**COMMISSION**
**NINETEENTH REGULAR SESSION**

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# Reference Document for the Review of CMM 2009-03 (Southwest Pacific Swordfish) and CMM 2010-01 (North Pacific Striped Marlin)

**WCPFC19-2022-18**
11 November 2022

**Prepared by the Secretariat**

## A. INTRODUCTION

1. The purpose of this paper is to provide a quick reference guide to the latest recommendations of the Scientific Committee (SC18) and Technical and Compliance Committee (TCC18) for the review of CMM for Swordfish (CMM 2009-03) and CMM North Pacific Striped Marlin (CMM 2010-01). This paper includes SC18's review of a draft CMM for Southwest Pacific Swordfish (SC18-MI-WP-08 *A revised draft conservation and management measure for South Pacific Swordfish in the WCPFC Area*) and the results of 2022 stock assessment for North Pacific striped marlin. The stock status and management advice for the North Pacific striped marlin carried over from SC15 (2019) are in **Attachment 1.**

## B. SCIENTIFIC COMMITTEE RECOMMENDATIONS

### B.1 Southwest Pacific swordfish conservation and management measure *(Paragraphs 102 - 106, SC18 Outcomes Document)*

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

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

4. Most CCMs supported this draft CMM, stressing the importance of developing a strengthened measure for this stock, noting that SC17 highlighted that the current measure (CMM 2009-03) for SWPO swordfish does not contain provisions to limit total fishing mortality on the stock and subsequently puts at risk the future sustainability of the stock, future fishery development opportunities for SIDS, and ongoing

economic viability of current fisheries targeting this stock. They also noted the Commission now has a comprehensive suite of data and technical information with which to inform and base a revised and strengthened measure for this stock. They noted and supported provisions in the measure that seek to prevent any transfer of disproportionate burden to SIDS while at the same time, recognising coastal state sovereign rights, a commitment to zone-based management, and protecting and explicitly allowing for future fishery development opportunity for SIDS. Of the two alternate management options proposed for fisheries taking swordfish as bycatch, bycatch limits were seen as the most easily implemented and monitored, noting that swordfish bycatch contributes a very significant component of the overall fishing mortality.

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

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

**B.2 North Pacific Striped Marlin** *(Paragraph 49 – 50, SC18 Outcomes Document)*

**1) Stock status and trends**

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

**2) Management advice and implications**

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

## C. TECHNICAL AND COMPLIANCE COMMITTEE RECOMMENDATIONS

**CMM 2009-03 Southwest Pacific swordfish** *(paragraph 213, TCC18 draft Summary Report)*

9. TCC noted the updated proposal from Australia and that Australia plans to prepare an updated proposal for consideration at WCPFC19.

**Attachment 1**

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

**Scientific Committee**
**Fifteenth Regular Session**

Pohnpei, Federated States of Micronesia
12–20 August 2019

# NORTH PACIFIC STRIPED MARLIN STOCK ASSESSMENT

(Paragraphs 350 – 359, SC15 Summary Report)

## PROVISION OF SCIENTIFIC INFORMATION

### a. Stock status and trends

1. SC15 noted that ISC provided the following conclusions on the stock status of Western and Central North Pacific Striped Marlin:

