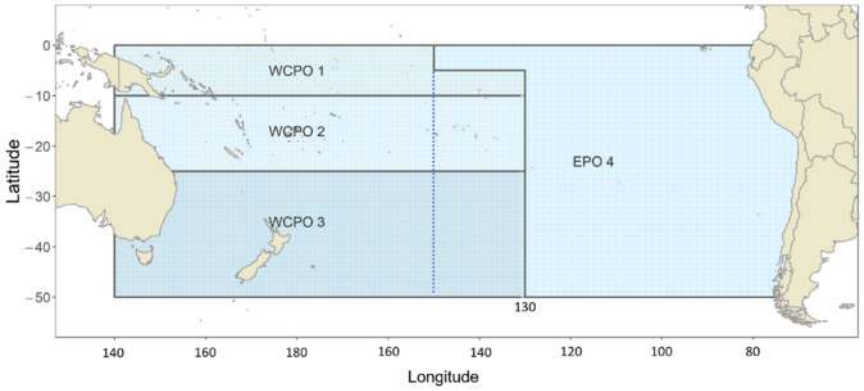


**Figure SPA-01**. The geographical area covered by the stock assessment and the boundaries of the four model regions used for South Pacific-wide 2021 albacore assessment. The overlap region between the WCPFC and IATTC convention areas is the area between 130º - 150º west demarcated by the dashed line. The catch from the 'overlap' area is included within the WCPFC-CA for this assessment.

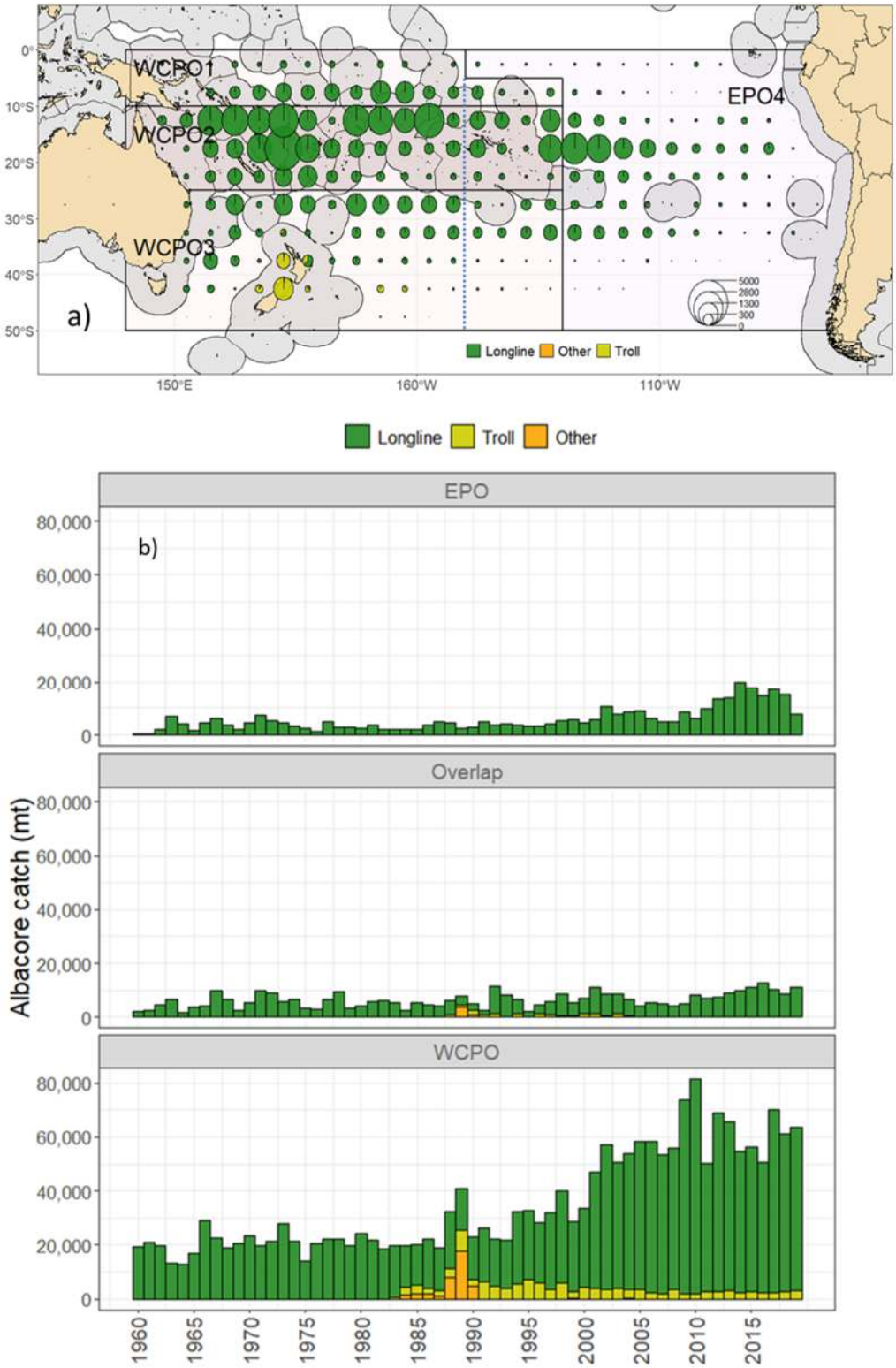


**Figure SPA-02**. a) Spatial pattern of albacore catch by gear type over the last decade, and b) historical catches of albacore across the model region from 1952-2019 by gear type.

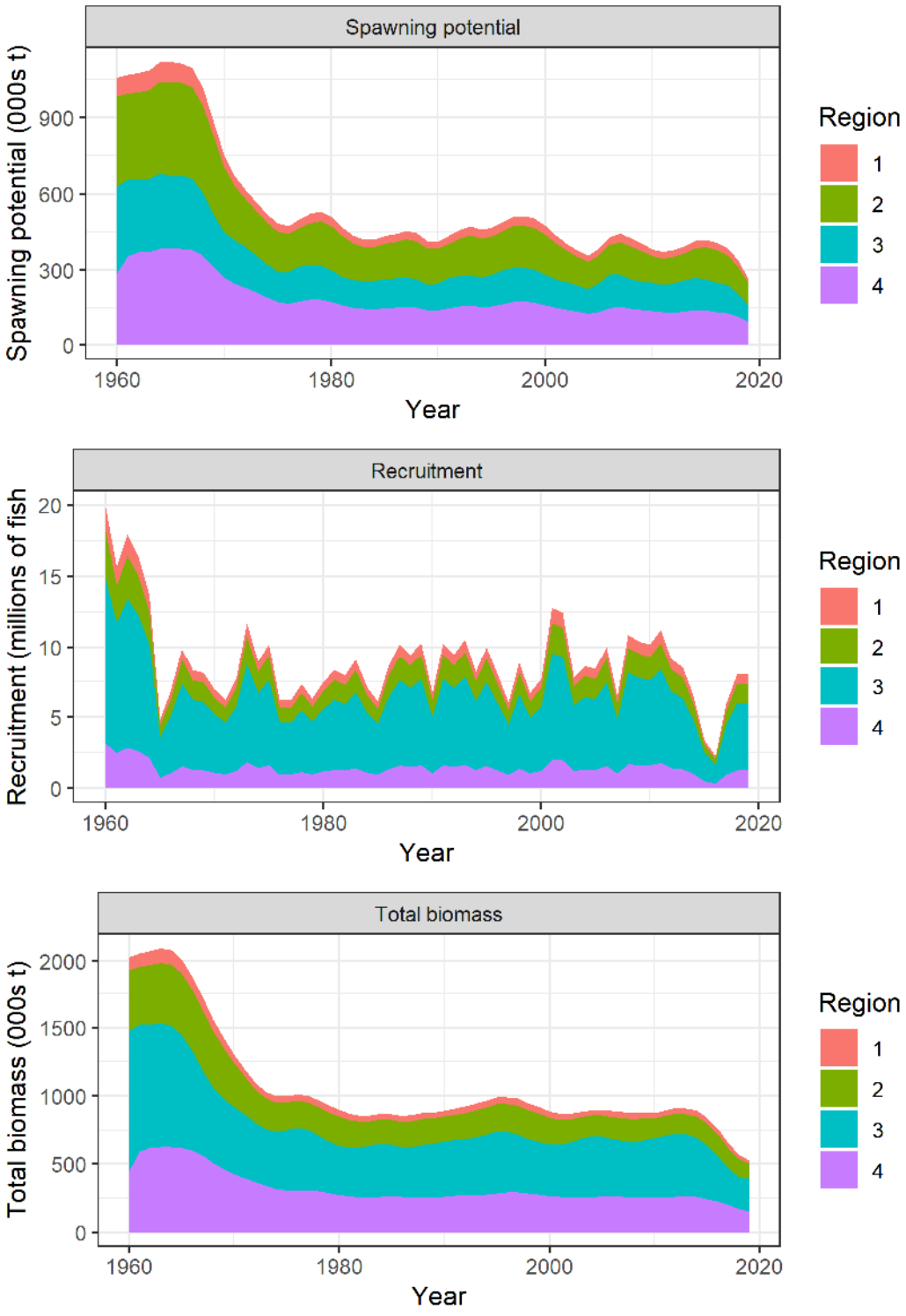


**Figure SPA-03**. Estimated annual average a) spawning potential, b) recruitment, and c) total biomass by model region for the diagnostic case model, showing the relative levels among regions.

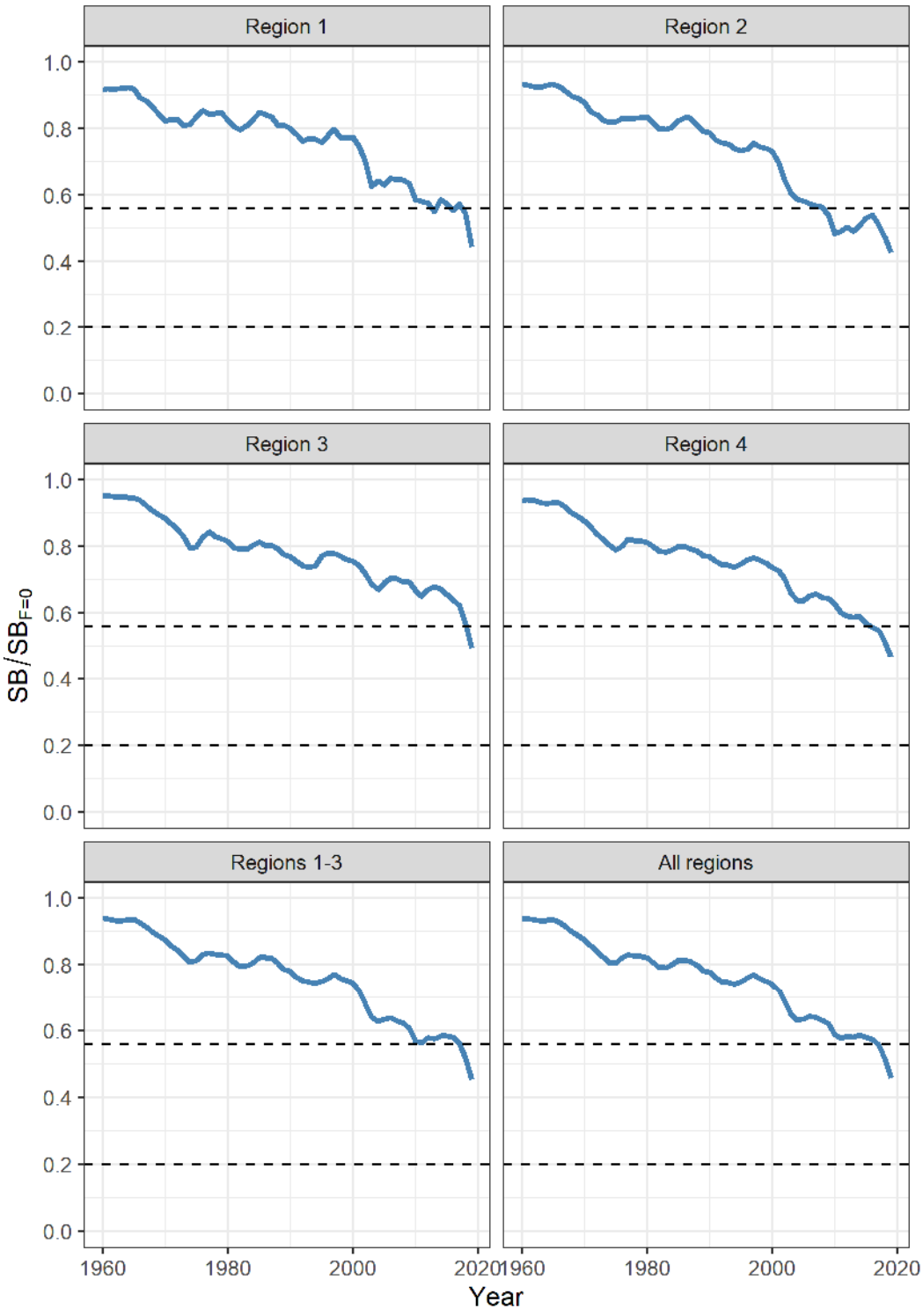


**Figure SPA-04**. Estimated temporal spawning potential by model region, grouped by region (WCPFC-CA, EPO) and South Pacific as a whole for the diagnostic case model. The dotted lines are included to indicate the $SB/SB_{F=0}$ interim target reference point (iTRP)=0.56 and the LRP=0.2 for the WCPFC-CA albacore fishery. Regions 1-3 represent the WCPFC-CA (including the "overlap"), Region 4 is the IATTC-CA.

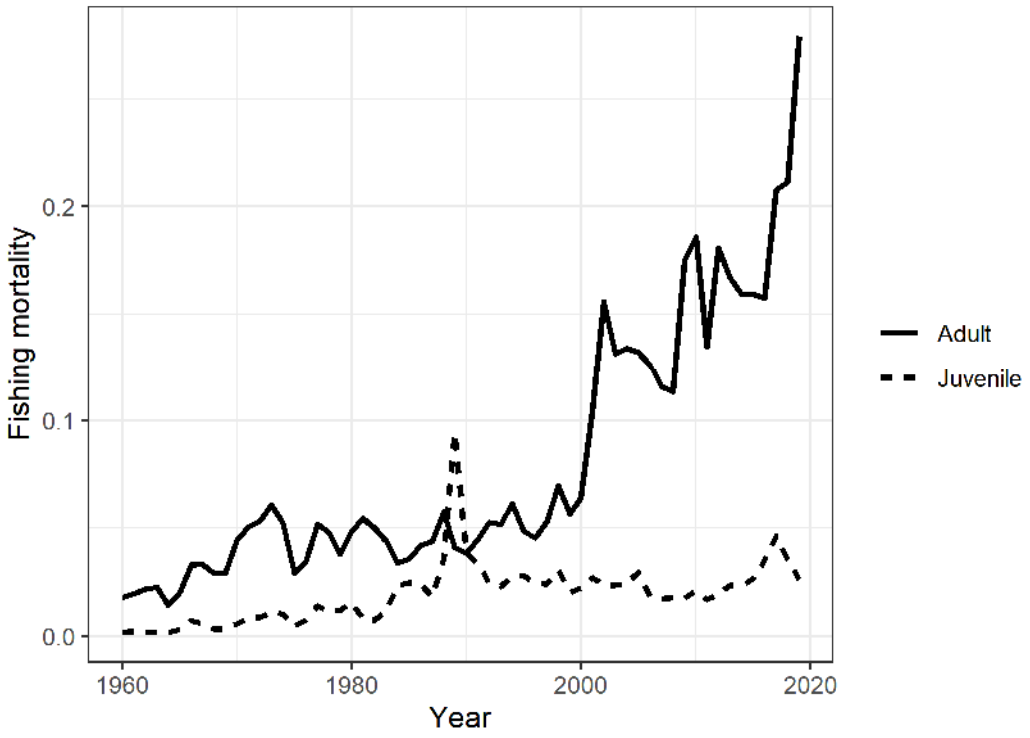


**Figure SPA-05**. Estimated annual average juvenile and adult fishing mortality for the diagnostic case model.

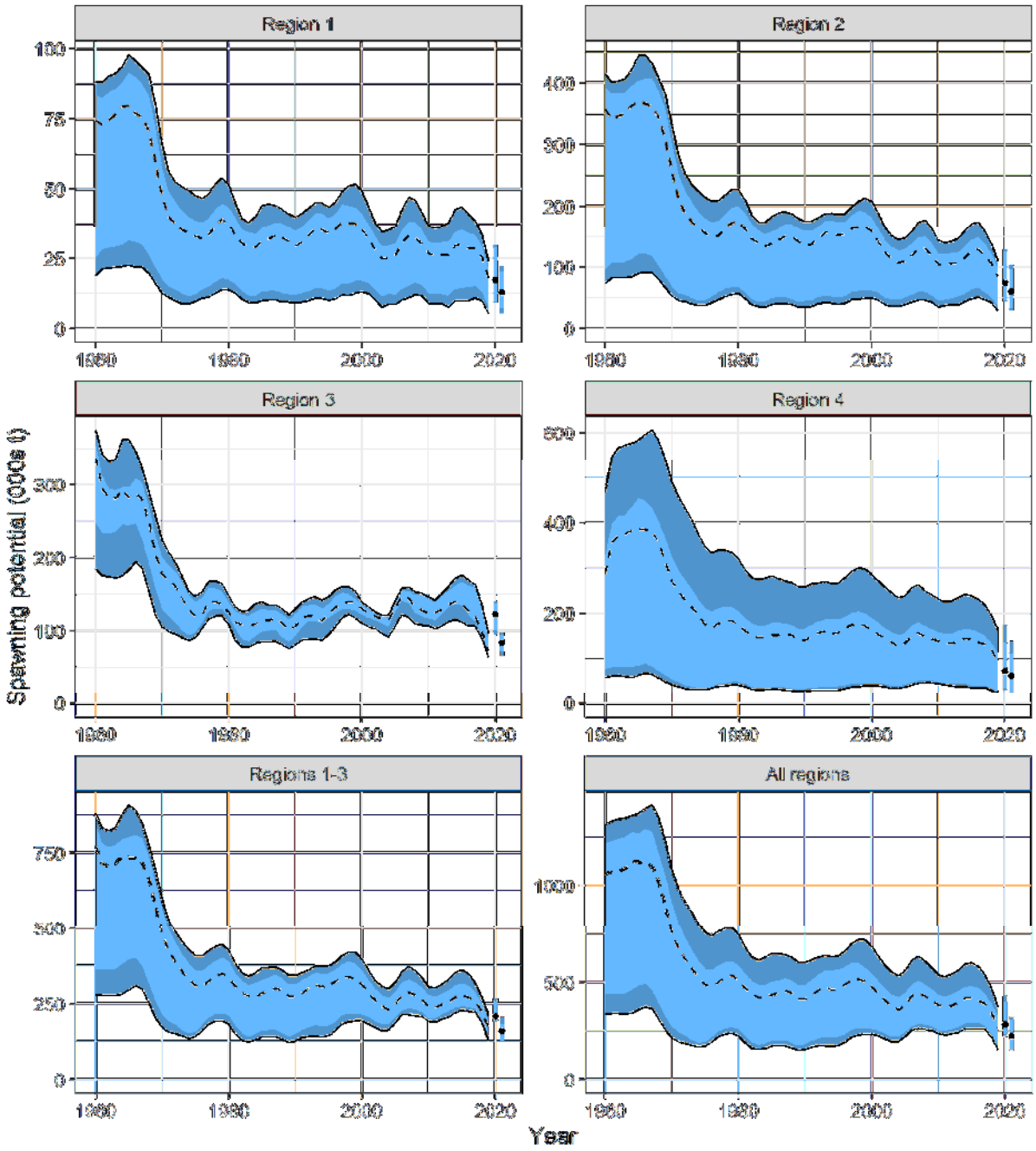


**Figure SPA-06**. Estimated spawning potential across all models in the structural uncertainty grid over the period 1960-2019. The dashed line represents the median. The darker band shows the 10th-90th percentile, and the lighter band shows the 25th-75th percentile of the model estimates. Regions 1-3 represent the WCPFC-CA (including the "overlap"), Region 4 is the IATTC-CA. The bars at right in each plot are the median values (points) and percentiles for recent (left) and latest (right) spawning potential.

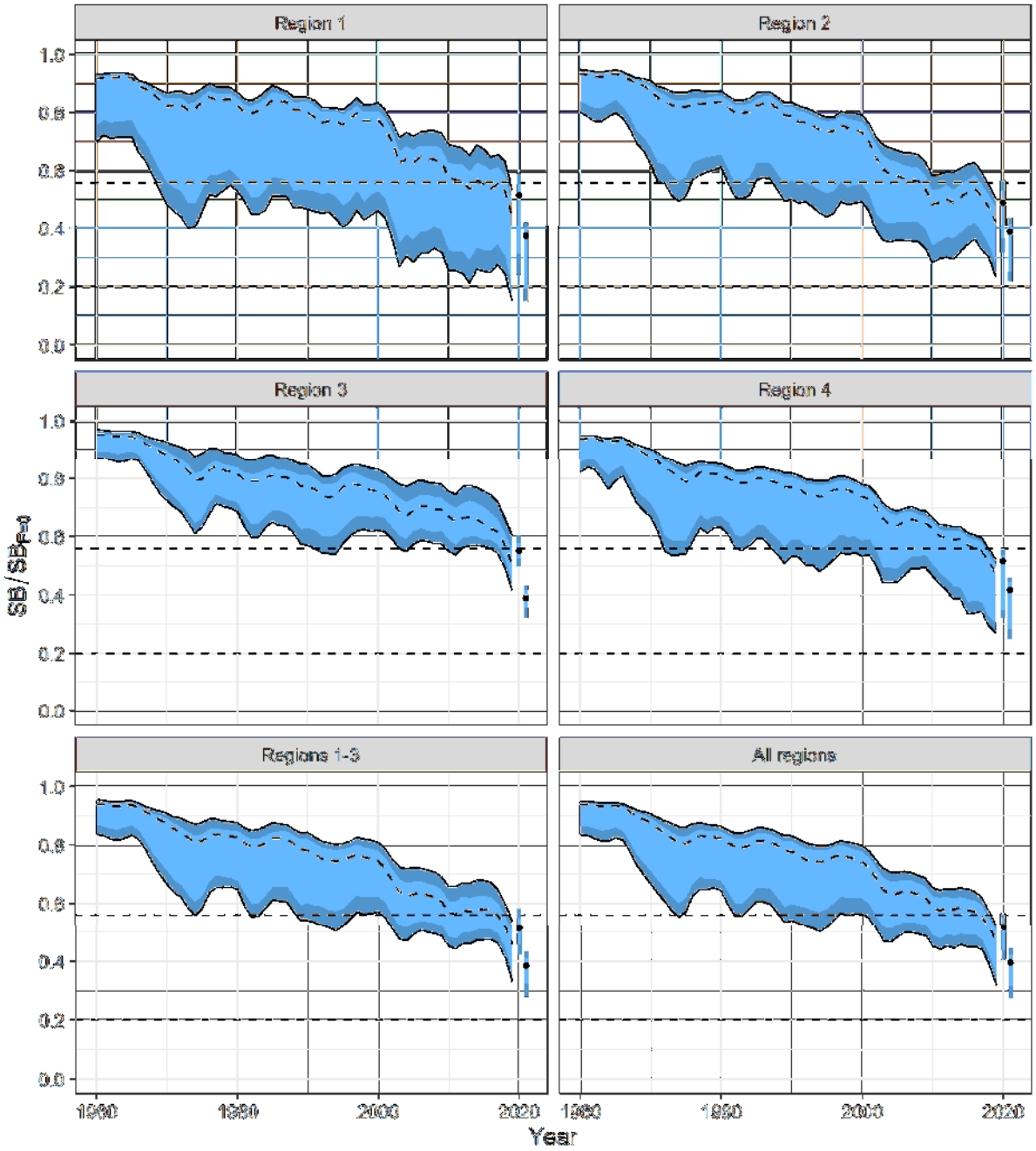


**Figure SPA-07**. Estimated spawning depletion across all models in the structural uncertainty grid over the period 1960-2019. The dashed line represents the median. The darker band shows the 10th-90th percentile, and the lighter band shows the 25th-75th percentile of the model estimates. Regions 1-3 represent the WCPFC-CA (including the "overlap"), Region 4 is the IATTC-CA. The dashed horizontal lines indicate the depletion LRP (0.2) and the WCPFC-CA TRP for $SB/SB_{F=0}$ (0.56). The bars at right in each plot are the median values (points) and percentiles for $SB_{recent}/SB_{F=0}$ (left) and $SB_{latest}/SB_{F=0}$ (right).

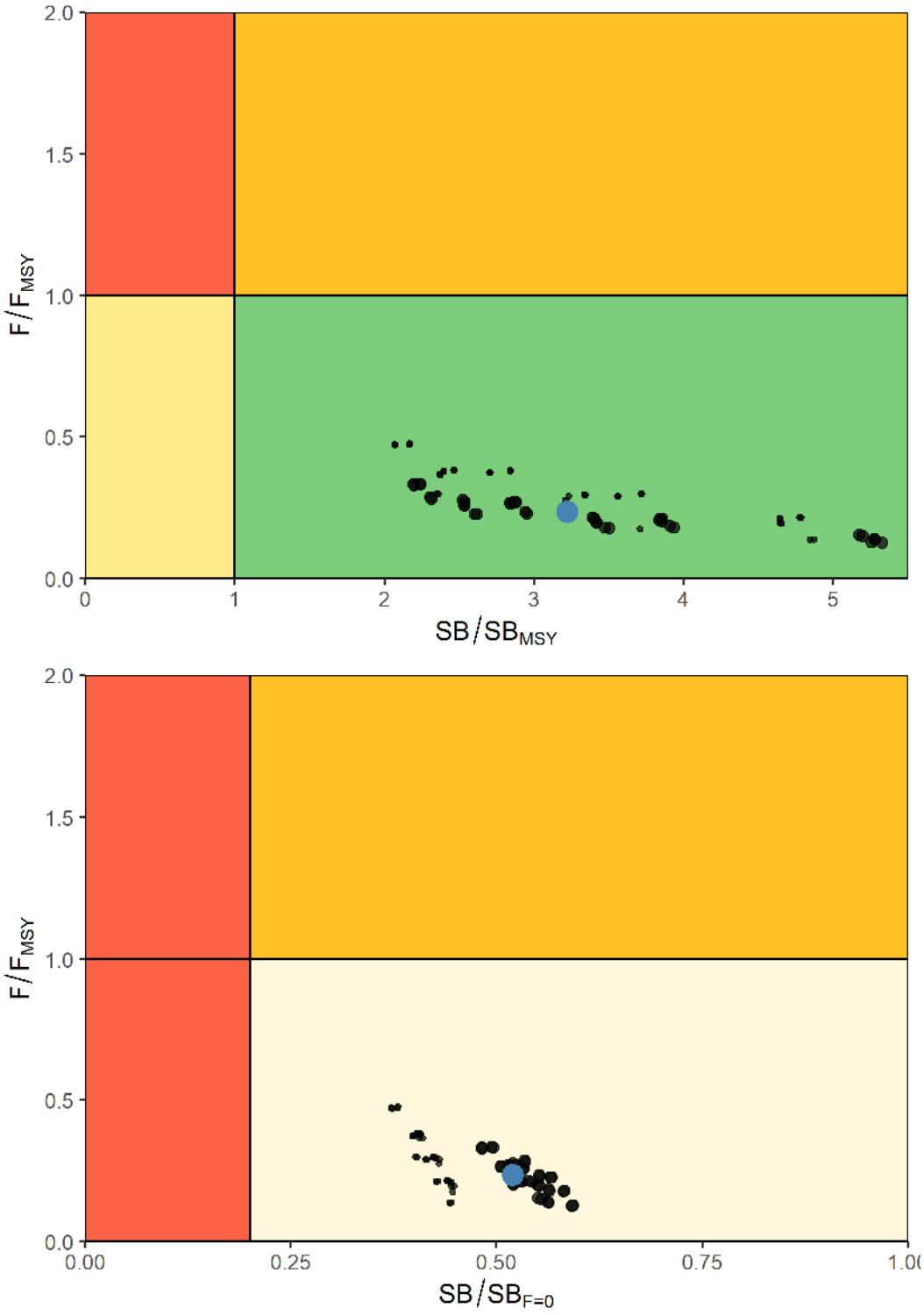


**Figure SPA-08**. Majuro (bottom) and Kobe (top) plots summarizing the Pacific-wide results for each of the models in the structural uncertainty grid for the 'recent' (2016-2019) period. The blue point is the median value based on the weighted grid models, with the more heavily weight models indicated by the larger black dots.

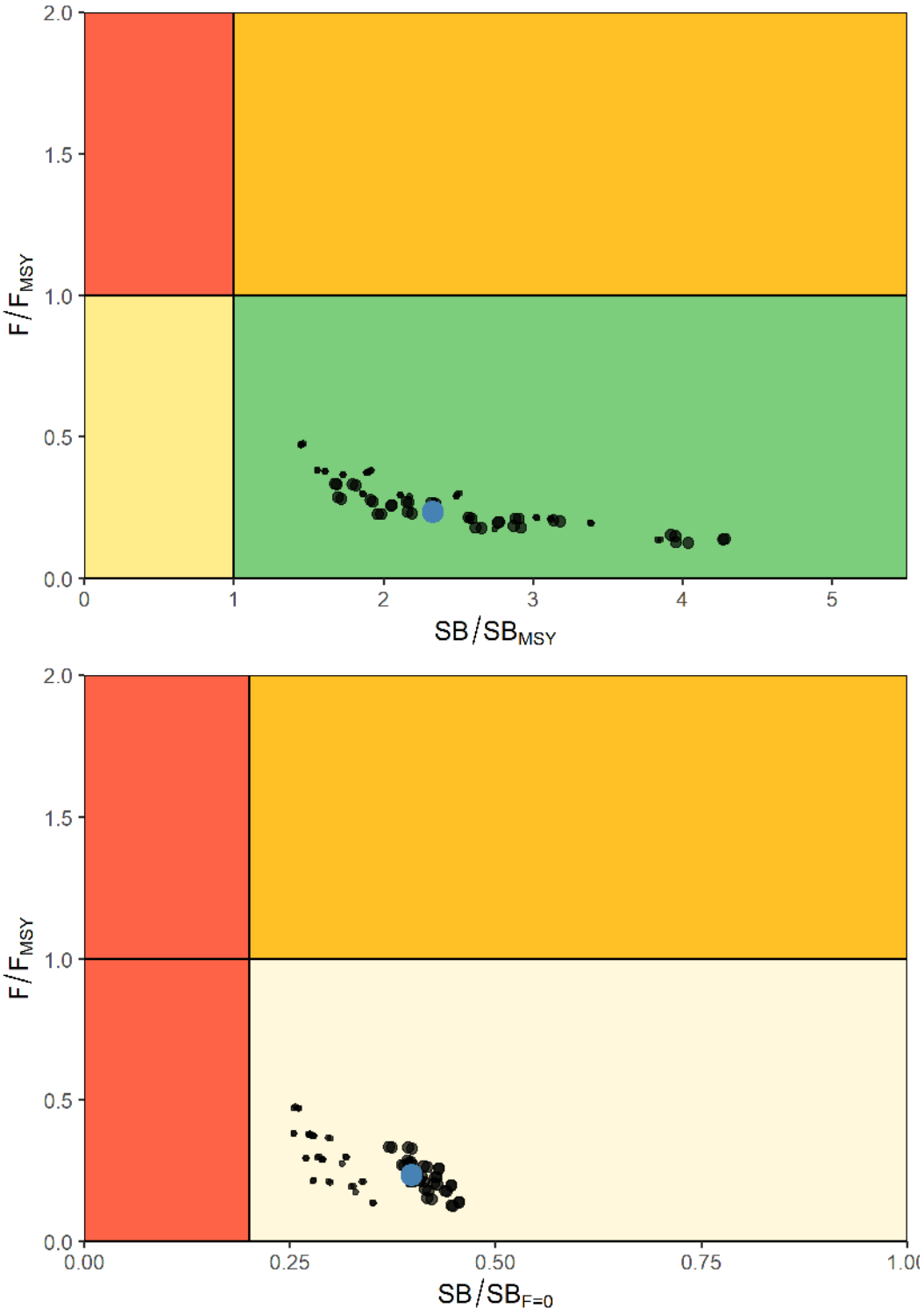


**Figure SPA-09**. Majuro (bottom) and Kobe (top) plots summarizing the Pacific-wide results for each of the models in the structural uncertainty grid for the 'latest' (2019) period. The blue point is the median value based on the weighted grid models, with the more heavily weighted models indicated by the larger black dots.

**b. Management advice and implications**

120. **Annual catch estimates for albacore in the South Pacific peaked at 93,835 mt (all gears) in 2017 (SC17-SA-IP-04). Catch by longliners represented 93% of the catch weight in 2020 at 64,963 mt and represented a 21% decrease from 2019 despite a shift of effort from the tropical to the southern longline fishery in 2020. By comparison, the 2020 total albacore catch within the southern part of the WCPFC-CA was 61,778 mt and the longline catch was 57,006 mt.**

121. **The 2021 South Pacific albacore stock assessment provided results consistent with the 2018 assessment. The addition of the EPO region into the current entire South Pacific assessment did not notably alter the main assessment outcomes, and similar trajectories and terminal depletion were estimated in both RFMO regions.**

122. **The spawning stock biomass has become more depleted across the model period (1960-2019), with a notable increase in depletion in the most recent years. Based on the set of models in the SC endorsed structural uncertainty grid, the South Pacific albacore assessment indicates the stock is not overfished, and there was zero estimated risk of the stock being below the Limit Reference Point of 20%$SB_{F=0}$. However, the decline in the latest estimated $SB_{latest}/SB_{F=0}$ (year 2019; median 0.40; 10th and 90th percentiles 0.27 - 0.45) is notably more pessimistic than those of $SB_{recent}/SB_{F=0}$ (years 2016-2019; median 0.52; 10th and 90th percentiles 0.41 - 0.57) indicating that there has been a substantial decline in stock status estimated over the last three years. The general trends are consistent for estimates across all regions of the South Pacific stock, and for the WCPFC-CA only.**

123. **For the WCPFC-CA region, the 'recent' and 'latest' SB estimates are on average both below the interim TRP of 0.56. Further, 86% of models (62 out of 72 models) in the structural uncertainty grid endorsed by SC17 estimated that $SB_{recent}/SB_{F=0}$ was below the interim TRP. In relation to management objectives for the WCPFC-CA longline fishery, this assessment estimated that the median `latest' (2019) and `recent' (2016-2019) longline vulnerable biomass for the WCPFC-CA are 56% and 76% of the 2013+8% target level that defined the interim TRP.**

124. **SC17 noted CPUE declines in many domestic longline fisheries in the southern portion of the WCPFC-CA.**

125. **SC17 noted that depletion is greatest in regions north of 25ºS, specifically in assessment Regions 1 and 2 where most domestic Pacific Island Countries and Territories (PICTs) fleets operate, including Small Island Developing States (SIDS) and Participating Territories that may have no high seas access. These are areas mostly unaffected by current management measure for South Pacific albacore (CMM 2015-02), which prescribe effort controls and reporting provisions south of 20ºS.**

126. **SC17 expressed great concern with the projected status of South Pacific albacore if recent catch or effort levels are maintained (SC17-SA-WP-02a REV2). Projections indicated that South Pacific albacore stock has a greater than 20% risk of falling below the LRP in 2021 under both catch and effort scenarios. These projections indicate an extended period where biomass is below the current interim TRP and in most cases the TRP is not achieved within the 30-year projection period.**

127. **Recalling its previous advice from SC11, SC12, and SC13, SC17 recommended that longline catch be reduced to avoid further and extended declines in the vulnerable biomass so that economically viable catch rates can be maintained, especially for longline catch of adult albacore.**

128. **SC17 recommended a recalibration of the interim TRP for review at WCPFC18 in accordance with the process agreed at WCPFC15 (WCPFC15 Summary Report, para 207). Further,**

**SC17 recommended projections be undertaken to estimate the constant catch levels that would achieve that TRP on average over the long-term. SC17 recommended that these analyses be provided to WCPFC18 to guide its consideration of reductions in longline fishing mortality that will be required to return the vulnerable biomass to the 2013 +8% level as agreed.**

**c. Future research recommendations**

129. **SC17 noted with concern that the standardized CPUE indices do not show linear contrast with catches over the past 20 years when the catch has increased by 2 to 3-fold and also that the fit to the indices show a residual pattern over time. SC17 supported the assessment scientist's suggestion to consider split indices in future assessments, which might allow for the incorporation of more informative catchability and density covariates during the contemporary period, which is more important for estimates of recent status.**

130. **SC17 noted a possible nonlinear relationship between catch and effort or a time-varying relationship with changing fishing power and catchability. The next assessment could investigate such nonlinear relationships and explore alternative effort metrics.**

131. **SC17 noted with concern that the standardized CPUE model with hooks between floats (HBF) did not converge. The time-series is almost 70 years with substantial shifts to deploy more HBF though time. These gear changes have probably altered South Pacific albacore catchability and require additional research. HBF is one characteristic of longline gear that could affect catchability; operational longline data are largely absent of detailed vessel and gear characteristics that could be valuable in a standardization model. Reliably collecting additional gear characteristics will better inform these models on variability in catchability among vessels and fleets and over time and these data enhancements could be achieved by revisiting the minimum logsheet data standards, increasing observer coverage, or expanding electronic monitoring applications. Without this additional information the large uncertainties associated with the use of standardised-CPUE in assessments will remain unresolved and continue to impact on future assessments.**

132. **SC17 noted the need to both recalibrate the interim TRP according to the procedure agreed at WCPFC15 (WCPFC15 Summary Report, para 207) and estimate the constant catch levels that would achieve that TRP on average over the long-term. Specifically, based upon the SC-agreed 2021 South Pacific albacore stock assessment:**

- **a) re-calibrate the WCPFC interim TRP (the median depletion in the WCPFC-CA, $SB/SB_{F=0}$) that would on average achieve the agreed objective of an 8 % increase in vulnerable biomass (CPUE proxy) for the southern longline fishery as compared to 2013 levels.**
- **b) undertake projections to estimate the constant catch levels that would achieve the recalibrated TRP, on average, over the long-term.**
- **c) within that projection-based analysis, WCPFC-CA longline and troll fisheries should be modelled based upon catch, and fishing levels within the EPO should be adjusted in the same way as the WCPO for one scenario and fixed at recent catch levels for another scenario. Future recruitment should be sampled from the long-term recruitment pattern.**

133. **A number of key research needs were identified in undertaking the assessment that should be investigated either internally or through directed research.**

134. **As with the previous South Pacific albacore assessment, the fishery dependent CPUE-based indices of abundance lacked contrast to inform population responses to increased fishing pressure. This continues to be a significant concern for the reliability of estimates of population size. The CPUE**

**analysis has been a major focus of preparatory work for this and previous assessments, and despite the attempts of various scientists, application of new approaches including attempts at splitting time series and testing various covariates, the CPUE continues to lack contrast. It is recommended that alternative fishery independent estimates of population size be explored, especially the genetic method of Close-Kin Mark-Recapture (CKMR).**

135. **The implications of uncertainty in movement were clearly evident in this year's assessment, with this being the most influential uncertainty for management advice. In the absence of strong empirical data to inform decisions on alternative movement hypotheses and based on the quality of fits to the data, the SC decided to downweight one of the two movement hypothesis for provision of management advice. This is an unsatisfactory situation and there is a clear need to improve understanding of connectivity among albacore populations across the South Pacific, and, in particular, the fishery regions in the WCPFC and IATTC convention areas. This is particularly critical if South Pacific-wide assessments are to continue. The CKMR method as a by-product can also address this uncertainty.**

136. **Despite applying the new growth data to this assessment, the modal structure in the New Zealand troll fishery size composition was still not fit adequately. Further work on growth modelling is required. It should also be noted that otolith-based growth data being used is mostly derived for otolith samples collected in 2009 -2010. Further, to update the growth information for albacore, samples from the IATTC-CA are needed. Again, samples required to address this issue could be collected as part of a CKMR project that would also include a component to develop (tissue-based) epigenetic ageing methods and sex determination. This would be a major advance in including more contemporary growth information in tuna assessments.**

137. **Follow-up studies to assess the reliability of size composition data for providing information on recruitment and population trends, and if necessary, develop better stratification methods to improve the representativeness of size composition data should be considered.**

138. **Finally, the current model is highly parameterized, and reducing model parameters and complexity should be considered to improve model fits and diagnostics. One key advancement would be the application of the "catch conditioned" approach that will be available in MULTIFAN-CL for the next assessment.**

## 3.2 WCPO sharks

### 3.2.1 Southwest Pacific blue shark (*Prionace glauca*)

#### 3.2.1.1 Review of 2021 Southwest Pacific blue shark stock assessment (Project 107)

139. P. Neubauer (Dragonfly Data Science) presented SC17-SA-WP-03 *Stock assessment of Southwest Pacific blue shark*. Blue sharks are caught in large numbers in a range of fisheries in the Southwest Pacific. Blue sharks in the Southwest Pacific are thought to make up a single stock, but an initial attempt at assessing this stock in 2016 was not successful. Here, we used a range of CPUE indices, length frequencies and predicted catch scenarios to infer stock status and trends of blue shark in this region. The stock assessment was set up in Stock Synthesis as a three-fleet model, using an approach with fleets covering: high-latitude fisheries on juveniles and adults around New Zealand and South-Eastern Australia; the EU-Spain mid-latitude fishery that operates to the north and east of New Zealand; and, a high latitude and high seas fishery capturing adult sharks. The model was run for a 26-year period from 1995 to 2020, with the start year taken to be 1995 due to highly uncertain catches prior to this period. The catches were reconstructed from observer data and were comparable to previous analyses, albeit at lower median estimated total catches. The catch

reconstruction model also produced high uncertainties in catches between the mid-1990s and early 2000s. A range of catch scenarios were applied in this assessment to reflect these uncertainties. In addition to catches, discard rates are uncertain for all but the most recent (i.e., last 5) years in the time series, as are catches from the drift net fisheries that operated in south Tasman and north-east Australian waters in the 1980s. Additional uncertainties pertain to individual CPUE time series from log-sheet data, as any individual time series is likely to suffer from changing degrees of under-reporting (although we attempted to address this problem by grooming out vessels with poor reporting records). To adequately reflect uncertainties, we ran an extensive sensitivity grid with nine grid axes, covering catch, discard, CPUE and biological assumptions, totalling over 3500 models. Across the sensitivity grid, a large majority of stock trajectories showed a decline from relatively high stock levels in 1995, reflecting increasing effort during that time, followed by a steady increase in biomass as effort plateaued and discard rates increased, especially in lower latitude fisheries. The mean outcome suggested a current stock status near $SB_0$, with a range of outcomes between 0.58 to 1.49 $SB_0$. Dynamic surplus production models provided additional support for the conclusion that the stock has likely recovered from low levels in the mid to late 2000s to levels close to the estimates of biomass under average recruitment. CPUE series, although in agreement about recent increases in the stock, were in conflict with regards to stock size (average recruitment) and, consequently, were the largest drivers of differences among sensitivity runs. Removing the EU-Spain time series or removing initial years from the New Zealand index led to lower estimates of stock status and altogether lower stock trajectories, while including all indices with equal weight led to consistently higher stock status outcomes.

