

**The Commission for the Conservation and Management of**

**Highly Migratory Fish Stocks in the Western and Central Pacific Ocean**

**Scientific Committee**

**South Pacific Swordfish (*Xiphias gladius*)**

Stock Status AND Management Advice

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# **SC17-2021 (STOCK ASSESSMENT CONDUCTED)**

1. SC17 accepted SC17-SA-WP-04 (*Stock assessment of Southwest Pacific swordfish*), providing the best available scientific information for the purpose of stock assessment determination.
2. **Stock status and trends**
3. The median values of relative latest (2019) spawning potential depletion (SBlatest/ SBF=0), spawning potential relative to MSY (SBlatest/ SBMSY) and relative recent (2015-2018) fishing mortality (Frecent/FMSY) over the 25-model ensemble (Table SWO-03) were used to define Southwest Pacific swordfish stock status. The values of the upper 90th and lower 10th 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.

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 (SBlatest/SBF=0), spawning potential relative to spawning potential at MSY (SBlatest/SBMSY), and relative recent (2015-2018) fishing mortality (Frecent/FMSY) 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.

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 (SBt/SBt,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.

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.

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.

SC17 noted that latest spawning potential depletion levels estimated by this assessment (SBlatest/SBF=0)indicated a median of 0.39 (10th and 90th percentiles 0.18 - 0.79).

SC17 noted that there was 13% risk that the latest (2019) spawning potential was lower than 20% SB/SBF=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.

SC17 noted that the stock is estimated to have spawning potential above the MSY level (SBlatest/SBMSY median 2.95; 10th and 90th percentiles 0.99 – 6.78) and SBrecent/SBMSY has a median value of 3.61, 10th and 90th percentiles 1.23–7.39.

SC17 noted that there was 10% risk that SBlatest/SBMSY < 1 when considering model and estimation uncertainty. Using only model-based uncertainty would have resulted in an 4% risk.

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.

SC17 noted that the median of relative recent fishing mortality for Southwest Pacific swordfish Frecent/FMSY is 0.47 and 10th and 90th percentiles are 0.25 – 1.29.

SC17 noted that there was 20% risk that F/FMSY > 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** |
|  | 29.51 | 28.50 | 25.76 | 26.13 | 34.10 | 40.66 |
|  | 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 |
|  | 0.0000130 | 0.0000131 | 0.0000117 | 0.0000121 | 0.0000139 | 0.0000154 |
|  | 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 |
|  | 241.13 | 242.02 | 228.62 | 235.17 | 248.09 | 250.59 |
|  | -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 |
| Female maturity | 179.85 | 179.90 | 176.78 | 177.81 | 181.62 | 182.55 |
|  | 0.036 | 0.036 | 0.008 | 0.011 | 0.065 | 0.096 |
|  | 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 | t0 prior - Uninformative | t0 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 SBrecent/SBF=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** |
| *Clatest* | 7,772 | 7,723 | 7,364 | 7,524 | 8,259 | 8,453 |
| *Y Frecent* | 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 |
| *Frecent/FMSY* | 0.67 | 0.47 | 0.16 | 0.25 | 1.29 | 2.34 |
| *SB0* | 83,853 | 69,390 | 16,491 | 31,472 | 145,944 | 334,518 |
| *SBlatest* | 38,287 | 31,517 | 10,588 | 16,096 | 69,370 | 125,681 |
| *SBrecent* | 41,916 | 38,106 | 14,975 | 18,956 | 68,550 | 99,304 |
| *SBMSY* | 12,507 | 11,480 | 2,427 | 5,212 | 21,722 | 29,297 |
| *SBlatest/SBMSY* | 3.7 | 2.95 | 0.44 | 0.99 | 6.78 | 18 |
| *SBrecent/SBMSY* | 4.1 | 3.61 | 0.64 | 1.23 | 7.39 | 16 |
| *SBlatest/SB0* | 0.59 | 0.46 | 0.1 | 0.2 | 1.09 | 2.49 |
| *SBlatest/SBF=0* | 0.45 | 0.39 | 0.08 | 0.18 | 0.79 | 1.42 |

Chart, scatter chart

Description automatically generated

**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.

Chart, histogram

Description automatically generated

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

Chart

Description automatically generated

**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).

Chart, histogram

Description automatically generated

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

Chart, line chart

Description automatically generated

**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 SBlatest/SBF=0 are shown to the right of the Figure. For reference, the WCPFC tropical tuna LRP 20%SBF=0 is shown with the dotted line.

|  |  |
| --- | --- |
| Chart  Description automatically generated | Chart  Description automatically generated |
| **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. |

1. **Management advice and implications**

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%.