> Estimates of population biomass of the WCNPO MLS fluctuated without trend between 1975 and 1993. The population deceased substantially in 1994 and fluctuated without trend until the present year. Population biomass (age-1 and older) averaged roughly 17,969 mt, or 54% below unfished biomass during the 1975-1993 period and declined to 4,508 mt, or 89% below unfished biomass by 2008. The minimum spawning stock biomass was estimated to be 618 t in 2011 (76% below $SSB_{MSY}$, the spawning stock biomass to produce MSY, Figure 1a). In 2017, SSB = 981 t and $SSB/SSB_{MSY}$ = 0.38. Fishing mortality on the stock (average *F* on ages 3-12) has been around FMSY since 2014 (Figure 1b). It averaged roughly 0.64 $yr^{-1}$ during 2015-2017, or 7% above *F*MSY and in 2017, F=0.80 $yr^{-1}$ with a relative fishing mortality of $F/F_{MSY}$ = 1.33 (Table 2). Fishing mortality has been above FMSY in every year except 1984, 1992, and 2016. The predicted value of the spawning potential ratio (SPR, the predicted spawning output at current *F* as a fraction of unfished spawning output) is estimated to be $SPR_{2015-2017}$ = 17% and is approximately equal to the SPR required to produce MSY. Recruitment averaged about 263,000 age-0 recruits between 1994 and 2017, which was 34% below the 1975-2017 average. No target or limit reference points have been established for the WCNPO MLS stock under the auspices of the WCPFC. Despite the relatively large L50/Linf ratio for WCNPO MLS, the stock is expected to be highly productive due to its rapid growth and high resilience to reductions in spawning potential. Recent recruitments have been lower than expected and have been below the long-term trend since 2005. Although fishing mortality has decreased since 2000, due to the prolonged low recruitment and landings of immature fish, the biomass of the stock has remained below MSY. When the status of WCNPO MLS is evaluated relative to MSY-based reference points, the 2017 spawning stock biomass of 981 mt is 62% below $SSB_{MSY}$ (2,604 t) and the 2015-2017 fishing mortality exceeds $F_{MSY}$ by 7%. Therefore, relative to MSY-based reference points, overfishing is occurring and the WCNPO MLS stock is overfished (Figure 2).
>
> Biological reference points were computed for the base case model with Stock Synthesis (Table 1 and Table 2). The point estimate of MSY was 4,946 t. The point estimate of the spawning biomass

to produce MSY (adult female biomass, $SSB_{MSY}$) was 2,604 t. The point estimate of $F_{MSY}$, the fishing mortality rate to produce MSY (average fishing mortality on ages 3 – 12) was 0.60 and the corresponding equilibrium value of spawning potential ratio at MSY was $SPR_{MSY}$ = 18%.

Stock projections for WCNPO MLS were conducted using the age-structured projection model software AGEPRO. Stochastic projections were conducted using results from the base case model to evaluate the probable impacts of alternative fishing intensities or constant catch quotas on future spawning stock biomass and yield for MLS in the WCNPO. For fishing mortality projections, a standard set of F-based projections were conducted. For catch quota projections, the set of rebuilding projection analyses requested by NC14 were conducted. Two future recruitment scenarios were evaluated (Figure 3 and Figure 4): (1) a short-term recruitment scenario based on resampling the empirical cumulative distribution function of recruitment observed during 2012-2016 and (2) a long-term recruitment scenario based on resampling the empirical cumulative distribution function of recruitment observed during 1975- 2016. The short-term recruitment scenario had an average recruitment of 134,020 age-0 fish and the long-term recruitment mean was 306,989 age-0 fish. The stochastic projections employed model estimates of the multi-fleet, multi-season, size- and age-selectivity, and structural complexity in the assessment model to produce consistent results. Fishing mortality-based projections started in 2018 and continued through 2037 under five levels of fishing mortality and the two recruitment scenarios. The five fishing mortality stock projection scenarios were: 1) F status quo (average F during 2015-2017), 2) $F_{MSY}$, 3) F at $0.2 \cdot SSB_0$, 4) FHigh at the highest 3-year average during 1975-2017, and 5) $F_{Low}$ at $F_{30\%}$. For the F-based scenarios, fishing mortality in 2018-2019 was set to be $F_{status\ quo}$ (0.64) and fishing mortality during 2020-2037 was set to the projected level of F. Catch-based projections also ran from 2018 to 2037 and included seven levels of constant catch for the long-term recruitment scenario and 10 levels of catch for the short-term recruitment scenario. For the catch-based scenarios, catch biomass in 2018-2019 was set to be the status quo catch during 2015-2017 (2,151 t) and annual catches during 2020-2037 were set to the projected catch quota. The ten constant catch stock projection scenarios were: 1) Quota based upon WCPFC CMM10-01, 2) 90% of the quota, 3) 80% of the quota, 4) 70% of the quota, 5) 60% of the quota, 6) 50% of the quota, 7) 40% of the quota, 8) 30% of the quota, 9) 20% of the quota, and 10) 10% of the quota. Results show the projected female spawning stock biomasses and the catch biomasses under each of the scenarios (Table 3, Figure 3 and Figure 4).

