**Western and**
**Central Pacific**
**Fisheries**
**Commission**

**COMMISSION**
**EIGTEENTH REGULAR SESSION**
**Electronic Meeting**
1 – 7 December 2021

**REFERENCE DOCUMENT FOR SOUTHWEST PACIFIC SWORDFISH FOR THE REVIEW**
**OF CMM 2009-03**

**WCPFC18-2021-21**
**9 November 2021**

**Paper prepared by the Secretariat**

**A.     INTRODUCTION**

1.      The purpose of this paper is to provide a quick reference guide to the recommendations of the WCPFC16 and SC17 in support of discussions for the review of CMM 2009-03 (CMM for Southwest Pacific swordfish). This paper includes the stock status, management advice, and recommendations for the Southwest Pacific swordfish stock based on the latest 2021 stock assessment.

**B.     COMMISSION RECOMMENDATIONS** *(Paragraphs 481 – 483, WCPFC16 Summary Report)*

2.      The Commission tasked the Scientific Committee in 2021 (SC17) to provide an evaluation of the long-term future of the southwest Pacific swordfish stock status under CMM 2009-03 based upon the latest SC-agreed stock assessment, utilising a limited number of projections. Projections should include:

 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 2009-03) 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.

WCPFC16 noted that this work would be funded via a voluntary contribution by Australia so as to not impact on Commission budget allocations for other priority work.

3.      The Commission tasked the Scientific Committee in 2020 (SC16) to consider a review (self-funded and developed by Australia, in consultation with interested CCMs) of possible measures and options relevant to the management of swordfish taken as bycatch in longline fisheries. The review may include information from available research and literature, logbook and observer data (in appropriately aggregated forms).

4.      The Commission requested the WCPFC Chair to write to the IATTC Chair to:

 a. Express the Commission's significant concern over the lack of scientific assessment and specific management measures for South Pacific Swordfish in the IATTC area;

b.   Seek that the IATTC prioritise the development of a management measure that ensures catch levels are maintained within sustainable levels, and

c.   Urge cooperation between IATTC and WCPFC on this issue.

## C.   SCIENTIFIC COMMITTEE RECOMMENDATIONS

5.      The following paragraphs provide a brief summary of stock status and management advice from the results of 2021 stock assessment for Southwest Pacific swordfish. For the full description of the stock status and management advice, refer to Paragraphs 208 – 231 of the SC17 Summary Report (in **Attachment A**).

*Stock Status and management advice*
6.      SC17 noted that:
   a)   the median value[1] of the latest (year 2019) spawning potential depletion for Southwest Pacific swordfish ($SB_{latest}/SB_{F=0}$) was 0.39 ($10^{th}$ and $90^{th}$ percentiles 0.18 - 0.79), and there was 13% risk that the latest spawning potential was lower than $20\%SB/SB_{F=0}$ when considering structural + estimation uncertainty;

   b)   the median value of latest spawning potential above the MSY level $SB_{latest}/SB_{MSY}$ was 2.95 ($10^{th}$ and $90^{th}$ percentiles 0.99 – 6.78) and the recent (years 2016-2019) $SB_{recent}/SB_{MSY}$ was 3.61 ($10^{th}$ and $90^{th}$ percentiles 1.23–7.39); and

   c)   the median of relative recent (2015-2018) fishing mortality $F_{recent}/F_{MSY}$ is 0.47 ($10^{th}$ and $90^{th}$ percentiles 0.25 – 1.29), and there was 20% risk that $F/F_{MSY} > 1$ when considering structural + estimation uncertainty.

7.      As the median latest 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 $SB_{latest}/SB_{F=0}<0.2$).

8.      Annual catch estimates for Southwest Pacific swordfish peaked at 11,128 mt in 2012. Catch by longline vessels in 2020 was 5,373 mt compared to 5,812 mt in 2019, a decline of 7.6%. 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%) and fleets taking swordfish as a bycatch on the high seas (in particular in the eastern stock area north of 20°S; 34%).