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.

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 SBMSY and the LRP 20%SBF=0 applied to tunas, and recent fishing mortality is below FMSY. The stock is likely not experiencing overfishing (80% probability F<FMSY and 20% probability F>FMSY) and is likely not in an overfished condition (13% probability that SBlatest/SBMSY < 1 and a 10% probability that SBlatest/SBF=0<0.2).

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).

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.

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).

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.

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.

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.

1. **Future research recommendations**

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.

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.

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).

# **SC16-2020 (NO STOCK ASSESSMENT)**

There was no stock assessment for south Pacific swordfish in 2020. This was not discussed at SC17 due to its streamlined agenda and discussion were conducted virtually due to the impacts of COVID-19 pandemic. Therefore, the stock status descriptions and management advice from SC13 are still current for south Pacific swordfish.

# **SC15-2019 (NO STOCK ASSESSMENT)**

* 1. **Stock Status and trends**

1. SC15 noted that no stock assessments were conducted for south Pacific swordfish in 2019. Therefore, the stock status descriptions from SC13 are still current for south Pacific swordfish. For further information on the stock status and trends from SC13, please see <https://www.wcpfc.int/node/29904>. Updated information on catches was not compiled for and reviewed by SC15.
2. **Management Advice and implications**
3. SC15 noted that no management advice has been provided since SC13 for south Pacific swordfish. Therefore, previous advice should be maintained, pending a new assessment or other new information. For further information on the management advice and implications from SC13, please see <https://www.wcpfc.int/node/29904>

# **SC14-2018 (NO STOCK ASSESSMENT)**

1. Stock status and trends
2. SC14 noted that no stock assessments were conducted for south Pacific swordfish in 2018. Therefore, the stock status descriptions from SC13 are still current for south Pacific swordfish. Updated information on catches was compiled but not reviewed by SC14.

b. Management advice and implications

1. SC14 noted that no management advice has been provided since SC13 for south Pacific swordfish. Therefore, previous advice should be maintained, pending a new assessment or other new information. For further information on the management advice and implications from SC13, please see <https://www.wcpfc.int/node/29904>

# **SC13-2017 (Stock Assessment Conducted)**

1. SC13 endorsed the 2017 SWO stock assessment as the best and most up to date scientific information available for this species.
2. SC13 also endorsed the use of the SWO assessment model uncertainty grid to characterize stock status and management advice and implications.
3. **Stock status and trends**
4. The median values of relative recent (2012-2015) spawning biomass (SBrecent/SBMSY) and relative recent fishing mortality (Frecent/FMSY) over the uncertainty grid were used to measure the central tendency of stock status. The values of the upper 90th and lower 10th percentiles of the empirical distributions of relative spawning biomass and relative fishing mortality from the uncertainty grid were used to characterize the probable range of stock status.
5. Description of the updated structural sensitivity grid used to characterize uncertainty in the assessment is provided in Table SWO-1. Time trends in estimated catch, recruitment, biomass, fishing mortality and depletion are shown in Figures SWO-1 – 5. Figures SWO-6 and SWO-7 show Majuro plot summarising the results for each of the models in the structural uncertainty grid retained for management advice. Kobe plots are shown in Figures SWO-8 and SWO-9. Figure SWO-10 provides estimated time-series (or “dynamic”) Majuro and Kobe plots from the SW Pacific swordfish ‘diagnostic case’ model run. Figure SWO-11 shows Estimates of reduction in spawning potential due to fishing by region, and over all regions (lower left panel), attributed to various fishery groups (distant water ‘north’, ‘central’ and ‘south’, corresponding to the model regions, and a combined domestic fleet) for the diagnostic case model. Summary of reference points over all 72 individual models in the structural uncertainty grid are shown in Table SWO-2.