2. **SC15 noted the following stock status from ISC:**

Biomass (age 1 and older) for the WCNPO MLS stock decreased from 17,000 t in 1975 to 6,000 t in 2017. Estimated fishing mortality averaged F=0.97 $yr^{-1}$ during the 1975-1994 period with a range of 0.60 to 1.59 $yr^{-1}$, peaked at F=1.71 $year^{-1}$ in 2001, and declined sharply to F=0.64 $yr^{-1}$ in the most recent years (2015-2017). Fishing mortality has fluctuated around $F_{MSY}$ since 2013. Compared to MSY-based reference points, the current spawning biomass (average for 2015- 2017) was 76% below $SSB_{MSY}$ and the current fishing mortality (average for ages 3 – 12 in 2015-2017) was 7% above $F_{MSY}$.

**Based on these findings, the following information on the status of the WCNPO MLS stock is provided:**

**a) There are no established reference points for WCNPO MLS;**

**b) Results from the base case assessment model show that under current conditions the WCNPO MLS stock is overfished and is subject to overfishing relative to MSY- based reference points (Table 1, Table 2, and Figure 1).**

3. SC15 noted that the assessment results are sensitive to the growth assumption and the ISC billfish working group (hereafter, WG) chair noted that the WG will attempt to revise the growth curve at the next stock assessment.

4. SC15 also highlighted the sharp decline in the stock biomass in the mid-1990s and recommends that ISC further investigate the reasons for this decline.

**b. Management advice and implications**

5. SC15 noted that some CCMs expressed concerns that based on the new assessment the WCNPO striped marlin stock was overfished and overfishing was occurring relative to MSY-based reference points.

6. SC15 noted that while fishing mortality has declined since 2000 fishing mortality has generally remained above $F_{MSY}$ since the introduction of CMM 2010-01 and the stock biomass continues to remain well below $SB_{MSY}$ and the NC target, while noting that the assessment model overestimate biomass in the terminal years. This is despite the phased reduction of the total catch to 80% of the levels caught in 2000-2003 as prescribed in the CMM. SC15 recommends that WCPFC16 note that further reduction in catch will be required to rebuild the stock to MSY levels and the NC target.

7. SC15 also noted that this stock does not have agreed upon limit reference points and measures on catch limits and reductions in fishing mortality to allow rebuilding of this stock.

8. SC15 recommends that WCPFC16 consider identifying appropriate limit reference points for WCNPO striped marlin.

9. SC15 recommends the WCPFC consider appropriate actions to ensure rebuilding this stock to the NC14 rebuilding target. SC15 noted that if lower than average recruitments persist over the near future the probability of rebuilding the stock would be low, noting that there has been a long-term decline in recruitment since the 1990s. Under the $F_{MSY}$ scenario with short-term recruitment assumptions, the probability of achieving $20\%SB_0$ in 2027 is <0.5%.

10. **SC15 noted the following conservation advice from ISC:**

The status of the WCNPO striped marlin stock shows evidence of substantial depletion of spawning potential ($SSB_{2017}$ is 62% below $SSB_{MSY}$), however fishing mortality has fluctuated around $F_{MSY}$ in the last four years. The WCNPO striped marlin stock has produced average annual yields of around 2,100 t per year since 2012, or about 40% of the MSY catch amount. However, the majority of the catch are likely immature fish. All of the projections show an increasing trend in spawning stock biomass during the 2018-2020 periods, with the exception of the high F scenario under the short-term recruitment scenario. This increasing trend in SSB is due to the 2017 year class, which is estimated from the stock-recruitment curve and is more than twice as large as recent average recruitment.

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

**a) Projection results under the long-term recruitment scenario show that the stock has at least a 60% probability of rebuilding to $20\%SSB_0$, the rebuilding target specified**

**by NC14, by 2022 for all harvest scenarios, with the exception of the highest F scenario (Average F 1975-1977);**

**b) However, if the stock continues to experience recruitment consistent with the short-term recruitment scenario (2012-2016), catches must be reduced to 60% of the WCPFC catch quota from CMM 2010-01 (3,397 t) to 1,359 t in order to achieve a 60% probability of rebuilding to 20%$SSB_0$=3,610 t[4] by 2022. This corresponds to a reduction of roughly 37% from the recent average yield of 2,151 t;**

**c) For the constant catch projection scenarios that were tested, it was notable that all of the projections under the long-term recruitment scenario would be expected to achieve the spawning biomass target by 2020 with probabilities ranging from 61% to 73% and corresponding catch quotas ranging from 3,397 to 1,359 t (Table NMLS-03).**

It was also noted that retrospective analyses show that the assessment model appears to overestimate spawning potential in recent years, which may mean the projection results are ecologically optimistic.