9.      SC17 emphasized the continued importance of WCPFC to develop a revised and strengthened CMM that will ensure the ongoing future sustainability of the SWP swordfish, and 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.

10.     Because of the significant unresolved uncertainties and further needs to refine estimation methods in the assessment, SC17 suggested additional caution may be appropriate when interpreting the current assessment outcomes to guide management decisions, and 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.

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[1] 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.

**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 2020

**SOUTHWEST PACIFIC SWORDFISH STOCK ASSESSMENT**
(*SC17 Summary Report, Paragraphs 208 – 231*)

*Provision of scientific information*

*Stock status and trends*

1.      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.

2.      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.

3.      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.

4.      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.

5.      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.

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

7.	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.

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

9.	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.

10.	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.

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

12.	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.

| | Aggre gate | 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 |
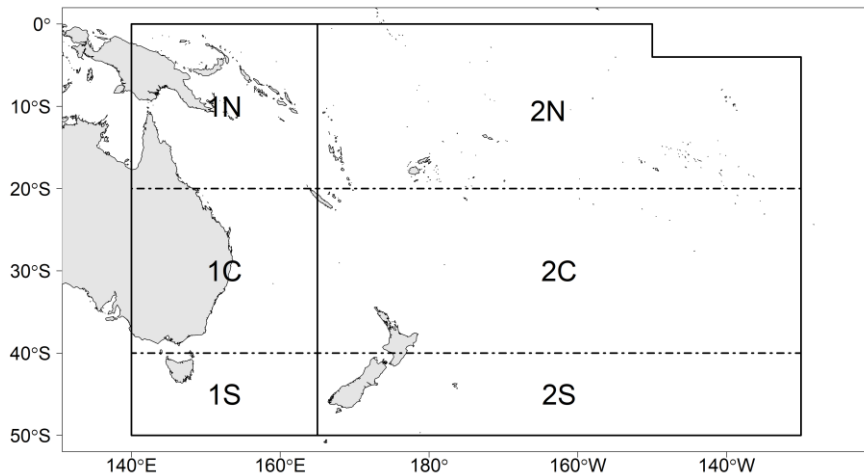