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

|  |  |  |
| --- | --- | --- |
| Axis | Levels | Option |
| Steepness | 3 | 0.65, 0.80, 0.95 |
| Diffusion rate | 3 | 0, 0.11, 0.25 |
| Size frequency weighting | 2 | Sample size divided by 20,40 |
| Natural mortality vectors | 4 | M1,M2,M3, M4 |

|  |  |
| --- | --- |
|  | Fig18_Rec_diag |
| **Figure SWO-1**. Total swordfish catches in weight grouped by major longline-method fisheries in the model regions, 1952–2011. (DW1 - distant water fleet region 1; AUS – Australian region 1; Other1 - Other fisheries region 1; DW2 - distant water fleet region 2; NZ2 - New Zealand region 2; EU2 – EU (Spanish) region 2; Other2 - other fisheries region 2) | **Figure SWO2.** Estimated annual average recruitment by model region for the diagnostic case model, showing the relative sizes among regions. |
|  | Fig25_FAAtrenddiag |
| **Figure SWO3.** Estimated annual average spawning potential by model region for the diagnostic case model, showing the relative sizes among regions. | **Figure SWO-4.** Estimated annual average juvenile (age classes 1-3), maturing adult (4-6) and adult (7+) fishing mortality for the diagnostic case model. |

|  |  |
| --- | --- |
| **Fig28d_plot_depletion_compare_2017Grid_steepness** | |
| **Figure SWO-5.** Plot showing the trajectories of fishing depletion (of spawning potential) for the 72 model runs retained for the structural uncertainty grid used for management advice. The colours depict the models in the grid with three levels of steepness (0.65, 0.8 and 0.95). | |
| Majuro-summary-rep | Majuro-SBrec-summary-rep |
| **Figure SWO-6.** Majuro plot summarising the results for each of the models in the structural uncertainty grid retained for management advice. The plots represent estimates of stock status in terms of spawning potential depletion and fishing mortality. The red zone represents spawning potential levels lower than the agreed limit reference point which is marked with the solid black line. The orange region is for fishing mortality greater than FMSY (FMSY is marked with the black dashed line). The points represent SBlatest /SBF=0, and the colours depict the models in the grid with three levels of steepness (0.65, 0.8 and 0.95). | **Figure SWO-7**. Majuro plot summarising the results for each of the models in the structural uncertainty grid retained for management advice. The plots represent estimates of stock status in terms of spawning potential depletion and fishing mortality. The red zone represents spawning potential levels lower than the agreed limit reference point which is marked with the solid black line. The orange region is for fishing mortality greater than FMSY (FMSY is marked with the black dashed line). The points represent SB*recent*/SB*F=0*, and the colours depict the models in the grid with three levels of steepness (0.65, 0.8 and 0.95). Note, SB*recent* is defined as the mean of SB over 2012-2015. |
|  |  |
| **Figure SWO-8.** Kobe plot summarising the results for each of the models in the structural uncertainty grid, where the x-axis represents SBlatest /SBMSY. The colours depict the models in the grid with three levels of steepness (0.65, 0.8 and 0.95). | **Figure SWO-9.** Kobe plot summarising the results for each of the models in the structural uncertainty grid. The colours depict the models in the grid with three levels of steepness (0.65, 0.8 and 0.95). As in Figure SWO7, SB*recent* was used instead of SB*latest*. |
| **Assessment/plots/Fig35a_Majuro.plot.pdf** | **Assessment/plots/Fig35b_Kobe.plot.pdf** |
| **Figure SWO-10.** Estimated time-series (or “dynamic”) Majuro and Kobe plots from the SW Pacific swordfish ‘diagnostic case’ model run. | |

**/Users/yukiot/Dropbox/MFCL/SC13/SWO/Assessment/plots/Fig36_splotimpactAdult.pdf**

**Figure SWO-11**. Estimates of reduction in spawning potential due to fishing by region, and over all regions (lower left panel), attributed to various fishery groups (distant water ‘north’, ‘central’ and ‘south’, corresponding to the model regions, and a combined domestic fleet) for the diagnostic case model.