140. Although the sensitivity analysis highlighted a number of uncertainties, we found a number of consistent patterns in the outcomes:

- The most influential axes of uncertainty were the weighting and inclusion of CPUE indices; high uncertainty remains in many model outputs across the sensitivity grid.
- The stock biomass was low throughout the region through the early 2000s following the expansion of longline fishing effort in the region.
- Estimates across the uncertainty grid largely indicated that the stock has recovered from lower biomass levels.
- 90% of model runs indicate that fishing mortality at the end of the assessment period was below $F_{MSY}$ and 96% of model runs show that the biomass is above $SB_{MSY}$, with high estimated spawning biomass levels near those expected under F = 0 and average recruitment across model runs, and minimum estimated SB of $0.3SB_0$.
- Fishing mortality has declined over the last decade and is currently relatively low. This is largely as a result of most sharks being released upon capture in the majority of longline fleets.
- Finally, considered against all conventional reference points the stock on average does not appear to be overfished and overfishing is not occurring.

**Discussion**

**a. Discussion on the technical aspects of the assessment**

141. The USA recognized the challenging nature of modelling the data available for blue sharks in the Southwest Pacific and applaud the authors for developing the datasets presented in SC17-SA-IP-18, stating that the ensemble approach selected for this assessment is reasonable because it represents all possible states of nature of the stock under analysis based on several sources of biological and fisheries uncertainty. However, the USA could not find sufficient diagnostics such as a retrospective analysis that could have been used to evaluate the models' performance. The USA would like to encourage SC to develop an approach to evaluate the models' plausibility in the current grid. The USA posed two questions:

(i) For the diagnostic case, the (length-frequency) data was downweighted to reduce conflicts with the CPUE, and that probably did not help the fit of length-frequency presented on Figure 19. In Figure 17, the 95% confidence interval (CI) of the observed CPUEs don't overlap with the expected values for different years. For example, for the low latitude/high sea fisheries, the model predicts much higher values, way outside the 95% CI in the last five years of the modelled time series. The USA inquired regarding the average coefficient of variation (CV) input in Stock Synthesis for each one of three CPUE time series and thoughts on the CPUE being potentially overweighed in the model. The author stated that the L-F data were down-weighted, not to resolve a conflict but because of high variability, and it is unclear how well they represent the fishery, in terms of being representative, and by year. It means that it carries very little weight in the assessment in terms of driving the biomass. It is useful to see how well the stock assessment fits the L-F once they are down-weighted, and whether a conflict is visible at that point. This is visible in the New Zealand plot of the L-F, which doesn't fit very well at that point. The authors did not explore this very much, but there is a potential further uncertainty not included in the grid (in terms of changing the frequency of those L-Fs). Regarding the fit of the CPUE: the authors did not add any process error to the CPUE time series. This is commonly done but on a fairly arbitrary basis; here we only represent the estimate error in the index. This makes the fits look pretty bad in terms of the time series.

(ii) For the diagnostic case and the vast majority of the grid runs, the population is close, at, or above pristine levels at the beginning and end of the modelled time series. The model started in 1995, so at least some level of fishing had occurred before that. The deterministic expectation is that in 1995, SB would be below $SB_0$, if F is higher than zero. So, we need to understand more about the process variation, which in Stock Synthesis is restricted to recruitment deviations. The USA could not find information on the recruitment deviation in the report, and inquired whether the authors checked the recruitment patterns over time, and if there is any evidence of a series of super recruitment years. Also inquired if the observed increase in SB is plausible given the life history of blue sharks. The author acknowledged the issue raised by the USA and stated they do not have a plot of recruitment deviation in the paper. The model can't explain these things without the recruitment deviations, and thus it estimated a series of high and low deviations to explain the decline followed by higher recruitments that drive some of the increase. A lot of the increase is explained by declines in fishing mortality. Fishing recruitment deviations are what lead the model to overshoot the theoretical unfished equilibrium over the recovery. The model needs additional recruits to explain that level of increase. When the EU time series with a rapid CPUE increase results in a lower stock status because the amount of recruitment doesn't need to be generated, it is not necessarily plausible.

(iii) The USA requested that the recruitment deviations be made available.

142. Japan noted that the assessment is much better than the prior assessment, asked the following questions:

(i) Why was the assessment model changed? the author stated that Stock Synthesis was used rather than MFCL because it was found to be easier to produce the desired results.

(ii) It is reasonable to define three fleets based on the different area coverage and L-F data of each fleet because blue shark is well known to have spatial segregation by life-history stages. Figure 12 shows there were many CPUE series candidates, but chose three CPUEs based on the logbook data. There are issues regarding area and data coverage for observer data, but the New Zealand data quality and quantity are better than other observer data in this area, and CPUE trends are similar. Why did you not use New Zealand logbook data for the CPUE at high latitude? The author replied that would have been possible to use New Zealand observer CPUE, but was not seen as necessary; the New Zealand CPUE

series and how it is handled is one of the more influential components, and including it could have been useful, but would have increased the number of grid runs.

(iii) In Figure 25 (likelihood profile), the biomass level is mainly controlled by the CPUE which is reasonable because CPUE is the primary factor in the model. In the lower left panel, there is a large conflict between low latitude/high seas CPUE and EU CPUE, while in Figure 17, there is no large conflict between them, and requested explanations. The author stated that this was largely a function of the level or scale of the increase. May also be because the low latitude seems to respond less rapidly to changes in overall catches and mortality, so the timing of the increase can lead to different outcomes. This is not a conflict in terms of the increase but how it matches, and the scale of the increase; this translates to the estimate of stock size needed to explain the patterns.

(iv) For Figure 18 regarding the fitting of length at high latitude, there are two modes, but the fitted curve is just one mode. It would be better to consider the improvement of the fitting using such as time varying selectivity or non-parametric cubic spline.

(v) The grid approach is one method to show the uncertainty in the estimation, and the combination of the grid totals over 3800. This is too much to evaluate uncertainty simultaneously with equal weighting. Japan stated that choosing the best available combinations of the biological parameters or the CPUE time series based on the model fitting is advisable; Japan suggested checking the model fitting, and comparing these, choosing the better model, and reducing the grid in the future work. Japan noted that the table in Slide 28 implies that the authors had already chosen the best available model structure and parameters subjectively.

(vi) Japan concluded by stating the methodology is more reasonable than the previous assessment and the results are consistent for any types of uncertainties.

143. Tuvalu, on behalf of FFA members, stated they note the improvements in catch reconstructions, biological information and assessment models used in this stock assessment. Due to these improvements, FFA members accept the stock assessment and the conclusions reached on the status of the stock. FFA members noted the improved status of Southwest Pacific blue shark stocks and the reference points provided in Tables 4-11. These reference points are useful as there are no established reference points for this species and they also provide insight into the types of reference points that should be considered under agenda item 4.2.1. Finally, FFA members support the recommendations made by the authors, which include additional growth, tagging and genomic studies, to mitigate against the uncertainties in the stock assessment.

144. Solomon Islands, on behalf of PNA members, thanked the authors for the assessment and the characterisation and underlying catch reconstructions, stating that these are welcome improvements on the previous attempts to assess Southwest Pacific blue sharks. PNA members noted that the broader contributions into the inputs paper (SC17-SA-IP-18) included CPUE analyses of a number of DWFN fleets from the high seas fleets and thanked them for those inputs. PNA members also noted, with appreciation, the broad range of reference point metrics reported in this assessment report as recommended by the Shark Research Plan. FFA members believe that other shark assessments should do the same because it gives a sense of the implications of the different reference points. The PNA members accept this assessment and the stock status outcomes as a basis for advice to the Commission. Finally, they agreed with the assessment recommendations, as well as Recommendations 2 and 3 from SC17-SA-IP-06 which should be reflected in the SC report.

145. SFP proposed an additional recommendation to TCC and the Commission: to review and document the quality of current and recent shark catch reporting and ensure that CMMs require future catch reporting of all shark species to be comprehensive in order to better support stock assessments and the development of management advice.

**b. Discussion on the structural uncertainty grid**

146. CCMs held a discussion regarding various approaches to weighting the models or reducing the size of the grid. In response to a query regarding whether convergence was checked among the models, the author stated that they looked at final gradient for all models, and looked to ensure a positive definite Hessian, and all models converged. Most had a small gradient, except for few runs where the gradient was larger; these were throughout the grid, and no patterns stood out as different; thus, convergence was not seen as a large concern. The author stated they did not look at retrospective patterns, noting these can be useful but hard to interpret, and while there are some metrics that can be used it is not straightforward, and not simple to go from those diagnostics to grid selection, especially when input data are not completely certain. A lack of fit does not necessarily indicate a poor model if we are unsure input data is correct.

147. USA proposed an approach to reduce the grid focusing on model diagnostics. The USA stated that good information was supplied on convergence and regarding the Hessian matrix, but additional information was desired on the goodness of fit and retrospective patterns. The USA advocated strongly to perform retrospective analysis at least on the diagnostic case, given the recent strong increase in SB.

148. Solomon Islands inquired how long would it take to construct the grid as indicated by the USA. The author indicated that running retrospective analyses against the whole grid would take more time than was available at SC17, but that a more limited analysis could be done within the current time constraints. Solomon Islands, on behalf of PNA members, agreed with the proposal by the author.

149. The EU referenced slide 41 in the presentation showing the main determinants of stock status, and suggested these could be used for this exercise.

150. Japan noted the point raised by the USA, stating that the basic concern is that the uncertainty has expanded, which is OK, but that SC had not done the normal diagnostics, even for the representative case or any of the models. Japan stated that even when using an ensemble approach, it should be possible to assess whether the models would pass normal diagnostics, and observed that having many models is not a guarantee of good results.

151. The author outlined the results of rapid analyses performed at the request of CCMs to examine diagnostics and inform reduction of the grid size using what is hopefully a principled approach. Regarding convergence of the grid models, all models were confirmed to have a positive definite Hessian, most with a small gradient; some have a higher gradient but show no unique trajectory, and they do not appear to be associated with particular outliers in the model grid. There is no suggestion that they did not converge. A stricter check on convergence for the diagnostic case applied a jitter fraction of 0.2 in Stock Synthesis, with 10 restarts of the model; all had the same likelihood. Thus, for diagnostic case the model did reach a reasonable optimum. Also, a retrospective analysis on the diagnostic case that fits to the CPUE while removing the most recent years (0-5) in steps found minimal retrospective pattern, with no large movements in one direction. Regarding recruitment deviations, more extreme trends in some parts of the grid reflect more extreme recruitment trends in the model, and not only differences in fishing and life history. There was a pattern of low recruitment in the 1990s; the model fit to the early New Zealand index and EU index was not so good. Aggregate diagnostics do not look far from normal. Regarding trimming the grid as proposed by the EU and USA, using the axes that are most influential introduces the concern that the metrics to be used must then be selected. When the number of models was reduced to 624 as proposed by the EU many show much the same result, with fewer unique trajectories. Insufficient time was available to run all the requested diagnostics. All jitter runs suggested that the global optimum was reached. Retrospectives showed no discernible patterns; the author noted it was not clear how best to report on retrospectives, which are difficult to interpret. When are retrospectives OK and should a model be rejected? Normality test

assumes data are unbiased by observer error, but indices are not "data"; they are imperfect representations of probable biomass. He asked if one should be dropped in an effort to get a better fit with normal residuals in another. The author observed that when uncertainty is mostly in the inputs, classical model diagnostic and selection tools are not useful expect to identify models that don't work. In this instance trimming has made little difference to the outcome. The author stated that it may be better to use the full grid to provide management advice, and thereby avoid unintended bias that may come through some ad hoc selection conducted with minimal time for analysis and consideration.

152. The USA noted the additional diagnostics were very helpful, and stated that these were helpful even in cases here the uncertainties were in the inputs by using the diagnostics collectively; it stated that this discussion was one that goes beyond this stock assessment. With regards to the blue shark stock assessment the USA stated that in its view the performance of the base case requires further evaluation. The model has issues in fitting the CPUE indices with strong residual patterns for the EU and high seas indices, especially in the last 5 years. That alone indicates something is not right. Recruitment deviations are largely driving the population trend. The USA stated it can't pinpoint a specific diagnostic to give a pass or fail but see that something needs to be further evaluated. It appears the model is driven by process error, and fishing has relatively little impact. The author stated that there is a misfit among the factors. The model needs to adjust recruitment to deal with the catch inputs. CPUE trends are hard to interpret on their own for each series. It is a sign that something isn't right, but not necessarily that something that is fundamentally wrong. Other model runs have far lower recruitment deviations but get similar patterns. It could be interesting to look at more extreme case with high discards, with much stronger decline in recent catches. The author noted that most of the inputs are uncertain, and that it is not clear how to fit the CPUE better, given that this is a single region model with no movement, and it is attempting to fit slightly different trends. The USA stated regarding the grid that it recognizes one cannot evaluate all the runs in the base case diagnostics. At a minimum if SB is greater than $SB_0$ it should be discarded as implausible. In the current grid $SB_0$ ranged from 10,000 to 450,000 MT, which is a large variation. It advocated a focus on model quality over quantity.

153. Japan stated it remains sceptical, and noted that there are many mis-combinations of the parameters in the structure, and given this it is unclear why most of the model converged well. The author stated that this is largely due to the fact that most parameters are fixed, and recruitment variation is allowed to absorb any process error that stems from potential model mis-specification. The models are not overly constrained, as you can use recruitment to explain away a lot of things. In some cases, you need fairly strong recruitment patterns to explain the data and the patterns the model wants to create, while in others you don't. The author stated it is hard to argue about the plausibility of recruitment patterns.

154. Japan proposed that the analyses be redone for SC18. It stated it could accept the diagnostic result for the diagnostic case, but was unsure about grid selection, and the uncertainty of the grid and convergence. It advocated giving more scrutiny to the model setting, and advocated redoing the assessment in 2022 instead of short fin mako shark.

155. SPC stated that from their perspective the work done by the authors was outstanding. Regarding the grid and its size: much of this reflects the underlying data uncertainty. Data issues include different methods and outcomes of catch reconstruction, different CPUE time series, etc. The performance of all the grid models is conditional on the data – all assume that the data is correct. SPC would not advocate reducing the grid on the basis of reducing data uncertainties, which are a fundamental aspect of the situation in the region. One cannot create certainty in the assessment where there isn't any.

156. RMI, on behalf of PNA members, noted that the assessment used both an integrated assessment and a surplus production approach, and that both approaches were largely in agreement with respect to the stock status outcomes, which gives the PNA some confidence that the very optimistic status of this assessment is a valid result. They noted that when considered against all conventional reference points, the

stock, on average, does not appear to be overfished and overfishing is not occurring. From the new analysis conducted by the authors during SC17 that conclusion remains unchanged, and PNA members are comfortable that the new grid has moved SC forward. They also agreed that trimming made little difference to the outcome, and advocated using the full grid to provide management advice to avoid unintended bias through ad-hoc grid selection. Moving forward the approach taken in this assessment is, as Japan noted yesterday, a great improvement on what was done previously and has progressed shark assessment within the WCPO substantially. The PNA stated its hope that this approach for catch reconstruction and the assessment can be utilised in future, not only on Southwest Pacific blue sharks, but also for other key shark species.

157. USA stated they need more time to explore the model and look hard at the data, and that there was a need for at least a third of the model runs to show that the population is above pristine levels. SPC stated that stock assessment doesn't say the population is above pristine levels, just that it has risen above the levels estimated under equilibrium conditions in 1995, which it is known are not pristine. The stock may have increased since then; it is unknow what pristine levels are without extensive historical reconstruction and additional data, which unfortunately does not exist. The author agreed it is not correct to interpret $B_0$ and $R_0$ as pristine; the stock was not unexploited at the start of the time series. $R_0$ and $B_0$ are conditions under average recruitment that the model can calculate; it doesn't indicate what might have been the case 50+ years ago. It would be better to have dynamic reference points, rather than $R_0$ or $B_0$.

158. CCMs discussed how to proceed in providing management advice. Some CCMs suggested adopting the outcomes of the stock assessments, while noting the caveats expressed, as there are patterns and trends that could help inform the Commission. Other CCMs proposed further work in advance of SC18 to objectively evaluate and select model runs under the current grid, and advocated against using the current results to inform management advice. As a compromise CCMs agreed to provide interim advice to the Commission while noting the need for additional analysis, which would be provided to SC18.

#### 3.2.1.2 Provision of scientific information

*Provision of information about indicators*

159. SC17 noted that in 2021, the three major CPUE time series (high-latitude fisheries around New Zealand and South-East Australia; mid-latitude EU-Spain fishery; and the high latitude and high seas Japan fishery) for blue shark in the Southwest Pacific from 1995 to 2020 indicated a consistent trend of increasing CPUE in the recent decade.

160. SC17 noted that the CPUE of low latitude/high seas Japanese fishery suggested a declining trend in biomass from relatively high values of CPUE in the 1990s, reflecting increasing effort during that time, followed by a steady increase of biomass since around 2010 as effort plateaued and discard rates increased, and returned to biomass levels estimated at the beginning of the assessment period.

161. SC17 noted that blue sharks are relatively productive with fast growth and high fecundity compared to other sharks. In addition, the population is structured spatially with smaller fish in the higher latitudes.

**a. Stock status and trends**

162. **SC17 noted that WCPFC has not yet agreed on any reference points for Southwest Pacific blue shark.**

163. **SC17 noted that Southwest Pacific blue shark assessment was undertaken using the Stock Synthesis model framework and the structural uncertainty grid approach with 9 structural**

**uncertainties (Catch, Discard, Initial-F, Rec. dev., High latitude CPUE, Low latitude CPUE, Natural mortality, survival function, growth) resulting in 3,888 models. In addition, a surplus production model was run. SC17 noted that both assessment methods produced similar results.**

164. **SC17 agreed that the assessment was an improvement on the 2016 assessment. In particular, the catch reconstruction, CPUE time series, and re-parameterization of biological parameters using combined information from south and north Pacific assessments.**

165. **SC17 noted that 90% of model runs indicated that $F_{2020}$ was below $F_{MSY}$ and 96% of model runs shows that $SB_{2020}$ was above $SB_{MSY}$. However, the model grid was not adopted by SC17 due to the views of some CCMs that a more thorough investigation of diagnostics across the grid of models was required. These CCMs recommended that residual pattern and retrospective analysis, among other approaches, would be informative, and a deeper investigation into the grid model selection and uncertainty was advised.**

166. **SC17 noted that fishing mortality has likely declined over the last decade and is currently relatively low due to the fact that most sharks are released upon capture in most longline fleets.**

167. **SC17 requested several diagnostics (i.e., CPUE's residuals, retrospective analysis, jitter analysis, and recruitment deviations) for the diagnostic case.**

168. **These diagnostics showed that the model convergence was reasonable for the models in the uncertainty grid with low maximum gradient and positive definite of hessian matrix, but the model fitting of the CPUEs and recruitment deviations were contended by some members of the SC.**

**b. Management advice and implications**

169. **SC17 noted, based on the above information, that stock biomass is likely increasing, and fishing pressure has declined through the recent decade. The results indicate that, if assessed against conventional reference points, it is likely that the stock will not be found to be overfished nor would overfishing be occurring.**

170. **SC17 recommended improving the manner in which the grid was selected before approving the results for providing management advice and proposed developing objective criteria for evaluating the plausibility of the grid. It was suggested that an attempt be made to use diagnostic tests as criteria for determining the final grid of results to inform management advice and uncertainty in the assessment. The performance of each model would be assessed against the following four criteria.**

1) **Model convergence and stability: the analysis should assess the final gradient (the final gradient should be relatively small; $<1e^{4}$), and check that the Hessian matrix is definite. Apply the jitter procedure to verify the stability of the model to evaluate whether the model has converged to a global solution rather than a local minimum.**
2) **Goodness-of-fit: evaluate whether residuals patterns of the CPUE and length-frequency distributions were normally distributed or/and had temporal trends.**
3) **Model consistency: retrospective analysis to check the consistency of model estimates, for example, the invariance in SB and F as the model is updated with new data in retrospect.**
4) **Prediction skill: hindcasting analysis could be done to evaluate the model prediction skill of the CPUE. When conducting hindcasting, a model is fitted to the first part of a time series and then projected over the period omitted in the original fit. Prediction skill can then be evaluated by comparing the predictions from the projection with the observations.**

**c. Future research recommendations**

171. **SC17 recommended that:**

1) **increased effort be made to re-construct catch histories for sharks (and other bycatch species) from a range of sources;**
2) **dynamic/non-equilibrium reference points, such as $SB_{F=0}$ be investigated for shark stock status, as they may be more appropriate for fisheries with uncertain early exploitation history and strong environmental influences;**
3) **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;**
4) **additional growth studies from a range of locations be undertaken to help build a better understanding of typical growth, as well as regional growth differences;**
5) **genetic/genomic studies be undertaken to augment the tagging work to help resolve these stock/sub-stock structure patterns;**
6) **aggregated data for key sharks are submitted as by ocean area not simply as WCPO and, where possible, these data should be retrospectively corrected; and**
7) **observers (or the vessel) should record number of shark lines deployed per set or the number of floats with shark lines.**

## 3.3 WCPO billfishes

### 3.3.1 Southwest Pacific swordfish (*Xiphias gladius*)

#### 3.3.1.1 Structural Uncertainty Grids and Projections

172. N. Ducharme-Barth presented SC17-SA-WP-05 (*Focusing on the front end: A framework for incorporating uncertainty in biological parameters in model ensembles of integrated stock assessments*). In the WCPFC, uncertainty in management reference points is derived from one of two stock assessment modelling approaches: 1) one that solely incorporates the statistical (estimation) uncertainty from a single "best" model, or 2) one that characterizes the model uncertainty across a model ensemble or structural (model) uncertainty grid. Either approach, when considered independently, is likely to under-represent the uncertainty in management reference points. However, these approaches are not mutually exclusive and can be combined to characterize uncertainty in a more holistic and transparent manner. The authors encouraged the SC to recommend that combining both the statistical and structural uncertainty across an ensemble of models be the standard approach for characterizing uncertainty for all assessed stocks under the management of the WCPFC. The authors also noted that the 2021 Southwest Pacific swordfish assessment applies this approach to a WCPFC assessment for the first time. This work also responds to concerns expressed at SC15 that approaches are needed to reduce the requirement to make subjective decisions on model weighting in structural uncertainty grids and provides a strong basis for addressing this issue (below).

173. Adopting the approach of combining statistical and structural uncertainty across an ensemble necessitates having a sound framework for developing the ensemble. The principal criticism of the structural uncertainty grid approach was that the choice of axis levels could be subjective, and that a clear approach for objectively weighting different models in the grid was lacking. The paper describes a framework for creating an ensemble that addresses both of these criticisms, and demonstrates it using the 2017 Southwest Pacific swordfish stock assessment as a case-study. This approach centers on developing a joint prior distribution for parameters that are fixed within an assessment model.

174. The authors invited the SC to:

- Recommend that the WCPFC considers adopting a standard approach for presenting uncertainty in management reference points and that the standard approach combines the statistical and structural uncertainty across an ensemble of models.
- Consider the merits of the framework outlined in this paper as a suitable approach for combining statistical and structural uncertainty across an ensemble of models for WCPFC assessments.
- Note the application of this framework in the 2021 Southwest Pacific swordfish assessment.
- Support additional research into ensemble modelling and model weighting for the provision of management advice.

**Discussion**

175. The EU commented that this could be a very useful approach that may help avoid the difficult ad-hoc decisions on weighting various parameters, which in the past were based on qualitative evaluation of the different axes, and then translated into weightings through what were to some extent arbitrary decisions. The EU encouraged CCMs to focus their comments on the general approach rather than the species used for the proof of concept. The EU inquired regarding the level of decision-making required before the stock assessment is conducted (e.g., to define the priors) and whether this should this take place through a meeting such as the PAW. SPC noted that the approach moved decision-making discussions to the PAW (or before) where decisions would be made on how to construct the joint prior and any model weights (which diagnostic to use, and how to turn that into a weight). SPC observed that because the PAW is an SPC meeting, without funding for CCMs, discussions might need to be held in SC the year before.

176. USA stated it was a solid technical contribution, and the USA supported the approach. It inquired regarding post-hoc weighting of models, stating that if neither likelihood-based weighting or computation of hindcast cross validation are feasible then expert opinion would have to be used, which is what has been used for many years in the WCPFC; this seems a practical difficulty with this approach. SPC agreed, stating that there will be such situations, but stated they sought to make some models that were problematic from a computational standpoint more tractable. It may still be necessary to rely on expert opinion to apply post hoc re-weighting, but this approach uses a weighting based on the construction of the joint prior. If constructed appropriately post hoc weighting may become unnecessary.

177. Australia gave its support to the work. Regarding Figure 9, it noted the large difference between false positive and true Hessian solutions, which could be a result of the inclusion of implausible combinations of parameters in the full factorial approach, and noted that this method appeared to be a good means to filter out those combinations. Australia also commented that in using equations to create the prior distributions this moves the discussion from the current practice of focussing on single absolute values in the uncertainty grid to a focus on the appropriate relationships to be used for the prior distributions. Australia referenced one example shown by SPC regarding the creation of the prior for adult maturity and concurred that the PAW could be an appropriate forum for such discussions.

178. Chinese Taipei stated it looked to be a useful framework, and a more objective way to create assessment results. It addressed how to establish the joint priors, and noted that how much uncertainty is included may have an important impact on the final results. It queried how joint priors should be established, and how managers could be informed. SPC confirmed that work would have to take place, either within delegations or as a stand-alone session, to make people familiar and comfortable with this approach, and stated this could be discussed. Development of the prior is flexible, and in the test case being discussed entirely data driven. The tightness in the growth curve reflects the data, but it is possible to inflate the uncertainty. If using a Bayesian analysis, you can create priors in that analysis in such a way as to inflate the uncertainty in the resulting growth estimates if this is considered desirable. One thing SPC did in the

swordfish stock assessment was to consider two types of prior for T=0, an informative one centered on 0 based on theory, and an uninformative one based on the data. This can be done to further increase the uncertainty if it is believed to exist. This assumed a single functional form for the growth curve but it can be combined in a factorial-type approach if there are additional growth curves that are believed to be plausible. There is flexibility to make the joint prior as certain or as uncertain as it needs to be. This places significant importance on the discussions regarding the priors to ensure these are created in a sound and defensible manner.

179. PNG agreed that this was a useful way to start looking at how to deal with the uncertainty grid. It inquired how the methodology would work when applied to a species such as South Pacific albacore, rather than the swordfish test case. SPC stated it would be applicable to any stock assessment. The joint prior approach won't necessarily directly address freely estimated parameters (e.g., recent recruitment). But the joint prior approach could affect the level of weighting applied to the different data components that may be driving specific aspects of recruitment. Some analyses have indicated that recent recruitments may be sensitive to different source of data. One way this approach could impact estimation of such parameters is if there was a component of the joint prior that was related to the data weight for that component. For South Pacific albacore, it is reasonable to expect that if you changed the weighting on data components using a joint prior then you could see different estimated recruitments. Including estimation uncertainty as a component would influence how well recent recruitment is addressed in any model. Including the estimated uncertainty for each model in the final ensemble would address that concern.

180. Australia voiced its support for the development of this new approach to characterise model uncertainty via ensemble modelling, stating that as seen for South Pacific albacore and as noted by Japan, a more objective approach is needed. A major issue noted in previous SCs was that the structural uncertainty grid approach can result in model runs with implausible combinations of parameters and arbitrary model weightings. The development of a joint prior is a positive step towards generating more realistic estimates of uncertainty. Australia further welcomed the inclusion of statistical estimation uncertainty into the overall representation of uncertainty. It is clear from the swordfish test case that this statistical uncertainty can be significant. Australia expects future refinements and scrutiny of the general approach will be required. It seems likely that some form of post-hoc approach to model selection may still be required if a factorial grid is retained (i.e., a hybrid factorial ensemble approach, used by SPC in the Southwest Pacific swordfish assessment). There is a need for additional work on the objective process for post hoc filtering of this grid (such as using likelihood or model diagnostics).

#### 3.3.1.2 Review of 2021 Southwest Pacific swordfish stock assessment

181. Nicholas Ducharme-Barth (SPC-OFP) presented SC17-SA-WP-04 (*Stock assessment of Southwest Pacific swordfish*), which described the 2021 stock assessment of Southwest Pacific Ocean swordfish *Xiphias gladius*. An additional four years of data were available since the previous assessment in 2017 that included data to 2015. The new assessment extends through to the end of 2019. New developments to the stock assessment include a new approach for developing a model ensemble, a more holistic representation of the uncertainty in management reference points as the model plus estimation uncertainty, updates to the biological assumptions, defining reproductive potential as a function of length, and implementation of an "index" fishery approach. The assessment is supported by the development of a new framework for developing a model ensemble and presenting the uncertainty in reference points (SC17-SA-WP-05), background analyses of biological parameters, preparation of the length-weight composition data and definition of the fisheries structures (SC17-SA-IP-07), re-analysis of tagging data to create a movement prior for the stock assessment (SC17-SA-IP-17), and a review of swordfish biology, status and stock structure in the Pacific (SC17-SA-IP-08). Key changes made in the progression from the 2017 to 2021 diagnostic case models include:

- Updating all data up to the end of 2019.

- Updating the biological assumptions, including defining reproductive potential as the product of sex-ratio and female maturity at length.
- Implementation of the "index" fishery approach.
- Adding the New Zealand index fishery and removing the Japanese and Chinese Taipei index from the diagnostic case model.
- Assuming that the population was at an unfished equilibrium at the start of the model period in 1952.

182. The assessment provides management advice on stock status from a model ensemble. A model ensemble was developed based on SC17-SA-WP-05 for consideration in developing management advice where presented uncertainty is the combination of model (structural) and estimation (statistical) uncertainty. This is a more holistic and transparent approach to presenting uncertainty than has been previously considered in other WCPFC assessments. This ensemble combined a factorial component that considered axes for DWFN CPUE scenario (x4), recruitment variability (x3), natural mortality prior type (x2), and von Bertalanffy t0 prior (x2). These factorial levels were combined with a joint prior which considered uncertainty in growth, natural mortality, steepness, reproductive potential, length-weight, movement, CPUE CV, and size composition scalar to create a full 384 model ensemble.

183. Post-hoc filtering reduced the full ensemble to a final 25 models which were used as the basis for the management advice. Post-hoc filtering included removing models where:

- Average spawning potential was greater in Region 1 than Region 2
- Spawning potential was larger in 2019 than 1952
- Spawning potential in 1952 was less than 250,000 mt
- Effort deviates were estimated to be on a parameter bound
- Selectivity parameters were estimated to be on a parameter bound
- Growth curve variability was greater than 45cm
- A positive definite Hessian solution was not achieved

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

(i) Spawning *Potential*: The model ensemble predicts the stock to have gradually declined from the 1950s to the mid-1990s before rapidly declining to an overall low point near 2010. Current stock status is estimated to be at a similar level as the overall low with a declining trend in the terminal 4 years of the model.

(ii) Depletion *($SB/SB_{F=0}$)*: The terminal depletion levels estimated by this assessment $SB_{latest}/SB_{F=0}$ median of 0.39 (0.18 - 0.79, $10^{th}$ and $90^{th}$ percentiles) with a 13% risk that the stock is below 20% $SB_{F=0}$.

(iii) *Fishing Morality and Yield*: Fishing mortality is predicted to have increased gradually across the assessment region through the mid-1990s. Fishing mortality is estimated to have sharply increased in the early-2000s and appears to have stabilized at high levels in the last decade. Recent fishing mortality is estimated to be below $F_{MSY}$ ($F_{recent}/F_{MSY}$ median 0.47; 0.25 – 1.29, $10^{th}$ and $90^{th}$ percentiles) with a 20% risk of $F_{recent}$ exceeding $F_{MSY}$. Relative to spawning potential at maximum sustainable yield (MSY) the stock is estimated to have spawning potential above the MSY level ($SB_{latest}/SB_{MSY}$ median 2.95; 0.99 – 6.78, $10^{th}$ and $90^{th}$ percentiles) with a 10% risk of $SB_{latest}$ being below $SB_{MSY}$.

185. Broadly speaking, the results from the current assessment are consistent with those from the previous stock assessment (SC13-SA-WP-13) in terms of the central tendency of estimates, albeit more uncertain. This is expected given the change in approach for presenting uncertainty. The most important factors contributing to the uncertainty around the estimated stock status are the assumptions for movement rate, and natural mortality. Choice of distant water fishing nation (DWFN) index, length frequency scalar,

and average penalty for the Australian index were also influential but to a lesser extent. Larger assumed values of natural mortality resulted in a smaller, less depleted stock. High rates of movement from the South Pacific to the Tasman region, coupled with low rates of movement in the inverse direction resulted in a larger, less depleted stock.

186. A number of key research needs were identified in undertaking the assessment that should be investigated either internally or through directed research.

- Development of a statistically robust sampling plan for the collection of fisheries dependent biological samples, including but not limited to size frequency data (by sex), and genetic samples.
- Expand minimum reporting requirements for longline operational characteristics to include *a priori* target species, light stick use, bait type, setting time (or fraction of night time soak), and gear settings that influence fishing depth (e.g. hooks between floats, branch line length, float line length, and/or line setting speed).
- Directed longitudinal genetic sampling and tagging of individuals across the Southwest Pacific (e.g. French Polynesia, Cook Islands, Kiribati, Tonga, Fiji, New Zealand, New Caledonia, and Australia) is needed to properly determine: 1) the connectivity of the high exploitation zone in the northeast of the Southwest Pacific to the rest of the Southwest Pacific, 2) if the 165◦E boundary needs revising given the genetic similarity between Australian and New Zealand individuals, 3) better estimates of movement between assessment regions given the high uncertainty in movement and the impact on management quantities.
- Improved collection of sex-specific catch and length composition to improve estimates of sex specific selectivity in a sex-disaggregated model.
- Conduct a feasibility study to see if a CKMR approach can be applied to swordfish to provide information on total population scale and natural mortality, two components of the model that have large uncertainty.

**Discussion**

**a. General discussion on the stock assessment**

187. Australia made an intervention with several comments and related questions:

(i) Whether or not to include the large catches taken in the north-east region of the assessment area (as shown in Figure 4a) has always been a source of uncertainty for this assessment; Australia noted that SPC looked into several scenarios that removed parts of these catches as shown in Figure 26. Unfortunately, the two scenarios that come closest to removing most of these NE catches gave opposing results. For example, the "*subtract 15° S*" scenario results in a less depleted stock than the diagnostic while the "*subtract 165° W*" scenario results in a more depleted stock. As such there would appear to be strong support for SPC's recommendation to conduct further research to understand the relationship and connectivity of swordfish in this northeast region with swordfish in the other parts of the Southwest Pacific.

(ii) In filtering the ensemble, it is assumed that the biomass in Region 2 should be larger than the biomass in Region 1, as the former region is considerably larger. Figure 17 indicates that the spawning biomass in Region 2 is about twice that in Region 1 for the diagnostic case. However, Figure 18a indicates that recruitment in Region 1 is around twice the recruitment in Region 2, at least for the diagnostic case. Is this inconsistent with the former assumption? If not, what might be driving it? SPC noted that the portioning in recruitment is not inconsistent with the assumption that there is greater spawning biomass in Region 2. SPC assumes a single stock-recruitment relationship for the entire stock (there do not

appear to be multiple recruitment stocks in the South Pacific). Recruitment is then partitioned between regions; this could be fixed at some value, but limited information is available to identify what level. Instead, the model is allowed to freely estimate recruitment, and partitions those recruits freely to best fit the underlying data. This does result in some models having higher recruitment in Region 1, despite spawning potential being higher in Region 2. This seems to be related to the magnitude of the movement rates, as more mixing seems to fit with a greater proportion of recruits in Region 1 than 2. In 2017, in the diagnostic case, Region 1 had fewer recruits than Region 2, but the reverse is true in 2021. SPC found that for each step in the stepwise diagnostic model development the proportion of recruitment in Region 2 was estimated to be slightly higher. There were no steps that resulted in drastically different estimates of recruitment proportions between region 1 and 2. However just looking at the first step and the last steps it looks like the recruitment proportions flipped, when in reality it was more of a gradual change. Models with higher levels of Region 1 recruitment had more movement.

(iii) Figure 20 indicates that there has been a large increase in unfished spawning potential since the late 1990s, likely due to the estimated increase in recruitment since this time as shown in Figure 18a. This increase in unfished spawning potential also coincides with the large increase in catches taken in both regions around this time. It appears possible that the assessment has generated more recruits simply to account for an increase in catches. Is it possible that the model is struggling to correctly model the early history of the fishery? Apart from catch data there are no CPUE indices to index stock biomass in the years prior to 1998. Or is there an alternate explanation? SPC stated it is important to look carefully at models that appear to have recruitment that matches increased catch and mortality, and whether increased mortality and catch are driving increased recruitment. If that was the case – where depletion was driven by an increase in recruitment to compensate for increased catches – we would expect fished biomass to be relatively constant over time. In this case the fished biomass trajectories do decline quite a bit and this matches the CPUE. If the CPUE is informative of the trend, and has some contrast and shows a decline, then the recruitment is likely not driven by the catches and mortality.

(iv) In Figure 5b, for the diagnostic case, the parameter values assumed for steepness and movement (Tasman → South Pacific) are quite different from the median. It would perhaps have been better to use the median values in the diagnostic case to make it more representative and perhaps this can be taken into account in future assessments.

188. Chinese Taipei commented regarding movement uncertainty, and noted that the selection of the EU CPUE index is also important in the current diagnostic case for the DWFN index. Looking at the sensitivity plot, current recruitment in the early time period is very flat, and variability is allowed only in the later time period. This pattern was not seen in the Japanese or Chinese Taipei CPUE indices, and these seem more consistent with each other. So why use only the EU index for the diagnostic model? SPC stated that consideredon this issue. Previous stock assessments were simultaneously fit to many DWFN indices, but when the model approach was updated, it became very hard for the model to fit to these indices simultaneously (selectivity and data fit became poor). The EU index was used in the diagnostic case because there was sufficient composition data to reliably estimate selectivity for this fishery. SPC confirmed that there are differences in the early period recruitment and in the stock status when the Japanese and Chinese Taipei indices are added to the model, and thus these indices are included in the model ensemble. The diagnostic case is used to identify if the main structural assumptions in the model are sensible. Although some assumptions with respect to steepness and movement are not necessarily centered, this is not necessarily inconsistent with the approaches taken for other stock assessments. The current diagnostic case is representative of the types of models in the ensemble. Regarding the level of recruitment in the early period, data is lacking prior to 1990, and in that case the model defaults to an estimate of recruitment close

to the stock-recruitment relationship. If Japanese or Chinese Taipei data are used (these begin prior to the EU data), then the model tracks the abundance illustrated by that data.

189. The USA made several comments and questions:

(i) It is good to see the progress on developing a sex-disaggregated model. Development of this model should continue so that it can be used for management advice in the future to better account for the significant differences in life history between male and female swordfish, specifically for growth, natural mortality and maturity, which may bias the model results.