**Figure SWO-01**. Spatial structure for the 2021 Southwest Pacific swordfish stock assessment. Sub-regions used to differentiate fisheries are shown with the dotted lines.
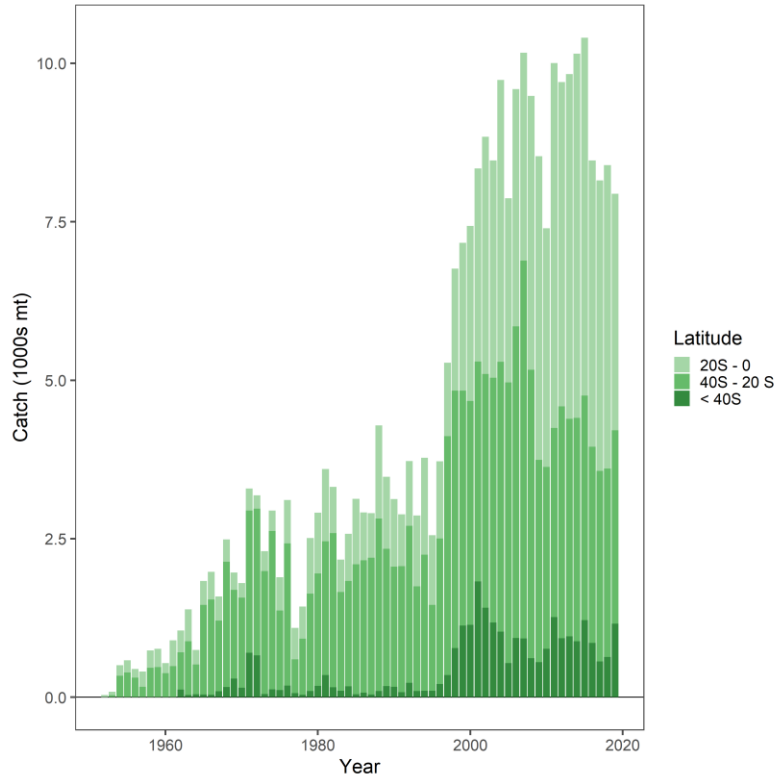
**Figure SWO-02.** Annual catch (mt) where the colors indicate latitudinal location of the catch.
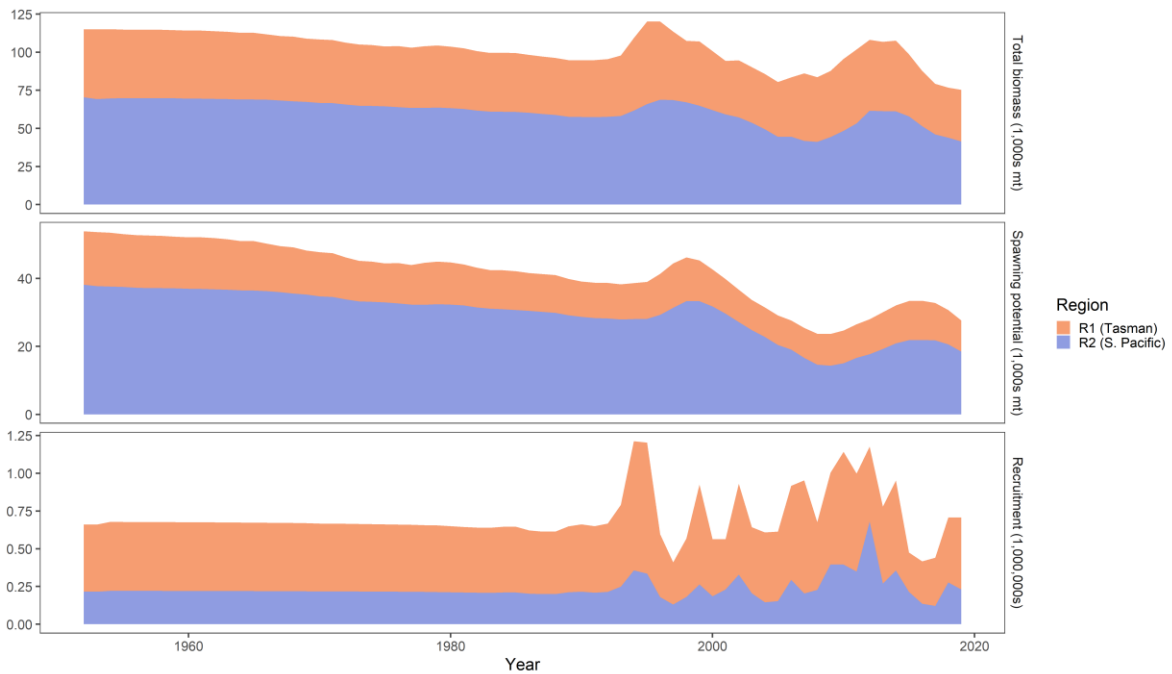