**Table SWO-2**. Summary of reference points over the 72 models in the structural uncertainty grid for management advice. Note that SB*recent*/SB*F=0* is calculated where SB*recent* is the mean SB over 2012-2015 instead of 2011-2014 (used in the stock assessment report), at the request of the Scientific Committee.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Mean** | **Median** | **Min** | **10%** | **90%** | **Max** |
| *Clatest* | 9,884 | 9,884 | 9,318 | 9,343 | 10,157 | 10,287 |
| *MSY* | 8,172 | 7,913 | 5,905 | 6,396 | 10,150 | 11,360 |
| *YFrecent* | 7,628 | 7,775 | 4,998 | 6,062 | 8,948 | 9,684 |
| *fmult* | 1.27 | 1.15 | 0.66 | 0.79 | 1.89 | 2.32 |
| *F*MSY | 0.16 | 0.14 | 0.10 | 0.10 | 0.22 | 0.23 |
| *Frecent/F*MSY | 0.88 | 0.87 | 0.43 | 0.53 | 1.26 | 1.51 |
| *SB*MSY | 17,314 | 17,740 | 7,278 | 8,943 | 26,661 | 30,460 |
| *SB0* | 84,173 | 84,075 | 57,070 | 71,199 | 98,039 | 111,000 |
| *SB*MSY*/SB0* | 0.20 | 0.21 | 0.11 | 0.12 | 0.28 | 0.28 |
| *SBF=0* | 78,619 | 78,301 | 61,996 | 64,342 | 92,120 | 100,691 |
| *SB*MSY*/SBF=0* | 0.22 | 0.23 | 0.10 | 0.12 | 0.32 | 0.33 |
| *SBlatest /SB0* | 0.33 | 0.32 | 0.24 | 0.25 | 0.44 | 0.46 |
| *SBlatest /SBF=0* | 0.35 | 0.35 | 0.26 | 0.27 | 0.44 | 0.49 |
| *SBlatest /SB*MSY | 1.85 | 1.61 | 0.85 | 0.99 | 3.14 | 4.05 |
| *SBrecent/SBF=0* | 0.36 | 0.35 | 0.27 | 0.29 | 0.43 | 0.48 |
| *SBrecent/SB*MSY | 1.86 | 1.58 | 0.88 | 1.02 | 3.10 | 3.96 |