(ii) The US has some concerns about how the life-history parameters have been estimated for this assessment. Specifically, it is unclear how the life-history parameters for the diagnostic case were pulled from the joint posteriors of the sex-aggregated parameters. For growth, natural mortality, and maturity, the USA stated that using sex-aggregated parameters may result in an underestimate of the exploited female spawning stock biomass. Work by Wang et al., 2005[6] has shown that the estimates of MSY and $SB_{MSY}$ are substantially more biased (median relative errors (MREs) of −53.8 and −75.5%, respectively) when based on the sex-aggregated estimation model. The estimates of $F_{MSY}$ are also more biased when sexual dimorphism is ignored when conducting the assessment (Wang et al 2005, p 88-89). Errors for biomass estimates have MREs that are roughly 2-fold larger when using a pooled-sex model. Errors for estimates of fishing mortalities are more similar but the pooled-sex model still has larger relative errors than the more appropriate two-gender model.

(iii) Further, the US is concerned about the calculation of the length-weight relationship. The parameters of the allometric equation used to describe the length–weight relationship in fish are usually estimated by linear regression of log-transformed data. In general, estimates of mean weight-at-length are biased low. This bias occurs because the use of the logarithmic transformation shifts the basis of the regression from the mean to the geometric mean (equivalent to the median in this case). However, it is not clear that the appropriate bias-correction factor for mean weight-at-length ($\exp(\sigma 2/2)$ where $\sigma 2$ is the residual variance of the regression) was applied in this case, which means there could be an underestimation of mean weight at length when translating catch in numbers at length to catch weight in biomass. The USA asked SPC to clarify if this bias correction was applied and if not, why? SPC stated that the length-weight relationship was estimated in a Bayesian context and back transformed in that model, with no bias transformation applied; SPC welcomed input on how this could be done.

(iv) Work should continue to better understand and define the complex stock structure of swordfish. Regarding SC17-SA-IP-12, the USA recommended that genetic sampling be continued both in the Southwest Pacific and the WCPFC area in general. Also, the stock structure for the Southwest Pacific swordfish assessment should consider these results; currently the stock is split into two regions, but movement rates are not well estimated and movement between regions is assumed to be small. As the initial genetic results indicate these are the same stock, care should be taken to ensure movement rates of future assessments take into account the apparent mixing of the two regions.

(v) The USA stated that the authors note that the Australia and New Zealand indices are in conflict and result in more pessimistic stock status when Australia is fit well and less pessimistic when New Zealand is fit well. Do the authors have reason to believe one index is more representative of the overall swordfish abundance trends? What is driving the rapid increase in CPUE in New Zealand from 2004 to 2014 as this is driving the less pessimistic outlook on stock status? SPC stated that this was discussed at the PAW, where it was

[6] S. Wang et al. 2005. Evaluation of a sex-specific age-structured assessment method for the swordfish, *Xiphias gladius*, in the North Pacific Ocean. *Fisheries Research*. 73 (2005) 79-97.

considered reliable; New Zealand considered a large number of covariates, both environmental and logbook data. SPC advised this issue was thoroughly explored in the PAW report (SC17-SA-IP-02). Regarding the increase through 2015 and subsequent decline, SPC stated that this trend is also visible in other fisheries.

190. Japan stated that the approach was a significant advancement, as illustrated by the Kobe charts, but observed that the selection or elimination process for the models, although using the ensemble approach, still appeared to rely on expert opinion; it reflected that this may be unavoidable. Japan also stated that the model uses recruitment CVs similar to those used elsewhere. In contrast, SPC (based on advice from peer reviewers) used very high CV for recruitment (such as 2) for other stock assessments. This stock assessment seems to be a departure from the SPC approach for recruitment CV. SPC agreed that the model filtering steps are subjective, and stated it is not fully satisfied with that, and is working to develop a less subjective approach. Model filtering would have been worse with a traditional factorial approach. SPC did try an alternative to the filtering, using the diagnostic-based model weighting approach. When an extreme weighting scenario was applied to select the models with the best hindcast performance, the result was similar to the that derived with the post-hoc filtering approach. SPC agreed that this CV is more in line with what others in the stock assessment community have been doing. SPC noted that recommendations from the prior bigeye stock assessment review is to allow for a low CV, or low impact of the stock-recruitment relationship on management advice and stock status when possible. If you really reduce the penalty on the stock-recruitment relationship, there is little data in the Southwest Pacific swordfish model compared to the tuna species. Assumptions made for these recruitment CVs do not appear to be as important as some other ensemble components.

191. Japan suggested that fixing the initial fishing mortality to 0 is a faulty assumption. Before 2000 there is no data for length and CPUE, but catch is also uncertain for the early period. Therefore, Japan suggested an alternative ensemble, such as a different start year (e.g., 1970s, or 1990s), because such models need to estimate the initial conditions. Japan also noted the current result includes a conflict between the data sets. Hopefully this can be addressed in the future to reduce the conflict.

192. The EU offered several comments and questions:

(i) The EU noted that it was positive that despite several significant changes, results are consistent with the previous assessment: results are slightly better in terms of stock depletion and much better in terms of MSY-related values. However, estimates are more uncertain, due to the inclusion of statistical uncertainty. The increase in the uncertainty naturally increases the chance of going beyond or below any reference point. The EU noted this may have many implications, particularly when applied to other stocks with adopted levels of risk and LRPs.

(ii) The EU remarked that in spite of the consistency with the previous assessment in the final outcomes, it seems a bit worrying than less than 7% of the models were retained. As SPC mentioned, the first two steps of the filtering make the greatest difference and mainly remove models showing more optimistic status. This seems to point to an issue elsewhere. Also, noting that 93% of the models are deemed unrealistic or do not converge, the EU noted some concerns about how representative the remaining 7% are, while noting the comment by SPC on the diagnostic-based weighting, which appears to be good news in this regard. The EU welcomed comment on this. SPC concurred that many models are removed, but observed that this had no real impact on management advice. The first 2 filtration steps had the largest impact, and this occurred because the movement rates are so uncertain. If a longitudinal tagging program is in place even a small number of additional fish tagged in the right place can lead to a better estimate of movement. Precision of movement estimates could improve a lot and movement estimates in the ensemble become much more certain, without significant tails in the distribution. If that is addressed, then

fewer models need to be filtered out and the ensemble remains larger. SPC acknowledged that this is subjective; if one takes an approach that is "more" subjective and give high weights then you tend to get to the same answer.

(iii) The EU referenced the prior query by Australia on the estimated increasing trend in unfished biomass in recent years, and inquired if it can be linked to the adjustment in recruitment expected to occur under unfished conditions and not only the recruitment estimate. SPC stated that the increase could be because of the correction in the stock-recruitment relationship. In the unfished case, any increase in recruitment above the mean level will linger longer than in the fished population. There tends to be a biomass stacking effect in the unfished population. If biomass stacking does not occur and biomass stays flat, then calculated depletion would be even more optimistic than shown. Thus, the advice is not biased optimistically.

**b. Discussion on the Southwest Pacific swordfish uncertainty grid**

193. SPC thanked the USA for its prior comment on the length-weight relationship bias correction factor, stating that it had investigated the issue and could conclude that applying the bias-correction factor would not qualitatively change the management advice in this instance. SPC's analysis indicates that applying the bias-correction factor across the model ensemble with the same post-hoc filtering criteria would result in a 2%-3% reduction in the risks to both the Southwest Pacific swordfish stock undergoing overfishing and being overfished.

194. In response to a comment from Japan regarding the challenges of evaluating the grid, the SA Theme Convener noted that SC15 and SC16 both requested better model diagnostics, which led to development of this approach. He noted his view that this is a good path forward, and asked for input on the Southwest Pacific swordfish grid.

195. Australia made several comments:

(i) It stated that it agrees with Japan that it is more difficult to discuss the uncertainty grid this year as the use of the ensemble approach to model uncertainty in the assessment has changed the inputs into the model in several ways. For example, instead of just using the fixed axes of uncertainty to change a small set of input parameters (with the others all held fixed across all models), this year we have used the same fixed axes of uncertainty for the same parameters (the factorial grid) but most of the other input parameters are now selected from a joint prior. The distribution of some of these parameter values across the full set of ensemble models down to the final set are shown Figure 50. It may be useful to compare the fixed values used in previous years with the central values of these distributions to see how the inputs have changed between this and the last assessment. Looking at the distribution for steepness in the final set of 25 models, it is seen that steepness is now centred around 0.9 and is generally >0.8, with some values greater than 0.95. So, this represents an appreciable shift from the previous axis which gave equal weight to steepness values of 0.65, 0.8 and 0.95. This shift is likely to partly explain the more positive stock status. A large part of this shift is due to the prior chosen for steepness as described on page 23 of SC17-SA-WP-04. From Table 4 it is seen that while the diagnostic case used a value of h=0.8, the median value of the beta distribution used in the ensemble of models is 0.883 with 80th percentile range being 0.771 and 0.95. So, two things are changed with the steepness values used in this assessment related to those used previously: (i) the assumed prior distribution for steepness is quite different for the (say) uniform prior assumed before between 0.65 and 0.95 – with the median for the new distribution being higher than the previous; and (ii) the filtering of the ensemble further truncates the lower values in the prior distribution, shifting the final distribution to a smaller set of higher values. So, the previous

approach used where SC approved a distinct set of parameter values used for each uncertainty axis, has in this assessment been replaced by a distribution of parameter values resulting from the analyst's decision about what are reasonable priors and filtering rules. This change makes it more difficult for the SC to identify specific axes and related values in the adopted structural uncertainty grid. Australia suggested that the place for a discussion on what priors and filters should be used in future assessments would best to undertaken at the PAW, and the conclusions of these discussions provided to the SC for consideration. SPC stated that steepness was discussed at the PAW. The choice of the steepness prior is influential, but SPC received no strong feedback on what that should be at the PAW. Subsequently it did receive feedback from a CCM on what steepness could be for Southwest Pacific swordfish, and this informed creation of the joint prior. The beta prior used in the stock assessment represents SPC's best understanding of what it should be. The former steepness values were those commonly applied for tuna species absent other data.

(ii) In relation to the use of the ad-hoc filtering to drop models from the ensemble, Australia stated that the first three filters are generally based on what can be considered biologically 'sensible' criteria while the others can be considered technical 'sensibility' criteria. It is interesting that more than half of the models in the full ensemble were dropped after applying the first filter based on a movement criterion. Australia also noted that one of the large uncertainties in the assessment model (whether or not to include the large catches in the NE-region of the assessment model) is presently not included in the 'structural uncertainty' - and inclusion or not of these catches may have influence on the filtering out of models based on what is considered biologically 'sensible' criteria (such as the use of the movement criterion mentioned above). While the connectivity/stock issue around the NE-corner catches remains unresolved, future assessments should include an axis of uncertainty around different scenarios concerning the inclusion or not of these catches in the factorial grid. Indeed, the SC discussed the need to undertake research on this issue earlier and so it has been identified as an important uncertainty. SPC noted that many models are filtered out largely due to the first filtration step, which results from the assumption that biomass in Region 1 is not larger than in Region 2. A more precise movement prior would result in many fewer models being dropped. But post hoc filtration of models can be seen as arbitrary. So SPC developed a diagnostic model-based weighting scheme, using hindcast performance prediction of CPUE. Doing that SPC gets a distribution of management quantities that are very similar to the results obtained after the filtering applied here. Finally, regarding steepness, in terms of management advice, it was not influential in estimating stock status, although it does impact yield-based reference points.

196. Australia reiterated its support for the selection done by SPC while reflecting that this made SC's job concerning selecting axes of uncertainty very hard. Australia also remarked on the use of $SB_{latest}$ vs. $SB_{recent}$. SPC clarified that in the current version of MFCL, only $SB_{latest}$ was defined, and not $SB_{recent}$, but that this would be corrected in MFCL, and in the future the full range of value managers are accustomed to could be reported.

197. The EU stated the construction of the ensemble model for Southwest Pacific swordfish follows an approach completely new to WCPFC, from the use of multinomial priors to the filtering that removes most of the models (with a clear rationale, but with the potential to bias the perception) and the inclusion of statistical uncertainty. While EU consider this as a good practice, and the way forward, it changes the way uncertainty has been treated so far in a substantial manner. This has implications for the swordfish assessment, because the outcomes of the assessment are on average more optimistic in relation to the previous one, but since the uncertainty assumed has increased there is now a 20% of models with fishing mortality falling above $F_{MSY}$. At the same time, 10% of the models indicate fishing mortality is less than

$0.25F_{MSY}$. The same occurs with the probability of the stock being overfished. There is a 10% probability the stock is overfished, but at the same time there is also a 10% probability the stock is at 7 times $SB_{MSY}$. The EU considered it is central to let the Commission understand the implications of the new approach. Telling the managers there is a 20% risk the stock is undergoing overfishing alone might be completely misleading. The EU noted the implications this approach might have for other stocks with adopted LRPs and associated levels of risk. They stated concern that this approach may not be applicable to tropical tunas in the short term. As mentioned earlier, we see this as a preferred approach, but at the same time there is the need of having consistency in the way the SC provide advice or at least clearly note when this is not happening for whatever reason. Having in mind all of the above, the EU strongly recommended having information on the risks derived when statistical uncertainty is not included.

198. The USA stated that although there were some uncertainties regarding what weighting measures are optimal, these were research question to address over time. It stated that the current stock assessment basis was sound and appropriate for proceeding on the issue of stock status and management advice. The USA referenced several sources that supported the use of steepness values of approximately 0.9 for swordfish in both the Pacific and Atlantic, and urged CCMs to take into account this information, which is based on life history parameters.

199. The EU stated it would be preferable to use the 25 models after the filtering, but with a clear explanation of the approach, and also having information on the risks that would result when not including the statistical uncertainty.

200. PNG inquired whether SPC could point to a table that illustrates the 25 models that have been retained. SPC indicated that information is in Figures 50 and 51 in the stock assessment report, and that it could provide further information in a separate file.

**c. Discussion on the Southwest Pacific swordfish management advice**

201. Australia stated it was reasonably comfortable with the 25-model grid, but with some caveats. Regarding uncertainty it preferred to include both statistical and model uncertainty.

202. SPC stated that the management advice would be based on the 25 models. As with the tuna stock assessments there are a subset of plots that are shown to representative. For the tuna stocks those are based on the diagnostic case model, and SPC would do the same for swordfish.

203. Australia stated that regarding the reference case, the new ensemble modelling framework means that the reference case may not be one of the 25 models; it is the terminal case in the sequence of changes from the last stock assessment, but perhaps not as reflective as it could be of the 25 models in the framework.

204. The USA agreed with Australia in terms of the interpretation of the ensemble model information, but noted that this is an ongoing process, and supported what SPC had suggested.

205. The EU suggested rolling over the previous management advice in light of the stock assessment results.

206. Cook Islands, on behalf of FFA members, thanked SPC for the comprehensive assessment and the suite of associated information and working papers, including the fishery characterisation paper which outlines where, when and which fleets account for the majority of fishing mortality on this stock. It is reassuring to see that the assessment is not predicting a significant decline or negative change in the status of the stock since the last assessment. However, FFA members noted a number of outcomes from the assessment that emphasise the continued importance of developing, as soon as possible, a revised and

strengthened CMM that will ensure the ongoing future sustainability of this stock. First, while median depletion is above the depletion levels associated with either $SB_{MSY}$ or with the LRP currently adopted for tunas ($20\%SB_{F=0}$), the assessment estimates a 10%-13% risk of the stock being overfished against those reference levels and a 20% risk of overfishing occurring. Secondly, after a brief period of recovery, the stock has become more depleted in recent years, consistent with declines in catch rates in recent years that have been experienced by a number of longline fleets.

207. Japan noted the EU's comments, and suggested that while the approach was a great improvement in terms of scientific aspects of the stock assessment, it could serve to confuse the Commission. The uncertainty associated with the current approach is larger, will produce a larger distribution, and thus a larger chance of exceeding the LRPs. Thus, generally the stock status is more optimistic but with a larger chance of exceeding the LRP. Japan stated this would be difficult to explain to its fisheries managers. This results in a dilemma in how to treat and present the results.

#### 3.3.1.3 Provision of scientific information

**a. Stock status and trends**

208. **The median values of relative latest (2019) spawning potential depletion ($SB_{latest}/ SB_{F=0}$), spawning potential relative to MSY ($SB_{latest}/ SB_{MSY}$) and relative recent (2015-2018) fishing mortality ($F_{recent}/F_{MSY}$) over the 25-model ensemble (Table SWO-03) were used to define Southwest Pacific swordfish stock status. The values of the upper 90$^{th}$ and lower 10$^{th}$ percentiles of the empirical distributions of relative spawning potential depletion, spawning potential relative to MSY and relative fishing mortality from the uncertainty ensemble (that included both structure and estimation uncertainty) were used to characterize the probable range of stock status.**

209. **A description of the model ensemble used to characterize uncertainty in the assessment is illustrated in Tables SWO-01 and SWO-02. Table SWO-03 shows reference points for Southwest Pacific swordfish, including the median values of relative 'latest' (2019) spawning biomass depletion ($SB_{latest}/SB_{F=0}$), spawning potential relative to spawning potential at MSY ($SB_{latest}/SB_{MSY}$), and relative recent (2015-2018) fishing mortality ($F_{recent}/F_{MSY}$) over the final 25-model ensemble used to define stock status. These values present a more holistic view of uncertainty, accounting for both model (structural) and estimation (statistical) uncertainty.**

210. **The spatial structure used in the 2021 stock assessment is shown in Figure SWO-01. Time series of total annual catch by fishing gear over the full assessment period and by regions is shown in Figure SWO-02. Estimated annual average recruitment, spawning potential, and total biomass by model region for the diagnostic case model are shown in Figure SWO-03. Estimated trends in fishing mortality rates by age and region from the diagnostic model are shown in Figure SWO-04. Time-dynamic median and percentiles of depletion ($SB_t/SB_{t,F=0}$) for the 25 models are shown in Figure SWO-05. Majuro and Kobe plots summarizing the results for each of the 25 models in the ensemble are shown in Figures SWO-06 and SWO-07, respectively.**

211. **Estimated stock status was most impacted by the uncertainties in movement and natural mortality. Low natural mortality and higher rates of movement from Region 1 into Region 2 resulted in more pessimistic stock status.**

212. **SC17 noted that the stock is estimated to have gradually declined from the 1950s to the mid-1990s before rapidly declining to an overall low point near 2010. Current stock status is estimated to be at a similar level as the overall low with a declining trend in the terminal 4 years of the model.**

213. **SC17 noted that latest spawning potential depletion levels estimated by this assessment ($SB_{latest}/SB_{F=0}$) indicated a median of 0.39 ($10^{th}$ and $90^{th}$ percentiles 0.18 - 0.79).**

214. **SC17 noted that there was 13% risk that the latest (2019) spawning potential was lower than 20% $SB/SB_{F=0}$ when considering structural + estimation uncertainty. Omitting the estimation uncertainty as was done in the previous assessment, although this is known to exist, would have resulted in an 8% risk.**

215. **SC17 noted that the stock is estimated to have spawning potential above the MSY level ($SB_{latest}/SB_{MSY}$ median 2.95; $10^{th}$ and $90^{th}$ percentiles 0.99 – 6.78) and $SB_{recent}/SB_{MSY}$ has a median value of 3.61, $10^{th}$ and $90^{th}$ percentiles 1.23–7.39.**

216. **SC17 noted that there was 10% risk that $SB_{latest}/SB_{MSY} < 1$ when considering model and estimation uncertainty. Using only model-based uncertainty would have resulted in an 4% risk.**

217. **SC17 noted that fishing mortality is predicted to have increased gradually across the assessment region through the mid-1990s. Fishing mortality is estimated to have sharply increased in the early-2000s and appears to have stabilized at high levels in the last decade.**

218. **SC17 noted that the median of relative recent fishing mortality for Southwest Pacific swordfish $F_{recent}/F_{MSY}$ is 0.47 and $10^{th}$ and $90^{th}$ percentiles are 0.25 – 1.29.**

219. **SC17 noted that there was 20% risk that $F/F_{MSY} > 1$ when considering structural + estimation uncertainty. Omitting the estimation uncertainty, as was done in the previous assessment, although this is known to exit, would not have changed the level of risk.**

**Table SWO-01**. Summary of fixed assumptions made in the final model ensemble. The minimum, maximum, median and $10^{th}$ and $90^{th}$ percentiles are given for the ensemble parameters.

| | Mean | Median | Min | 10 | 90 | Max |
|---|---|---|---|---|---|---|
| $\sigma_{Age}$ | 29.51 | 28.50 | 25.76 | 26.13 | 34.10 | 40.66 |
| $\sigma_{Length}$ | 0.39 | 0.37 | 0.18 | 0.24 | 0.60 | 0.85 |
| Steepness | 0.89 | 0.90 | 0.71 | 0.85 | 0.94 | 0.98 |
| $\alpha_{LW}$ | 0.0000130 | 0.0000131 | 0.0000117 | 0.0000121 | 0.0000139 | 0.0000154 |
| $\beta_{LW}$ | 3.00 | 3.00 | 2.97 | 2.98 | 3.01 | 3.02 |
| $k$ | 0.20 | 0.19 | 0.16 | 0.17 | 0.22 | 0.26 |
| $L_\infty$ | 241.13 | 242.02 | 228.62 | 235.17 | 248.09 | 250.59 |
| $t_0$ | -2.07 | -2.12 | -2.60 | -2.39 | -1.74 | -1.15 |
| Average $M$ | 0.27 | 0.27 | 0.11 | 0.17 | 0.35 | 0.39 |
| $L_{50}$ Female maturity | 179.85 | 179.90 | 176.78 | 177.81 | 181.62 | 182.55 |
| $Region\ 1 \rightarrow\ 2$ | 0.036 | 0.036 | 0.008 | 0.011 | 0.065 | 0.096 |
| $Region\ 2 \rightarrow\ 1$ | 0.017 | 0.015 | 0.002 | 0.006 | 0.034 | 0.044 |
| LF scalar | 33.04 | 32.00 | 20.00 | 22.00 | 46.60 | 49.00 |
| WF scalar | 30.24 | 30.00 | 11.24 | 13.40 | 45.20 | 47.76 |
| Recruitment CV | 0.52 | 0.50 | 0.29 | 0.29 | 0.71 | 0.71 |
| AU index CV | 0.46 | 0.37 | 0.11 | 0.13 | 0.78 | 0.80 |
| NZ index CV | 0.43 | 0.42 | 0.11 | 0.19 | 0.71 | 0.78 |

**Table SWO-02**. Percentage of models remaining across the ensemble (Aggregate) and for each factorial level following each post-hoc filtration step.

| | Aggregate | DWFN - EU | DWFN - JP | DWFN - TW | DWFN - None | BH CV - 0.7 | BH CV - 0.5 | BH CV - 0.3 | $t_0$ prior - Uninformative | $t_0$ prior- Informative | M prior - VB | M prior - max Age |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 40% | 32% | 46% | 40% | 41% | 44% | 36% | 39% | 33% | 46% | 40% | 40% |
| 2 | 29% | 31% | 18% | 25% | 41% | 30% | 26% | 30% | 24% | 33% | 30% | 28% |
| 3 | 28% | 31% | 18% | 24% | 41% | 30% | 26% | 30% | 24% | 32% | 30% | 27% |
| 4 | 27% | 31% | 18% | 21% | 40% | 29% | 25% | 28% | 23% | 31% | 29% | 26% |
| 5 | 14% | 20% | 5% | 5% | 27% | 16% | 14% | 13% | 18% | 11% | 15% | 14% |
| 6 | 11% | 18% | 3% | 4% | 18% | 11% | 11% | 10% | 18% | 4% | 11% | 10% |
| 7 | 7% | 13% | 2% | 2% | 9% | 9% | 4% | 7% | 12% | 1% | 6% | 7% |

**Table SWO-03**. Summary of reference points (measures of central tendency, min, max and relevant percentiles, 10$^{th}$ and 90$^{th}$) including model and estimation uncertainty from the 25 models in the final ensemble. Models were equally weighted in the ensemble. The quantity of $SB_{recent}/SB_{F=0}$ was not available from the current MFCL version due to the inclusion of both model and statistical uncertainty.

| | **Mean** | **Median** | **Min** | **10** | **90** | **Max** |
|---|---|---|---|---|---|---|
| $C_{latest}$ | 7,772 | 7,723 | 7,364 | 7,524 | 8,259 | 8,453 |
| $Y\ F_{recent}$ | 6,558 | 6,608 | 3,351 | 4,964 | 8,106 | 9,347 |
| $MSY$ | 9,922 | 9,543 | 3,869 | 5,470 | 14,738 | 22,278 |
| $F_{recent}/F_{MSY}$ | 0.67 | 0.47 | 0.16 | 0.25 | 1.29 | 2.34 |
| $SB_0$ | 83,853 | 69,390 | 16,491 | 31,472 | 145,944 | 334,518 |
| $SB_{latest}$ | 38,287 | 31,517 | 10,588 | 16,096 | 69,370 | 125,681 |
| $SB_{recent}$ | 41,916 | 38,106 | 14,975 | 18,956 | 68,550 | 99,304 |
| $SB_{MSY}$ | 12,507 | 11,480 | 2,427 | 5,212 | 21,722 | 29,297 |
| $SB_{latest}/SB_{MSY}$ | 3.7 | 2.95 | 0.44 | 0.99 | 6.78 | 18 |
| $SB_{recent}/SB_{MSY}$ | 4.1 | 3.61 | 0.64 | 1.23 | 7.39 | 16 |
| $SB_{latest}/SB_0$ | 0.59 | 0.46 | 0.1 | 0.2 | 1.09 | 2.49 |
| $SB_{latest}/SB_{F=0}$ | 0.45 | 0.39 | 0.08 | 0.18 | 0.79 | 1.42 |

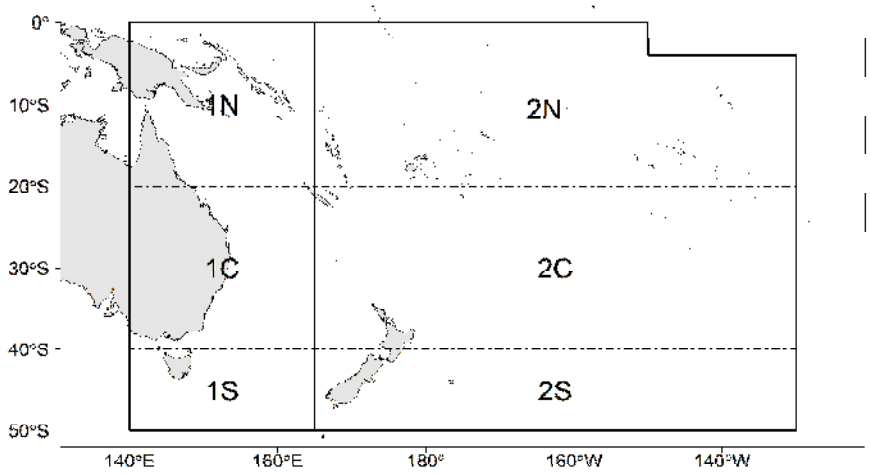


**Figure SWO-08**. Spatial structure for the 2021 Southwest Pacific swordfish stock assessment. Sub-regions used to differentiate fisheries are shown with the dotted lines.

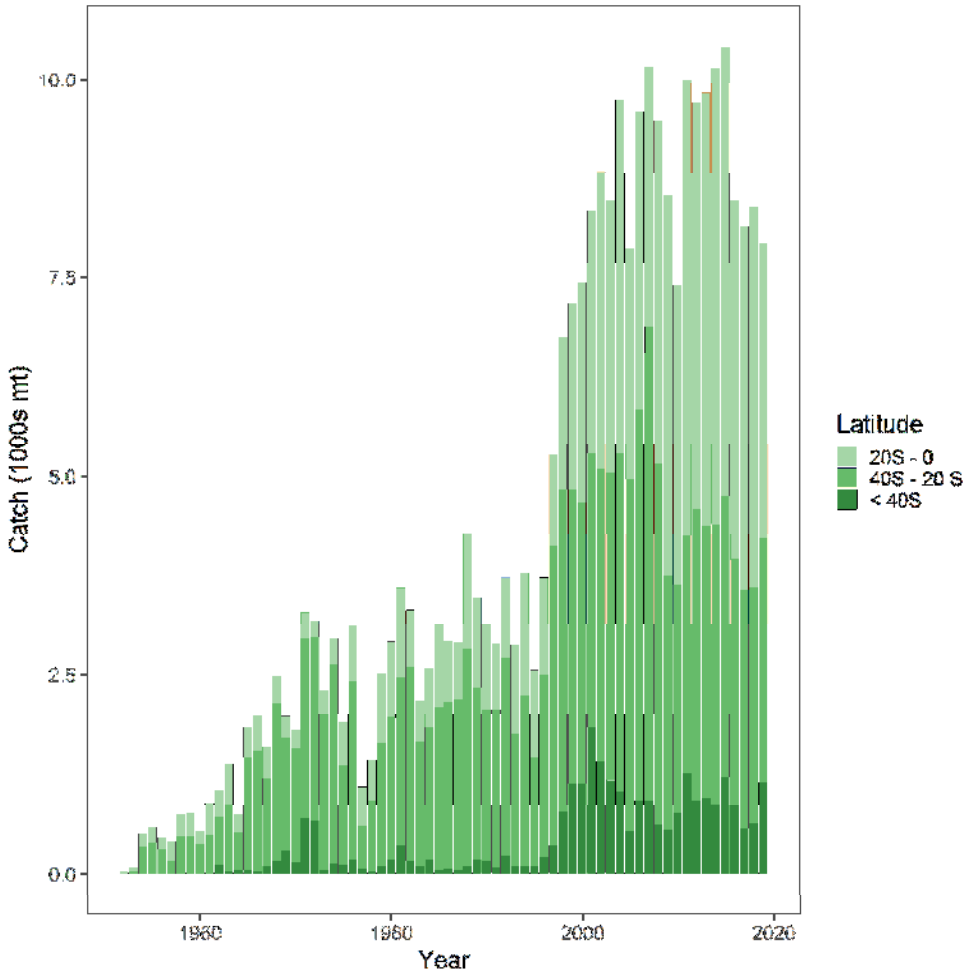


**Figure SWO-09.** Annual catch (mt) where the colors indicate latitudinal location of the catch.

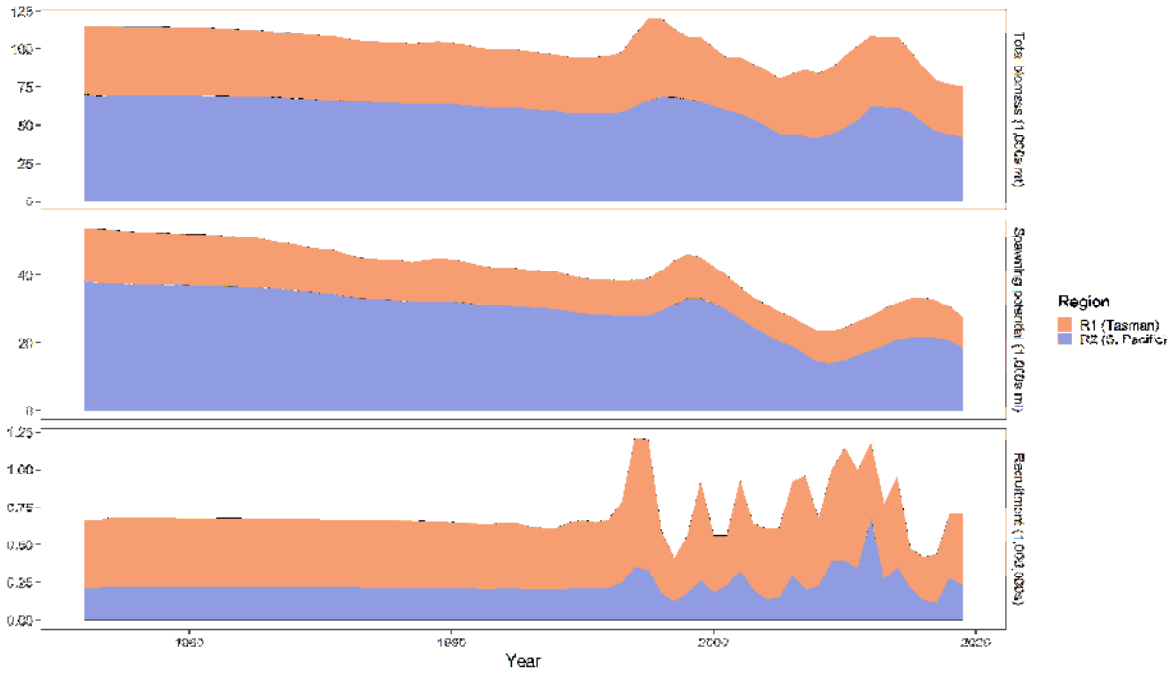


**Figure SWO-010**. Estimated total biomass (top panel), spawning potential (middle panel), and recruitment (lower panel) for the diagnostic case model. Color indicates the model region: Region 1 (orange) and Region 2 (blue).

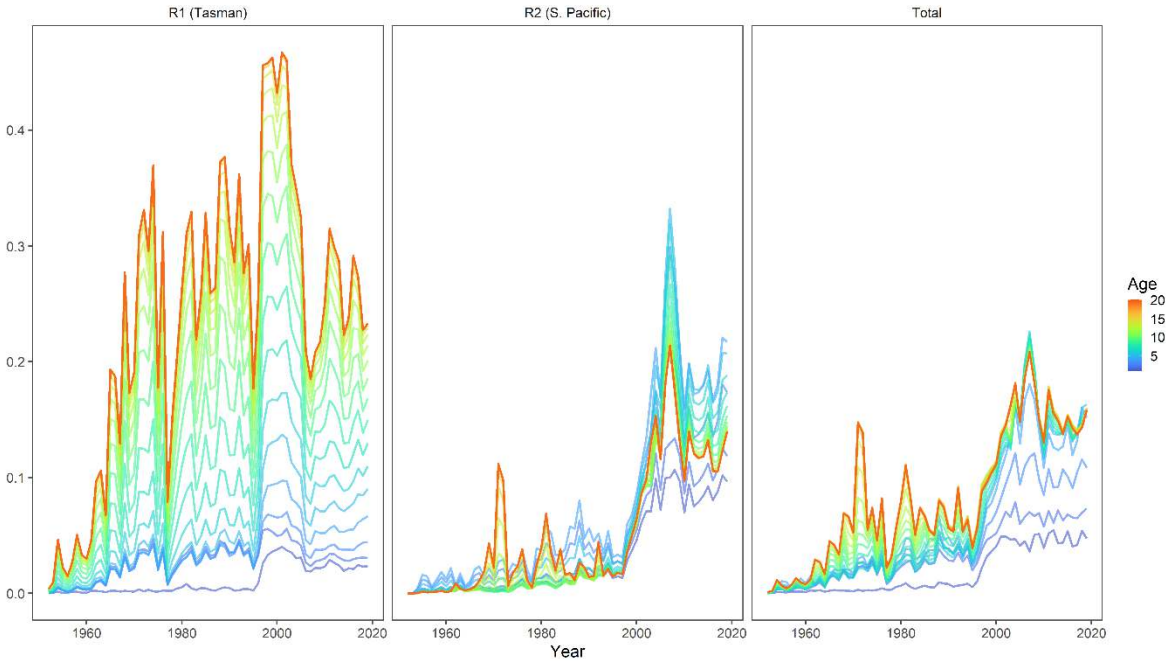


**Figure SWO-011**. Annual fishing mortality by age (color) and region (panel: Region 1 - left, Region 2 - center, and total - right).

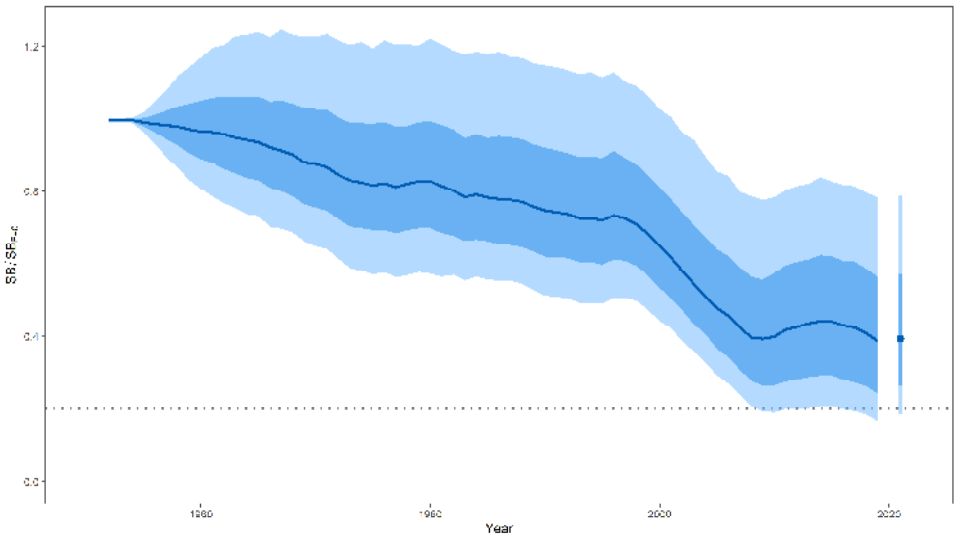


**Figure SWO-012**. Uncertainty in depletion where uncertainty is characterized as structural + estimation uncertainty. The median is showed by the dark line, the 25th-75th percentiles shown by the dark band, and the 10th-90th percentiles by the light band. The median and percentiles for total $SB_{latest}/SB_{F=0}$ are shown to the right of the Figure. For reference, the WCPFC tropical tuna LRP 20%$SB_{F=0}$ is shown with the dotted line.

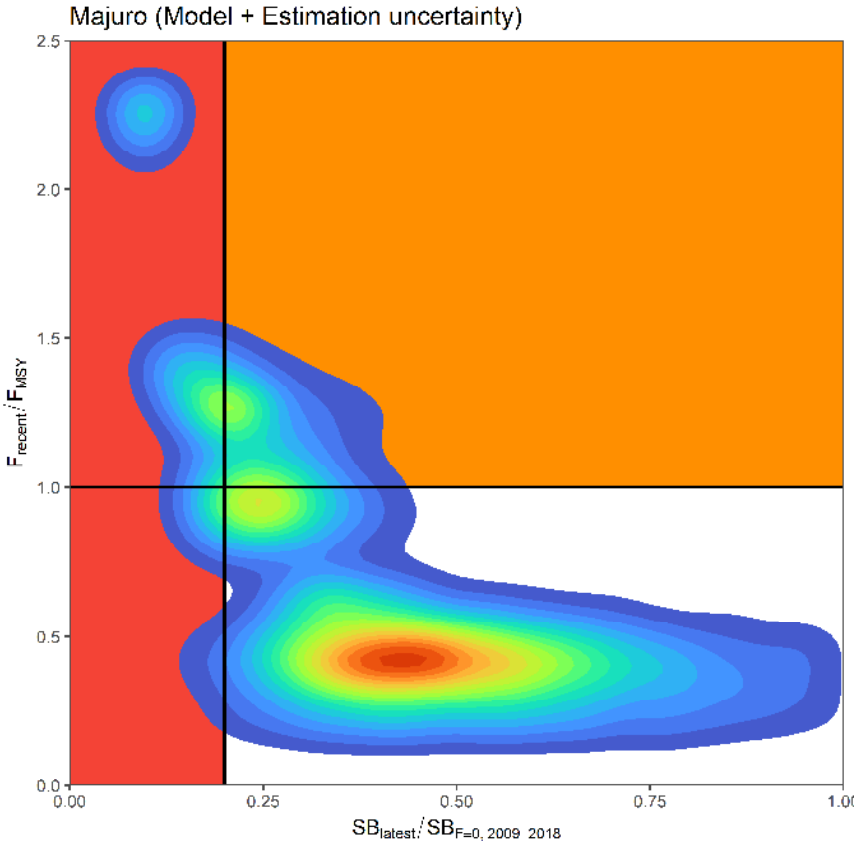


**Figure SWO-013**. Uncertainty in terminal stock status, based on the 12,500 bootstrap samples characterizing the structural + estimation uncertainty. Warmer colors indicate a greater density of samples, while cooler colors show the fringe of the distribution.