**Figure SWO-03**. Estimated total biomass (top panel), spawning potential (middle panel), and recruitment (lower panel) for the diagnostic case model. Color indicates the model region: Region 1 (orange) and Region 2 (blue).
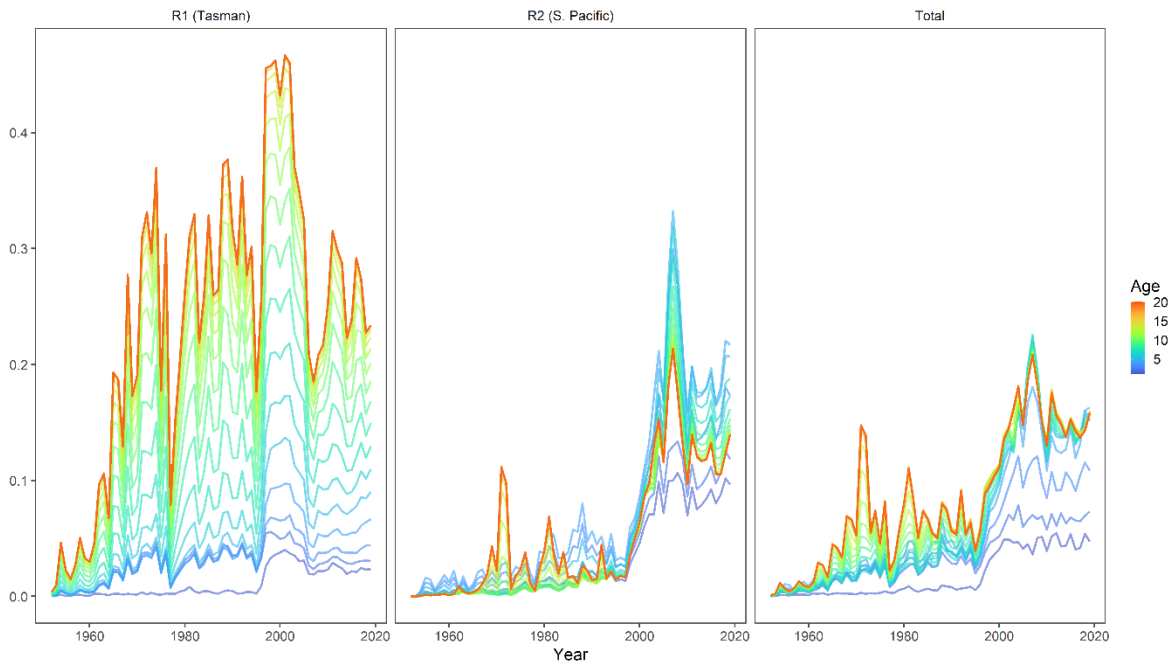
**Figure SWO-04**. Annual fishing mortality by age (color) and region (panel: Region 1 - left, Region 2 - center, and total - right).
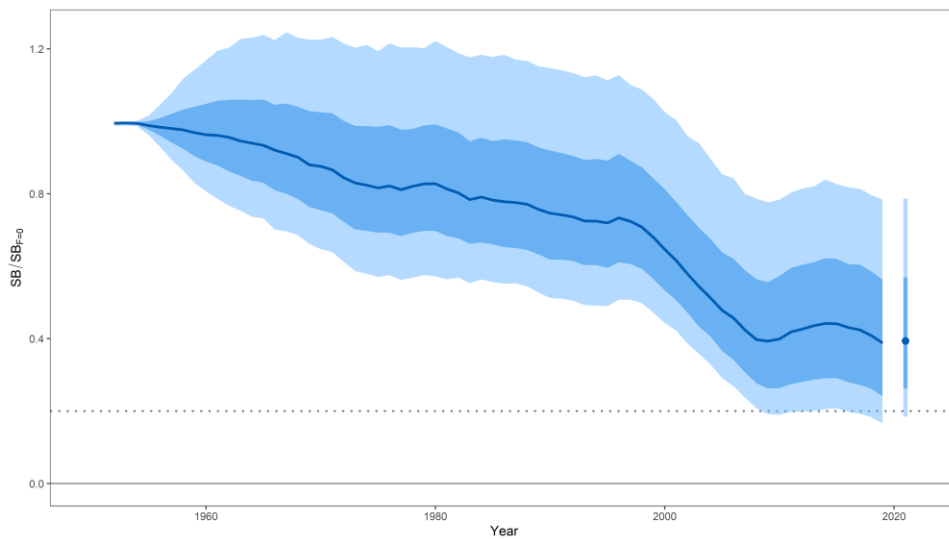