1. SC13 noted that the central tendency of relative recent spawning biomass was median (SBrecent/SBF=0) = 0.35 with a probable range of 0.29 to 0.43 (80% probability interval). The median estimate (0.35) is below that estimated from the 2014 assessment grid((SBcurrent/SBF=0) = 0.49, see SC9-SA-WP-05), noting the differences in grid uncertainty axes used in that assessment, due to the inclusion of two representations of growth and maturity. SC13 also noted that in the previous assessment this central tendency was not considered for the provision of management advice given the uncertainties in growth assumptions. The median estimate for SBrecent/SBMSY is 1.23, which is below that estimated from the 2014 assessment grid ((SBcurrent/SBMSY) = 2.07, see SC9-SA-WP-05).
2. SC13 noted that the central tendency of relative recent fishing mortality was median (Frecent/FMSY) = 0.86 with an 80% probability interval of 0.51 to 1.23. While this suggested that there was likely a buffer between recent fishing mortality and FMSY, it also showed that there was some probability that recent fishing mortality was above FMSY.
3. SC13 also noted that there was a roughly 32% probability (23 out of 72 models) that the recent fishing mortality was above FMSY with Prob((Frecent/FMSY)>1) = 0.32. The median estimate (0.86) is above that estimated from the 2014 assessment grid (Fcurrent/FMSY = 0.74, see SC9-SA-WP-05).
4. Fishing mortality rate increased notably from the mid-1990s in both model regions, on maturing swordfish aged 4-6 fish in particular.
5. Across all models in the uncertainty grid the spawning biomass declines steeply between the late 1990s and 2010 but since then the rate of decline has been less. Those declines are found in both model regions, but are higher in the eastern Region 2 (equator to 50°S, 165°E to 130°W).
6. SC13 noted that in comparison with the bigeye and yellowfin assessments, evidence for an increase in recent recruitment for southwest Pacific swordfish was not found in either the CPUE time series or estimates of recruitment. SC13 noted that the longline only nature of the fishery catching mainly larger, older swordfish, is not strongly informative with regards to recruitment dynamics.
7. **Management advice and implications**
8. Based on the uncertainty grid adopted by SC13, the south west Pacific swordfish spawning biomass is likely above the 20%SBF=0, biomass LRP adopted for tunas and the SBMSY level (noting that the Commission has yet to adopted an LRP for south Pacific swordfish) and it is highly likely that the stock is not in an overfished condition (0% probability). Recent F is likely below FMSY, and it appears that the stock is not experiencing overfishing (32% probability of overfishing).
9. SC13 noted that there has been an increase in fishing mortality notably from the mid-1990s, and that the biomass relative to unfished levels is estimated to have declined rapidly during the period late-1990s to 2010 followed by a more gradual but continued decline after 2010, across the uncertainty grid. It was noted the fishing mortality was likely below FMSY.
10. Consistent with its previous advice (from SC9), SC13 recommends that the Commission consider developing appropriate management measures for the area north of 20°S to the equator which is not covered by CMM 2009-03, noting that:

* recent catches between the equator and 20°S continue to represent the largest component of the catch in Region 2 (equator to 50°S, 165°E to 130°W) and represent half the total catches from the stock, and,
* catches in that area contribute substantially to fishing mortality and spawning biomass depletion levels in eastern Region 2 that are substantially higher than in the western region (Region 1).

1. Further, SC13 recommends that current restrictions on catches south of 20°S also be maintained.

# **Useful References**

SC17-SA-WP-04 Stock assessment of Southwest Pacific swordfish. N. Ducharme-Barth, C. Castillo-Jordan, J. Hampton, P. Williams, G. Pilling, P.Hamer (SPC-OFP)

<https://meetings.wcpfc.int/node/12553>

SC17-SA-IP-07 Background analyses for the 2021 stock assessment of Southwest Pacific swordfish. N. Ducharme-Barth, T. Peatman, and P. Hamer

<https://meetings.wcpfc.int/node/12565>

SC17-SA-IP-08 Biology, stock structure, fisheries, and status of swordfish, Xiphias gladius, in the Pacific Ocean - a review. Bradley Moore (NIWA)

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SC12-SA-WP-11 Determination of swordfish growth and maturity relevant to the southwest Pacific stock. Farley J., N. Clear, D. Kolody, K. Krusic-Golub, P. Eveson and J. Young. (AFMA)

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SC9-SA-WP-01 Stock assessment of swordfish (Xiphias gladius) in the southwest Pacific Ocean. Davies, N., G. Pilling, S. Harley, and J. Hampton. (SPC-OFP)

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# **Previous Assessments**

SC13-SA-WP-13 Stock assessment of swordfish in the SW Pacific. Takeuchi Y, G. Pilling and J. Hampton. (SPC-OFP)

<https://www.wcpfc.int/node/29526>

SC9-SA-WP-05 Stock assessment of swordfish (Xiphias gladius) in the southwest Pacific Ocean. <https://wcpfc.int/node/3683>

SC4-SA-WP-06 Multifan-CL Stock Assessment of Southern Western-Central Pacific Swordfish 1952-2007. <https://wcpfc.int/node/1223>

SC2-SA-WP-07 SW Pacific Swordfish Stock Status Summary from multiple assessment models. <https://wcpfc.int/node/1752>

SC1-SA-WP-07 Southwest Pacific swordfish assessment: 2005-6 objectives and preliminary results. <https://wcpfc.int/node/1891>