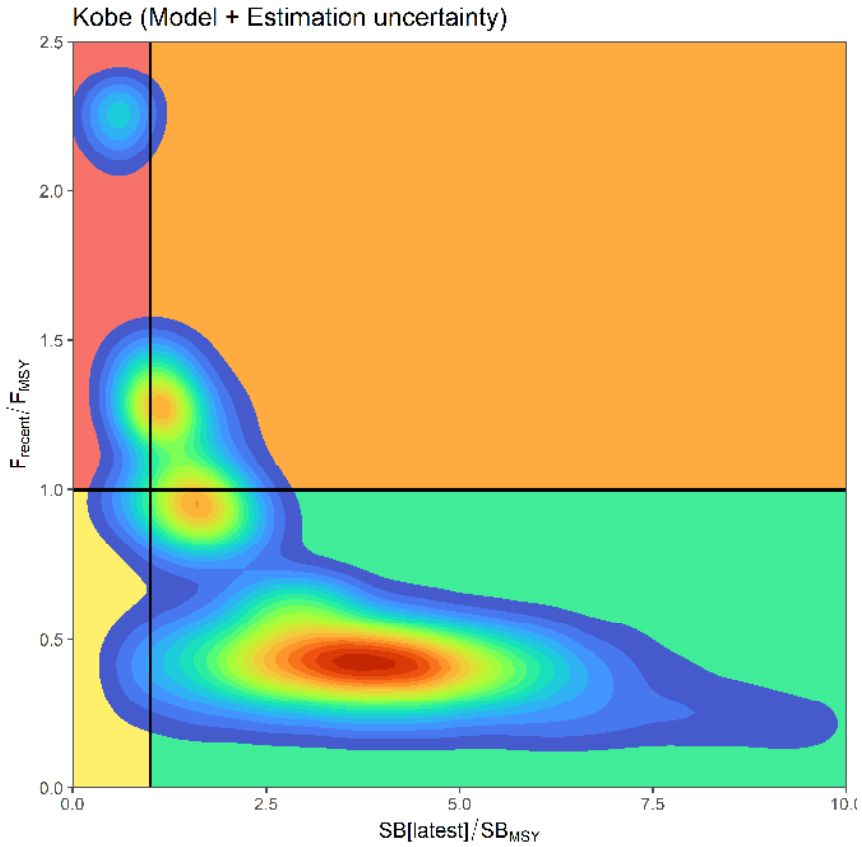


**Figure SWO-014**. Uncertainty in terminal stock status, based on the 12,500 bootstrap samples characterizing the structural + estimation uncertainty. Warmer colors indicate a greater density of samples, while cooler colors show the fringe of the distribution.

**b. Management advice and implications**

220. **Annual catch estimates for Southwest Pacific swordfish peaked at 11,128 mt in 2012 (SC17-ST-IP-01). Catch by longline vessels in 2020 was 5,373 mt compared to 5,812 mt in 2019, a decline of 7.6%.**

221. **SC17 supported the new model ensemble approach for developing management advice for this stock, noting that this approach, including the process for review of priors and decisions on post-hoc filtering rules, would continue to be refined and improved in future. SC17 also noted this new approach may result in significant changes in the level of uncertainty assumed so far. This may have implications in the perception of risks, particularly when applied to species with adopted LRPs.**

222. **The outcomes of the assessment are on average more optimistic in relation to the 2017 assessment, but the estimated uncertainty has increased. Noting that a LRP for Southwest Pacific swordfish has not yet been adopted by WCPFC, SC17 noted that the median latest Southwest Pacific swordfish spawning biomass is above both $SB_{MSY}$ and the LRP $20\%SB_{F=0}$ applied to tunas, and recent fishing mortality is below $F_{MSY}$. The stock is likely not experiencing overfishing (80% probability $F<F_{MSY}$ and 20% probability $F>F_{MSY}$) and is likely not in an overfished condition (13% probability that $SB_{latest}/SB_{MSY} < 1$ and a 10% probability that $SB_{latest}/SB_{F=0}<0.2$).**

223. **SC17 noted that the levels of fishing mortality and depletion in the diagnostic case differ between the two model regions, with fishing mortality higher in Region 1 but spawning biomass depletion greater (more depleted) in Region 2. SC17 noted that over the past two decades, the majority of catch has been taken by a combination of swordfish targeting fleets (in the area south of 20°S; 42% of catches) and fleets taking swordfish as a bycatch on the high seas (in particular in the eastern stock area north of 20°S; 34% of catches).**

224. **While SC17 advocated for the adoption of the new ensemble approach, it is nevertheless important that the Commission understand the implications of the new approach and that additional work is required to refine this approach.**

225. **SC17 noted the significant unresolved uncertainties in the assessment relating to the reliability of CPUE indices, longitudinal movements, spatial connectivity and absolute population size. These uncertainties, combined with the need to further refine and review the new ensemble approach, suggest additional caution may be appropriate when interpreting the current assessment outcomes to guide management decisions. SC17 recommended that research priorities for this stock include directed longitudinal tagging of swordfish and a feasibility study on the utility of Close Kin Mark Recapture (CKMR).**

226. **SC17 noted the current measure (CMM 2009-03) for this stock does not contain provisions to limit total fishing mortality on the stock and emphasized the continued importance of WCPFC to develop a revised and strengthened CMM that will ensure the ongoing future sustainability of the Southwest Pacific swordfish. SC17 noted that the suite of catch projections requested by WCPFC16, which are to be undertaken by the SSP post-SC17 and prior to WCPFC18, are intended to test the future likely state of the stock under a range of potential future catch or effort scenarios. This information will inform the revision of the future measure.**

227. **SC17 recommended that a number of additional projection runs be explored alongside the WCPFC16 requested projections to be presented for consideration at WCPFC18:**

1) **No change to recent catch and effort levels.**
2) **10% and 20%reduction in total swordfish catch.**

228. **SC17 noted that the current CMM does not cover catches north of 20°S. SC17 recommends that the Commission take note of the swordfish projections in framing any future CMM.**

**c. Future research recommendations**

229. **Contingent on the collection of comprehensive sex-specific catch and size composition data, SC17 recommended to continue progress on developing a sex-disaggregated model to better account for the significant differences in life history between male and female swordfish. Implementation of a sex-disaggregated model applied to comprehensive sex-specific data could reduce bias in the model results. The Scientific Services Provider however did note that lack of sex specific size composition data was a major limitation to a sex disaggregate approach that would need to be improved.**

230. **The SPC investigated the application of a length-weight relationship bias correction factor during SC17. The analysis concluded that applying the bias-correction factor would not qualitatively change the management advice in this instance as it resulted in a 2-3% reduction in the risks to both the SW swordfish stock undergoing overfishing and being overfished. The Co-Convener advocated not to change the assessment runs for SC17 and to consider the correction for the next assessment.**

231. **The following three key research needs were identified in undertaking the assessment that should be investigated either internally or through directed research.**

1) **Directed longitudinal tagging of swordfish to reduce the uncertainty in movement rates, and a feasibility study to explore applying CKMR techniques to Southwest Pacific swordfish are the two most critical research items.**
2) **Development of a statistically robust sampling plan for the collection of fisheries dependent biological samples (by sex), including but not limited to age, catch, size frequency data, and genetic samples.**
3) **In order to improve quality of abundance indices there is a need to expand minimum reporting requirements for longline operational characteristics to include: *a priori* target species, light stick use, bait type, setting time (or fraction of night-time soak), and gear settings that influence fishing depth (e.g., hooks between floats, branch line length, float line length, and/or line setting speed).**

### 3.3.2 Pacific blue marlin (*Makaira nigricans*)

#### 3.3.2.1 Review of 2021 Pacific blue marlin stock assessment

232. H. Ijima (Japan) presented SC17-SA-WP-08 (*Stock assessment report for Pacific blue marlin (Makaira Nigricans) through 2019*). The ISC Billfish working group, IATTC, and SPC scientists conducted the current benchmark stock assessment. The data set, biological parameters, model developing process, model diagnostics, sensitivity runs, future projections, model averaging, stock status, and conservation information were reported. It was also reported the answer to the requests from the WCPFC commission that was concern about the rebuilding plan for the WCNPO striped marlin stock.

**Discussion**

233. The EU commented regarding the treatment of uncertainty in the stock assessment. It has become a standard practice with an ensemble model to multiple levels with several axes of uncertainty. In this case the ensemble consists of two models, with the difference being the growth curve. There is no consideration of other uncertainties (e.g., steepness, data weighting, CPUE indices, natural mortality). WCPFC takes a different approach to uncertainty for other stocks, and the EU noted this it may impact significantly the consistency in the perception of the stock and fisheries status, and the associated provision of management advice.

234. Australia referenced the CPUE indices, and the removal of the Hawaiian CPUE-index from the assessment, as it had a strong negative correlation with the Chinese-Taipei index. However, it appears that the Hawaiian index has a relatively strong positive correlation with the late Japanese index. So there appear to be two indices displaying a decline in the later period and only one displaying an increase. Australia inquired why only the Hawaiian-index was removed (especially given that the uncertainty associated with this index appears to be smaller than the other indices) and perhaps not the Chinese-Taipei index. Furthermore, there is obviously a fair degree of conflict between the two late CPUE indices included in the model; was an assessment run with all three late CPUE indices included as a sensitivity? The author stated that they checked the correlation analyses for all CPUEs. The Japanese and Chinese Taipei indices are closely correlated, while the Hawaii index is negatively correlated, and the index model fit is very poor. If we fit to that index, it needs to be strongly weighted, and so it was dropped. The authors did not check the Hawaii longline sensitivity. Australia reiterated that the correlation between the late Japan and Chinese Taipei indices had been positive but recently were going in opposite directions, and it is the recent period that is of most concern. Chinese Taipei noted Australia's comment and referenced page 76 in SC17-SA-WP-08 where the figure is clearer and it can be seen that the series of the Japanese index is consistent with that of Chinese Taipei.

235. The USA supported continuing the work and noted the need for enhanced input data to reduce modelling uncertainty; in that context it encouraged CCMs to consider participating in the billfish sampling program to collect samples to help refine growth and other parameters and better characterize stock structure. The author noted they are planning biological sampling for three billfish species in the north Pacific, but noted that Pacific blue marlin is pan-Pacific stock, and encouraged cooperation by all CCMs.

236. New Zealand raised the issue of steepness estimation, which was 0.87 (relatively high). It noted the methods used to estimate steepness are very sensitive to quite strong assumptions about early life history such as assumptions about natural mortality (e.g., egg survival and larvae mortality). In 2019 this method was reviewed when applied to sharks and recommended that it was an interesting biological hypothesis, but the treatment of uncertainty was inadequate, and not really appropriate to use in stock assessments for management. It would be much better to use SC's standard approach of a range of steepness levels to encompass the uncertainty. Some sensitivity runs were below the steepness. Some lower steepness runs suggested that overfishing was occurring and the stock was overfished, but this uncertainty was not included in the ensemble. The author stated they tried to check the sensitivity analysis using the ensemble results, and planned to discuss this at length in the next stock assessment. It stated it has concerns about the ensemble approach for the models, and must check the model fitting for each model ensemble. Here the authors carefully checked for model fit and model diagnostics. There is also a need to carefully check each grid, especially for sensitive values such as steepness. This would be look at in the next stock assessment; there is also a need for careful model development.

#### 3.3.2.2 Provision of scientific information

**a. Stock status and trends**

237. **SC17 noted that ISC[7] provided the following conclusions on the stock status of Pacific blue marlin**:

> Stock status, biomass trends, and recruitment of Pacific blue marlin for both models in the ensemble had equal weights and similar trends, although the estimates of initial conditions are different. All reported results are the model-averaged estimates from the ensemble model unless otherwise noted.
>
> Estimates of population biomass declined until the mid-2000s, increased again until 2019, and were relatively flat until the present. The minimum spawning stock biomass is estimated to be 17,592 mt (95% C.I. 14,512-20,703 mt) in 2006 which corresponds to 5% above $SB_{MSY}$, the spawning stock biomass to produce MSY, (i.e., $SB/SB_{MSY} = 1.05$; 95% C.I. 0.70-1.01, Figure PBUM-1). In 2019, SB = 24,272 mt and the relative $SB/SB_{MSY} = 1.17$ (95% C.I. 0.87-1.51).
>
> Combined median fishing mortality on the stock (average F on ages 1-10) is currently below $F_{MSY}$ (Figure PBUM-1). It averaged roughly F = 0.13 during 2017-2019, or 40% below $F_{MSY}$, and in 2019, F=0.11 with a relative fishing mortality of $F/F_{MSY} = 0.50$ (95% C.I. 0.37-0.69). Median fishing mortality has been below $F_{MSY}$ in all years except the period 2003 to 2006.
>
> The predicted value of the spawning potential ratio (SPR, the predicted spawning output at current *F* as a fraction of unfished spawning output) is currently $SPR_{2017\text{-}2019} = 31\%$ for the average of the ensemble model, which is above the SPR required to produce MSY (17%). Recruitment was

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

relatively consistent throughout the assessment time horizon, with occasional pulses in recruitment, but no notable periods of below-average recruitment.

No target or limit reference points have been established for Pacific blue marlin under the auspices of the WCPFC. Blue marlin is expected to be highly productive due to its rapid growth and high resilience to reductions in spawning potential. Although fishing mortality has approached $F_{MSY}$ and exceeded MSY from 2003 to 2006, the biomass of the stock has remained above $SB_{MSY}$ since this time. With continued decreases in fishing effort and associated catches of Pacific blue marlin, the stock is expected to remain within MSY limits. When the status of blue marlin is evaluated relative to MSY-based reference points, the 2019 spawning stock biomass of 24,272 mt is 17% above $SB_{MSY}$ (20,677 mt, 95% C.I. -13% to +50%) and the 2017-2019 fishing mortality is 50% of $F_{MSY}$ (95% C.I. 37% to 69%). Therefore, relative to MSY-based reference points, overfishing was very likely not occurring (>90% probability) and Pacific blue marlin is likely not overfished (81% probability, Figure PBUM-2).

Deterministic stock projections were conducted with Stock Synthesis to evaluate the impact of alternative future levels of harvest intensity on female spawning stock biomass, fishing mortality, and yield for Pacific blue marlin. Future recruitment was predicted based on the stock- recruitment curve. These projections used all the multi-fleet, multi-season, size- and age- selectivity, and complexity in the assessment model to produce consistent results. The stock projections started in 2020 and continued through 2029 (10 years) under 4 levels of constant fishing mortality: (1) constant fishing mortality equal to the 2003-2005 average ($F_{2003-2005}$); (2) constant fishing mortality equal to $F_{MSY}$; (3) constant fishing mortality equal to the 2016-2018 average defined as current; and (4) constant fishing mortality equal to F30% (F30% corresponds to the fishing mortality that produces 30% of the spawning potential ratio). Stock projections for each F scenario were run for both growth models in the ensemble and combined using the multivariate lognormal method. Using the deterministic projection result, the multivariate lognormal approximation was applied to generate 10,000 trajectories of SSB and F to calculate the model-averaged results of the new and old growth models. Results showing the projected female spawning stock biomasses, fishing mortality, and the catch biomasses under each of the combined scenarios are provided in Table PBUM-3 and Figure PBUM-3.

238. **SC17 noted the following stock status from ISC:**

Based on these findings, the following information on the status of the WCNPO blue marlin stock is provided:

1) No target or limit reference points have been established for Pacific blue marlin by the WCPFC;
2) Female spawning stock biomass was estimated to be 24,241 mt in 2019, or about 17% above $SSB_{MSY}$ and 17% above $20\%SSB_0$.
3) Fishing mortality on the stock (average F, ages 1 to 10) averaged roughly F = 0.13 during 2016-2019, or about 40% below $F_{MSY}$ and 28% below $F_{20\%SSB0}$.
4) Blue marlin stock status from the ensemble model indicates that relative to MSY-based reference points, overfishing was very likely not occurring (>90% probability) and Pacific blue marlin is likely not overfished (81% probability, Figure PBUM-2).

239. **SC17 noted that this result is predicated on the use of the Japanese and Taiwanese longline CPUE indices in the assessment, and the exclusion of the Hawaii longline CPUE index, which shows a somewhat different trend (declining by about 50% from 1995-2005, then flat) to the Taiwanese CPUE index in particular. The ISC Billfish Working Group (BILLWG) doesn't believe that the**

**Hawaii longline CPUE index was representative of the Pacific-wide relative abundance of Pacific blue marlin due to the small area it represents, rather a measure of local density. In addition, the CPUE index was in conflict with both Taiwanese and Japanese indices over the same time period. Further, the decision to remove the Hawaii longline CPUE index was consistent with the model decisions made for the 2016 assessment.**

**b. Management advice and implications**

240. **SC17 noted the following conservation information from ISC**:

The Pacific blue marlin stock has produced annual yields of around 18,800 mt per year since 2015, or about 90% of the MSY catch (Table PBUM-1). Blue marlin stock status from the ensemble model indicates that the current median spawning biomass is above $SSB_{MSY}$ and that the current median fishing mortality is below $F_{MSY}$. However, uncertainty in the stock status indicates a 19% chance of Pacific blue marlin being overfished relative to $SSB_{MSY}$. Both the old and new growth models show evidence of spawning biomass being above $SSB_{MSY}$ and fishing mortality being below $F_{MSY}$ during the last 5 years. Catch biomass has been declining for the last 5 years, and therefore the stock has a low risk of experiencing overfishing or being overfished unless fishing mortality increases to above $F_{MSY}$ based upon stock projections (Table PBUM-3 and Figure PBUM-3). However, it is also important to note that retrospective analyses show that the assessment model tends to overestimate biomass and underestimate fishing mortality in recent years, in part due to rapid changes in longline CPUE.

Based on these findings, the following conservation information is provided:

1. There is no evidence of excess fishing mortality above $F_{MSY}$ ($F_{2016\text{-}2019}$ is 40% of $F_{MSY}$) or substantial depletion of spawning potential ($SSB_{2019}$ is 17% above $SSB_{MSY}$);
2. It is important to note that retrospective analyses show that the assessment model tends to overestimate spawning stock biomass in recent years; and
3. The results show that projected female spawning biomass is expected to increase under the Fstatus quo and $F_{30\%}$ harvest scenarios and decline to $SSB_{MSY}$ under the High F and $F_{MSY}$ harvest scenarios. The probability that the stock is overfished or overfishing occurring by 2029 under each harvest scenario is low.

Special Comments

1. Uncertainty regarding the choice of BUM growth curve led to the ensemble model approach for this assessment. The BILLWG recognized that there is considerable uncertainty in input CPUE data in the recent years and life history parameters, especially growth. The BILLWG considered an extensive suite of model formulations and associated diagnostics for developing the assessment models. Overall, the BILLWG found issues with both the new growth and old growth model diagnostics and sensitivity runs that are consistent with the presence of data conflicts, but none of the model diagnostics show that the results of either model were invalid. It is recommended model development work to reduce data conflicts and modeling uncertainties continue and that input assessment data be reevaluated to improve the time series.
2. It is recommended that biological sampling to improve life history parameter estimates continue to be collected and ISC countries participate in the BILLWG International Biological Sampling program to improve those estimates.

**Table PBUM-1.** Reported catch (mt) used in the stock assessment along with annual model-averaged estimates of female spawning biomass (mt), relative female spawning biomass ($SSB/SSB_{MSY}$), recruitment (thousands of age-0 fish), fishing mortality (average F, ages 1 – 10), relative fishing mortality ($F/F_{MSY}$), and spawning potential ratio (SPR) of Pacific blue marlin.

| Year | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | Mean[1] | Min[1] | Max[1] |
|---|---|---|---|---|---|---|---|---|---|---|
| **Reported Catch** | 22,166 | 23,741 | 21,861 | 22,644 | 14,443 | 18,589 | 16,503 | 18,873 | 10,882 | 26,138 |
| **Spawning Biomass** | 27,707 | 26,321 | 25,476 | 23,693 | 22,942 | 23,222 | 24,279 | 35,007 | 17,601 | 69,331 |
| **Relative Spawning Biomass** | 1.33 | 1.26 | 1.22 | 1.15 | 1.11 | 1.12 | 1.18 | 1.70 | 0.84 | 3.51 |
| **Recruitment (thousands of age 0 fish)** | 960 | 785 | 608 | 862 | 870 | 1,399 | 876 | 895 | 502 | 1,399 |
| **Fishing Mortality** | 0.18 | 0.19 | 0.19 | 0.21 | 0.13 | 0.16 | 0.11 | 0.16 | 0.08 | 0.25 |
| **Relative Fishing Mortality** | 0.81 | 0.85 | 0.83 | 0.95 | 0.58 | 0.71 | 0.50 | 0.71 | 0.35 | 1.11 |
| **Spawning Potential Ratio** | 0.26 | 0.24 | 0.25 | 0.22 | 0.33 | 0.27 | 0.34 | 0.33 | 0.17 | 0.60 |

[1]During 1971-2019

**Table PBUM-2**. Estimates of biological reference points along with estimates of fishing mortality (F), spawning stock biomass (SSB), recent average yield (C), and spawning potential ratio (SPR) of Pacific blue marlin, derived from the assessment ensemble model, where "MSY" indicates reference points based on maximum sustainable yield.

| Reference Point | Estimate |
|---|---|
| $F_{MSY}$ (age 1-10) | 0.23 |
| $F_{2019}$ (age 1-10) | 0.11 |
| $F_{20\%SSB0}$ | 0.18 |
| $SSB_{MSY}$ | 20,677 mt |
| $SSB_{2019}$ | 24,241 mt |
| $SSB_{20\%SSB0}$ | 20,729 mt |
| MSY | 24,600 mt |
| $C_{2017\text{-}2019}$ | 16,512 mt |
| $SPR_{MSY}$ | 17% |
| $SPR_{2019}$ | 34% |
| $SPR_{20\%SSB0}$ | 23% |

**Table PBUM-3**. Projected median values of Pacific blue marlin spawning stock biomass (SSB, mt) and catch (mt) under four constant fishing mortality rate (F) scenarios during 2020-2029.

| Year | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Scenario 1: F = $F_{2003-2005}$** | | | | | | | | | | |
| SSB | 25,459 | 23,462 | 21,752 | 20,498 | 19,262 | 18,689 | 18,252 | 17,835 | 17,583 | 17,475 |
| Catch | 33,111 | 30,527 | 28,638 | 27,331 | 26,431 | 25,806 | 25,363 | 25,044 | 24,811 | 24,641 |
| **Scenario 2: F = $F_{MSY}$** | | | | | | | | | | |
| SSB | 25,318 | 23,351 | 21,583 | 20,255 | 19,216 | 18,405 | 18,186 | 17,809 | 17,513 | 17,466 |
| Catch | 32,875 | 30,436 | 28,662 | 27,439 | 26,606 | 26,037 | 25,645 | 25,370 | 25,177 | 25,039 |
| **Scenario 3: F = $F_{2016-2018}$** | | | | | | | | | | |
| SSB | 26,930 | 28,182 | 28,764 | 28,675 | 28,428 | 28,731 | 28,052 | 28,142 | 27,861 | 28,081 |
| Catch | 23,321 | 23,546 | 23,591 | 23,561 | 23,513 | 23,472 | 23,443 | 23,422 | 23,407 | 23,397 |
| **Scenario 4: F = $F_{30\%}$** | | | | | | | | | | |
| SSB | 27,757 | 30,064 | 30,624 | 30,976 | 31,072 | 31,624 | 31,415 | 31,800 | 31,753 | 32,132 |
| Catch | 20,828 | 21,404 | 21,764 | 22,001 | 22,167 | 22,294 | 22,393 | 22,471 | 22,532 | 22,580 |

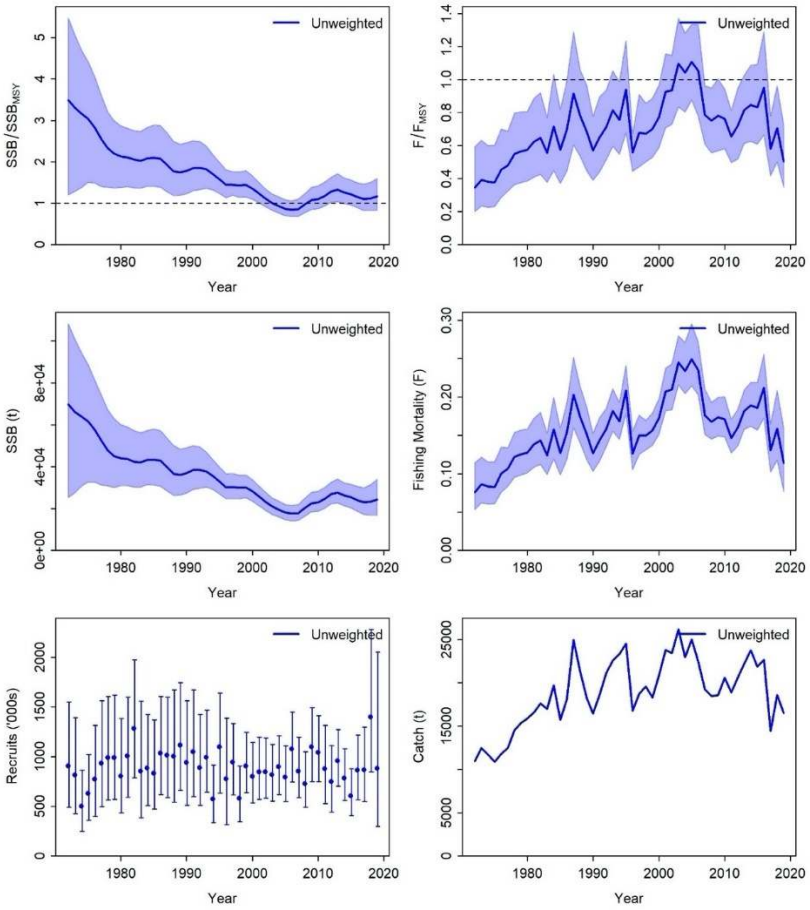


**Figure PBUM-1**. Time series of estimates of female spawning stock biomass over female spawning stock biomass at MSY (top left), fishing mortality overfishing mortality at MSY (top right), spawning stock biomass (center left), instantaneous fishing mortality (ages 1-10 $year^{-1}$, center right), recruitment (age-0 fish, bottom left), and catch (bottom right) for Pacific blue marlin (*Makaira nigricans*) derived from the 2021 stock assessment model ensemble. Lines (or points for recruitment) indicate the median value estimated from the joint multivariate delta-lognormal estimation, shaded areas (or error bars for recruitment) indicate the 95% confidence intervals. Unweighted indicates that both models have equal weights in the ensemble.

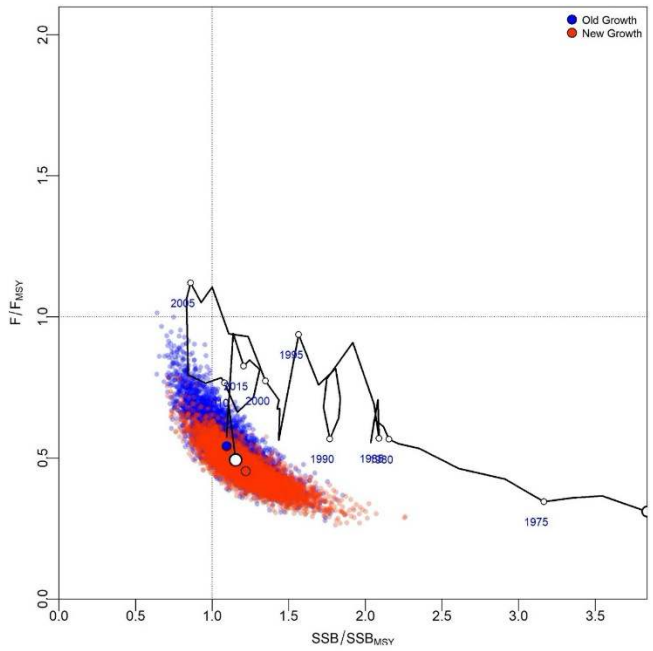


**Figure PBUM-2**. Kobe plot of the time series of estimates of relative fishing mortality (average of age 1-10) and relative spawning stock biomass of Pacific blue marlin (*Makaira nigricans*) during 1971-2019. The white circle denotes the delta-lognormal multivariate estimate of the combined models in 2019, blue dots indicate the final year stock status of the old growth model with the 10,000 multivariate draws, and red dots indicate the final year stock status of the new growth model with the 10,000 multivariate draws.

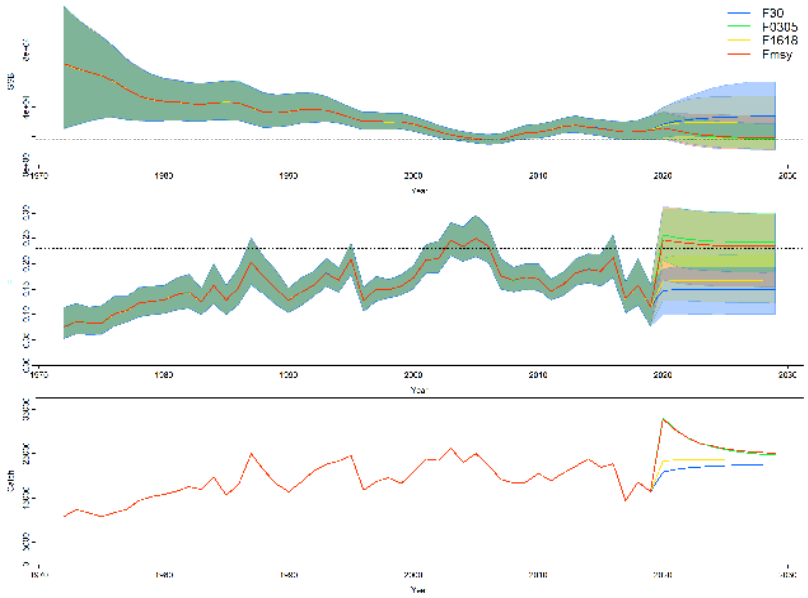


**Figure PBUM-3**. Historical and projected trajectories of spawning biomass and total catch from the Pacific blue marlin combined models based upon the four F scenarios: projected spawning biomass, dotted line indicates $SSB_{MSY}$, shading indicates 95% confidence intervals (top); projected instantaneous fishing mortality (ages 1-10 $year^{-1}$), dotted line indicates $F_{MSY}$, shading indicates 95% confidence intervals (center); and projected catch (mt. bottom). Green indicates scenario 1, $F_{2003\text{-}2005;}$ red indicates scenario 2, $F_{MSY}$; yellow indicates scenario 3, $F_{2016\text{-}2018}$; and blue indicates scenario 4, $F_{30\%}$. The list of projection scenarios can be found in Table 3.

### 3.4 Peer Review

241. Paul Hamer (SPC) introduced SC17-SA-WP-06 (*Draft terms of reference for an independent peer review of the 2020 WCPO yellowfin tuna assessment*), and updated SC17 on the arrangements to conduct the review. He stated that the 2020 yellowfin tuna assessment (SC16-SA-WP-04_Rev2) in the WCPO conducted by SPC using the MULTIFAN-CL assessment software was accepted by SC16 as the 'best available science' to inform managers of stock status. However, SPC noted that areas of uncertainty in the assessment required follow up investigation and expert advice, and that the assessment outcomes might provide an overly optimistic perception of stock status and the impact of fishing. SC16 recommended that follow-up work, including an independent peer review, was important to improve confidence in future yellowfin assessments for the WCPO. Given the similarities in model structure and data inputs, the follow-up work and peer review of the yellowfin assessment would also be relevant to the bigeye assessment (SC16-SA-WP-03_REV3). The draft TOR in SC17-SA-WPO-06 for the peer review of the yellowfin assessment will guide the external review panel in their work. Appendix 1 has the relevant extract relating to the SC16 recommendation for this peer review and suggested timelines. The TOR provide the objectives and scope for the peer review. The process for running peer reviews of WCPFC stock assessments is outlined in the WCPFC guidelines from SC12: *Process for the Independent Review of stock assessments* (Attachment K, SC12 Summary Report). Following the process for the review set up in 2016, three experts were selected by CCMs through the ranking process: Dr Mark Maunder, Dr Andre Punt, and Dr Jim Ianelli. SPC stated that it views conducting an in-person modelling workshop in real time with the experts as an essential part of the review, but that this is greatly complicated by the constraints imposed by COVID-19. To date SPC has not been able to settle on arrangements that are workable for all parties, and it may not be possible to hold the workshop in the first half of 2022 as planned, with results reported to SC18. There will be some work to report by SC18 in any event, but this may not include the in-person workshop results if the latter is delayed. SPC stated that the results could be reported through an alternative venue, such as the pre-stock assessment workshop, or through an out of session meeting or an ODF. The review does need to be concluded in sufficient time to inform the 2023 stock assessments for bigeye and yellowfin. SPC suggested that one possible solution would be to bring in the expert that was ranked 4$^{th}$ by CCMs to replace one of the top-three candidates, if that would facilitate having a timely in-person modelling workshop with the reviewers.

**Discussion**

242. FSM, on behalf of PNA members, agreed with the Terms of Reference and arrangements for the Review. PNA members supported option 2 in the report – submitting the review report sometime after SC18 for intersessional consideration, either through an 'Online Discussion Forum' or an online meeting, or potentially both, with a revised report and responses posted by the Secretariat, and a presentation of findings and recommendations at the 2023 PAW. The PNA asked the Secretariat to confirm whether the 3 persons preferred by CCMs will be available for the Review. The PNA also stated that considering SC17's deliberations on grid selection and/or weighting, it would be useful to get the review panel to comment on methods to select a grid a priori in an unbiased statistically relevant manner, rather than relying on post hoc expert opinion. PNA members recommended that this be added to the terms of reference for the review, or if necessary that an additional review panel be developed to assess methods for assessment grid selection. SPC stated that inclusion of uncertainty in the review would be specific to the yellowfin and bigeye assessments, as if this was approached more broadly it would take away from the time available for the main tasks of the yellowfin review. For that reason, a broader review of uncertainty should be undertaken as a standalone process.

243. Japan agreed with the TOR as proposed. It noted that the review would inform the 2023 stock assessments for yellowfin and bigeye, and inquired how SPC would address bigeye-specific issues such as

the recruitment regime. SPC stated that the review would examine all the input data, the modelling assumptions, and recruitment regime, in terms of how SPC considers the model estimates of historic and recent recruitment, and how much those are real or perhaps artifacts of other aspects of the modelling.

244. Australia stated it was broadly fine with the TOR as proposed, and agreed that a face-to-face meeting with the review panel and SPC is desirable, while noting the need to remain flexible should such a meeting prove impossible to arrange in time for results to be presented to SC18. In that case it stated that SC needs to be prepared to meet again for a day or 2 in a special session after the review but before the 2023 stock assessments commence in earnest.

245. The USA stated that its preference is for in-person reviews and supported having a separate evaluation of the grid structure.

246. FSM, on behalf of PNA members, stated that it recommends that an additional review panel be developed to assess methods for stock assessment grid selection, which could be undertaken after the currently scheduled review.

247. In response to a query from PNG, the Science Manager stated that if one of the three highest-ranked candidates was unable to undertake the review, the 4th-ranked candidate would take the position.

## AGENDA ITEM 4 — MANAGEMENT ISSUES THEME

248. The Management Issues (MI) theme was convened by R. Campbell (Australia), who stated that the MI Theme has two major agenda items to consider: i) development of the harvest strategy framework for key tuna species (which includes consideration of TRPs), and ii) LRPs for sharks and billfish. These topics are covered in 7 working papers and 14 information papers (4 of which were posted on the ODF). He noted some papers would not be presented in plenary and encouraged participants to provide input through the ODF. He stated that the first Harvest Strategy Workplan was developed in 2015 in accordance with CMM-2014-06. It set out a deliberately ambitious schedule of work and Commission decision making for the development of harvest strategies across the four key tuna stocks. The workplan has been updated annually to reflect actual progress as well as other needs and developments. The Harvest Strategy Workplan was subject to a substantial review by the Commission in 2019. The current Harvest Strategy Workplan (Attachment H to the WCPFC17 Summary Report) extends only as far as 2022, at which point WCPFC is scheduled to adopt management procedures for WCPO skipjack and South Pacific albacore tuna.

249. Key tasks requiring SC and Commission consideration in 2021 are to
- (i) continue development and testing of management procedures for skipjack and South Pacific albacore;
- (ii) agree to TRPs for bigeye and yellowfin tuna;
- (iii) provide advice on a TRP for skipjack and consider any potential update of the TRP for South Pacific albacore in the light of the most recent assessment; and
- (iv) continue development of the mixed fishery framework.

### 4.1 Development of the Harvest Strategy Framework for key tuna species

#### 4.1.1 Overview on the progress and updates to the harvest strategy workplan

250. Discussion on this topic was held under Agenda Item 4.1.6.

#### 4.1.2 Target reference points (TRPs)

#### 4.1.2.1 Bigeye and yellowfin tuna TRP analyses

251. Steven Hare (SPC) presented SC17-MI-WP-01 **(***Updated WCPO bigeye and yellowfin TRP evaluations*). The paper presents results of analyses requested by SC16, with further requests from WCPFC17, to assist in identifying interim target reference points (iTRPs) for WCPO bigeye and yellowfin tuna stocks. It presents the stock and fishery consequences of SC16-defined stock depletion levels ($SB/SB_{F=0}$) consistent with specified historical conditions and stock risk levels. For each depletion level (computed at the end of the 30-year projection period in 2048), results presented are: changes in biomass from both 2012–2015 and recent (2015–2018 average) levels, changes in fishing from baseline (2016–2018 average) levels, median equilibrium yield (as a proportion of MSY), risk relative to the agreed limit reference point, SC16-requested per-recruit metrics, and the equivalent depletion level for skipjack and either yellowfin (for bigeye iTRP levels) or bigeye (for yellowfin iTRP levels). Under baseline fishing conditions (i.e., catch/effort projected at 2016-2018 levels) and both the short- and long-term recruitment scenarios, the 2048 depletion level of bigeye was higher than both 2012-2015 and 2015-2018 levels. Yellowfin depletion was the same as the 2015-2018 level and higher than the 2012-2015 level, while skipjack was about the same as the 2015-2018 level and somewhat below the 2012-2015 level. Risk of the spawning biomass being below the limit reference point was 5% for the bigeye long-term recruitment scenario and nil for long-term bigeye and yellowfin. To achieve the 2012-2015 depletion levels, fishing effort/catch would be increased by either 22% (long term) or 35% (short-term) for bigeye, and by 29% for yellowfin. To achieve iTRPs +/- 10% of 2012-2015 depletion levels, fishing levels would need to be a bit high/lower. Risk that the LRP would be breached was low (0%-14%) for either bigeye recruitment scenario and nil for yellowfin. To achieve the 2000-2004 level of depletion, fishing would be cut by either 15% (long term) or 4% (short term) for bigeye, but increased by 34% for yellowfin, with little risk of breaching the LRP for any of the scenarios. To achieve an iTRP with a 10% risk of breaching the LRP, fishing would be increased by 12% (long term) or 55% (short term) for bigeye and by 200% for yellowfin. The equivalent depletion for the other stocks under the 10% (and especially the 20%) LRP scenarios was considerably greater than under the specified iTRP scenarios. SPC noted that the 2020 yellowfin stock assessment implied a more robust stock than estimated previously, and an upcoming review of that assessment may lead to changes in the perception of stock status and robustness.

**Discussion**

252. In response to a query from the USA, SPC noted that WCPFC-TTMW1-2021-02_rev1 includes a 0.5–2.0 scalar for longline/purse seine and provides resulting depletion and risk of breaching the LRP.

253. Japan observed that this analysis was an important input for the Commission, and that the most important aspect is that this be understood by the commissioners, which requires that it be presented with that in mind. Japan noted the difficulty in understanding some of the summary tables (e.g., the depletion level for bigeye and skipjack), which are expressed in %, and suggested it could be useful to have the probability of breaching the LRP for each row of the table. Japan expressed concerns regarding setting a TRP based on LRP risk, because this risk can change drastically based on the stock assessment model structure, especially the uncertainty assumptions. If the method used for Southwest Pacific swordfish is employed, then the probability of breaching the LRP could be very different. The author stated they had received concerns regarding the complexity of the tables and welcomed suggestions on how to make them more understandable. SPC noted that changes to risk levels are based on the current uncertainty framework, and may underestimate future uncertainty.

254. Vanuatu, on behalf of FFA members, thanked SPC for the updated WCPO bigeye and yellowfin TRP evaluations and noted the 2020 yellowfin tuna stock assessment implies a more robust stock than estimated previously. They acknowledged that due to uncertainty in the stock assessment an external review

is planned for 2022, and further work is underway that may lead to changes in the perception of stock status and robustness. However, FFA members stated the updates facilitate improved understanding of multi-species implications of alternative harvest levels, and illustrate the resultant depletion levels for skipjack and yellowfin tuna (under bigeye TRP calculations), and for skipjack and bigeye tuna (under yellowfin TRP calculations), which will greatly aid in considering candidate TRPs for bigeye and yellowfin tuna. FFA members noted South Pacific albacore is not included in the TRP evaluations, and inquired whether SPC could update the report and include South Pacific albacore in future evaluations to help inform discussions on possible TRPs for bigeye and yellowfin tuna. SPC stated this probably should be raised at the Commission level, noting that technically there are challenges, because there is a need to make assumptions about what is happening outside the tropical areas in terms of effort and mortality. This can be considered through a multispecies MSE.

255. Kiribati, on behalf of PNA members, supported the FFA statement, considered that the analysis in the paper accurately reflects the original request made by SC16, and the request by the Commission for additional information. Members found the new information on the multi-species implications of the different candidate TRP levels valuable, and supported forwarding this paper to the Commission; they stated it could also be useful for TTMW2.

256. Pew noted the assumptions (e.g., no effort creep, directly proportional scalars, no targeting shifts in longline), which are influential, and inquired whether as more facets are introduced into the stock assessment the uncertainty increases with each additional assumption. SPC stated that results may be somewhat more reliable if more aspects of the analysis are specified. Running the models requires making some assumptions; the harvest strategy approach has an advantage in that information can be updated, while uncertainty is captured in the models.

257. Cook Islands inquired whether it would be feasible to have a South Pacific albacore equivalent column in the bigeye paper. SPC stated this is similar to the question from Vanuatu. There are some challenges in doing that but SPC stated it would try if this was requested by the Commission. The Cook Islands noted its interest in exploring the relationships and stated it would like this to be considered for South Pacific albacore.