**Figure SWO-05**. Uncertainty in depletion where uncertainty is characterized as structural + estimation uncertainty. The median is showed by the dark line, the $25^{th}$-$75^{th}$ percentiles shown by the dark band, and the $10^{th}$-$90^{th}$ percentiles by the light band. The median and percentiles 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.
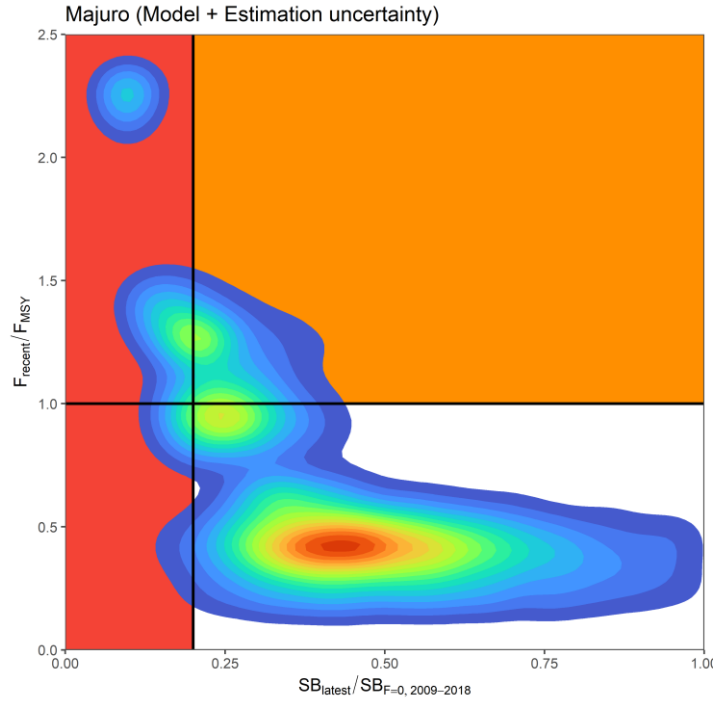
**Figure SWO-06**. Uncertainty in terminal stock status, based on the 12,500 bootstrap samples characterizing the structural + estimation uncertainty. Warmer colors indicate a greater density of samples, while cooler colors show the fringe of the distribution.



**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.
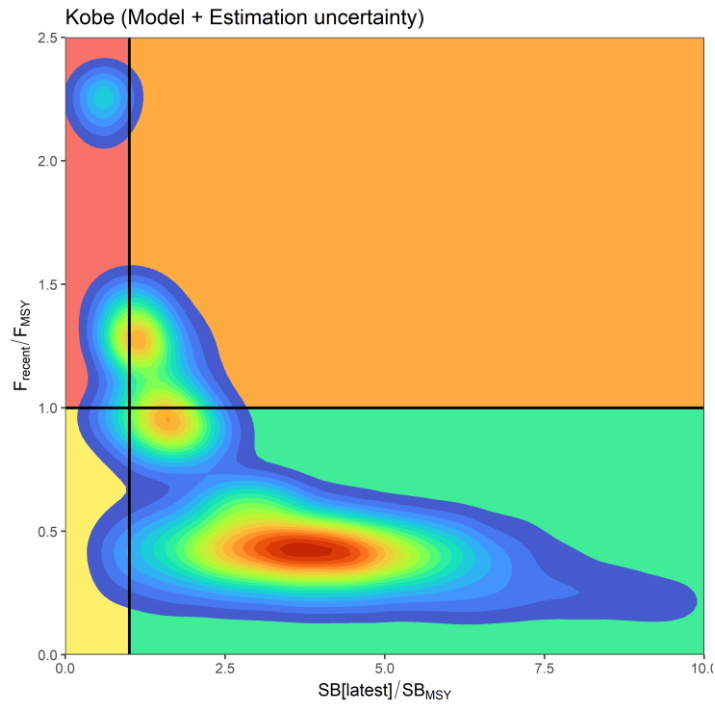
*Management advice and implications*

13.    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%.

14.    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.

15.    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 $SB_{latest}/SB_{F=0}<0.2$).

16.     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).

17.    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.

18.    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).

19.    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.

20.    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.

21.     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.

*Future research recommendations*

22.     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.

23.     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.

24.     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).