258. The EU noted the importance of how uncertainty is treated, and agreed it is good practice to show statistical uncertainty, but that it is important to understand what it implies. The EU stated that for the Southwest Pacific swordfish stock assessment it would request that SPC include results without the statistical uncertainty.

**Recommendations**

259. **Noting the request from WCPFC17 to review any updated information on TRPs for bigeye and yellowfin tuna, SC17 reviewed SC17-MI-WP-01 (*Updated WCPO bigeye and yellowfin TRP evaluations*).**

260. **SC17 noted that these analyses 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.**

261. **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.**

262. **SC17 noted that the analyses will greatly aid in considering candidate TRPs for bigeye and yellowfin tuna.**

263. **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.**

264. **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.**

265. **SC17 noted that South Pacific albacore had not been included in the TRP evaluations and asked the Scientific Services Provider (SSP) to update this report to include South Pacific albacore in future evaluations.**

#### 4.1.2.2 Skipjack tuna TRP analyses

266. G. Pilling (SPC) presented SC17-MI-WP-02 (*Further updates to WCPO skipjack tuna projected stock status to inform consideration of an updated target reference point*). The paper provides results of specific analyses as requested by WCPFC16, SC16, WCPFC17 and TTMW1, in particular examining a wider range of candidate revised interim skipjack TRPs from 36% to 50% of $SB/SB_{F=0}$ based upon the agreed 2019 skipjack stock assessment and presenting for SC discussion, fishing mortality-at-age outputs as requested by TTMW1. Other WCPFC16 requested information is maintained in an annex.

267. Under baseline (2012) fishing levels the stock is predicted, on average, to fall slightly compared to 'recent' (2015-2018) levels (44% $SB_{F=0}$), to 42% $SB_{F=0}$. This is very slightly below 2012 depletion levels but is an equivalent % $SB_{F=0}$ value at 2 decimal places. Examining the four other median depletion levels requested by WCPFC16 (50%, 48%, 46% and 44% $SB_{F=0}$), these levels imply reductions in purse seine effort from 2012 levels of 7 to 25%, lead to predicted increases in spawning biomass from 2012 levels of between 3 and 18%, and either maintained biomass at recent assessed levels, or predict an increase in biomass by 5 to 13%. Total equilibrium yield is predicted to reduce compared to that under 2012 'baseline' levels, to 78-95% of MSY. For the three median depletion levels requested by WCPFC17 (36%, 38% and 40% $SB_{F=0}$), these levels imply increases in purse seine effort from 2012 levels of between 5 and 30%, and lead to predicted decreases in spawning biomass from 2012 levels of between 5 and 14%. Total equilibrium yield is predicted to increase very slightly compared to that under 2012 'baseline' levels, to 98% of MSY (reaching the flatter peak of the yield curve). There was no risk of falling below the LRP associated with any of these depletion levels based on the current uncertainty framework.

268. Addressing TTMW1's request for estimated fishing mortality under each candidate depletion level, resulting stock-wide age-averaged F for juvenile and adult components of the population and median fishing mortality-at-age are presented. Interpretation of the results is challenging given that future fishing mortality is strongly influenced by the required settings within the projection, in particular that future domestic fishery and pole-and-line catches continue at set levels (2016-2018 and 2012 respectively), while purse seine is projected on effort. The composition of gears within the projected fishery and their impacts on the stock will therefore change relative to that in the historical (2012) period. This is clear when examining the relative change in fishing mortality in juvenile and adult segments of the population, with that on juveniles increasing notably at all examined depletion levels. This was driven by significant increases in fishing mortality within Region 5 of the skipjack assessment model (western tropical WCPO

encompassing Indonesia and Philippines), where future domestic fishery catches continue at 2016-2018 levels.

**Discussion**

269. The EU commented on the implication of the selection of depletion level, and asked SPC to comment how levels of purse seine effort in 2012 compared to recent levels and how any change affected the results, noting this would be useful to understand the implication of each TRP. SPC stated it would provide that information to TTMW2. The recent 2019 level is about 8% lower than 2012; there have been year-to-year changes in the fishery, effort in 2020 was relatively high.

270. Indonesia posed the following questions to SPC:

(i) Please explain what is included in the 42% $SB_{F=0}$ depletion level: is this a pool of all catches from all gear, can we identify which gears contribute the most to this figure? Many gear types operate in this area. SPC stated that it can work out the different levels by gear in the analyses in Region 5. The data come from CCM's annual catch estimates.

(ii) Indonesia stated this it is important to know the gears contributing to the catch, specifically juveniles, as this is related to the advice that is given to managers, and asked if it is possible to track the impact of a specific fishery. SPC stated it would look at this issue and add this to the paper for TTMW2.

(iii) Indonesia asked if the age shown on the x-axis in Figure 4 is based on model estimates or on biological information. SPC stated this corresponds to modelled skipjack age quarters; thus 15 is in quarters. The information in the stock assessment model is based on the biological sampling undertaken within the region. The growth is estimated in the model and based on size data from sampling in the region. Thus, the outputs used in Figure 4 are based on sampling and biology.

271. USA reiterated a request from SC16 to receive curves for yield and spawning biomass per recruit by fisheries sector to better see and understand the trade-offs by sector (longline, purse seine, and others) for species. In response to queries by SPC, the USA stated it would provide examples of what it was requesting.

272. Cook Islands, on behalf of FFA members, acknowledged and thanked the SPC for the analysis as FFA members had requested an evaluation of some of these candidate TRPs, stating that information was now available to analyse the candidate TRPs of 36%-50%. The preferred position for FFA members is to adopt a skipjack TRP that is consistent with the intent of the previous interim TRP and maintain spawning biomass at the 2012 levels, on average, with effort across the fishery maintained at a level consistent with the level of purse seine fishing effort for skipjack tuna in 2012. Regarding fishing mortality, FFA members expressed concern because SPC has noted the challenges to interpreting future fishing mortality. FFA members proposed that SC consider how the fishing mortality estimated within the analysis is driven by the assumptions, particularly regarding catch in the small gear fisheries of the western Pacific.

273. Pew noted a leftward shift in the curve for 2048 and inquired regarding the cause, and why this is not shown in the 42% scenario by region. SPC stated that patterns detected are actually a weighted average across all the different regions, and thus will not be apparent in individual regions.

274. Kiribati, on behalf of PNA members, supported the FFA statement. They stated that the paper accurately responds to the request from the Commission for additional analysis, and they would look carefully at the results in conjunction with FFA members. In reviewing additional skipjack TRP options, the PNA will be looking at taking into account two factors: i) the impact of increased skipjack catches by

Indonesia, Philippines and Vietnam; and ii) the potential impact from further easing of measures in the Tropical Tuna CMM that would increase purse seine effort and skipjack catches. They thanked SPC for including the previous advice to the Commission in Annex 3 on the formulation of a skipjack TRP, stated that in their view this advice remains valuable.

275. The EU noted that as requested SPC has provided information on the impact of target TRPs on the spawning biomass over different baseline periods. Noting that the rationale for these different baseline periods is not entirely clear, they encouraged CCMs to provide this information at TTMW2.

**Recommendations**

276. **Noting the request from WCPFC17 to review the updated information provided by the SSP on the performance of candidate TRPs and provide advice to the Commission for its potential update of the skipjack TRP, SC17 reviewed SC17-MI-WP-02 (*Further updates to WCPO skipjack tuna projected stock status to inform consideration of an updated target reference poin*t).**

277. **SC17 noted the challenges outlined in the paper on interpreting future fishing mortality and several CCMs proposed that additional analyses should be undertaken to consider how the fishing mortality estimated within the analysis is driven by the assumptions, particularly the contributions of the different gear types to the catch in Region 5. To better understand the importance of each sector, one CCM also requested yield or spawning biomass per-recruit curves by fishing sector be added to the paper.**

278. **SC17 recommended forwarding this working paper, and any updates, to the Commission and that the results be taken into account at the next Tropical Tuna Measure Workshop (TTMW2).**

### 4.1.3 Review of the overall harvest strategy work

279. The MI Theme Convener stated that substantial technical progress towards the development of harvest strategies was made during 2020, specifically with regard to the development of candidate harvest control rule (HCR) designs for both skipjack and South Pacific albacore; accounting for uncertainties in the MSE frameworks; development of an efficient estimation model for skipjack; calculation of performance indicators for the skipjack monitoring strategy and communication of MSE results for decision makers. However, SC16 was unable to discuss much of this work in part due to time restrictions of the online meeting format due to COVID-19. As such SC16 was unable to provide advice to WCPFC17 on a number of issues to guide the direction of further development of the harvest strategy approach. During both SC16 and WCPFC17 many members also noted the need for further capacity building to better understand how harvest strategies function and their implications. SC16 did however note progress on the Harvest Strategy Workplan and recommended that with further input from CCMs during the upcoming year that adoption of the operating models (OMs) for both skipjack and South Pacific albacore could be undertaken at SC17 with the review of a final suite of management procedures to be undertaken by SC18.

280. Rob Scott (SPC) presented SC17-MI-WP-03 (*Harvest strategy technical work: progress summary*), an overview of recent progress in the technical development of harvest strategies for WCPFC stocks and fisheries, focussing on WCPO skipjack, bigeye and yellowfin tuna and South Pacific albacore tuna. The modelling and evaluation framework for skipjack is well advanced and the results of evaluations of a range of candidate management procedures are presented to this meeting (SC17-MI-WP-04). Ongoing work for skipjack includes refining the monitoring strategy, and further developing elements of the robustness set. The evaluation framework for South Pacific albacore is fully operational and has been used to evaluate a number of exploratory management procedures having empirical HCRs. Recent work has focussed on the simulation of future CPUE by the OMs which will be a critical component of the evaluation

framework for South Pacific albacore. The results (SC17-MI-IP-01) indicate that for some fisheries and in some regions, simulated CPUE can be used to test empirical HCRs. However, model-based approaches may be more successful and the next phase of work will be to design and test a range of management procedures that use relatively simple biomass dynamic models to estimate stock status. Preliminary trials of the mixed fishery framework (SC17-MI-WP-05), for a simplified scenario, indicate the conceptual approach is tractable. Further work will include the conditioning of OMs for both bigeye and yellowfin; the development of management procedures for bigeye and the development of mixed fishery performance indicators. Development of the single species evaluation frameworks is broadly keeping pace with the WCPFC harvest strategy workplan, however, full development of the mixed fishery framework is expected to take longer.

**Discussion**

281. Indonesia inquired whether given the challenges of determining purse seine CPUE, the use of purse seine CPUE is due to limited pole-and-line data. It also asked whether the model-based approach requires abundance data or is it included in the model as a source of uncertainty. SPC noted the shortcomings with various data sources that could be used to estimate CPUE; although purse seine CPUE may be more difficult to interpret, SPC was concerned with the decline in pole-and-line effort, especially in some regions, which reduced its utility as an index of stock status. SPC has used a model-based approach for skipjack evaluation to date, based on the 2019 stock assessment; purse seine is disaggregated into free-school and FAD fisheries.

282. Tonga, on behalf of FFA members, stated they are very committed to the successful implementation of the Harvest Strategy Workplan and noted the progress so far, and supported extension of the Harvest Strategy Workplan past the current end year of 2022. FFA members continued to encourage a focus on capacity building workshops among CCMs, particularly for SIDS, on understanding of harvest strategy functioning and implications. Building capacity will assist all CCMs to participate fully in this complex process and have the confidence in the harvest strategy development process and its outcomes when implemented. FFA members stated they look forward to the continuation of these workshops, which are an essential precursor to the effective participation of all CCMs in any future 'science-management' dialogue. FFA encouraged CCMs to use the web-based tools such as PIMPLE to explore and compare the performance of alternative candidate management procedures and provide feedback back to SPC.

283. Japan commented regarding the overall WCPFC MSE process. The ideal of MSE is advertised as inclusiveness of the process for stakeholders, but Japan noted a lack of clarity regarding how the discussion and in particular the scientific aspects of the MSE are planned or scheduled. Japan raised several questions: whether an OM was to be adopted; when a proper discussion and review of the model would be held, when it would be formally adopted; and when candidate management measures would be reviewed and presented to the Commission. It noted the ODF discussions, but expressed uncertainty over the formal process of the MSE. The MI Theme Convener stated that the prior intention (expressed in 2020) had been for SC17 to be in a position to formally adopt the OM, and asked SPC to address the issue. SPC stated it was not working to a strict schedule with regard to finalizing OMs. SPC stated it produced the Hierophant online tool to allow people to interrogate all the models, results and diagnostics (this was presented at SC16). The outcome of the discussion at SC16 was to have further discussion and engagement, but this has proven difficult given COVID-19 situation. SPC stated it was up to CCMs to determine how this would evolve.

284. The MI Theme Convener stated that as development progressed at some point the SC would have to approve development of the OM because that is what will be used to develop the management procedures.

285. Chinese Taipei raised two issues:

(i) Regarding South Pacific albacore, in the CPUE-based HCR work there is an indication of an issue of retrospective patterns, and model underestimates given less data. What happens when more data comes into the model – will it estimate higher biomass? And what might cause this type of retrospective pattern? SPC stated it was seeking to determine what drives the retrospective pattern, which is most marked in terms of adult biomass, and would be an input into potential management procedures. It is less pronounced in depletion, and the TRP is expressed in terms of depletion.

(ii) Chinese Taipei inquired regarding the rationale of using a simple model for model-based approaches to determine CPUE for HCRs, given that this is a complicated fishery, extending across two convention areas. How can a simple arrangement fit in? SPC stated that the discussions on the South Pacific albacore stock assessment at SC17 and around CPUE generation indicate how hard it is to use these data reliably and to simulate future data; SPC is trying to move to a simplified stock assessment model, but testing work has yet to be completed.

286. Australia remarked regarding South Pacific albacore that SPC noted the potential to update the OM after the stock assessment was accepted, but suggested inclusion of the EPO may complicate this. It supported the use of model-based approaches for harvest control rules, given the complexities identified. A production model would be one approach; for skipjack it is a simplified MFCL – could this work for South Pacific albacore? SPC stated this might be possible. It takes longer to evaluate, but this could be done if necessary. Regarding the EPO issue, the model includes the WCPO as a separate region, so that does not pose a problem.

287. The EU addressed the range of uncertainty currently considered, and whether the approach used for Southwest Pacific swordfish should be applied to the MSE work as well. The EU also inquired whether a procedure similar to the PAW could be useful to engage stakeholders. SPC stated it needed to do more work to determine how to apply the swordfish ensemble approach to other species, noting the intense computational work involved. On capacity building, it confirmed the desire to increase the level of stakeholder input and feedback.

288. PNG, on behalf of PNA members, acknowledged the impressive work undertaken in the last year on the multi-species modelling framework for the mixed fishery MSE. The PNA supported the approach being taken on a mixed fisheries harvest strategy and the proposed next steps. On the skipjack MSE work, PNA thanked SPC for the paper and the continuing high quality of the work on a skipjack MSE framework. PNA recognised that the questions posed in SC17-MI-WP-04 for SC17 and the Commission are important questions. PNA considered that these questions might be a focus of work for a science-management dialogue in 2022.

289. The USA stated that SC should advise the Commission very clearly that its timeline for completing the harvest strategies is too ambitious, especially for the bigeye and yellowfin fisheries, with the considerable mixed-fishery analyses yet to be done. The paper uses six performance indicators, and notes that "the full list of PIs [performance indicators] currently being developed for skipjack is detailed in Scott et al. (2018)" (SC14-MI-WP-04). The USA believes it is important that this larger list be kept alive, though some PIs are difficult to estimate, such as *maximize SIDS revenues and food security*. In preparing that paper, SPC deleted columns that provided necessary context for some of the indicators, particularly MSY. For PI-10 (*avoid adverse impacts on small scale fisheries*) several CCMs at SC14 advocated that the estimation of MSY for the tropical tunas can be used as a proxy to assess downstream effects from the purse seine fishery and recommended that further work be undertaken. This is detailed in paragraph 451 of the SC14 summary report. As a result, the USA stated the table in that paper will need to be corrected back to the original, Commission-adopted list for it to make sense. The Theme Convener confirmed that the work would continue beyond 2022. SPC stated that as noted the framework only goes to 2022. Much of work is

funded by New Zealand through the Pacific Tuna Management Strategy Evaluation project, and that funding has been extended to 2024. Regarding the PIMPLE app, results include Kobe and Majuro plots, which may help address some of the issues raised by the USA.

290. Some CCMs also encourage the development of mechanisms for a greater engagement between the SSP and CCMs scientists in the development of harvest strategies, similar to the PAW.

**Recommendations**

291. **Noting the revised work plan for the adoption of the WCPFC Harvest Strategy under CMM 2014-06 (Attachment H, WCPFC17 Summary Report), SC17 reviewed the overall progress to date in the development of the harvest strategy covered by this workplan as outlined in SC17-MI-WP-03 (*Recent progress in the technical development of harvest strategies for WCPFC stocks and fisheries*).**

292. **SC17 noted several difficulties with the use of CPUE to inform a management procedure for South Pacific albacore and supported the continuing investigation of simple model-based alternatives. Incorporation of the new treatment of uncertainty (as included in the updated assessment for Southwest Pacific swordfish reviewed by SC17) should also be investigated.**

293. **SC17 continued to encourage a focus on capacity building workshops, particularly for SIDS and developing states, on understanding of harvest strategy functioning and implications. Building such capacity will assist all CCMs to participate fully in this complex process and have the confidence in the harvest strategy development process and its outcomes when implemented. It will also assist the effective participation of all CCMs in any future Science-Management Dialogue.**

294. **SC17 endorsed the work outlined in SC17-MI-WP-03 and to progress the Harvest Strategy Workplan recommends that the Commission take note of this work and provide advice on the following issues:**

- **Definition of fisheries and fishery controls within the harvest strategy.**
- **Procedures for identifying, selecting, and implementing the 'best' management procedure.**

295. **Finally, SC17 noted that while the current Harvest Strategy Workplan only goes through 2022, the funding support from New Zealand for the associated project (Pacific Tuna Management Strategy Evaluation) has been extended to the beginning of 2024. SC17 noted that the current timeline for completing the harvest strategy is ambitious.**

### 4.1.4 Skipjack MSE framework

296. R. Scott (SPC) presented SC17-MI-WP-04 (*Skipjack Management Procedure evaluations*), the latest information on the MSE framework for WCPO skipjack tuna. It provides an overview of the framework and a summary of the results of recent evaluations of candidate management procedures. The modelling framework is well advanced and has changed very little from that presented to SC16. Specific details of the framework are provided in the appendices of the report including information on how to access the input data and code used to run the evaluations. The results presented in this report include a number of harvest control rules that have been proposed by members. The results of all evaluations are available online at https://ofp-sam.shinyapps.io/pimple/.

**Discussion**

297. Japan stated that the information should be presented to managers and stakeholders, and noted that MSE should be an iterative process, in which a presentation is made to stakeholders, feedback obtained, and changes made as needed to ensure their questions are being answered. Japan encouraged sharing the presentation with a wider audience.

298. RMI, on behalf of FFA members, acknowledged and thanked SPC for their work and progress on the management procedures for skipjack. They encouraged CCMs to provide input into the HCR design, and noted the usefulness of SPC's PIMPLE App, which has served an important role in enhancing understanding of HCR; they encouraged that it be used by managers to provide advice on the scientific aspects of candidate HCRs.

299. Pew referenced the comment by Japan and recalled SC's support for a dialogue between various stakeholders, and suggested that this be recommended again.

300. Chinese Taipei commented on effort creep, noting the estimate provided in SC17-MI-IP-06 *Effort Creep within the WCPO Purse Seine Fishery* of 3%-6% per year. Chinese Taipei suggested these figures be included in the skipjack MSE work. SPC stated that it was considering using a figure of 0% and 2% in the reference set, and 3% for the robustness set; other values could be included if needed.

301. PNG, on behalf of PNA members, reiterated that the following questions in Working Paper 4 could be taken up at the science-management dialogue next year:

- Input into Management Procedure and Harvest Control Rule designs.
- Feedback on presentation approaches to enhance decision making.
- Approaches to delivering advice on the scientific aspects of Harvest Control Rules to managers.
- Definition of fisheries and fishery controls within the harvest strategy.
- Procedures for selecting the "best" Management Procedure.

302. Japan reiterated the importance of performance indicators that measure the impact on small scale fisheries.

303. Commenting specifically regarding performance indicator 10 (*avoid adverse impacts on small scale fisheries*), two CCMs advocated that the estimation of MSY for tropical tunas is important to retain. One CCM would like to see a metric of skipjack tuna fisheries impact on bigeye tuna mortality.

**Recommendations**

304. **Noting the planned schedule of adopting the management procedure for skipjack tuna in 2022, SC17 reviewed the progress on analysing the performance of candidate management procedures outlined in SC17-MI-WP-04 (*Evaluations of candidate management procedures for skipjack tuna in the WCPO*).**

305. **SC17 noted the SC14 recommendation to retain the full list of performance indicators for skipjack even for those that may be difficult to estimate. SC17 also noted that a scenario which assumes an annual 3% effort creep in the purse-seine fishery will be included in the robustness set for skipjack.**

306. **SC17 also noted that current candidate Management Procedures are developed using a single schedule applicable for both effort-controlled fisheries (PS) and catch-controlled (non-PS) fisheries, resulting in different projected yield patterns between two types of fisheries. For PS, the catch will increase if stock increases even if the effort is kept constant, while for non-PS fisheries catch will be**

**kept constant even if the stock increases. This could cause problems as this may be seen as unequitable among stakeholders.**

307. **SC17 also commended the SSP for the PIMPLE app as it has served an important role in enhancing understanding of Management Procedures (MPs) and encouraged its use with managers in providing advice on the scientific aspects of candidate MPs. SC17 noted there are some MSY indicators presented within the PIMPLE software as this tool now includes both Kobe and Majuro plots.**

308. **SC17 noted that evaluations of candidate management procedures for skipjack tuna were based on a grid of operating models that was initially proposed at SC15 and subsequently revised at SC16. However, no formal agreement on the range of OMs to be used has been made by the SC. SC17 further noted that the details of the OMs including model diagnostics were available for inspection online at https://ofp-sam.shinyapps.io/hierophant but more detailed presentation and discussion are warranted at SC18.**

309. **SC17 noted the continuing high quality of the work on a skipjack MSE framework.**

310. **To progress the development of harvest strategies for skipjack, SC17 recommends that the Commission take note of the analyses outlined in SC17-MI-WP-04 and requests the Commission to provide advice on the following issues:**

- **Multispecies impacts on other tropical tuna related harvest strategies;**
- **Definition of fisheries and fishery controls within the harvest strategy;**
- **Input into candidate MP designs;**
- **Feedback on presentational approaches to enhance decision making;**
- **Procedures for selecting the 'best performing' MP.**

311. **SC17 saw much value in presenting this work to managers and other stakeholders, and to achieve this and help address the requests made above a Science-Management Dialogue to be held in 2022 was strongly supported.**

### 4.1.5 Mixed fisheries

312. Finley Scott presented SC17-MI-WP-05 (*Mixed fishery harvest strategy developments*). The paper focuses on a simplified management strategy evaluation framework that includes WCPO skipjack, bigeye and yellowfin tuna. The framework includes a skipjack management procedure that sets skipjack catch and fishing effort limits for the purse seine, pole and line and fisheries of Indonesia, Philippines and Vietnam, given the estimated skipjack stock status. There is no bigeye management procedure and the future catch of bigeye taken by the tropical longline fishery is set to the recent average. South Pacific albacore is not yet considered and will be included in future developments. The future catch of yellowfin and bigeye taken by the southern longline fishery are set to the recent average. Three example skipjack management procedures, with different harvest control rules, are tested. The impact of the skipjack management procedure on all three stocks is demonstrated. The results demonstrate that the technical challenges involved in implementing the multi-species modelling framework can be addressed and the framework remains tractable. The example results are sufficiently encouraging to support the continued development of this approach. The next steps include building a full suite of OMs for bigeye and yellowfin; developing candidate bigeye management procedures for the tropical longline fishery; and agreeing multi-species performance indicators.

**Discussion**

313. Tonga, on behalf of FFA members, stated that as previously mentioned under Agenda item 4.1.3, FFA members are very committed to the successful implementation of the Harvest Strategy Workplan and encouraged by the initial results of the multi-species modelling framework. They fully support continued work by SPC to further develop this multi-species modelling framework as it is critical to the future management of tuna stocks in the WCPO and it is imperative that WCPFC gets this right.

314. Japan remarked on the encouraging results, and suggested that in checking if the three MPs are working, to try depleting one stock and examining the impact on the others. Regarding the relationship between the MPs, while agreement has been reached to take a hierarchical approach, there has not been agreement on the order of the hierarchy; Japan suggested either determining a way to decide the order, or proceeding on the basis of feedback from the impact of bigeye and yellowfin MPs on the skipjack MP. SPC stated that it is currently following the roadmap set out for the harvest strategy work, which starts with skipjack, then proceeds to bigeye and yellowfin. This is an initial approach that was agreed to by SC to see how it would work. SPC welcomed input from the Commission or SC if they would like to use an alternative approach to prioritization.

315. Indonesia requested a clarification regarding differences in reference year used for archipelagic waters for catch and effort of the various species. SPC stated that these reference years and other assumptions would need to be agreed to by SC.

**Recommendations**

316. **Noting the initial work presented to SC16 in developing a multi-species modelling framework for mixed fishery interactions when developing and testing harvest strategies for the four main WCPO tuna stocks, SC17 reviewed an update on the development of this framework outlined in SC17-MI-WP-05 (*Mixed-fishery harvest strategy developments*).**

317. **SC17 noted that in the present 'proof of concept' analyses there are differences between the reference year used for the archipelagic waters (2012) whereas the tropical and southern longline fisheries are held to the average of 2016-2018. There will need to be agreement on various assumptions that underpin these simulations noting that as the mixed fishery framework develops, the tropical and southern longline fisheries will not be held constant but will be managed through management procedures.**

318. **SC17 also noted that while there is agreement on the hierarchical approach, the order of the hierarchy (i.e., the order in which the species-specific management procedures are implemented) has not yet been agreed and that a process to get such an agreement is required.**

319. **SC17 welcomed the initial work and results of SC17-MI-WP-05 as demonstrating the 'proof of concept' and supported continued work by the SSP to further develop this modelling framework as it is critical to the future management of the key tuna stocks in the WCPO.**

320. **SC17 endorsed the work outlined in SC17-MI-WP-05 and noted the next steps to progress this work, including i) building a full suite of OMs for bigeye and yellowfin, ii) developing candidate MPs for bigeye for the tropical longline fishery, iii) the inclusion of South Pacific albacore in the modelling framework, and iv) agreeing multi-species performance indicators.**

321. **SC17 recommends that the Commission take note of the progress on the development of a mixed fishery MSE framework and provide advice on the issues listed in the previous paragraph.**

### 4.1.6 Review of future progress of the WCPFC Harvest Strategy Workplan

322. The MI Theme Convener stated that there is no working paper for agenda item 4.1.6, but that the topic had been discussed at length at previous SC meetings in recent years. It has generally been agreed that in order to progress to the stage of adopting and implementing harvest strategies, managers and stakeholders need to be in a position to make informed decisions based on the outputs of the evaluations of alternative candidate MPs. A common understanding of the key issues supported by clear and well understood science advice is crucial. To support continued progress of the Harvest Strategy Workplan, practical mechanisms are needed to allow scientific outputs to be reviewed by managers, and for managers to guide further work undertaken by the SC to inform their decision making. Toward this end, SC14 recommended that WCPFC15 take the necessary steps to establish such a common dialogue, and draft TOR for establishing a Harvest Strategy Working Group were provided for the Commission to consider. Similar recommendations for such a working group (or science-management dialogue) were made at both SC15 and SC16. However, while acknowledging the utility of such a working group, the Commission has deferred making a final decision on facilitating such a working group due to issues related to identifying an appropriate time as to when such a meeting could be held.

323. The MI Theme Convener suggested that perhaps the convening of an online meeting may offer a way forward on this issue.

324. The Commission requested that SC17 review the steps required to further progress the Harvest Strategy Workplan and highlight issues for further guidance by the Commission, including how decisions on Management Procedures can be made and what the role of the SC might be in this process. This includes continuing to consider options to convene a science-management dialogue to assist this process and provide recommendations to the Commission as needed. The MI Theme Convener noted that MI theme presentations at SC17 include several recommendations on feedback, advice and direction being sought from the Commission to further the Harvest Strategy Workplan which SC could include in any of its recommendations, and that SC could consider a recommendation in relation to the need for a science-management dialogue.

**Discussion**

325. Australia offered the following comments.

(i) The Harvest Strategy Workplan does not currently extend beyond 2022. It will require amendment to encompass future technical work and decision making particularly on bigeye, yellowfin and the multispecies framework. Australia stated its intention to again take a role in amending the Harvest Strategy Workplan to reflect decisions made and progress to date and to cover the work and decisions for years 2023 and beyond for consideration by WCPFC18. It looked forward to input from SC17 and stated it would work with SPC on the update.

(ii) As noted by the Theme Convener and SPC in SC17-MI-WP-03, SPC has in recent years made substantial progress on the technical work to support harvest strategies according to the Harvest Strategy Workplan. However, there have been delays in the overall execution of the Harvest Strategy Workplan in some other respects. This is not surprising given the complexity of developing harvest strategies for multiple species within the multilateral WCPFC environment. Contributing to this in 2020 was the limited agendas of SC16 and WCPFC17 due to the pandemic, which has also delayed and impacted the vital capacity building required to allow CCMs to understand and participate fully in the harvest strategy development process (see SC17-MI-IP-02). In 2021 the attention of the Commission will be on negotiating potential revision of the Tropical Tuna Measure (CMM 2020-01). Australia stated that in recent years SPC's technical work has kept pace with the Harvest

Strategy Workplan while WCPFC consideration, engagement and decision-making has stalled somewhat. Greater input from WCPFC bodies in general but particularly commissioners, managers and stakeholders will be vital over the coming years to inform the testing of candidate MPs for skipjack and South Pacific albacore in the WCPO, and in the iterative process of their review and refinement prior to formal adoption.

(iii) Australia strongly supported some form of science-management dialogue in 2022 and beyond, and advocated that SC17 should again make a recommendation to support the dialogue. It noted the difficulties in establishing a separate meeting during the WCPFC calendar for the dialogue, and proposed the potential of holding such a dialogue within an amended agenda of both the SC and the Commission. Even in the case of face-to-face meetings in 2022 (which all CCMs hope will occur) the attendance of managers or scientists at these dialogues could be accommodated through electronic means. Australia advocated for a substantial refocus and commitment to progressing harvest strategies during 2022, and stated it was pleased to see similar statements from other CCMs.

326. PNG, on behalf of PNA members, agreed with the need to give more priority to harvest strategy work within the Commission's workplan. PNA continued to support the position stated by FFA members when the workplan was adopted, that the work should be integrated into the existing structure of Commission meetings and bodies. This means that PNA does not support the establishment of any new working groups or other subsidiary bodies. However, as a compromise, PNA stated it was prepared to support a science-management dialogue in 2022 on a trial basis, back-to-back with the SC18. This could address some of the questions raised by SPC in SC17-MI-WP-04. In addition, PNA stated its support for additional meeting time for Harvest Strategy work in 2022. However, PNA are not prepared to just add the time for harvest strategy work on to the existing schedules of SC and the Commission. PNA consider that the Commission should prioritise harvest strategy work, including cutting back on other tasks to make more time for harvest strategy work. PNA supported revision of the Harvest Strategy Workplan along the lines suggested by Australia.

327. The EU stated it is generally supportive of the need for an increased science-management dialogue, and previous recommendations from the SC can be re-iterated to the Commission. However, any discussions about the best timing for a science-management dialogue or the convenience of developing such a procedure for a greater participation of CCMs in the technical harvest strategy work should be tackled at the Commission level.

328. S. Miller (Ocean Foundation) made a presentation that introducing their website, showing the tools available for users, including for education and capacity building, as outlined in SC17-MI-IP-13 (*The Ocean Foundation: www.harveststrategies.org*).

**Recommendations**

329. **SC17 noted the request from the Commission to review the steps required to further progress the Harvest Strategy Workplan and highlight issues for further guidance by the Commission, including how decisions on Management Procedures can be made and what the role of the SC might be in this process. This includes continuing to consider options to convene a Science-Management Dialogue to assist this process.**

330. **SC17 noted that while substantial progress has been made on the technical work to support harvest strategies according to the workplan, the workplan does not currently extend beyond 2022 and that it will require amendment to encompass future technical work and decision making, particularly on bigeye, yellowfin and the multispecies framework. Toward this end SC17 noted Australia's intention to again take a leading role in amending the Harvest Strategy Workplan to**

**reflect decisions made, progress to date, and to cover the work and decisions for years 2023 and beyond for the consideration of the Commission this year.**

331. **While SC17 noted that the technical work by the SSP has generally kept pace with the Harvest Strategy Workplan, it was also noted that capacity-building initiatives, as well as WCPFC consideration, engagement and decision-making has perhaps not kept pace. SC17 noted that greater input from WCPFC bodies in general, but particularly commissioners, managers and stakeholders, will be vital over the coming years to inform the testing of candidate management procedures for skipjack and South Pacific albacore in the WCPO, and in the iterative process of their review and refinement prior to formal adoption.**

332. **Finally, noting that the development of the WCPFC harvest strategy framework is reaching a mature stage, and the increasing number of issues that require the attention of, and feedback from, managers in order to progress the Harvest Strategy Workplan (as noted in several recommendations above). SC17 again reiterates its previous recommendations for a Science-Management Dialogue to be convened in 2022. In addition, SC17 calls attention to the importance of such a dialogue to ensure the input of managers and stakeholders to the MSE process and to ensure timely execution of the Commission's harvest strategies workplan.**

333. **SC17 also recommended that greater priority should be given during 2022 to Harvest Strategy work within the Commission Workplan.**

### 4.2 Limit Reference Points for Species other than Tuna

334. The MI Theme Convener introduced Agenda Item 4.2, noting there were two working papers to review: i) LRPs for elasmobranchs, and ii) LRPs for Southwest Pacific striped marlin and other billfish. He noted that application of an LRP is usually seen as the combination of two components:

(i) First, there is an identified value of the reference point which should not be breached, and as a principle this level defines a state of the fishery that is considered to be undesirable and which management action should avoid. For example, for the key tuna stocks managed by the Commission the LRP adopted for spawning biomass (SB) is based on the depletion reference point $SB_{recent}/SB_{unfished} = 20\%$.

(ii) Second, there is also usually a need to adopt an associated probability that is considered an unacceptable level of breaching this limit. For example, it may be considered unacceptable if the results of the assessment (based on the uncertainty grid) indicate that there is a greater than say an X% probability of breaching the LRP. SC has considered a range of probabilities to be associated with the SB LRP for key tuna stocks (5% to 20%) and while the Commission has yet to adopt an explicit value it has agreed that this probability should not exceed 20%.

335. The MI Theme Convener noted that SC has considered LRPs for sharks for a number of years. Based on a previous report by Clarke and Hoyle in 2014 (SC10-MI-WP-07), SC10 supported the tiered, species-specific approach for identifying LRPs for sharks that is similar to that adopted for target species. However, SC10 also noted that more work would be required to specify the values of the LRPs for key shark species. After reviewing an initial progress report on the current project SC14 supported the general approaches being developed as a way of avoiding the weaknesses of conventional stock assessment on data poor species and the general hierarchical approach to LRP setting. Due to the need for SC16 to be an online meeting, and the related need to reduce the agenda, discussion of the outcomes of Project 103 (*LRPs for elasmobranchs within the WCPFC*) was deferred. Instead SC16-MI-IP-21 was posted on the SC16-ODF, under Topic 11, and several comments were received. Responses to these comments have been incorporated into SC17-MI-WP-07.

### 4.2.1 Limit reference points for elasmobranchs

336. S. Zhou presented SC17-MI-WP-07 (*Appropriate reference points for WCPO elasmobranchs – Project 103*), which summarized major sections from the previous project. Four methods were used to estimate risk-based reference points for 15 WCPO elasmobranch stocks. The authors provided two fishing mortality rate reference points, $F_{msy}$ and $F_{lim}$. They devoted additional effort to explain the rationale of identifying appropriate LRPs, and reviewed new development closely related to this subject. They continued to support the tier-based approach and recommended adopting $B_{lim} = 0.25B_0$ and corresponding $F_{lim} = 1.5F_{msy}$ as interim LRPs for WCPO elasmobranchs. They did not support the use of a constant percentage of SPR (such as $F_{60\%SPR}$) as a reference point for all stocks. They recommended that it was important to continue research to provide and improve estimates of life-history parameters and gear selectivity.

**Discussion**

337. Japan supported the recommendation, and agreed that it is reasonable to define the LRP for sharks in a manner similar as for both target and bycatch species; setting a higher TRP or lower LRP on bycatch species may have a negative effect on target species catch, where bycatch species become a choke point. The recommended LRP values derived from the previous analysis are quite different from this presentation. Japan noted that there are data rich and data poor approaches, and suggested use of the results from the data rich analysis. The author agreed with most of the comments, and stated they found the values derived from different (species) stock assessments to be quite different; he noted the data rich approach may not necessarily have lower uncertainty.

338. Vanuatu, on behalf of FFA members, stated they had carefully considered the recommendations made in the report. They noted that some of the feedback provided at SC15 and SC16 was not fully addressed and the report had largely focused on providing life-history benchmarks for elasmobranchs, rather than developing appropriate LRPs, the main objective of Project 103. As a result, FFA members believe a wider view of other reference points for elasmobranchs should be considered. They suggested that a good place to start is an appraisal of the LRP metrics recommended in Table 7 of working paper SC17-MI-WP-08 for Southwest Pacific striped marlin and other billfish species be appraised as to whether they are also applicable to elasmobranchs. The Theme Convener noted Clarke and Hoyle conducted a thorough review of LRPs for shark species in 2014 (SC10-MI-WP-07). The author stated that the 2014 report addressed the use of a CPUE-based LRP. Given the number of species and the data limitations, the author stated that simple approaches were preferable.

339. The USA supported the recommendations from the working paper, and stated it would also be very valuable to use the MSE approach. The author agreed, but stated that would have to be done through a future project.

340. RMI, on behalf of PNA members, supported the statement by FFA members, and thanked the consultants their work, in particular on individual elasmobranch stocks, and for taking into account the comments made by PNA in the SC16 Online Forum. The PNA stated they do not share the consultants' views on the application of the Convention text to target and non-target stocks, but would offer comments on that in the billfish LRP discussion. PNA supported the approach of using different metrics for stocks assessed using data-rich and data-poor assessment types, and using life history benchmarks as interim LRPs where no data rich assessment is possible, but also noted the static nature of these metrics. PNA members stated there are some other important elements of the report that can be built on, and others they did not support, but stated it was time to close the project and include the discussion with that on LRPs for billfish

so that there is a broader discussion on LRPs for species other than tuna. PNA offered to provide more detailed comments on the report text if SC decided the report needs further revision.

341. Indonesia inquired whether it was possible to use a model approach for life history, or if it was best to base this on biological sampling; asked about gear selectivity; and inquired if the LRPs could be applied to additional species, or just those being discussed. The author noted that the life history approach proposed is very similar to what is done in Australia, where a risk-based approach is used for most bycatch species, and covers 100 or so species impacted by the same gear. This is very cost effective, and similar to the approach used for stock assessments. He noted gear selectivity is hard to estimate for non-target species.

342. SFP inquired whether LRPs should be higher for non-target than target species, and whether the risk of breaching the LRP should be higher for endangered species. The author stated that the reference point based on the level of deletion will vary by species; depletion levels of 20% or 30% have been widely adopted for many species, but the actual risk to the stock depends on the productivity of the stock. Regarding whether the risk of breach should be lower for a threatened or endangered species: this is more of a management question, and risk will be different if considering a single species. He suggested guidelines are needed.

343. The EU inquired regarding the use of stock collapse ($F_{crash}$) in an LRP definition. The author stated that although it can be calculated, it is not recommended as an LRP basis, and thus was not included in this report.

344. SC17 noted a view that an LRP should be higher for less productive species such as elasmobranchs and that the associated risk of breaching the LRP should be lower for threatened or endangered species.

**Recommendations**

345. **Noting the request from WCPFC16 to identity appropriate LRPs for elasmobranchs in the WCPO, SC17 reviewed the outcomes of Project 103 outlined in SC17-MI-WP-07 (*Appropriate Limit Reference Points for WCPO Elasmobranchs*).**

346. **SC17 noted the comprehensive scope of the project report and that this work had built on the results of several other reports previously reviewed by the SC (SC10-MI-WP-07; SC11-EB-IP-13; SC14-MI-WP-07).**

347. **SC17 noted and discussed the recommendations made in SC17-MI-WP-07 and conveyed the following conclusions to the Commission:**

- **SC17 continued to support the tier-based approach first recommended by SC10:**
  - **For stocks assessed using a stock assessment model (i.e., data-rich stocks), reference points estimated in the same stock-assessment should be adopted.**
  - **For stock without a stock assessment (i.e., data-poor stocks), or when the results are not robust, risk-based RPs should be used.**
- **SC17 noted that the data rich approach might not necessarily have lower uncertainty than the data poor approach.**
- **While an LRP for WCPO elasmobranchs equivalent to $B_{lim}=0.25B_0$ (consistent with $20\%SB_{unfished}$ for target species) and the corresponding $F_{lim}=1.5F_{MSY}$ was supported by a number of CCMs, several other CCMs did not support the use of this LRP, instead suggesting that a broader range of reference points should be appraised (such as outlined in Table 7 of SC17-MI-WP-08) to assess their applicability to WCPO elasmobranchs, and that these be considered under a broader banner of reference points for non-tuna species.**

**However, there was some concern expressed that such a review of other metrics had already been undertaken by earlier reports (e.g., SC10-MI-WP-07).**

- **The use of a constant percentage of SPR (spawning potential ratio) such as $F_{60\%}$SPR (i.e., F that produces an SPR of 60% of unfished) as a reference point for all stocks was not supported.**
- **It was noted that continued fishing at or above $F_{crash}$ would lead to stock collapse. In the long term, an LRP should constrain fishing mortality to below this level.**
- **Finally, SC17 noted that it is important to continue research to provide or improve estimates of life-history parameters and gear selectivity to improve the determination of risk-based reference points.**
- **SC17 noted that a management strategy evaluation approach could be helpful in determining what LRPs would work best when there is uncertainty in the input assessment data, population dynamics, model structure and other dynamic features of the WCPO fishery system.**

348. **SC17 agreed that Project 103, and the other projects that had preceded it, had provided a good framework for progressing the development and identification of appropriate LRP for WCPO elasmobranchs. However, SC17 expressed disappointment that after such lengthy consideration that the SC was at this time unable to make a final recommendation on appropriate LRPs to the Commission.**

349. **SC17 recommended that the Commission take note of the work and recommendations outlined in SC17-MI-WP-07 together with the conclusions reached by SC17 and the need for further work as noted above.**

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

350. Stephen Brouwer (Saggitus Limited) presented SC17-MI-WP-08 (*Appropriate limit reference points for Southwest Pacific Ocean striped marlin and other billfish – Project 104*). The paper reviews the work done on establishing LRPs within the WCPFC and considers options for a LRP and relevant performance indicators for Southwest Pacific striped marlin and other billfish. The paper discusses potential LRPs for stocks assessed with data-rich, medium-data and data-poor assessment methods.[8] For data-rich assessments LRPs measuring the dynamic spawning biomass depletion ($SB/SB_{F=0}$) seem appropriate for Southwest Pacific striped marlin and other billfish. Stocks assessed using medium-data assessment methods could use empirical LRPs (e.g., CPUE-based), but these require a reliable index with a reasonable degree of confidence that the index tracks trends in the stock biomass consistently. Stocks assessed using data-poor methods could also use empirical LRPs provided there is an informative signal in the data used to indicate stock abundance, or risk-based fishing mortality benchmarks, derived from life history information, as an interim once off assessment of stock vulnerability. Due to the insufficient knowledge of steepness for WCPO billfish stocks, consistent with the target tuna stocks and the hierarchical approach for tuna LRPs endorsed by WCPFC8, MSY-based reference points for stock biomass are currently not recommended as LRPs for WCPO billfish.

351. Life history parameters (growth, maximum age, natural mortality, age-at-maturity) of Southwest Pacific striped marlin and Southwest Pacific swordfish are comparable to the WCPO target tuna species.

[8] **Data-Rich Assessments:** fully integrated stock assessment model using multiple sources of data including catch, effort and biological information in a model such as MFCL, Stock Syntheses or similar; **Medium-Data Assessment:** model that uses catch and effort data with or without some biological parameters to get an estimate of fishing mortality (F), such as Surplus Production models; **Data-Poor Assessments:** analyses that estimate a level of risk but do not derive estimates of F.

Therefore, using a depletion based LRP for these stocks would be consistent with the approach applied to target tuna stocks (i.e., 20% $SB/SB_{F=0}$). Prior to the agreement of fishery objectives for these stocks, the LRPs applied to tuna could be used as interim LRPs for Southwest Pacific striped marlin and Southwest Pacific swordfish. Noting also that striped marlin and swordfish were previously considered in SC7-MI-WP-03, which guided the choice of the depletion LRP for target tuna. For stocks where biological knowledge is more limited, an extension to the hierarchical approach to developing LRPs defined by SC7-MI-WP-03 is suggested for WCPO billfish stocks.

352. The wider review notes that in some settings, fishery managers have considered a more risk prone approach to LRPs for bycatch species if the objectives for those stocks are different to target tuna species. Characterisation of species as bycatch, non-target and target species and the development of alternative objectives for each has not been considered by the WCPFC. Significantly, we note that where the underlying biology of target and bycatch stocks are comparable, there is no clear basis for setting the biological limits, defined by their LRPs, at different levels. The acceptable risk of falling below a LRP is a management decision, however; that risk may be explicitly stated to be different between target and bycatch stocks, and should ideally be determined to support the achievement of fishery objectives for each stock.

353. The following recommendations are proposed for SC17 to consider.

(i) The WCPFC should develop interim objectives for SWP striped marlin to guide the appropriate levels for any agreed LRP and the associated maximum risk levels for breaching an LRP.

(ii) In the interim, a LRP equivalent to 20% $SB/SB_{F=0}$ for SWP striped marlin could be used, consistent with the logic behind the application to key tuna stocks.

(iii) For the other WCPO billfish - develop objectives as species groups, by dividing WCPO billfish into: target species (swordfish); data-rich bycatch species (striped and blue marlin); medium information species with moderate levels of catch (black marlin); and data-poor low-catch bycatch (shortbilled spearfish and sailfish).

(iv) Consider Table 7 as a list of Limit Referent Point metrics that could be used for WCPO billfish.

(v) Consider the values presented in Table 9 for SWP striped marlin and swordfish as potential LRPs levels for these and other billfish species.

(vi) Assess the remaining stocks against the proposed LRPs in Table 7 and Table 9 to determine the appropriate LRPs.

(vii) Any new proposed LRP metrics that are developed in the future, should be assessed against those presented in Table 7.

(viii) Incorporate these decisions into the Billfish Research Plan that is scheduled to be developed in 2022 and focus that work on developing objectives, assessing LRPs for each species, and determining if a pathway to a higher level of information and knowledge should be developed.

(ix) The proposed risk-based fishing mortality benchmarks should be defined as dependent variables in the two main assessment platforms used (SS and MFCL) so that statistical uncertainty of the estimates can be calculated.

**Discussion**

354. Kiribati, on behalf of FFA members, thanked SPC for progressing Project 104, noting the work done. FFA members supported recommendation 1, 3, 4 and 6–9, stating that the other recommendations would require further consideration.

355. Chinese Taipei referenced the recommendation of an interim LRP of 20% $SB/SB_{F=0}$ for Southwest Pacific striped marlin, and observed that the biology for tuna is quite different from billfish or swordfish;

the latter have quite different growth curves, and possibly slightly higher productivity, with higher fecundity. Chinese Taipei suggested that because of these differences use of a similar LRP as tuna may not be appropriate. The author stated that these were valid issues, and referenced Table 4, which indicates age at maturity is relatively similar; he stated that seasonal fecundity is probably similar. Regarding the setting of the LRP, he stated that it should reflect the management objective for the species.

356. Australia inquired whether in setting objectives for each species they should all be categorized as target, or target and bycatch. The author stated categorizing species would help provide clarity over which matrix to use (there are now 13) and help in articulating the acceptable level of risk of breaching the LRP, which needs to be clearly stated. In the absence of such objectives the Commission could agree on an interim LRP, with the objectives to be provided later, and the LRP then adjusted.

357. The EU commented on how the LRPs can be interpreted or linked to the biomass at MSY. Referring to the results of the SWO stock assessment in SC17-SA-WP-04, Table 5 indicates that $SB_{MSY}$ is less than 20% of $SB_0$. The author stated that when deciding on setting reference points, there is a need to look at the level of depletion relative to MSY. For some stocks $B_{MSY}$ is close to 20% of unfished biomass, others can be lower or higher. This needs to be analyzed before determining the matrix value.

358. The USA emphasized that WCPO billfishes are substantially different from tropical tunas, especially with respect to stock-recruitment resilience. As a result, the following conclusion in SC17-WP-MI-08 (p. 24) is not well supported: "… *there is no clear biological justification that a LRP for SWPO striped marlin should be any different …[than] LRPs for tropical tunas*". The USA stated that further work and a fresh look at the scientific issue of setting LRPs for billfishes is needed and indicated its interest in engaging in such work. It noted that MSY-based reference points have worked very well for managing USA domestic fisheries with the maximum fishing mortality threshold equal to $F_{MSY}$. The rationale behind using $F_{MSY}$ and $B_{MSY}$ as the basis for setting LRPs is well-established.[9] The USA also noted that the WCPFC convention is based on a goal of maintaining biomasses sufficient to support MSY catches. Given this, the USA submits that it makes sense a priori and would be consistent with the WCPFC Convention to develop billfish LRPs using $B_{MSY}$ and $F_{MSY}$ estimates, or proxies, that incorporate precautionary buffers to account for scientific and management uncertainties. That way, the science of assessing the status of WCPO billfishes would be risk-neutral relative to MSY and is separate from the management actions needed to account for the risk preferences of member countries. The author noted these were relevant comments, and observed that MSY-based limit should be avoided.

359. New Zealand supported the recommendations in the paper, including the recommendation (setting the LRP equivalent to 20% $SB/SB_{F=0}$), and supported progress on LRPs and development of management objectives for important billfish species.

360. FSM, on behalf of PNA members, stated that this report substantially advances the Commission's work on billfish LRPs, and on LRPs for species other than tuna more generally, and supported the FFA statement. The PNA supported the recommendations in principle. The PNA also appreciated that the paper distinguishes between LRPs for target stocks and bycatch species, as set out in the Convention. However, the PNA did not support Recommendations 2 and 5, as their basis is that the life history parameters of striped marlin and swordfish are comparable to those of the WCPO target tuna stocks, so a depletion-based LRP for these stocks would be consistent with the approach applied by the Commission to target tuna stocks. PNA agreed with that comparison as a basis for applying a depletion based LRP for billfish, but did not agree with applying a 20% depletion ratio to billfish. That decision by the Commission was based on the working definition of an LRP as defining a state of the fishery which is considered to be undesirable

[9] See Mace, P. M. (2001). A new role for MSY in single-species and ecosystem approaches to fisheries stock assessment and management. *Fish and Fisheries*, 2:2–32, which is cited in SC17-MI-WP-08.

and which management action should avoid. The Commission applied that definition to key tuna stocks in a way that went beyond specifically biological considerations. In particular, the Commission took into account the broader impacts of features such as increased fluctuations in recruitments, and reductions in fish size and value with a lower biomass, because of the socio-economic importance of these key tuna stocks. That approach resulted in LRPs for the key tuna stocks that are above $SB_{MSY}$ in some places, and close to it in others. PNA members are not convinced that applying a similar approach to striped marlin and other billfish contributes to optimal utilization of regional target stocks.

361. Tokelau, on behalf of PNA members, supported the proposed additions to the hierarchical approach in Table 1 of the report, and agreed with classifying the stocks into target species, data-rich bycatch species, medium information species with moderate levels of catch, and data-poor low-catch bycatch. They also agreed that the future billfish research plan could provide further guidance for developing objectives, assessing LRPs for each species, and determining if a pathway to a higher level of information and knowledge is appropriate. PNA members also noted the utility of defining the benchmark metrics in Stock Synthesis and MFCL, and recommended SPC include that in their MFCL work plan. PNA members also raised this under ODF Topic 8 (SC17-ODF-01) where they noted that the WCPFC Secretariat should also raise this point with those in charge of Stock Synthesis development work.

362. RMI, on behalf of PNA members, agreed with the list of potential LRPs presented in Table 7, and suggested that any of these could be presented in assessment reports. They supported forwarding the table to the Commission for consideration, but stated the values of the metrics needed further consideration, so the values of 20% for $SB_{F=0}$, 25% for $SB_0$, and $F/F_{MSY} = 1$ should be replaced by an x as in the other metrics. Similarly, Table 9 can be considered only if the values are amended to x rather than the specific values as presented in that table. PNA members stated that deciding on a specific value for each metric requires more work. To this end they requested that the SPC compile a table based on existing assessments of billfish and sharks that shows $SB_{MSY}$, $SB_0$ and $SB_{F=0}$ levels and the percentage of $SB_{MSY}$ relative to the other two metrics. However, the list is long, and the PNA suggested that SC should work towards developing a minimum list of metrics that should appear in any future billfish assessment reports and a preferred metric for each WCPO billfish stock. They stated that the F-based LRPs can be removed.

363. Japan noted that when summarizing Table 7, those stocks with agreed LRPs and recovery plans should be noted.

**Recommendations**

364. **Noting the agreed outcome from WCPFC16 to revisit the identification of an appropriate limit reference point for South Pacific Striped marlin, SC17 reviewed the outcomes of Project 104 outlined in SC17-MI-WP-08 (*Appropriate LRPs for Southwest Pacific Ocean Striped Marlin and Other Billfish*).**

365. **SC17 noted the comprehensive scope of the project report and discussed the nine recommendations made in SC17-MI-WP-08 and while broadly supporting these recommendations conveys the following conclusions to the Commission:**

- **The WCPFC should develop interim objectives for Southwest Pacific striped marlin to guide the appropriate levels for any agreed LRP and the associated maximum risk levels for breaching this LRP.**
- **While an LRP equivalent to 20% $SB/SB_{F=0}$ for Southwest Pacific striped marlin was supported by several CCMs (consistent with the logic behind the application to key tuna stocks), several other CCMs pointed out that the life-history of billfish are substantially different to key tuna species and therefore did not support this LRP. Several CCMs also noted that in adopting the tuna LRPs, in their view the Commission took into account**

**factors such as the risk of greater fluctuations in recruitment and smaller fish sizes and values as biomass declined, and these factors may not be as applicable to setting LRPs for billfish.**

- **Several CCMs supported the development of billfish LRPs based on MSY criteria with appropriate risk choices.**
- **For WCPO billfish species the identification of appropriate LRPs should be guided by developing management objectives for different species divided into the following groups: target species (swordfish); data-rich bycatch species (striped and blue marlin); medium information bycatch species with levels of catch (black marlin); and data-poor low-catch bycatch species (shortbilled spearfish and sailfish). Having agreed objectives would help clarify which approach to use and inform selection of the acceptable risk of breaching the LRP.**
- **Each billfish species should initially be assessed against the potential LRPs listed in Table MI-1. The SC should also work towards developing a minimum list of metrics that should appear in any future billfish assessment reports and a preferred metric for each WCPO billfish stock. For example, several CCMs suggested the addition of $F_{MSY}$ and $SB_{MSY}$-related values, as it is related to the spirit of the Convention in their view and is the reference point used by other RFMOs for billfish species. In the interim SC agreed to retain Table MI-1 as an interim list of candidate LRPs for billfish.**
- **The applicability of LRPs should be evaluated, whenever possible, at the stock level. Some CCMs noted that for some species, like the south Pacific swordfish, the adopted LRP for tropical tuna species ($20\%SB_{F=0}$) is significantly above $SB_{MSY}$.**
- **There was support for the proposed additions to the hierarchical approach, originally endorsed by WCPFC8 for key target species and SC10 for elasmobranchs, to cater for empirical and risk-based reference points of medium and low data stocks. The updated table is presented in Table MI-2.**
- **These decisions should be incorporated into the Billfish Research Plan that is scheduled to be developed in 2022 and focus that work on developing objectives, assessing LRPs for each species, and determining if a pathway to a higher level of information and knowledge should be developed. This Plan should also consider a request that the SSP compile a table based on existing assessments of billfish and sharks that shows $SB_{MSY}$, $SB_0$ and $SB_{F=0}$ levels and the percentage of $SB_{MSY}$ relative to the other two metrics, with associated uncertainty.**
- **The risk-based fishing mortality benchmarks should be defined as dependent variables in the two main assessment platforms used (Stock Synthesis and MFCL) so that statistical uncertainty of the estimates can be calculated.**

366. **SC17 agreed that Project 104 had developed a good framework for progressing the development and identification of appropriate LRP for WCPO billfish and recommends that the Commission take note of the above conclusions reached by SC17 and the need for further work as outlined above.**

**Table MI-1**. Proposed list of potential limit reference points for consideration for WCPFC billfish, categorized as Target and Bycatch and by assessment type. Gray shading is simply for easy separation of LRP groups.

| LRP | Group | Assessment type | Comments |
|---|---|---|---|
| x% $F/F_{MSY}$ | Target & Bycatch | Data rich | Choose the level of x based on an evaluation. |
| x% $SB/SB_{F=0}$ | Target & Bycatch | Data rich | Choose the level of x based on an evaluation. |
| x% $SB_0$ | Target & Bycatch | Data rich | Choose the level of x based on an evaluation. |

| | | | |
|---|---|---|---|
| SPR x% $SB_{F=0}$ | Bycatch | Medium data or data poor | Choose the level of x based on an evaluation. |
| x% $CPUE_0$ | Target & Bycatch | Data rich or medium data | Choose the start of a reliable CPUE series and the level of x. |
| $SB/SB_{F=0, t1-t2}$ | Target & Bycatch | Data rich | Choose a time period where the stock was considered in an undesirable state (and should be avoided in future) but recovered back to suitable levels. |
| $SB_{t1-t2}$ | Target & Bycatch | Data rich | Choose a time period where the stock was considered in an undesirable state (and should be avoided in future) but recovered back to suitable levels. |
| $CPUE_{t1-t2}$ | Target & Bycatch | Data rich or medium data | Choose a time period where the stock was considered in an undesirable state (and should be avoided in future) but recovered back to suitable levels. |
| $SB/SB_{F=0}$_ low | Target & Bycatch | Data rich | Choose a low year where the stock was considered in an undesirable state (and should be avoided in future) but recovered back to suitable levels. |
| SB_low | Target & Bycatch | Data rich | Choose a low year where the stock was considered in an undesirable state (and should be avoided in future) but recovered back to suitable levels. |
| CPUE_low | Target & Bycatch | Data rich or medium data | Choose a low year where the stock was considered in an undesirable state (and should be avoided in future) but recovered back to suitable levels. Note CPUEt1 − t2 is more precautionary. |
| $F/F_{lim}$ >1 | Bycatch | Data poor | Use as an interim LRP until a more reliable metric can be generated. |
| $F/F_{crash}$ >1 | Bycatch | Data poor | Use as an interim LRP until a more reliable metric can be generated. |

**Table MI-2**. The 5-level hierarchical approach for defining LRPs for bycatch species modified from that endorsed by WCPFC8.

| Level | Condition | LRP metrics |
|---|---|---|
| Level 1 | A reliable estimate of steepness is available. | $F_{MSY}$ and $B_{MSY}$ |
| Level 2 | Steepness is not known well, if at all, but the key biological (natural mortality, maturity) and fishery (selectivity) variables are reasonably well estimated. | $Fx\%_{SPR\_F=0}$ and either x% $SB_0$ or x% $SB_{current,F=0}$ |
| Level 3 | The key biological and fishery variables are not well estimated or understood. | x% $SB_0$ or x% $SB_{current,F=0}$ |
| Level 4 | Poor biological information, fishery data sparse or patchy with no ability to estimate parameters noted above, or other metrics considered important. But a reliable CPUE index is available. | $CPUE_{t1-t2}$ or CPUE_low |
| Level 5 | The key biological variables (age, reproduction, intrinsic rate of increase and carrying capacity) are reliably estimated. | $F/F_{crash}$ >1 or $F/F_{lim}$ >1 |

## AGENDA ITEM 5 — ECOSYSTEM AND BYCATCH MITIGATION THEME

367. The Ecosystem and Bycatch Mitigation (EB) theme was convened by Y. Swimmer (USA). The Convener outlined the theme session structure and meeting protocols, and noted that there were 2 working papers and 17 information papers, some of which were covered on the online discussion forum.

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

368. K. Bigelow (USA) presented SC17-EB-WP-01 (*Review of potential mitigation measures to reduce fishing-related mortality on silky and oceanic whitetip sharks – Project 101*). The paper develops and applies a model for how silky (*Carcharhinus falciformis*) and oceanic whitetip (*C. longimanus*) shark might interact with longline gear in the WCPO and potential reductions in mortality with two different management measures: 1) removal of shark lines and 2) transition from branchlines with wire leaders to monofilament leaders. Using ROP data, the study compared absolute values of total catch and total mortality across scenarios and the relative change in fishing related mortality from the status-quo option given a conversion from wire to monofilament leaders, no shark lines used and both a conversion to monofilament leaders and no shark lines. The analysis also explores reduction rates of both shark species under a variety of management scenarios, including banning both shark lines and wire leaders. The study provides an update to SC11-EB-WP-02 by using recently available observer information (2010–2018) on longline gear characteristics and spatial distribution of effort (2015–2019). The study used previous assumptions from SC11-EB-WP-02 on: 1) results of previous studies on catchability and survival and 2) spatial differences in the density of the two species. The key conclusions of the current analyses are:

- Banning shark lines has the potential to reduce fishing mortality by 2.6% and 5.4% for silky shark and oceanic whitetip shark, respectively. These percentages are lower than predicted estimates from SC11-EB-WP-02 which may be explained by a decrease in use of shark lines in more recent observer data.
- Banning branchline wire leaders has the potential to reduce fishing mortality by 28.2% and 35.8% for silky shark and oceanic whitetip shark, respectively. These percentages are higher than estimates from SC11-EB-WP-02 and are perhaps due to improved characterization of gear use in the distant-water longline fisheries.
- Banning both shark lines and wire leaders has the potential to reduce fishing mortality by 30.8% and 40.5% for silky shark and oceanic whitetip shark, respectively.
- Submission of ROP observer data has increased in recent years. Future analyses would benefit from both in-zone and ROP data to estimate catchability effects for shark lines, wire and monofilament leaders and further characterize WCPFC member longline gear characteristics.

The paper provided the following recommendations:

- Continue Project 101, with the following potential modifications to the Monte Carlo analysis;
- Relevant members consider authorizing the release of their non-ROP longline data (facilitated through SPC) for this study, specifically to provide more complete gear configurations by flag, and allow analyses similar to Caneco et al. (2014) to estimate factors affecting shark catchability and condition on longline retrieval to be conducted using a more complete dataset;
- Conduct the Monte Carlo analyses with inputs on catchability, condition on longline retrieval and gear configurations by flag; and
- Conduct projections with inputs on the impact of banning shark lines and wire leaders or both and estimates of the probability of post release mortality (Hutchinson et al. 2021[10]).

**Discussion**

369. Japan stated that it is very important to consider mitigation measures to reduce mortality, noted that some aspects of the research (regarding post-release mortality) are incomplete, and supported continuing

[10] Hutchinson M, Siders Z, Stahl J, Bigelow K. 2021. Quantitative estimates of post-release survival rates of sharks captured in Pacific tuna longline fisheries reveal handling and discard practices that improve survivorship. PIFSC Data Report DR-21-001. Issued 10 March 2021. https://doi.org/10.25923/0m3c-2577

research. Japan supported the release of ROP data, but suggested that this be arranged through consultations with each CCM. The author agreed it was important to reach out to members to get more information on their specific gear type.

370. Australia supported the recommendations and inquired regarding the amount of non-ROP data that may be available (as referenced in recommendation 2). SPC stated they used about 100,000 longline sets in the ROP data set, with perhaps 7,000 longline non-ROP data sets remaining; most are from Chinese Taipei and Japan.

371. Palau, on behalf of FFA members, noted from the report that the use of wire leaders and their impacts on shark mortality are a real threat to their recovery, and proposed that SC consider a recommendation for stringent measures or banning of the wire leaders. FFA members supported the recommendations from the report and encourage work to update projections to examine the effects of banning shark lines or wire leaders or both. They noted the current Shark CMM 2019-04 para. 14 bans the carrying of wire traces as branch lines OR bans the use of branchlines directly off the longline floats or drop lines is now in effect. The assessment will improve CCMs' understanding of these mitigation measures for future implementation and strengthening of obligations.

372. Tokelau, on behalf of PNA members, supported more work on this subject, and the recommendations in the paper. They noted the conclusions that removal of both wire traces and shark lines is most effective at reducing mortality of these two species. PNA members and Tokelau have a number of domestic laws banning both wire traces and shark lines, in addition, some members have gone further by banning targeted shark fishing, finning of bycatch, and implemented shark sanctuaries; PNA members and Tokelau support a ban on both wire traces and shark lines.

373. Australia, on behalf of FFA members, proposed that SC17 draw the Commission's attention to the results contained in SC17-EB-WP-01. SC17 should note, with concern, the overall increased use of wire leaders and the substantial impact of wire leader use on silky and oceanic whitetip shark fishing mortality, which is likely to impact on the overfishing status of these stocks. Further, SC17 should advise the Commission that reducing or banning wire leaders is the single most effective measure to reduce fishing mortality for these two stocks.

374. In response to a query from Indonesia, the author clarified that all data pertained to the longline fishery and dealt only with silky and oceanic whitetip sharks.

375. Japan noted that it considers the results provisional, and as such, is OK with noting the results, but is not in a position to support recommending banning of all wire leaders and shark lines. Regarding release of non-ROP data, Japan stated it was unsure how much more data it could provide; it also indicated it could face obstacles in proving complete gear configuration information from logbook data.

376. China and Chinese Taipei supported continuation of the project and agreed with Japan regarding the recommendations.

377. The EU agreed with Australia regarding the benefits of updating this kind of analysis, and supported the recommendations. It noted that the scope of the study extended from 20°S to 20°N.

**Recommendations**

378. **SC17 recommends that the Project 101 be continued with the following modifications:**

- **Relevant CCMs should consider authorizing the release of their non-ROP longline data (facilitated through SPC) for this study, specifically to provide more complete gear**

**configurations by flag, or collaborating to conduct such an analysis for their flagged vessels, and allow analyses similar to Caneco et al. (2014)[11] to estimate factors affecting shark catchability and condition on longline retrieval to be conducted using a more complete dataset;**

- **Conduct the Monte Carlo analyses with inputs on catchability, condition on longline retrieval and gear configurations by flag;**
- **Conduct updated projections with inputs on the impact of banning shark lines and wire leaders or both and estimates of the probability of post release mortalities of silky and oceanic whitetip sharks (as based on Hutchinson et al. 2021 or other new information);**

**Additionally, results of the analyses should be shared to CCMs that made contributions to those analyses for their review and comments in advance of SC18.**

379. **SC17 also noted the result contained in SC17-EB-WP-01 and recommends that the Commission to be alerted to them, including:**

- **Banning shark lines has the potential to reduce fishing mortality by 2.6% and 5.4% for silky shark and oceanic whitetip shark, respectively. These percentages are lower than predicted estimates from Harley et al. (2015) which may be explained by a decrease in use of shark lines in more recent observer data; and**
- **Banning branchline wire leaders has the potential to reduce fishing mortality by 28.2% and 35.8% for silky shark and oceanic whitetip shark, respectively. These percentages are higher than estimates from Harley et al. (2015) and are due to a better representation of wire leader use in distant water fisheries.**

380. **Shark conservation and management measure (CMM 2019-04 paragraph 14) contains the option to either ban the carrying and use of wire leaders as branchlines or ban the use of branchlines directly off the longline floats or drop lines, known as shark lines, is currently in effect in many CCMs.**

### 5.2 Best handling practices for the release of cetaceans

381. Emily Crigler introduced SC17-EB-WP-02 (*Draft Best Handling Practices for the Safe Handling and Release of Cetaceans*), which includes guidelines for purse seine gear and longline gear.

382. The EB Theme Convener emphasized that the proposed guidelines were non-binding, and that similar guidelines have been recommended to the Commission for other taxonomic groups.

383. Japan advocated that the guidelines be forwarded to TCC for further discussion.

384. Chinese Taipei inquired regarding recommendations on the length of the line cutter. the USA stated that it had no specific suggestions or guidelines. It noted that the reference to de-hookers was included in the guidelines for shark and turtles, but those did not include length. SPREP stated that the main purpose of the cutter is to be able to lean over the vessel and release animal while still in water, so the length of the cutter would depend on how close it is possible to get to the animal; ideally the hook is removed or the leader needs to be cut down as short as possible. SPREP suggested some testing might be needed.

385. Niue, on behalf of FFA members, thanked the USA for the work and the initial draft, and looked forward to working with the USA in further developing these guidelines.

[11] SC10-EB-WP-10: https://meetings.wcpfc.int/node/8758

386. Korea stated that the guidelines could support implementation of a CMM requiring safe release of cetaceans from longline and purse seine vessels. It stated that priority should be given to crew safety, and indicated that Korea has published a guide for species identification and release of cetacean for use by vessel crew.

387. Tuvalu, on behalf of PNA members, stated it had comments on the draft aimed at clarifying wording and regarding equipment that it would share, and that it would consult it observers and industry and provide additional input.

**Recommendations**

388. **SC17 recommends the *Draft Best Handling Practices for the Safe Handling and Release of Cetaceans* be forwarded to TCC17 and WCPFC18 for consideration.**

389. **SC17 further recommends that the Commission develop graphics to be included with the *Best Handling Practices for the Safe Handling and Release of Cetaceans* for consideration at WCPFC19.**

### 5.3 Other issues

#### 5.3.1 Review of the ODF outputs on seabird mitigation measures

390. E. Crigler (USA) introduced SC17-EB-IP-15 (*Seabird Mitigation Measures on Small-Scale Longline Vessels North of 23° North*) on mitigation measure for seabirds. In adopting CMM 2015-03 the Commission agreed that the effectiveness of steamer-less tori lines would be reviewed no later than 3 years following from the CMM's implementation date. The paper was discussed through the SC17 ODF, where a number of CCMs commented in support of the paper's recommendation.

**Discussion**

391. Japan thanked the USA, and noted it had submitted several papers to SC previously on the issues discussed. It suggested it should summarize these and submit a final report for SC18.

392. New Zealand, on behalf of FFA members, supported the recommendations from the USA for all small-scale longline vessels (< 24m) operating north of 23°North to provide SC with information on the specific mitigation measures used by those vessels, and the associated seabird interaction rates for each mitigation measure, including streamer-less tori lines, and that SC18 review such information, to make findings and recommendations with respect to the effectiveness of the streamer-less tori line designs to inform the Commission's review under CMM 2015-03 (and its successor measures). In addition, FFA members stated that consideration should be given for further experimental investigation of 'strategic' offal discharge and blue-dyed bait to confirm the relative efficacy of these seabird bycatch mitigation methods, as recommended in SC17-EB-IP-05. This should be considered as neither offal discharges nor blue-dyed bait was helpful in reducing albatross interactions, yet they remain a seabird mitigation option in CMM 2018-03.

**Recommendations**

393. **SC17 recommends that Commission CCMs with small-scale longline vessels (< 24m) operating north of 23° North provide the SC with information, such as the results of scientific research or EM-based commercial vessel survey, as well as the specific mitigation measures used by those vessels and the associated seabird interaction rates for each mitigation measure, if available, including streamer-less tori lines, and that SC18 review such information, to make findings and**

**recommendations with respect to the effectiveness of the streamer-less tori line designs to inform the Commission's review under CMM 2015-03 (and its successor measures).**

394. **SC17 encourages further experimental investigation of 'strategic' offal discharge and blue-dyed bait to determine the relative efficacy of these seabird bycatch mitigation methods.**

## AGENDA ITEM 6 — FUTURE WORK PROGRAM AND BUDGET

### 6.1 Development of the 2022 work programme and budget, and projection of 2023-2024 provisional work programme and indicative budget

#### a. Review of *Scoring of the Proposed Scientific Committee Projects* (SC17-GN-WP-01)

395. PNG, on behalf of PNA members and Tokelau, introduced SC17-GN-WP-01_Rev2 (*Scoring of the Proposed Scientific* Committee *Projects*). They noted past problems and ambiguities in how proposals are scored, and outlined their proposed scoring system, which employs specific definitions for the scores applied to proposals, and averages these to provide a priority rank.

**Discussion**

396. CCMs supported the proposal, while noting that CCMs should rank all projects, and not simply those that they consider high priority.

**Recommendation**

397. **SC17 agreed that Table WP-01 be used to score and then rank SC projects. SC agreed to implement this approach at SC17 and thereafter. Ranking is derived from the average of the scores allocated by CCMs.**

**Table WP-01**. SC project scoring table. Colours represent priority rankings (6,9 = High; 3,4 = Medium; 1,2 = Low):

| | | Importance to WCPFC Management Outcomes or to the functioning of the SC | | |
|---|---|---|---|---|
| | Rank | Low | Moderate | High |
| Feasibility: Likelihood of Success | Low | 1 | 2 | 3 |
| | Moderate | 2 | 4 | 6 |
| | High | 3 | 6 | 9 |

Notes:
**Importance criteria** evaluate the significance of the outcomes of the proposal in contributing to the successful management of the WCPFC stocks or the functioning of the SC (e.g. is the proposal aligned with the WCPFC research and/or management priorities; does the proposal contribute to the effective planning and functioning of the SC; are the intended outputs/benefits well-defined and relevant; what is the level of impact and likelihood that the proposal outputs will be adopted; is the proposal cost effective). High= Essential; Moderate=Important but not essential; Low=Not Important.

**Feasibility criteria** evaluate the proposal's potential for success i.e., how likely is the proposal to achieve its stated objectives (e.g., are the objectives clearly stated, is the methodology sound, are the project objectives realistic and likely to be achieved, does the research team [if identified] have the ability, capacity and track record to deliver the outputs).

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

398. SC17 noted the progress of 2021 project outputs detailed in SC17-GN-IP-06 (*Intersessional activities of the Scientific Committee*). SC17 also noted there were no objections raised regarding the results of 2021 projects through the Online Discussion Forum, as detailed in SC17-ODF-01 (*Summary of Online Discussion Forum*).

### c. Review of *SPC assessment-related activities under the SSP standard SPC and additional resourcing budget* (SC17-GN-WP-02)

399. SPC addressed SC17-GN-WP-02 (*SPC assessment-related activities under the Scientific Services Provider standard budget and additional resourcing budget*). SPC highlighted that SC could choose 3 items in Table WP-02 (with a maximum of two from Column 1) to be funded by the SSP standard budget and additional resourcing budget. SPC further described the resource implications associated with various SC priority projects.

**Table WP-02.** Assessment-related activities under the SSP standard and additional resourcing budgets.

| Priority | Column 1 | Column 2 |
|---|---|---|
| 1 | SKJ assessment | Continue to develop the new ensemble approach – applicable approaches across species? |
| 2 | YFT peer review and additional analysis | Additional SWO projections (this would be expected by Dec. 2021) |
| 3 | SWP mako assessment | Revision of SP albacore TRP (this also expected by Dec. 2021) and Consequences for SP albacore of BET/YFT TRP levels (timeline to be defined) |

**Discussion**

400. Japan addressed the issue of coordination of the Commission's MSE work with other work performed by SPC. It noted that the Commission's current plan is to adopt MSE-based MPs, and that this requires a number of steps to be undertaken by the SC (e.g., detailed consideration and confirmation of an OM; review and selection of candidate MPs); this is currently scheduled to occur in 2022. It asked how this all was coordinated in the 2022 workplan. SPC stated that the technical work was supported by the Pacific Tuna Management Strategy Evaluation project. The process through which CCMs and managers will define a preferred management procedure will be determined at WCPFC18. SPC noted that Japan was correct in its assessment that there will be a lot of additional work in the first half of 2022 associated with the MSE process.

401. SPREP, in the context of the discussion on SC priority projects, noted the urgent need for a stock assessment for mako sharks (short fin and long fin), which were added to Appendix II of the Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES) in 2019, coming into effect on 26 November 2019. They are also on CMS Appendix II. Since 2019 Shortfin mako is listed as Endangered on the IUCN Red List. Appendix II CITES species would significantly benefit from international cooperation for their conservation. Mako sharks have low productivity, slow growth and take a long time to reach maturity so are highly vulnerable to over-exploitation and population depletion. CITES listed Appendix II species require a country to issue relevant permits/certificates for legal international trade to occur, including for the landing of individuals caught on the high seas into their own ports. The issuing of such permits/certificates requires a country to ensure the specimens are legally acquired (caught) and requires a positive non-detriment finding (NDF) assessment to ensure the harvest is sustainable. Any Mako

sharks caught and retained since the 26 November 2019 need to meet these requirements to be compliant with the CITES Convention. Retention bans that are implemented for CITES listed species would not require CITES permitting. New Zealand and Japan have made public their positive NDFs for shortfin mako sharks. Given the genetic evidence of a shared Mako stock structure in the Pacific it is imperative a formal stock assessment of the entire southwestern Pacific mako shark population is undertaken so that any NDFs undertaken consider all mortalities from the one population that are possible for sustainability. A regional approach would best serve meeting CITES obligations for Makos and ensuring a long-term sustainable population. Given that bycatch is occurring for this species and countries are wishing to trade, a stock assessment is urgently required.

402. Australia thanked Japan for its comments. It supported as top priorities continuing work on the skipjack stock assessment, yellowfin peer review, and work to re-examine the TRP for South Pacific albacore, which includes projection work for catches that would achieve the TRP. It noted that the mako stock assessment would be subject of subsequent budget discussions, that Southwest Pacific swordfish could be accommodated, and that Australia was eager to see the ensemble work progress.

403. The USA noted the need to be clear on which work was scheduled for 2021, and which for 2022. It stated that the skipjack stock assessment and yellowfin peer review are its top priorities, and supported work on the ensemble approach for 2022; it noted this is a proposed project for 2022, and stated the USA would like to provide assistance in that project. SPC indicated that work scheduled to be completed in 2021 would be covered by current funding, assuming the Commission did not choose to extend any of that work into 2022. Regarding the mako and other shark stock assessments, SPC noted that contracts for typical 1-year projects that are approved by the Commission in December often cannot be signed until February or March, leaving little time to complete the work prior to the SC meeting in August. It would be preferable if stock assessments have funding split across several years; if implemented at WCPFC18, it would result in the next shark stock assessment being presented to SC19 in 2023. Regarding the ensemble modelling approaches, SPC recommended that that TORs be developed following the completion of the blue shark follow-up work discussed by SC17, and a portion of the yellowfin peer review that would look at these issues; TORs for the ensemble approach could then be presented to SC18 for its consideration.

404. Several CCMs supported giving priority to the skipjack stock assessment and yellowfin peer review, and the proposed approach by SPC to the ensemble approach.

405. The EU supported the proposals that had been made. It noted the importance of conducting a mako shark stock assessment, and the demands of the MSE work as stated by Japan, and suggested that future shark stock assessments could benefit from using the ensemble approach, meaning a 1-year delay could be beneficial.

406. A number of CCMs stated that their rankings were provided for 2022 only, and not over the entire 3-year (2022–2024) timeframe.

407. SFP suggested that it would be useful to record the basis of the decisions that had been made.

408. Birdlife International stated its disappointment that there is opposition to Project 68 remaining as a high priority to be included in the work plan for 2022-2024. The TOR for project 68 states that “to date there have been limited assessments of risk of WCPFC fisheries to north Pacific albatrosses, or the more equatorial seabird populations”. Data limitations were mentioned as the reason for de-prioritisation of Project 68. The quality of data used for assessments is a consistent issue in the WCPFC, yet little progress has been made towards increasing observer coverage or adding effective electronic monitoring tools as they are developed to address these data limitations. But assessments continue to be carried out and Project 68 should be no exception. Annual reports from the 2020 fishing year reported prior to SC showed particularly

high seabird bycatch rates in the North Pacific, thereby providing data for gaps in assessing the impacts to north Pacific albatrosses, as stated in the TOR. In addition, Japan recently improved data collection and reporting for other areas – for example observed seabird bycatch in the 2019 fishing year of 1,665 birds – and recent data from Chinese Taipei are available that are not included in the previous assessment. Determining if seabird mortality in the WCPFC has been reduced through the recently adopted bycatch mitigation measures is increasingly critical as many of the species captured are experiencing rapid population declines. Birdlife International requested that Project 68 remain a high priority for the WCPFC in the 2022-2024 work plan

409. Japan stated that the FAC meeting (to which SC's project recommendations are provided) is restricted to CCMs, and stated it's view that beginning at SC18 the process of determining project priorities should likewise be limited to CCMs.

410. **SC17 agreed that the Commission's 2022 scientific services from SPC would comprise (i) the skipjack stock assessment; (ii) the YFT peer review and additional analyses; and (iii) continuing work to develop the new ensemble approach. Other additional priority work areas beyond the current agreed 2021 scientific services were identified for the remainder of 2021, including the requested stock projections for Southwest Pacific swordfish, and requested analyses related to the South Pacific albacore TRP and implications of the work presented in SC17-MI-WP-01 for that stock.**

**d. Review of proposed projects for 2022 – 2024**

411. **SC17 recommended the proposed work program and budget for 2022 and indicative budget for 2023 – 2024 in Table WP-03 to the Commission.**

**Table WP-03**. Recommended Future Work Program and Budget for 2022 – 2024, ordered by CCM's averaged score. (Essential projects are highlighted in gray; P17Xy represents a new project)

| Project Title | TOR | 2022 (SC18) | 2023 (SC19) | 2024 (SC20) | Responsibility | Avg. score | # CCMs |
|---|---|---|---|---|---|---|---|
| SPC-OFP scientific services[12] | | 961,874 | 981,112 | 1,000,734 | SPC | **8.8** | 18 |
| SPC Additional resourcing[2] | MFCL work | 173,206 | 176,670 | 180,204 | SPC | **8.2** | 18 |
| P35b. WCPFC Tissue Bank[2] | SC15-Att.G | 103,204 | 105,268 | 107,373 | SPC | **8.7** | 19 |
| P42. Pacific Tuna Tagging Program | SC15-Att.G | 730,000 | 730,000 | 730,000 | SPC | **8.9** | 19 |
| P65. Peer review | SC17-GN-IP-07 | 50,000 | | | SPC | **9.0** | 20 |
| P17X4. Further development of ensemble model approaches for presenting SA uncertainty | TOR - TBC | | 20,000 | | SPC | **7.9** | 20 |
| P17X1. Billfish Research Plan 2023 - 2027 | SC17-GN-IP-07 | 55,000 | | | SPC | **7.8** | 20 |
| P90. Length weight conversion | SC16-GN-IP-08 | 75,000 | | | SPC | **7.6** | 20 |
| P17X3. Preparing WCP tuna fisheries for application of CKMR methods to resolve key SA uncertainties. | SC17-GN-IP-07 | 40,000 | | | SPC; Contingent on EU support | **6.9** | 20 |
| P17X2. SWP mako shark SA | SC17-GN-IP-07 | 105,000 | | | SPC | **6.5** | 20 |
| P17X5. Scientific Advice for Southwest Pacific blue shark | SC17-GN-IP-07 | 40,000 | | | SPC | **6.2** | 20 |

[12] Budget – 2% annual increase

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| P108. WCPO silky shark assessment | SC17-GN-IP-07 | 50,000 | 50,000 | | SPC; Report to SC19 | **5.6** | 14 |
| P68. Seabird mortality | SC17-GN-IP-07 | 25,000 | 40,000 | 10,000 | SPC | **5.2** | 20 |
| P60. PS Species Composition (Carry over 2000 budget to 2022) | SC15-Att.G | | | | SPC | **N/A** | |
| **Total Project Budget** | | **1,446,410** | **1,121,938** | **1,027,577** | | | |
| **Total Project Budget + (SPC-OFP)** | | **2,408,284** | **2,103,050** | **2,028,311** | | | |

## AGENDA ITEM 7 — ADMINISTRATIVE MATTERS

### 7.1 Election of officers of the Scientific Committee

412. The Vice-Chair noted the discussion held at the Heads of Delegation meeting prior to SC17 regarding the need for a SC Chair, Vice-Chair, and Co-Conveners for the EB and MI themes for SC18. No nominations were made at SC17. The Executive Director advised that nominations for these positions would remain open until WCPFC18.

### 7.2 Next meeting

413. **SC17 recommended to the Commission that SC18 would be held from 10–18 August 2022, and that it had not identified a host country for the meeting if held in person. Tonga offered to host SC19 in 2023.**

## AGENDA ITEM 8 — OTHER MATTERS

### 8.1 Review of Online Discussion Forum outputs

414. PNG, on behalf of PNA members and Tokelau, thanked the Commission Secretariat and others engaged in the Online Discussion Forum, and stated that they have found the ODF to be an effective way to make progress on issues that are significant for the PNA but were not included in the SC17's abbreviated plenary agenda. The PNA and Tokelau additionally offered comments on Topic 26 (Assessing and addressing cetacean bycatch in tuna fisheries), noting that they were making these comments under Agenda Item 8 only because the proposal was included in the ODF at a late stage, after the initial closing date of the ODF, and there was insufficient time to prepare a post reflecting the PNA's collective views before the ODF closed. The PNA commented as follows regarding Topic 26: they thanked those involved for the Proposal, while stating that the PNA do not support the proposal or engagement by the WCPFC in the proposed Project. They do not consider that it is appropriate to analyse cetacean-related matters in the WCPO tuna fisheries through an ABNJ lens when the WCPO purse seine fishery occurs largely in national waters. The PNA has mixed experience with the FAO/GEF Project, and also has longstanding reservations about the value of global harmonisation processes based on previous experience. The PNA also does not support the approach proposed in the document. The PNA prefers that the Commission to set its own priorities for work on cetacean data and research, which could be done through the Ecosystem and Bycatch Research Plan proposed in SC17-SA-IP-05.

415. **SC17 noted the results of the Online Discussion Forum (SC17-ODF-01, *Summary of Online Discussion Forum*).** The paper is included as **Attachment F**.

### 8.2 Consideration of SC17-ST-IP-06 and SC17-ST-IP-10

416. Addressed under Agenda Item 2.3.

## AGENDA ITEM 9 — ADOPTION OF THE SUMMARY REPORT OF THE SEVENTEENTH REGULAR SESSION OF THE SCIENTIFIC COMMITTEE

417. **SC17 adopted the recommendations of the Seventeenth Regular Session of the Scientific Committee.**

418. **SC agreed that the SC17 Summary Report would be adopted intersessionally according to the following schedule:**

| Tentative Schedule | Actions to be taken |
|---|---|
| **19 August** | Close of SC17.<br>By 30 August, ***SC17 Outcomes Document*** will be distributed to all CCMs and observers (within 7 working days, Rules of Procedure). |
| **26 Aug – 6 Sep** | Secretariat will receive Draft Summary Report from the lead rapporteur and review the Draft Report |
| **6-14 September** | Secretariat will distribute the Report to all Theme Conveners for review. |
| **14-21 September** | Secretariat will clear the Report for posting and distribution |
| **21 Sep -30 Oct** | The Secretariat will post/distribute the draft Summary Report to all for CCMs and Observers for their review. Deadline for submission of comments by 30 October |
| **Early November** | Intersessional process for the adoption of the **SC17 Summary Report** |

## AGEDNA ITEM 10 — CLOSE OF MEETING

419. The Executive Director congratulated the Vice-Chair and Theme Conveners and the rest of the Members of the SC for successful completion of the business at hand. He noted that despite the need to streamline the online meeting agenda, SC17 held substantial discussions, with high quality presentations and interaction; he congratulated participants on the quality of the meeting. He expressed special thanks to SPC for the very large volume of documents and presentations that they provided. He also thanked the Secretariat's team and in particular the Science Manager and Assistant Science Manager for the leading the meeting preparations, the IT Team for ensuring the meeting's technical aspects, and the Lead Rapporteur. The Executive Director noted that the TTMW2 would be held in just two weeks, and that a number of SC delegates would also be involved in that meeting. He offered a special thanks to the Vice-Chair for assuming the Chair's duties at very short notice.

420. New Zealand acknowledged the very important work that Dr. John Annala has done in the region relating to tuna fisheries for many decades, including a number of years at WCPFC as the Convener for the Ecosystem and Bycatch Mitigation Theme sessions. On behalf of New Zealand, they acknowledged and thanked him for his many contributions.

421. The Vice-Chair acknowledged and commended participants whose localities are far from the Western Pacific, meaning they must work late at night or early in the morning, and yet continue to participate in our virtual meeting in a constructive manner. He also voiced his appreciation for other participants who have been patient with the technical difficulties in connecting to the virtual meetings. He noted the challenge of organizing a virtual meeting during the ongoing COVID-19 pandemic, and voiced

his pride that SC was able to successfully conclude its second virtual session. He thanked all CCMs and Observers for their contributions, and gave special appreciation to the Chair, Theme Conveners, the Lead and Support Rapporteurs, and all staff of the Scientific Services Provider and Consultants, stating that without their extraordinary support and contribution, SC17 could not have held such a successful meeting. He also sincerely thanked the Executive Director and his staff and the Commission's Legal Advisor for their continuous support and assistance in arranging and serving the virtual meeting.

422. The Vice-Chair closed SC17 at 12:10 Pohnpei time on Thursday, 19 August 2021.

**Attachment A**

**The Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean**
**Scientific Committee**
**Seventeenth Regular Session**
Electronic Meeting
11 – 19 August 2021

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**Attachment B**

**The Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean**
**Scientific Committee**
**Seventeenth Regular Session**
Electronic Meeting
11 – 19 August 2021

# Opening Remarks by the WCPFC Chair Jung-re Riley Kim

CCM delegates and observers, Dr. Halafihi, the Vice-Chair of the Scientific Committee, Mr. Feleti Teo, the ED and his team, especially our Science Manager Dr. Soh, Dr. Graham Piling and his team at the SPC,

It is a great pleasure and honor for me to address the 17th Regular Session of the Scientific Committee. Given the very limited time available for the SC sessions online, I will keep my remarks brief.

The COVID-19 pandemic has been dragging on even longer than many of us expected, and I would like to express my sincere appreciation to the SC Chair, and Vice-Chair, Theme Conveners, CCM scientific representatives, the Secretariat and the Scientific Services Providers for your tremendous effort to keep the scientific work going, which is crucial for the Commission to make informed decisions.

The review and advice of the Scientific Committee this year's is all the more important as the Commission has been working on a new tropical tuna measure, which will rely significantly on recommendations from the SC. In this regard, I note that the SC will be reviewing TRPs for the tropical tuna stocks reflecting on the requests made from our first tropical tuna workshop in April. South Pacific Albacore stock assessment results will also be reviewed, which will provide important information to the work of the intersessional working group on the stock. The SC is also going to address the Harvest Strategy framework in general so that the Commission can keep working on this important objective.

I see SC17 has a long to-do list this year as well under four different themes, and as the Chair of the Commission, I will keep my attentive eyes and ears.

With that, I would like to once again thank every one of you for this opportunity to address the 17th session of the Scientific Committee. I pray that each one of you will keep blessed with good health in these very challenging times and I wish you all the best over the next 6 days. Thank you.

**Attachment C**

**The Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean**
**Scientific Committee**
**Seventeenth Regular Session**
Electronic Meeting
11 – 19 August 2021

**Opening Remarks by WCPFC Executive Director Mr. Feleti P Teo**

Vice-Chair and Presiding Chair; Dr Tuikolongahau Halafihi,

Thank you for permitting me to make some remarks. And thank you for stepping up, at short notice, to take over the responsibility of presiding over the proceedings of this meeting in the absence of the Chair Mr Ueta Faasili Junior due to unavoidable personal commitments.

Vice-Chair, mindful of the time constraints on virtual meetings I will be brief. Let me join you Vice-Chair and the Commission Chair Madam Riley Kim in welcoming all delegates and observers to this, the meeting of the 17th regular session of the Scientific Committee. We, once again, find ourselves meeting under similar circumstances to those of the Committee's meeting last year. With the global COVID-19 pandemic continuing to impact the lives and health of people all over the world, and also causing major disruptions to international travels, we had no choice but to continue to conduct our businesses virtually for the second year in a row. From the perspective of preparations and conduct of virtual meetings, we are certainly better placed than last year, after a year of experience of virtual meetings. But as we all experienced, there are serious constraints and inhibitions to what virtual meetings can offer compared to face to face meetings. More so, for the Scientific Committee given the highly technical nature of issues involved.

As delegates may discern from the meeting arrangements announced for this meeting, we have retained basically the same meeting format and structure from last year. The main plenary will be utilizing, once again, the zoom virtual platform using its video conferencing facility. And because of the necessity to streamline and abbreviate the agenda for the plenary consisting mainly of essential issues requiring formal decisions, a number of other routine issues were placed as topics for the online discussion forum for Members to exchange views prior to the plenary and in the first few days of the plenary. I understand the arrangement agreed to at the Heads of delegation meeting is to have the online discussion forum closed on this coming Saturday 14th August. The key outcomes of those exchanges will be shared with the plenary towards the end of the plenary under agenda item 8. Given the experience of last year where the Committee was unable to complete its assessment of the work programme and budget for the science programme of the Commission in one session, an additional meeting day has been added making this meeting an 8-day meeting.

This year, unlike last year, has a heavier intersessional workload. In addition to the regular meetings of the subsidiary bodies of the Commission, there are two Commission level workshops tasked to progress the development of the new measure to succeed the current measure on tropical tuna due to expire in February next year in 2022. One workshop was convened in April and the other is scheduled after this meeting for early September and before the TCC17 meeting also in September. Like the Commission Chair I am hoping that the discussions related to the tropical tuna stocks in this meeting will feed neatly to the ongoing discourse to develop the new measure on tropical tunas.

So, leading up to this meeting, the Commission's scientific services provider (SPC-OFP) was seriously overburdened by the load of not only preparing for this meeting but also undertaking the numerous tasks

and analysis that was required by the first workshop in preparation for the second workshop on the new tropical tuna measure.

So, I wish to acknowledge with much appreciation the enormous contribution of Dr Graham Pilling and team SPC-OFP to the preparation and documentations for this meeting and the work in support of the efforts of the Commission to develop a new tropical tuna measure at the second workshop next month in September.

As we also know, the officers of the Scientific Committee, the Chair, Vice-Chair and the Theme Conveners and Co-Conveners play a lead role in coordinating and managing the preparation for and conduct of this meeting. These are non-paying officials that volunteer their own time and resources to support the work of the Scientific Committee, especially under prevailing difficult and very challenging conditions. I also acknowledge with much appreciation and commend highly their contributions and sacrifice.
I understand the terms of the Chair and Vice-Chair are due to lapse at the end of this year, and are open for nomination (and renomination) and appointment at the Commission meeting in December. It would be preferable that this meeting is able to come up with such nominations.

Despite efforts to streamline and abbreviate the agenda for this meeting, the provisional agenda for the meeting still include several substantive including to name a few:

a) the various stock assessment reports to be considered (for the south Pacific albacore, South Pacific blue shark, Southwest Pacific swordfish, and Pacific blue marlin);
b) the highly technical harvest strategy related issues – TRPs (bigeye, skipjack, yellowfin); management strategy evaluation framework for skipjack and mixed fisheries; and LRPs for sharks and billfish;
c) data gaps issue for the Commission including issues around other commercial fisheries in Indonesia and the Philippines; and
d) the more administrative and operational but important issue of the Committee's work programme and budget for 2022 to 2024.

These are highly technical issues and I hope the meeting functionalities of the zoom platform would enable the Committee to navigate well through these difficult issues so it can arrive at meaningful outcomes for onward transmission to the Commission for its consideration and decision at its annual session in December later in the year.

Vice-Chair, before I end my comments, I also wish to acknowledge with appreciation the contribution of my staff to the planning and preparation of this meeting under the leadership of the Science Manager Dr SungKwon (SK) Soh and the rest of the staff including our tireless IT team Tim Jones and Samuel Rikin.
The Secretariat stands ready to support the deliberations of the Scientific Committee over the next 8 or so days.

Vice-Chair, I wish you and the Committee well and for fruitful deliberations.
You stay safe and well.
Thank you and Kalanghan.

**Attachment D**

**The Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean**
**SCIENTIFIC COMMITTEE**
**SEVENTEENTH REGULAR SESSION**
ELECTRONIC MEETING
11-19 August 2021

**Opening Remarks by the Scientific Committee Vice-Chair Dr Tuikolongahau Halafihi**

Malo e lelei!
Chair of the Commission Ms Riley Kim, the Executive Director Mr Feleti Teo, distinguished delegates, ladies and gentlemen. Good morning, good afternoon, and good evening. I also recognize that for some delegates, this will be very early in the morning or outside your usual office hours.

With the continuing COVID-19 pandemic conditions, it is still fortunate for all of us to be able to convene this virtual meeting in order to continue the work of the Commission's science, and I sincerely appreciate the efforts of the Executive Director and his staff in organizing this meeting.

This is the 2nd year that the Commission has agreed to convene an electronic meeting of the Scientific Committee with an abbreviated agenda consisting of essential items necessary to progress the scientific work of the Commission in 2021. The abbreviated agenda was developed by the Secretariat, in collaboration with all SC officers and the Scientific Services Provider, SPC-OFP. On behalf of the SC and SC Chair, I sincerely appreciate the work done so far.

I also appreciate the establishment of the Online Discussion Forum website to facilitate the progress of SC projects and other key issues that were omitted from the abbreviated agenda. It was a forum for direct communications between authors and participants, and I anticipate that the results of the Online Discussion Forum would be briefly covered under the Agenda 6 (Future Work Program and Budget) and Agenda 8 (Other Matters). The Online Discussion Forum website was open for about two weeks with 25 Topics, and a Summary of the Online Discussion Forum will be posted later this week. Any issues from the Online Discussion Forum that require substantial discussions and decisions will be deferred to SC18.

On behalf of all SC participants, I sincerely appreciate all Theme Conveners, who will work for two weeks from now on, for their expertise and kind contribution to the work of the Scientific Committee. Finally, I appreciate Dr Graham Pilling and all his colleagues at SPC-OFP for your hard work to support the Commission's science, and all authors who also contributed their time and energy to produce valuable meeting papers, all much appreciated.

With the limited time frame of this virtual meeting, I am asking all participants to fully cooperate, in a constructive manner, to produce successful outcomes.

Thank you very much and stay safe at all times

Malo

**Attachment E**

**The Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean**
**Scientific Committee**
**Seventeenth Regular Session**
**Electronic Meeting**
**11 – 19 August 2021**

# AGENDA

## AGENDA ITEM 1 OPENING OF THE MEETING

**1.1 Welcome address**
**1.2 Meeting arrangements**
**1.3 Adoption of agenda**
**1.4 Reporting arrangements**

## AGENDA ITEM 2 DATA AND STATISTICS THEME

**2.1 Data gaps of the Commission**
2.1.1 Data gaps
2.1.2 Potential use of cannery data
**2.2 Other commercial fisheries for bigeye, yellowfin and skipjack tuna**

## AGENDA ITEM 3 STOCK ASSESSMENT THEME

**3.1 WCPO tunas**
**3.1.1 South Pacific albacore tuna (*Thunnus alalunga*)**
3.1.1.1 Review of 2021 South Pacific albacore tuna stock assessment
3.1.1.2 Provision of scientific information
a. Status and trends
b. Management advice and implications
**3.2 WCPO sharks**
**3.2.1 Southwest Pacific blue shark (*Prionace glauca*)**
3.2.1.1 Review of 2021 Southwest Pacific blue shark stock assessment (Project 107)
3.2.1.2 Provision of scientific information
a. Status and trends
b. Management advice and implications
**3.3 WCPO billfishes**
**3.3.1 Southwest Pacific swordfish (*Xiphias gladius*)**
3.3.1.1 Structural Uncertainty Grids and Projections
3.3.1.2 Review of 2021 Southwest Pacific swordfish stock assessment
3.3.1.3 Provision of scientific information
a. Status and trends
b. Management advice and implications
**3.3.2 Pacific blue marlin (*Makaira nigricans*)**
3.3.2.1 Review of 2021 Pacific blue marlin stock assessment
3.3.2.2 Provision of scientific information

a. Status and trends
b. Management advice and implications

**3.4 Peer Review**

**AGENDA ITEM 4 MANAGEMENT ISSUES THEME**

**4.1 Development of the Harvest Strategy Framework for key tuna species**
**4.1.1 Overview on the progress and updates to the harvest strategy workplan**
**4.1.2 Target reference points (TRPs)**
4.1.2.1 Bigeye and yellowfin tuna TRP analyses
4.1.2.2 Skipjack tuna TRP analyses
**4.1.3 Review of the overall harvest strategy work**
**4.1.4 Skipjack MSE framework**
**4.1.5 Mixed fisheries**
**4.1.6 Review of future progress of the WCPFC Harvest Strategy Workplan**
**4.2 Limit Reference Points for Species other than Tuna**
**4.2.1 Limit reference points for elasmobranchs**
**4.2.2 Review of appropriate LRPs for SWP striped marlin and other billfish (Project 104)**

**AGENDA ITEM 5 ECOSYSTEM AND BYCATCH MITIGATION THEME**

**5.1 Review of potential mitigation measures to reduce fishing-related mortality on silky and oceanic whitetip sharks (Project 101)**
**5.2 Best handling practices for the release of cetaceans**
**5.3 Other issues**
**5.3.1 Review of the ODF outputs on seabird mitigation measures**

**AGENDA ITEM 6 FUTURE WORK PROGRAM AND BUDGET**

**6.1 Development of the 2022 work programme and budget, and projection of 2023-2024 provisional work programme and indicative budget**

**AGENDA ITEM 7 ADMINISTRATIVE MATTERS**

**7.1 Election of Officers of the Scientific Committee**
**7.2 Next meeting**

**AGENDA ITEM 8 OTHER MATTERS**

**8.1 Review of Online Discussion Forum outputs**
**8.2 Consideration of SC17-ST-IP-06 and SC17-ST-IP-10**

**AGENDA ITEM 9 ADOPTION OF THE SUMMARY REPORT OF THE SEVENTEENTH REGULAR SESSION OF THE SCIENTIFIC COMMITTEE**

**AGENDA ITEM 10 CLOSE OF MEETING**

**Attachment F**

**The Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean**
**Scientific Committee**
**Seventeenth Regular Session**
**Electronic Meeting**
**11 – 19 August 2021**

# SUMMARY OF THE SC17 ONLINE DISCUSSION FORUM

**WCPFC-SC17-2021/ODF-01**

## INTRODUCTION

1. The **Secretariat** introduced the online discussion forum (ODF) in 2020 in conjunction with the sixteenth meeting of the Scientific Committee (SC16), which was held online as a result of the coronavirus disease (COVID-19), and therefore featured an abbreviated agenda. The ongoing COVID19 pandemic has resulted in SC17 also being held online with an abbreviated agenda, and the SC17 ODF was established to facilitate consideration of discussions on 2021 SC projects and other items omitted from the abbreviated SC17 agenda. The following guidelines were issued for the use of the SC17 ODF:

(i) All SC projects omitted from the abbreviated agenda of the SC17 virtual plenary session will be considered on the ODF and their outputs finalized in plenary under the Agenda Item 6 (Future Work Programme and Budget).
(ii) Information papers can be posted on the ODF if requested by the authors who wish to get feedback on their papers, noting that authors are fully responsible to provide feedback for any comments or questions, as needed.
(iii) The Summary of Online Discussion Forum paper prepared by the Secretariat will summarize exchanges on each Topic, and will be noted under the SC17 Agenda Item 8 (Other Matters). SC17 may take appropriate action on these as needed. Considering the continued overall disruptive impacts of the global COVID-19 pandemic on the work of the Commission, any substantive discussions and decisions related to Topic issues can be deferred to SC18.
(iv) Any 'non-controversial' recommendations that do not require substantial discussions or negotiations, e.g., "This project will continue in 2022," can be introduced and endorsed under appropriate SC17 agenda items (Agenda Item 6 Work Programme and Budget; or Agenda Item 8 Other Matters).

2. For reference during the SC17 Work Programme and Budget discussions, the table below summarizes the input provided by CCMs on ODF Topics related to WCPFC projects. CCMs' full comments are presented in this paper under each Topic.

**SUMMARY OF INPUT FROM CCMS ON THE PROGRESS OF SC PROJECTS**

| Topic No. | Subject | Comments |
|---|---|---|
| 4 | **Project 60 –** Species composition of purse seine catches | **PNA**: Support the paper's recommendations and the carryover of unused funds to 2022.<br>**USA**: Support project's message of higher levels of observer coverage. |
| 5 | **Project 90 –** Better size data for scientific analyses | **PNA**: Support work for next 12 months in Table 1, noting potential adverse impacts of COVID-19. |
| 6 | **Project 109 –** Training observers for elasmobranch biological sampling | **PNA**: Support the project, and a no-cost extension, and potentially refresher training prior to redeployment. Support development of a standardized sampling manual. |
| 9 | **Project 105 –** Bomb radiocarbon age validation (BET and YFT) | **PNA**: Support continuation of the work. |
| 10 | **Project 106 –** Aging of SP ALB | No comments. |
| 11 | **Project 99 –** Southwest Pacific striped marlin population biology | **PNA**: Advocate incorporating the additional work on striped marlin into the billfish research plan for prioritization against other billfish priorities. |
| 12 | **Project 100b –** Feasibility of CKMR assessment for SP ALB in the WCPO | **USA**: In response to a query from SPC, the USA will inquire regarding sampling opportunities for SP ALB caught east of New Zealand, and possible sampling of catch from troll vessels operating out of American Samoa. |
| 14 | **Project 102** – Population projections for oceanic whitetip shark | **FFA**: Comment that compliance with paragraph 20 of CMM 2019-04 is imperative for improvement of oceanic whitetip stocks. |
| 16 | **Project 88 –** Acoustic FAD analysis | **PNA**: Support the work, and the paper's recommendation for better identification of FAD buoys using the Manufacturers ID number. Request deletion of the reference to "labelling" of FAD buoys in the recommendation, and propose amended text regarding cooperation with industry. |
| 20 | **Project 110** – Review of non-entangling and biodegradable FAD trials in the WCPO | **PNA**: Support the project, the proposed revisions to timing of activities, and the request for a no-cost extension.<br>**USA**: Support the continuation of the project and the request for a no cost extension. |

## TOPIC 1. Review of the WCPO fisheries

### 1.1 Background

- **Task:** SC participants to review and ask questions or provide comments as needed.
- **Responsibility:** Pacific Community (SPC)

### 1.2 Relevant Documents

| | |
|---|---|
| SC17-GN-IP-01 | P. Williams and T. Ruaia. **Overview of tuna fisheries in the Western and Central Pacific Ocean, including economic conditions – 2020** |

### 1.3 Key Questions and Comments

3. **Kiribati** thanked SPC for the paper, noting it is truly useful. Kiribati is pleased that SPC has taken on board the suggestion made at SC16 to illustrate longline VMS days effort in the tropical and southern longline fisheries accumulated monthly for each of the last few years (Figures A3 and A4). In the absence of complete electronic logsheet reporting to WCPFC by longliners, VMS is the only comprehensive indicator of latest trends in these fisheries.

(i) **Request:** For the tropical purse-seine fishery, note that the cumulative VMS effort plot Figure A1 in last year's SC16-2020/GN IP-1 is now Figure 2 in SC17-MI-IP-11. For ease of reference, Kiribati suggests that this cumulative purse-seine VMS effort plot also be included in next year's GN-IP-01 paper.

- **Reply:** SPC thanked Kiribati for this comment and will respond to the request to include the tropical purse-seine fishery cumulative VMS effort plot in future versions of the GN-IP-01 paper.

4. **Nauru, on behalf of PNA** members, thanked SPC and FFA for the excellent paper. PNA members are particularly pleased to see that, overall catches for 2020 were around the same level as recent years, because of the importance of the regional tuna fisheries to many CCMs and the importance also of tuna products to global food security in these COVID times. PNA all thanked those involved in the efforts to keep the tuna supply chain functioning effectively. At the same time, PNA members are concerned at the more adverse effect on the longline fishery.

(i) **Request.** The PNA also thanked SPC also for including the information shown in Figure A1, on catches by jurisdictional area. This information is fundamentally important because it highlights the nature of this Commission where over 85% of the catch is owned by the coastal states and the Commission's role is focused on applying compatible measures in the high seas. Because of the importance of this information, which is frequently referred to in Commission discussions, PNA requests that some discussion of this data be included in the paper alongside the discussion on catches by species and fishery.

- **Reply**: SPC thanked PNA members for these comments. SPC will respond to the request to include discussion of the information presented in Figure A1 in future versions of this paper.

## TOPIC 2. Review of the Eastern Pacific Ocean (EPO) fisheries

### 2.1 Background

- **Task:** SC Participants will review the EPO tuna fisheries report and raise questions or provide comments as needed
- **Responsibility**: Inter-American Tropical Tuna Commission (IATTC)

### 2.2 Relevant Documents

| | |
|---|---|
| SC17-GN-IP-02 | IATTC. **The Tuna Fishery in the Eastern Pacific Ocean in 2020** |

### 2.3 Key Questions and Comments

5. There were no comments or questions.

## TOPIC 3. Trial Publishing of Annual Catch and Effort (ACE) Tables

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### 3.1 Background

- **Task:** As recommended by TCC16 (Para 101, TCC16 Summary Report) and endorsed by the Commission (Para 312i, WCPFC17 Summary Report), SC participants will review Section 4.2 (latest development on the Annual Catch Estimates [ACE] tables) of SC17-ST-WP-01 on the feasibility of expanding the ACE tables to include additional estimates of effort where it is practicable to be derived based on the April 30 scientific data submissions from CCMs, and raise questions or provide comments as needed.
- **Responsibility**: WCPFC Secretariat and SPC
- **Access:** The latest WCPFC Annual Catch and Effort Estimates (ACE) Tables by fleet may be accessed online
- **Notes by the Secretariat (23 July 2021):**

  (i) Maps of catch by species have been produced for 2019 and 2020 and are included in these tables. The maps are consistent with the WCPFC data dissemination rules in excluding the activities of less than 3 vessels. However, maps with all data (i.e., unfiltered) can be generated and included in the ACE Tables, if the flag-state CCM provides authorisation to do so. An alternative is that the unfiltered map can be provided directly to the flag-state CCM on request (but not published in the ACE Table on the WCPFC web site).

  (ii) New data summaries are now included: o additional EFFORT ESTIMATES where it is practicable to be derived based on the April 30 scientific data submissions from CCMs, and o Derived recent annual catch and effort estimates that could be relevant for reviews of implementation of some CMMs and for certain CCMs where it is practicable for the estimate to be derived based on the April 30 scientific data submissions from CCMs.

  (iii) DISCARDS by SPECIES in "number of fish" have been submitted for a number of longline fleets, but are not yet included in the ACE Tables. We hope to include an additional worksheet tabulating the "DISCARDS in number" for longline fleets in a future version of the ACE tables.

### 3.2 Relevant Documents

| | |
|---|---|
| SC17-ST-WP-01 | SPC-OFP. **Scientific data available to WCPFC (Section 4.2)** |

### 3.3 Key Questions and Comments

6. **Palau, on behalf of the PNA** commented that it welcomed the preparation of the expanded ACE tables by SPC, recalled that this expansion was a result of a request from the Secretariat relating to the value of the tables in preparing the dCMR, and looked forward to discussion on the outcome at TCC. PNA considered that having catch and effort data online in Excel is much more useful than having less information in a PDF form in the Annual Reports, including being more useful to the WCPFC Secretariat and in the Public Domain. On that basis, PNA Members stated it supports the adoption of the ACE Tables as an alternative to reporting this data in the Part 1 Reports.

## TOPIC 4. Project 60 – Species composition of purse seine catches

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### 4.1 Background

- **Task:** SC participants will review the progress and outcomes of Project 60 and raise questions or provide comments as needed. Attention is drawn to the request that, in light of COVID-related restrictions on planned fieldwork in 2020/21, the paper seeks approval to carry over unused funds into 2022.
- **Responsibility:** SPC

### 4.2 Relevant Documents

| | |
|---|---|
| SC17-ST-IP-04 | T. Peatman, P. Williams, and S. Nicol. **Project 60: Progress towards achieving SC16 recommendations** |

### 4.3 Key Questions and Comments

7. **Kiribati, on behalf of the PNA** thanked SPC and all those involved in their efforts to maintain progress in Project 60 towards achieving its recommendations from SC. PNA members supported the recommendations in the paper and the proposed activity priorities, and also supported carrying over unused funds into 2022.

8. **The USA** commended SPC for their work and supports the Project's message of higher levels of observer coverage in order to ensure more accurate estimates of purse seine catch composition and thus higher reliability of tropical tuna stock assessments.

## TOPIC 5. Better size data for scientific analyses (Project 90)

### 5.1 Background

- **Task:** WCPFC17 endorsed the extension of Project 90 to 57 months from January 2019 through September 2023 ($27,000 for 2021 and $75,000 for 2022). Comprehensive reports would be prepared for SC17 and SC18, and a final report for SC19. SC participants will review the progress of Project 90 and raise questions or provide comments as needed for 2022 project activities.
- **Responsibility:** SPC

### 5.2 Relevant Documents

| | |
|---|---|
| SC17-ST-IP-05 | J. Macdonald, et al. **Project 90 update: Better data on fish weights and lengths for scientific analyses** |

### 5.3 Key Questions and Comments

9. **FSM, on behalf of the PNA** thanked SPC and those involved for the work done so far and for the update on Project 90. PNA supported the anticipated work for the coming 12 months, provided in Table 1, noting that this could continue to be adversely impacted by the current situation with COVID-19 where the observer programmes have been severely constrained. PNA appreciated the effort made to develop a programme that enables participation by observers who would otherwise be unable to work.
   - **Reply:** SPC thanked the PNA for their interest and support.

## TOPIC 6. Training observers for elasmobranch biological sampling (Project 109)

### 6.1 Background

- **Task**: As recommended by SC16, WCPFC17 endorsed Project 109 for the training of observers to collect elasmobranch biological material for age growth and reproduction. SC participants will review the progress of this project and raise questions or provide comments as needed. Attention is drawn to the request that, in light of COVID-related restrictions on planned fieldwork in 2020/21, the paper seeks approval to carry over unused funds into 2022.
- **Responsibility: SPC**

### 6.2 Relevant Documents

| | |
|---|---|
| SC17-ST-IP-07 | SPC. **Training observers for elasmobranch biological sampling (Project 109)** |

### 6.3 Key Questions and Comments

10. **Solomon Islands, on behalf of PNA** members, supported both the Project and the no-cost extension requested. On the timing, PNA notes that if there are limited training resources available and refresher training is required before redeployment begins, priority in the early stages should probably be given to that.

(i) **Question**: Will the Project be developing any training material as part of this training? It would be good to have a standardised sampling manual to ensure the data are collected consistently across observer programmes and across years.

- **Reply:** SPC stated that new material will indeed be a key component of the biological sampling training, which will include the use of new shark ID keys (available from the PIRFO website, along with a growing body of online training materials), and materials to assist training of observers on the keys will be part of the work under this project. In turn, a sampling policy and manual will be an important planned development to enhance consistency as you note, and the shark training will build on a generic sampling policy/manual currently being developed.

## TOPIC 7. Electronic monitoring for improved accountability in Western Pacific tuna longline fisheries

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### 7.1 Background

- **Task:** SC participants will review the effectiveness of electronic monitoring in comparison with logbook and human observer data in the paper and raise questions or provide comments as needed.
- **Responsibility:** Paper authors

### 7.2 Relevant Documents

| | |
|---|---|
| SC17-ST-IP-12 | C.J. Brown, A. Desbiens, M.D. Campbell, E.T. Game, E. Gilman, R.J. Hamilton, C. Heberer, D. Itano, K. Pollock. **Electronic monitoring for improved accountability in western Pacific tuna longline fisheries** |

### 7.3 Key Questions and Comments

11. **The USA** supported the work presented in Brown et al. (2021) that confirmed the accuracy and efficacy of electronic monitoring (EM) in a Western Pacific tuna longline fishery. Expanded EM use can supplement human observer coverage and can be an especially useful alternative during a pandemic that has resulted in significant reduction of observed fishing activities globally.

12. **ISSF** agreed that EM is a very valuable tool that is being underutilized, and hope that the topic of EM will make it to this year's Commission Agenda.

13. **Birdlife International** thanked the authors for submitting their study demonstrating the utility of EM for improving data collection and accountability of catch (of both target and bycaught species). Birdlife expressed its increasing concern at the ongoing suspension of the ROP and its impact on data collection of seabird bycatch mitigation compliance. They acknowledged that there are serious human health concerns related to the pandemic, however, as this paper reports, EM is a key tool that can contribute to overcoming this ongoing challenge. The slow pace in developing guidelines on EM are critical factors contributing to poor data collection and should highlight the importance of taking urgent action to increase EM in the fleets operating in the WCPFC to avoid such disruptions in the future. While there are challenges in implementing EM fleet-wide, the benefits of EM are consistently demonstrated in trials including:
    a) Reduced workload for captains and crew
    b) Standardised data collection without spatial bias
    c) Reduced resource use from having human observers on board (accommodation, food, risk of covid transmission)
    d) Scalable (from small vessels to large)
    e) Flexibility in tools and data collection fields.
    f) Open source (free) software can be used.
    g) Reduced long-term financial costs.
    h) Verification of catch and methods to support certification in sustainable fisheries (MSC) which increases catch value.

    Birdlife International encouraged the Secretariat and CCMs to find time to discuss and progress this important issue.

14. **FSM** also welcomed the findings of this paper indicating the utility of EM in improving the quality of fishery data. FSM continues to build a national EM programme working towards meeting the T3 Challenge deadline in 2023. At this stage national programme objectives have been identified and various components of the programme are in development including a national EM regulation, performance standards and data review procedure. Importantly there is continued dialogue with industry partners on implementation of EM.

15. **Solomon Islands on behalf of the PNA** stated that the EM trials undertaken in Palau, FSM and RMI demonstrate the potential value of electronic monitoring to supplement observer reporting for the verification and enhancement of reporting on longline catches of target and bycatch species. The trials in the Solomon Islands confirm the value of EM reported in this paper. PNA have committed to the implementation of electronic monitoring in their waters and the development of a PNA EM Programme and look forward to the early implementation of requirements for EM by the Commission. PNA would welcome participation in this research by national scientists undertaking this work.

16. **TNC** commented that the reduction in monitoring activities due to the global pandemic has interrupted critical data collection systems needed for informed management of Commission resources. The reduction in regional observer coverage has had the greatest impact to the loss of data and monitoring efforts. Data loss in longline fisheries combine with existing data gaps resulting from historically low observer coverage rates. EM represents an important alternative data collection approach with many benefits that can blend with observer coverage. The Commission is encouraged to support additional research and the development of data standards and mechanisms to incorporate EM derived data into existing data streams as managed by SPC.

• **Reply: ISSF** agreed that EM does not collect information on all of the same items that observers do, and vice versa. But they largely overlap. There is a need to move from "pilot tests" to implementation.

## TOPIC 8. Tuna Research Plan

### 8.1 Background

- **Task**: SPC updated the *Draft research plan for 'key' tuna species in the WCPO* (SC16-SA-IP20) with the latest understanding of SC activities to highlight some important research and development areas arising from the most recent stock assessment discussions. SC participants should consider the draft and raise questions or provide comments, inputs and updates as needed.
- **Responsibility**: SPC

### 8.2 Relevant Documents

| | |
|---|---|
| SC17-SA-IP-05 | SPC-OFP **Updated draft research plan for 'key' tuna species in the WCPO** |

### 8.3 Key Questions and Comments

17. **PNG, on behalf of PNA members,** thanked SPC for providing this paper and noted the suggestion for the SC to develop an 'urgent and important' matrix to aid prioritization and budgetary discussions. PNA stated that here and in the workplan and budget, a better way to rank projects is to score them 05, with 5 being the highest priority and summing across the members scores to decide priority. PNA members note the proposal to develop research plans for other themes (Data and Statistics, Ecosystems and Bycatch, Management Issues) in the coming years and believe that this would be a good way to plan and prioritise the work of the SC.

(i) **Request.** Three things appear to be missing from the research plan, and PNA requests that these be considered for inclusion:

a) The New Zealand troll fishery characterisation and CPUE as presented in from SC17-SA-IP-18 would be more effectively incorporated into the assessment work if completed one year prior to the assessment. We therefore suggest that the next iteration of this work be completed for consideration at SC19 in 2023.

b) Stock Synthesis (SS) developments: currently SS, which is used for assessments on tuna stocks, particularly in the north Pacific, as well as sharks and billfish, cannot estimate $SB/SB_{F=0}$ ratios. It would be very useful to have these calculations included into that assessment framework.

c) As noted in SC17-MI-WP-08: The risk-based fishing mortality benchmarks should be defined as dependent variables in the two main assessment platforms used (SS and MFCL) so that statistical uncertainty of the estimates can be calculated.

• **Reply:** SPC replied as follows: (a) can be captured within the plan for further discussion at SC18. The MULTIFAN-CL element of (c) can also be captured for consideration within future MULTIFAN developments, and this may also be an area of discussion during SC17. With regards to the SS-related requests in (b) and (c), this will require liaison with the team developing SS – direct approaches by relevant CCMs would be useful.

## TOPIC 9. Bomb radiocarbon age validation for bigeye and yellowfin tuna (Project 105)

### 9.1 Background

- **Task**: The objective of Project 105 is to test the validity of age estimates for bigeye and yellowfin tuna from the WCPO using bomb radiocarbon dating. This project continues to

August 2022. The SC participants will review the progress report and raise questions or provide comments as needed.

- **Responsibility**: CSIRO

**9.2 Relevant Documents**

| | |
|---|---|
| SC17-SA-IP-09 | A. Andrews, K. Okamoto, K. Satoh, F. Rouspard, J. Farley. **Progress report on bomb radiocarbon age validation for bigeye and yellowfin tunas in the WCPO (Project 105)** |

**9.3 Key Questions and Comments**

18. **RMI, on behalf of PNA members,** thanked CSIRO and all those who are supporting this work. PNA stated it appreciates the progress report and supports the continuation of this work.

## TOPIC 10. Aging of South Pacific albacore (Project 106)

**10.1 Background**

- **Task**: The budget of this project was covered by the unspent fund from Project 81 ($23,000). SC17 will review improvements of ageing South Pacific albacore, focusing on the New Zealand troll fishery, for input into the 2021 stock assessment, and raise questions or provide comments as needed.
- **Responsibility**: CSIRO

**10.2 Relevant documents**

| | |
|---|---|
| SC17-SA-IP-10 | J. Farley, K. Krusic-Golub, P. Eveson. **Updating age and growth parameters for South Pacific albacore (project 106)** |

**10.3 Key Questions and Comments**

19. There were no questions of comments.

## TOPIC 11. Southwest Pacific striped marlin population biology (Project 99)

**11.1 Background**

- **Task**: The CSIRO and Fish Ageing Services (FAS) of Australia provided a progress report for Project 99 to SC16 relating to assessing age, growth and maturity estimates for Southwest Pacific striped marlin (SC16-SA-IP-21). The aim of the project is to evaluate the suitability of otoliths for providing estimates of age and growth, and to evaluate the histological criteria used to determine maturity status of females. The SC participants will review the final report and raise questions or provide comments as needed.
- **Responsibility**: CSIRO

**11.2 Relevant documents**

| | |
|---|---|
| SC17-SA-IP-11 | J. Farley, P. Eveson, K. Krusic-Golub, K. Kopf. **Review of Southwest Pacific striped marlin population biology (Project 99)** |

**11.3 Key Questions and Comments**

20. **RMI, on behalf of PNA members,** thanked CSIRO and all those who are supporting this work, and stated a good next step is to incorporate the additional work on striped marlin into the billfish research plan for prioritization against other billfish priorities.

## TOPIC 12. Feasibility of close-kin mark-recapture (CKMR) assessment for South Pacific albacore in the WCPFO (Project 100b)

### 12.1 Background

- **Task**: **This** project, funded by the SPC, provides an initial examination of the suitability of CKMR for South Pacific albacore in the WCPO for estimation of population size, reproductive potential, mortalities, and connectivity. The SC participants will consider the results of this project and raise questions or provide comments as needed.
- **Responsibility**: CSIRO

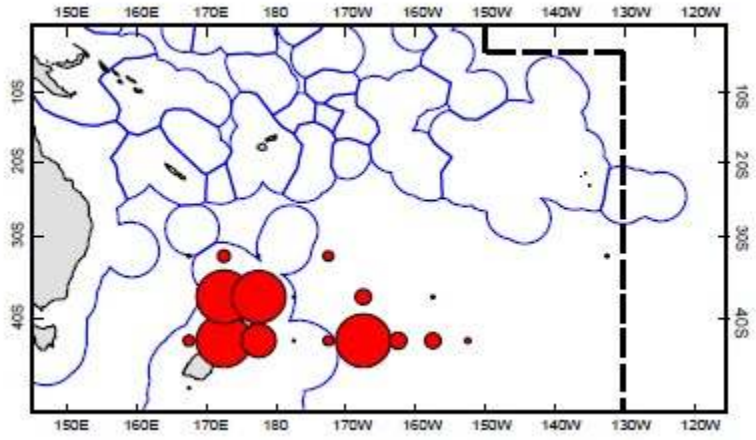
### 12.2 Relevant documents

| | |
|---|---|
| SC17-SA-IP-14 | M. Bravington, S. Nicol, G. Anderson. **Feasibility of Close-Kin Mark Recapture for albacore in the WCPO (Project 100b)** |

### 12.3 Key Questions and Comments:

21. **SPC** commented that thus far, the sampling design for juvenile albacore has only considered the New Zealand troll fishery. However. in 2020, 18 US troll vessels fished in the South Pacific catching about 1,900 t of albacore (see **SC17-GN-IP-01** paper and US Annual Report). These vessels fished east of NZ and in some years can fish out to 150W. See the map of troll fishery effort for 2020 from GEN-1. It might be useful to include these catches in the sampling plan. The US Annual Report indicates that these catches mainly go to Vancouver for sale.

(i) **Question:** Can the US advise on what the sampling opportunities for these fish may be? Are there any intermediate locations that might present sampling opportunities?




- **Reply:** The USA stated that it will inquire about sampling opportunities in Canada. There were also several vessels from American Samoa that converted from longlining and went trolling in 2020. USA will assess if this fishery continues and if so, there may be opportunity to sample in Pago Pago. o **Reply:** SPC thanked the USA and noted that sampling juvenile South Pacific albacore east of NZ would be extremely useful for the CKMR design.

## TOPIC 13. A compendium of fisheries indicators for target tuna stocks

### 13.1 Background

- **Task**: **Indicator** papers provide empirical information on recent patterns in fisheries for all `key' target tuna species (skipjack, bigeye, yellowfin and South Pacific albacore tuna) with explanatory details for the figures and a brief interpretation of the trends. The SC participants will review updates on fisheries indicators and raise questions or provide comments as needed.
- **Responsibility**: SPC

### 13.2 Relevant documents

| | |
|---|---|
| SC17-SA-IP-15 | S. Hare et al. **A compendium of fisheries indicators for target tuna stocks in the WCPFC Convention Area** |

### 13.3 Key Questions and Comments

22. **FFA members** thanked SPC for the comprehensive work undertaken to compile these fishery indicators. FFA members find these indicators very useful as they provide empirical information on recent patterns in fisheries for all `key' target tuna species for those years when a stock assessment is not conducted. Along with short-term stochastic projections, this helps members to assess potential stock status until such time as a full-blown stock assessment is undertaken.

23. **Kiribati** stated it finds this suite of empirical indicators extremely useful. Not only for the reasons highlighted by FFA, but also for helping explain the state of the fishery to non-specialists, and encouraged SPC to continue to refine and provide these indicators.

(i) **Question:** The catch-at-size (by weight and by number of fish) plots in Figures 6, 14, 22 and 31 are particularly informative. Could SPC advise whether or not it would be feasible, or useful, to overlay an estimated biomass-at-size line on each these plots to graphically demonstrate what proportion of the estimated in-the-water biomass (or numbers of fish) in each size-class is being caught? We understand this estimate of biomass-at-size would have to be derived from assessment models rather than empirical data and may not necessarily be easily compiled from existing model outputs.

- **Reply:** Yes, it would be possible to make a biomass-at-size plot combining the size-at-age data and assessment output; just a couple of reasonable assumptions would need to be made. However, this paper doesn't contain other assessment output, as those are not "data" nor "indicators" per se, and probably best that it doesn't set a precedent. We note that this suggestion is a very good one and we will contemplate on how best to illustrate and publish this information. The most obvious places would be as part of the assessments, but also as a new figure in the annual Tuna Fisheries Assessment Report ("TFAR"), which is generally published within a couple of months following SC.

## TOPIC 14. Population projections for oceanic whitetip shark (Project 102)

### 14.1 Background

- **Task**: The purpose of this US-funded project is to develop future projections for the 2019 WCPO oceanic whitetip stock assessment to assess the impacts of future fishing mortality on recovery timelines. The SC participants will review updates on fisheries indicators and raise questions or provide comments as needed.
- **Responsibility**: USA

### 14.2 Relevant documents

| | |
|---|---|
| SC17-SA-IP-21 | USA. **Population projections for oceanic whitetip shark (Project 102)** |

### 14.3 Key Questions and Comments

24. **FFA members** noted that the longline sector is the main contributor to the catch of this species, and that compliance with paragraph 20 of CMM 2019-04 is imperative for the further improvement of the oceanic whitetip shark population. While this has improved in recent years, there is still room for improvement.

## TOPIC 15. Retrospective forecasting of CPUE for South Pacific albacore

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### 15.1 Background

- **Task**: The harvest strategy work plan for 2021 is for SC17 to provide advice on the performance of candidate management procedures for South Pacific albacore tuna, with the Commission to adopt a management procedure in 2022. SC participants will review the related document, consider the recommendation to explore alternative empirical and model-based estimation approaches for South Pacific albacore, and raise questions or provide comments as needed.
- **Responsibility**: SPC.

### 15.2 Relevant documents

| | |
|---|---|
| SC17-MI-IP-01 | N. Yao et al. **Retrospective forecasting of CPUE for South Pacific albacore** |

### 15.3 Key Questions and Comments

25. There were no questions or comments.

## TOPIC 16. Acoustic FAD analysis (Project 88)

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### 16.1 Background

- **Task**: The objective of the acoustic FAD analysis is to
  (i) identify whether acoustic buoys on drifting FADs could provide new fishery independent data for stock assessments (e.g., indices of abundance), and
  (ii) identify whether limiting sets to only those FADs that have a large biomass beneath them can reduce the levels of small bigeye and yellowfin caught.

This project was funded through the EU's voluntary contribution and the WCPFC's 20% matching fund. Duration of the project is 18 months, closing in September 2021. SC participants will review the final report of Project 88 and its recommendations, in particular the need for additional data covering the whole WCPFC Convention Area and encouragement for other industry partners to become involved in the project, and raise questions or provide comments as needed.

- **Responsibility**: SPC

### 16.2 Relevant documents

| | |
|---|---|
| SC17-MI-IP-05 | L. Escalle et al. **Project 88 final report: FAD acoustics analysis** |

### 16.3 Key Questions and Comments

26. **Solomon Islands, on behalf of PNA members,** thanked SPC, Cape Fisheries, SPTC and NFD for their work. PNA understands that this work is very preliminary and this is a longer-term task, but it is important, and very welcome. PNA supports the recommendation for better identification of FAD buoys using the Manufacturers ID number. As noted in the ODF on this Topic at SC16, PNA is introducing a new FAD logsheet consistent with the decisions on FAD data by WCPFC14 in 2015, which will include a requirement for vessel operators to report Buoy IDs for all FAD operations from 2022. In addition, PNA members have now adopted a new PNA Implementing Arrangement that will require operators to register FAD Buoys and provide tracking data.

(i) **Request:** PNA request deletion of the reference to "labelling" of FAD buoys in the recommendation because we think there is further work to be done on the labelling of FAD buoys before the value of that step is established.

(ii) **Proposal:** PNA also support SC endorsement of continued cooperation with the industry, but propose that the text on this issue be amended as follows, noting the rights of coastal states to data on fishing in their waters, including Commission data:

> Endorse the continued cooperative relationship with the fishing community to obtain business confidential commercially sensitive data for analysis by regional scientists for the purpose of scientific and other research, particularly with regard to FADs, and the fishing strategies involved in their use.

**Reply:** SPC thanked PNA members for their support. A revision of the paper will be submitted with the two recommendations mentioned modified:

- Recommend the need for better identification of particular dFAD buoys (e.g., via the buoy identification numbers) by commercial vessel operators or via observer reports.
- Endorse the continued cooperative relationship with the fishing community to obtain business confidential commercially sensitive data for analysis by regional scientists for the purpose of scientific and other research*, particularly with regard to dFADs, and the fishing strategies involved in their use. Highlight the need for additional data covering the whole WCPFC convention area, including that from now available multi-frequency echosounder buoys, and encourage other industry partners to become involved in the project.

Two different approaches were used to investigate the potential to use FAD acoustic data in skipjack stock assessments:

1. The first method investigated the potential to derive an independent relative index of tuna abundance. This was a clustering approach to distinguish the characteristics of acoustic signals associated with tuna versus bycatch species. We were able to reliably identify patterns generally associated with tuna presence and computed relative index of tuna abundance that could be linked to purse seine catch levels. However, at this point we are unable to determine species composition from the acoustic signals alone. Further investigation, combined with enhanced data availability (e.g., multi-frequency buoy data) may improve the utility of this approach and provide valuable information moving forward.
2. The second method investigated an integrated CPUE standardization approach that combined two data sources: 1. purse seine CPUE from dFAD sets, and 2. estimated presence/absence from acoustic dFAD buoy data. This approach is intended to better inform the standardization model on encounter probability of skipjack across the spatial domain, using data from acoustic FAD buoys. The standardized CPUE time-series could then be used in the stock assessment to inform on trends in abundance. This approach used a random forest model to predict presence/absence of skipjack based on observations in a training set, but further vetting and validation (e.g., distinguishing bigeye and yellowfin from skipjack) is warranted to confirm these classifications. Currently, both approaches are still under development. The limiting factors for

further development being the short time-series of acoustic data currently available (2016–2018) and the spatial extent of the available data. An expansion of the current study, with a larger, longer and more comprehensive dataset from multiple fleets, should be promoted and would allow for further investigation of the inclusion of acoustic data from echosounder buoys deployed on FADs in stock assessments. While we will continue to investigate their use for future WCPO skipjack stock assessments, the applicability to the scheduled 2022 assessment is at present uncertain.

o **Reply** (PNA)**:** PNA apologised that their previous post didn't come out clearly. Our intention was:

a. To delete the words, "business confidential", and replace them with, "commercially sensitive"

b. To delete the words, "by regional scientists", and replace them with, "for the purpose of scientific and other research."

Our proposal is that the revised text should read:

Endorse the continued cooperative relationship with the fishing community to obtain commercially sensitive data for analysis for the purpose of scientific and other research, particularly with regard to FADs, and the fishing strategies involved in their use.

o **Reply:** (SPC): Ok noted. We will make the changes.

**(iii) Question:** PNA members inquired whether SPC could indicate how FAD acoustic data might be used in skipjack assessments.

• **Reply:** SPC stated such data could potentially be analysed to provide time series of SKJ relative abundance data, both over time and across spatial regions of the stock assessment model. This would rely on the acoustic data providing good information on local SKJ abundance, which is a reasonable working hypothesis but would require additional work e.g., verifying acoustic records with catches. An appropriate statistical design would also be needed, such that relative abundance indices would not be biased by spatial FAD deployment patterns. Given the above, acoustic-based relative abundance indices could be input to the stock assessment model as a fishery-independent data source and be fitted in the parameter estimation process, thus providing information on biomass time-series and spatial trends.

## TOPIC 17. North Pacific albacore MSE framework

### 17.1 Background

- **Task**: SC participants will note the work undertaken by the ISC on the development of management strategy evaluation for North Pacific albacore tuna. A YouTube presentation is available. SC participants are encouraged to give comments and/or ask clarifications on the ISC reports.
- **Responsibility**: ISC

### 17.2 Relevant Documents

| | |
|---|---|
| SC17-MI-IP-08 | ISC-Albacore Working Group. **Report of the North Pacific Albacore Tuna Management Strategy Evaluation** |
| SC17-GN-IP-03 | ISC. **Report of the 21st Meeting of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean** |

### 17.3 Key Questions and Comments

27. There were no comments or questions.

## TOPIC 18. Potential options for managing swordfish taken as bycatch

### 18.1 Background

- **Task**: Australia is providing an update to Information Paper SC16-MI-IP-22 (*A review of potential options for managing swordfish taken as bycatch in longline fisheries*), which was considered under the SC16-ODF, Topic 14. SC participants are encouraged to give comments and/or ask clarifications on this paper.
- **Responsibility**: Australia

### 18.2 Relevant Documents

| | |
|---|---|
| SC17-MI-IP-10 | Australia. **An updated review of potential options for managing swordfish taken as bycatch in longline fisheries** |

### 18.3 Key Questions and Comments

28. **The EU** thanked Australia for the overview.

(i) **Proposal:** Regarding the requests to SC17, the EU made one comment on the projections: Catch projection can become unrealistic when there are significant variations in stock biomass. Therefore, it would be interesting to also explore effort-based projections (e.g., if under a given scenario biomass doubles, can we assume catch levels in bycatch fisheries will remain constant?). Although the EU is not fully sure how this can be tackled other than in the status quo scenario, maybe SPC can provide some suggestions (e.g., if a measure is expected to reduce mortality by 50% in a given fishery, can effort be modified proportional to that in the projections?). The other idea around this is that it would be beneficial to have estimated effort levels under the different catch scenarios.

- **Reply** (Australia): Australia is open to these projection ideas but a little uncertain as to their technical feasibility and resourcing implications (for SPC). Australia has alerted SPC to your suggestions and invited them to respond, including regarding whether there are any technical challenges or other challenges associated with the proposed projections. For information, please note the projections already tasked by WCPFC16 listed below in Australia's response to the PNA, and some options for progressing depending on the resourcing implications of additional projection work (discussed below). Thank you very much again for your feedback and ideas.
- **Reply** (SPC): Status-quo effort projections are technically feasible, as indicated in the response to the PNA's request (below). If our understanding regarding the request for different patterns of fishing in fisheries 'constrained' and 'unconstrained' relative to 2009-03 is correct, where appropriate given the WCPFC16-requested scenario an approach could be to project unconstrained non-target (primarily 'PICT') fleets within the assessment model under effort, and project for other fleets in the model on a catch-limited basis given the management indicated in CMM 2009-03. That would mean, apart from the addition of effort-based status quo projection runs to the list, no additional projection scenarios beyond those requested by WCPFC16 arising from the EU request (noting the request from PNA and our response to that).

29. **Solomon Islands on behalf of the PNA** thanked Australia for the paper and the work that has been associated with it. The paper is a comprehensive response to the request made by PNA in the SC16 Online Forum. PNA also thank SPC for the swordfish catch and effort data set out in SC17-MI-IP-12. Figure 6 and Tables 4 and 5 frame very well the two key elements of any improved management arrangements identified on p16 of SC17-MI-IP-10 – high seas bycatch in the north, largely by 2 fleets; and target catch by 3 fleets in the south. Collectively these components of the fishery take over 80% of the catch and likely a larger share of the benefits.

(i) **Proposal**: In response to the request in the paper for feedback on catch scenarios that could be evaluated through projections using the revised 2021 assessment we propose testing the following:

- Projecting on recent (the average over the period 2015–2018) catch and effort:
  1. No change to recent catch and effort levels.
  2. 10% reduction of high seas bycatch.

3. 10% reduction in catch by the three main fleets catching swordfish.
4. 10% reduction in catch from in-zone target sets.
5. 10% reduction in catch from in-zone bycatch fisheries.
6. 10% effort reduction on the high seas.

- **Reply** (Australia): Thanks to the PNA for the response and Australia welcomes your proposed additional projections. Australia has alerted SPC to your suggestions and invited them to respond, including regarding whether there are any technical challenges or other challenges associated with the proposed projections. We would note that currently SPC has been tasked with the following projections by WCPFC16:
    a. "Status quo" – this projection will assume recent (2016 to 2018) levels of fishing both north and south of 20°S.
    b. "Fully caught limits" – this projection will assume recent (2016 to 2018) levels of fishing north of 20°S and CCM-nominated maximum total catch levels (para 4 CMM 2009-13) of fishing south of 20°S.
    c. "Max catch" - this projection will assume peak (2011 to 2013) levels of fishing north 20°S and CCM nominated maximum total catch levels (para 4 CMM 2009-13) of fishing south of 20°S.
    d. An additional limited number of projections which assume a range of fixed catch scenarios that are a percentage above and below "status quo" (such as -10% and +10%) that result in a range of upward and downward long-term biomass trends.

Projection (a) is perhaps the same as PNA suggestion "No change to recent catch and effort levels". If SPC is able to undertake the WCPFC16 tasked projections (a-d) and the additional projections together, then this would be ideal. However, if technical or resourcing constraints limit the amount of work that can be undertaken in the short term, consideration could be made as to whether to undertake the projections outlined in a-d above, first, and from those, determine if in fact any reductions are required from recent levels – if there are, WCPFC18 could look to task SPC with the additional projections as suggested above? For consideration. Thank you very much again for your feedback and ideas.

- **Reply** (SPC): responding from a technical point of view, the PNA suggestions are feasible, within the constraints of the fleet structures within the SWO assessment. Status quo effort projections are OK. Where things are broken out by 'target' and 'bycatch' fisheries, for 'target' fisheries the simplifying assumption can be made that key fleets (e.g., AU, NZ, EU) are 'target' within the model, and the DWFN/PICT fleets are 'bycatch'. Where spatial (in zone/high seas) changes are being proposed, we will need to proportion specific changes within fleets. This is not as straightforward. As noted by Australia, there are resource implications involved - the request approximately doubles the work involved - so some consideration/prioritisation would be welcomed.

## TOPIC 19. Progress of Shark Research Plan

### 19.1 Background

- **Task**: WCPFC17 adopted the 2021-2025 Shark Research Plan. SC17 will review the progress on the 2021 – 2025 Shark Research Plan and raise questions or provide comments as needed.
- **Responsibility**: WCPFC Secretariat and SPC

### 19.2 Relevant Documents

| | |
|---|---|
| SC17-EB-IP-02 | WCPFC Secretariat et al. **Progress of Shark research plan** |

### 19.3 Key Questions and Comments

30. **Japan** requested a small change of Table1 1-1)-b) and c): change NW Pacific to N Pacific in line with Table 2.

• **Reply** (WCPFC Secretariat): Thank you for the suggested changes in Table 1. The revised document is now posted.

## TOPIC 20. Review of non-entangling and biodegradable FAD trials in the WCPO (Project 110)

### 20.1 Background

- **Task**: The Commission endorsed Project 110 funded mainly by the EU and 20% matching fund provided by the USA and ISSF. The project is scheduled to start on 1 February 2021 and complete by 31 July 2023 (30 months). SC participants may consider the progress and future plan of the project and raise questions or provide comments as needed. Attention is drawn to the request that, in light of ongoing COVID-related restrictions on planned fieldwork, the paper seeks a no-cost extension to the project time period of at least a further year.
- **Responsibility**: SPC

### 20.2 Relevant Documents

| | |
|---|---|
| SC17-EB-IP-03 | L. Escalle, G. Moreno and P. Hamer. **Report of Project 110: Non-entangling and biodegradable FAD trial in the Western and Central Pacific Ocean** |

### 20.3 Key Questions and Comments

31. **Tokelau**, on behalf of the PNA, supported the Project, the proposed revisions to timing of activities and the request for a no-cost extension.

32. **The USA** also supported the continuation of this important Project and the request for a no cost extension.

33. **The World Bank** noted this was an excellent project.

(i) **Question**: Will consideration been given to estimating both weight of plastic and source of plastics (e.g., worn netting, ropes, salt bags, new material and re-used material) that go into each dFAD, irrespective of whether it entangles or not? Some systematic way of collecting the data would be valuable. A catalogue of dFAD dimensionalized construction plans (weights, material properties etc.) would be quite useful as a stock taking exercise.

• **Reply** (SPC): Thank you for the comment. The design of the non-entangling and biodegradable FADs will be developed in association with the participating fishing companies. The design and characteristics of the proposed dFAD will be recorded, including the type and amount of plastic use (if any).

## TOPIC 21. Guidelines for non-entangling and biodegradable FADs

### 21.1 Background

- **Task**: WCPFC17 noted the report of the FAD Management Options IWG (WCPFC17-2020FADMgmtOptions) and accepted its recommendations to continue to engage intersessionally to progress outstanding work. WCPFC17 further noted that FAD Management Options IWG prepared a revised set of guidelines for non-entangling and biodegradable FADs reflected in FADMO-IWG04-2020/WP-02. As requested by the WCPFC17 in Para 349 of the WCPFC17 Summary Report, SC participants will review the draft guidelines for non-entangling and biodegradable FADs and provide any inputs for consideration by the FAD-IWG. SC17 may review and endorse under Agenda Item 8.1 the compilation of participants' inputs on the guidelines for the FAD-IWG's consideration.

- **Responsibility**: FAD Management Options IWG

### 21.2 Relevant Documents

| | |
|---|---|
| SC17-EB-IP-07 | WCPFC FAD Management Options IWG. **Guidelines for Non-entangling and Biodegradable FAD Materials (FADMO-IWG-04-2020-WP-02)** |

### 21.3 Key Questions and Comments

34. **Tokelau, on behalf of PNA members**, supported strengthening the existing provisions to reduce entanglement along the lines proposed by the FAD IWG, stating that as the PNA understands it, this would involve tightening up the text of para. 19 of the Tropical Tuna CMM to ban the use of any mesh net on FADs. However, PNA consider more work is needed before further requirements are put in place for the use of biodegradable materials in FADs. PNA note that research on the use of biodegradable materials has been set back by the effects of COVID. In addition, we are concerned that domestic vessels may be disadvantaged by the extra costs of shipping biodegradable materials to ports in the region, and would like to see more work on the use of locally available materials for FAD construction.

35. **The USA** supported the efforts of the FAD IWG that aims to strengthen existing provisions to reduce entanglements of incidentally-caught species, including seabirds, sharks and marine mammals. Ideally there will be more ideas regarding design and materials used in the FAD structures for discussion during SC18.

36. **SPREP** stated that the risk to sharks and sea turtles of entanglement in dFADs is well recognized, but it is important to also recognise the potential risk to whales presented by dFADs. At recent online meetings (July and August 2021) bringing together SPREP member states, partners and NGOs and Signatories to the Pacific Cetacean MOU, participants heard from an IWC expert about evidence of entanglement of whales in dFADs as part of a discussion on disentanglement response. The issue is both an animal welfare issue as well as a conservation issue. Whales have been detected as entangled in dFADs in other oceans for example off Gabon, Guadeloupe and South Africa, where a whale had dragged the FAD from the Seychelles. Advice is that observer programmes are unlikely to witness these entanglements as large whales drag gear away from locations of deployment. Abandoned FADs may present more of a risk for coastal species as they drift close to shore, such as humpback whales while sperm whales may be more at risk in open ocean. The Pacific Islands region is home to half the world's species of whales and dolphins (37+). Some such as the Baleen whales are highly migratory migrating thousands of kilometers each year between winter tropical breeding grounds and summer feeding grounds. Many other species remain in the region. The high numbers of dFADs deployed in the WCPO resulting in their close proximity to each other (20km) as well as the high rates of abandonment presents a significant unquantified risk to the high diversity and numbers of whales and dolphins which live in WCPO. Rapid movement to non-entangling FADs and biodegradable FADs is important. Lower entanglement risk FADs are not ideal in the situation where loss or abandonment is likely. Although initially tightly wrapped netting can become unwrapped over time presenting a risk to marine species and to sensitive coral reef habitat. Banning use of mesh is highly desirable. Recovery of FADs also remains an important goal to protect the marine ecosystem and species as although biodegradable materials will break down eventually until that happens abandoned FADs which retain ropes and other attachments could still present a risk to marine species.

37. **ISSF** stated that lower entanglement risk FADs were considered as a transitional step. Moving to fully non-entangling FADs is feasible and highly desirable. IOTC already requires them.

38. **The World Bank** stated that tracking weights of dFADs is also important. It would be useful to use standardized construction plans for FADs that collect information on weights of materials, material

properties (PA, PP, PE etc.) in order to estimate the trends in plastic use in dFADs over time. Some standards vis a vis acceptable biodegradable material should also be considered as not all biodegradables have the same breakdown characteristics.

## TOPIC 22. Best handling and release for sharks

### 22.1 Background

- **Task:** SC participants will review the paper on improving the best handling and release practices for sharks in tuna purse seiners using hopper with ramp devices. SC participants are encouraged to give comments and/or ask clarifications on the paper.
- **Responsibility**: Jefferson Murua

### 22.2 Relevant Documents

| | |
|---|---|
| SC17-EB-IP-13 | J. Murua, et al. **Improving on deck best handling and release practices for sharks in tuna purse seiners using hopper with ramp devices** |

### 22.3 Key Comments and Questions

39. **The USA** stated it looks forward to updates regarding use of hoppers with ramps as a means to increase the post-release survival of incidentally captured sharks in tropical tuna purse seine vessels. Depending on the results of future research, new information may be useful to incorporate into recently adopted WCPFC shark handling guidelines.

40. **SPREP** stated that sharks such as silky and oceanic whitetip shark have been listed on Appendix II of CITES and Appendix II of CMS in recognition of their vulnerable population status. However silky sharks for example are continuing to be highly bycaught in large-scale equatorial purse seine fisheries. Increasing survivorship from these operations is highly desirable. The improvements outlined in this paper for hoppers and ramps to improve safety for crew and rapid safe release of sharks are welcome. SPREP support the USA's comments where trials assessing the survival rates with and without hoppers could lead the way to updating the best practice and shark handling guidelines for WCPFC.

## TOPIC 23. Seabird mitigation measures on small-scale longline vessels north of 23º North

### 23.1 Background

- **Task:** SC participants will review the seabird mitigation paper and raise questions or provide comments as needed. The proposed recommendation text will be considered under the SC17 Agenda Item 5.3.1.
- **Responsibility**: Emily Crigler

### 23.2 Relevant Documents

| | |
|---|---|
| SC17-EB-IP-15 | E. Crigler. **Seabird mitigation measures on small-scale longline vessels north of 23º North** |

### 23.3 Key Comments and Questions

41. **BirdLife International** supported the recommendation from the USA for CCMs to provide information on the effectiveness of tori-lines for reducing seabird bycatch on small-scale longline vessels less than 24m. They emphasized the evidence reported in the literature, including information paper SC17-

EB-IP-05 (Tori lines mitigate seabird bycatch in a pelagic longline fishery) that demonstrate tori-lines effectively reduce seabird bycatch. An accompanying report with additional details on this trial for tori-lines on small vessels is available. A review of the related CMM measures is overdue, and the annual reports from members demonstrate that seabird bycatch remains an issue despite effective mitigation tools being available. Further to this, Birdlife International recommend the involvement of ACAP to review and provide recommendations on the best practice for tori-line implementation on small scale fishing vessels. It is important for Members to also consider the results of the trial presented in information paper SC17-EB-IP-05 demonstrating that "neither blue-dyed bait nor offal discharges was helpful in reducing albatross interactions". These methods that have been reported in 2020 annual reports as mitigation measures used, often when operating in areas where these methods are not compliant with WCFPC CMM 2018-03.

42. **SPREP** stated that previously the overlap of longline fishing effort and albatross distribution in the North Pacific was highlighted as a concern (in SC9-EB-WP-14), particularly lack of mitigation in the high proportion of vessels less than 24m in length operating in the North Pacific. WCPFC adopted a CMM in 2015, but the effectiveness of tori lines without streamers remains uncertain and is overdue for analysis. SPREP also supports the USA call for a review of data available and to make further recommendations based on that review.

43. **New Zealand** thanked the USA for this timely reminder of the recommendations made at SC12 in 2016 to review the streamer-less tori line design option available in CMM 2018-03 for small vessels in the North Pacific. Recalling the concern noted by SC15 over the large number of seabirds incidentally caught in WCPFC fisheries in the Northern Pacific (as reported in SC15-EB-WP-03) New Zealand supported the recommendation made by the USA to review the streamer-less tori line design option in CMM 2018-03, and further recommend such a review at SC18 consider all mitigation options available in Table 1 of CMM 2018-03. New Zealand also welcomed SC17-EB-IP-05 and commended the authors for their robust experimental approach to testing the efficacy of seabird bycatch mitigation options; it contains important information, not only on the practicality and efficacy of tori line designs for small pelagic longline vessels in the North Pacific, but also on the efficacy of other seabird bycatch mitigation options included in the trial design. In particular, the findings raise concerns over the efficacy of blue-dyed bait and management of offal discharge, both options available in Table 1 of CMM 2018-03 for mitigation of seabird bycatch North of 23° North. New Zealand noted the information contained in the paper will make a useful contribution to any review of CMM 2018-03.

## TOPIC 24. Proposal for conducting a scientific survey by Chinese Fishery research vessel "Song Hang" in the WCPFC area.

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### 24.1 Background

- **Task:** China as a member country is planning to conduct a five-year scientific survey program using its fishery research vessel "Song Hang" with longline as main gear in the WCPFC Convention Area. The survey will aim to collect fundamental data and conduct experiments for improving the commission's scientific research relating to support better management advice. Main activities include:
  - (i) Collecting fishery-independent data including catch and effort and biological data for common species caught by longline;
  - (ii) Sampling for the study of the stock structure of target and bycatch species;
  - (iii) Assessing the influence of different types of longline hooks and baits on catch rate and survival rate of bycatch species;
  - (iv) Investigating the mechanisms of moving and aggregating of main species by incorporating environmental factors, and

(v) Conducting tagging and releasing experiments for sharks and other bycatch species when incidentally caught. SC participants will review the seabird mitigation paper and raise questions or provide comments as needed.

- **Responsibility:** Zhe Geng, Cheng Zhou, Xiaojie Dai, Feng Wu, Jiangfeng Zhu

### 24.2 Relevant Documents

| | |
|---|---|
| SC17-RP-SS-2021-01 | Z. Geng, C. Zhou, X. Dai, F. Wu, J. Zhu. **Proposal for conducting a scientific survey by Chinese fishery research vessel "Song Hang" in the WCPFC area** |

### 24.3 Key Comments and Questions

44. **PNG on behalf of the PNA** welcomed the increased commitment by China to regional tuna research. PNA noted that China is collaborating with SPC in this work, and encouraged China to continue to work with SPC to ensure that research undertaken fits in well with other relevant regional tuna research. Towards that end, PNA notes the importance of the sampling framework to ensure data obtained during the survey are consistent with other data collected within the region. As an overall comment on the proposed programme, the PNA wondered if it might be better to collect more data but do fewer tasks to get statistically robust results. For example, to get meaningful results might require a lot more fish to be tagged. So, an analysis of the species and life states intended for tagging and release for post-release mortality information should be explicitly detailed and we suggest an analysis of the number of releases required per species and life state be undertaken to assess how many releases are needed. In addition, PNA suggested using a stratified approach to sampling shark age and growth material to increase the chance of getting enough samples over a good size range to get informative age and growth estimates.

(i) **Question:** Will this work link with the proposed CKMR work and be available to collect those genetic samples?
(ii) **Question**: What is the basis for the choice of area of the first survey as it doesn't seem to be an important area for longlining?
(iii) **Request**: PNA national scientist and observers to participate in the cruises

• **Reply:** China stated it agrees it is important to keep the sampling framework consistent with SPC, thus we have referred standard procedures from the tuna tissue bank. China also appreciated the suggestion on assessing effective tag coverage of post-release. Unfortunately, China didn't reserve more tags to address the above issue in this cruise, but it can be assessed when enough data are accumulated in the future. The stratified approach is a good method for age and growth analysis, and China will undertake the PNA's suggestions. Answers to the three specific questions are as follows:

(i) This cruise hasn't linked with CKMR work so far. We would like to be a part of this project and other related projects, but we need more communication with them.
(ii) For the reason of time and logistics, China chose the nearest high sea as our first survey area. We are glad to talk with other CCMs about the possibility of extending our survey area to traditional longline fishing ground.
(iii) Joint scientists and observers are welcome to participate; however, it is not possible to implement this year due to limited time and the Covid-19 pandemic impact. We will be glad to make such arrangements when the Covid-19 pandemic was over.

## TOPIC 25. Broadbill swordfish movements and transition rates across stock assessment spatial regions in the western and central Pacific

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### 25.1 Background

- **Task:** This information paper details a new approach to modelling transition and movement rates of broadbill swordfish across spatial boundaries included in the stock assessment for the species and explores rates across a scenario of additional boundaries. The method suggests lower transition rates than previously used in assessments. SC members are encouraged to review this new approach and provide comments on its utility for providing transition and movement rates for future stock assessments.
- **Responsibility**: Toby Patterson, Karen Evans and Richard Hillary

### 25.2 Relevant Documents

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|---|---|
| SC17-SA-IP-17 | T. Patterson, K. Evans, R. Hillary. **Broadbill swordfish movements and transition rates across stock assessment spatial regions in the western and central Pacific** |

### 25.3 Key Comments and Questions

45. **Kiribati, on behalf of PNA members,** thanked the authors for this work. We think that the paper describes some good technical advances, and we would like to see this work progressed in future. However, we note that the sample sizes are small, there is a need to account for fish size and sex, if possible (from conventional tag recaptures), and also a need for longer-term tag deployments. We think additional tagging work is needed, particularly by fleets fishing in the south central and northeast areas of Region 3 and northern parts of Region 2, in order to resolve some of these issues.
(i) **Request**: We believe that the flags who catch the most swordfish could consider undertaking this work because they have vessels fishing in the right places and therefore the best opportunities for this work.

## TOPIC 26. Assessing and addressing cetacean bycatch in tuna fisheries

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### 26.1 Background

- **Task:** The International Whaling Commission has submitted a proposed project capsule within the framework of the GEF/FAO Common Oceans ABNJ Tuna II project. The objective of the capsule is to improve the understanding of cetacean bycatch in tuna fisheries–and the available solutions for mitigation-in collaboration with RFMOs, national governments, fishing industry and other stakeholders. The proposed project is geographically focused in two regions: the WCPO and the Indian Ocean. A range of activities are proposed to collaboratively identify and fill data and knowledge gaps and build capacity and awareness of both the issue and the solutions for monitoring and mitigation.SC participants are encouraged to give comments and/or ask clarifications on the paper.
- **Responsibility:** IWC Secretariat

### 26.2 Related Documents

| | |
|---|---|
| SC17-EB-IP-18 | IWC Secretariat: **Assessing and addressing cetacean bycatch in tuna fisheries – A collaborative project proposed to Common Oceans ABNJ Tuna Phase II** |

### 26.3 Key Comments and Questions

46. **SPREP** welcomed the proposed collaborative proposal by the IWC to Common Oceans ABNJ II. There has been increased interest in cetacean bycatch in WCPFC and recognition of the need to work effectively to reduce or mitigate interactions. The IWC has expertise which could significantly assist the Commission in achieving its objectives for sustainable tuna fisheries through addressing cetacean bycatch issues. SPREP

is currently undertaking a review of cetaceans that interact within the WCPO. Recent work by SPC submitted to SC meetings has provided information on the level of those interactions in the purse seine fishery and some models around longline interactions, however the impact of the level of interactions observed or estimated on the cetacean species concerned is unknown. The Commission itself has had little or no information provided to it on cetacean species in the WCPO. The review is intended to assess all available information on cetacean species and their subpopulations in the region, including what is known about their life history, geographic ranges, habitat use, population differentiation, population trends, conservation status and other risks to their survival, as well as fisheries by-catch. In addition, the review will include an assessment of the gaps in knowledge and the research needed to adequately inform fisheries managers of the risk from fisheries interactions with cetaceans. This information is needed as a minimum, to assist the Commission in meeting its obligations under the Convention, especially under Article 5 (d)(e) and (f). This type of information is also needed to inform potential risk assessments which the Commission could consider supporting as an outcome of this work. It could also inform improvements to the current CMM for example to include mitigation for longline interactions and improvements in the nature of data being collected. This review will support the work being proposed through the Common Oceans ABNJ Phase II project being proposed by the IWC. It is intended to provide this report to the SC18, but will be available within the next few months and posted on SPREP's website.

**Attachment G**

**The Commission for the Conservation and Management of**
**Highly Migratory Fish Stocks in the Western and Central Pacific Ocean**
**Scientific Committee**
**Seventeenth Regular Session**
Electronic Meeting
11 – 19 August 2021

## LIST OF ABBREVIATIONS

| | |
|---|---|
| ANCORS | Australian National Centre for Ocean Resources and Security |
| $B_{MSY}$ | biomass that will support the maximum sustainable yield |
| CCMs | Members, Cooperating Non-members and participating Territories |
| CI | confidence interval |
| CKMR | close-kin mark-recapture |
| CMM | Conservation and management measure |
| the Convention | The Convention for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean |
| COVID-19 | coronavirus disease 2019 |
| CPUE | catch per unit effort |
| CSIRO | Commonwealth Scientific and Industrial Research Organization (Australia) |
| CV | coefficient of variation |
| DWFN | distant water fishing nation |
| EM | electronic monitoring |
| EPO | Eastern Pacific Ocean |
| EU | European Union |
| FAD | fish aggregating device |
| FFA | Pacific Islands Forum Fisheries Agency |
| $F_{MSY}$ | fishing mortality that will support the maximum sustainable yield |
| FSM | Federated States of Micronesia |
| HCR | harvest control rule |
| HBF | hooks between floats |
| IATTC | Inter-American Tropical Tuna Commission |
| ISC | International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean |
| ISSF | International Seafood Sustainability Foundation |
| IWG | Intersessional working group |
| L-F | length-frequency |
| LRP | limit reference point |
| M | natural mortality |
| MFCL | MULTIFAN-CL |
| MOU | memorandum of understanding |
| MP | management procedure |
| MSE | management strategy evaluation |
| MSY | maximum sustainable yield |
| mt | metric tons |

| | |
|---|---|
| ODF | Online discussion forum |
| OM | operating model |
| PAW | SPC's Pre-assessment Workshop |
| PICTs | Pacific Island countries and territories |
| PIMPLE | Performance Indicators and Management Procedures Explorer |
| PNA | Parties to the Nauru Agreement |
| PNG | Papua New Guinea |
| PTTP | Pacific Tuna Tagging Program |
| ROP | Regional Observer Programme |
| RFMO | regional fisheries management organization |
| RMI | Republic of the Marshall Islands |
| SA | stock assessment |
| SB | spawning biomass |
| SC | Scientific Committee of the WCPFC |
| SFP | Sustainable Fisheries Partnership (SFP) Foundation |
| SIDS | small island developing state |
| SPC-OFP | Oceanic Fisheries Programme of the Pacific Community |
| SPR | spawning potential ratio |
| SPREP | Secretariat of the Pacific Regional Environment Programme |
| SSB | spawning stock biomass |
| SSP | scientific services provider |
| SWP | Southwest Pacific |
| TCC | Technical and Compliance Committee of the WCPFC |
| TOR | terms of reference |
| TRP | target reference point |
| TTMW | Tropical Tuna Measure Workshop |
| VB | von Bertalanffy (growth function) |
| VMS | vessel monitoring system |
| WCPFC | Western and Central Pacific Fisheries Commission |
| WCPFC Convention Area | The area of competence of the Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean |
| WCPFC Statistical Area | The WCPFC Statistical Area is defined in para. 8 of the document "Scientific data to be provided to the Commission" |
| WCPO | western and central Pacific Ocean |
| WG | working group |