**Special Comments**

The WG achieved a base-case model using the best available data and biological information. However, the WG recognized uncertainty in some assessment inputs including drift gillnet catches and initial catch amounts, life history parameters such as maturation and growth, and stock structure.

Overall, the base case model diagnostics and sensitivity runs show that there are some conflicts in the data (**ISC/19/ANNEX/11**). When developing a conservation and management measure to rebuild the resource, it is recommended that these issues be recognized and carefully considered, because they affect the perceived stock status and the probabilities and time frame for rebuilding of the WCNPO striped marlin stock.

**Research Needs**

To improve the stock assessment, the WG recommends continuing model development work, to reduce data conflicts and modelling uncertainties, and re-evaluating and improving input assessment data.

Existing genetic studies suggest regional spawning subgroups of striped marlin throughout the entire Pacific. More research is needed to improve upon knowledge of regional stock structure and regional mixing for incorporation into the stock assessment.

**Table NMLS-01.** Reported catch (t) used in the stock assessment along with annual estimates of population biomass (age-1 and older, t), female spawning biomass (t), relative female spawning biomass ($SSB/SSB_{MSY}$), recruitment (thousands of age-0 fish), fishing mortality (average F, ages-3 – 12), relative fishing mortality ($F/F_{MSY}$), and spawning potential ratio of WCNPO striped marlin.

| Year | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017[2] | Mean[1] | Min[1] | Max[1] |
|---|---|---|---|---|---|---|---|---|---|---|
| Reported Catch | 2,690 | 2,757 | 2,534 | 1,879 | 2,072 | 1,892 | 2,487 | 5,643 | 1,879 | 10,862 |
| Population Biomass | 5,874 | 6,057 | 4,937 | 6,241 | 5,745 | 5,832 | 6,196 | 12,153 | 4,509 | 22,303 |
| Spawning Biomass | 618 | 809 | 743 | 864 | 1,073 | 1,185 | 981 | 1,765 | 618 | 3,999 |
| Relative Spawning Biomass | 0.24 | 0.31 | 0.29 | 0.33 | 0.41 | 0.46 | 0.38 | 0.68 | 0.24 | 1.54 |
| Recruitment (age 0) | 196,590 | 87,956 | 330,550 | 77,274 | 185,438 | 195,069 | 354,391 | 396,218 | 77,274 | 1,049,460 |
| Fishing Mortality | 1.11 | 1.06 | 0.86 | 0.63 | 0.62 | 0.51 | 0.80 | 1.06 | 0.51 | 1.71 |
| Relative Fishing Mortality | 1.85 | 1.76 | 1.42 | 1.05 | 1.03 | 0.85 | 1.33 | 1.76 | 0.85 | 2.85 |
| Spawning Potential Ratio | 9% | 11% | 11% | 16% | 17% | 20% | 14% | 12% | 20% | 6% |

[1] During 1975-2017

[2] Recruitment in 2017 is estimated from the stock recruitment curve.

**Table NMLS-02.** 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 WCNPO MLS, derived from the base case model assessment model, where "MSY" indicates reference points based on maximum sustainable yield.

| Reference Point | Estimate |
|---|---|
| $F_{MSY}$ (age 3-12) | 0.60 |
| $F_{2017}$ (age 3-12) | 0.80 |
| $F_{20\%SSB(F=0)}$ | 0.47 |
| $SSB_{MSY}$ | 2,604 t |
| $SSB_{2017}$ | 981 t |
| $20\%SSB_0$ | 3,610 t |
| MSY | 4,946 t |
| $C_{2015\text{-}2017}$ | 2,151 t |
| $SPR_{MSY}$ | 18% |
| $SPR_{2017}$ | 14% |
| $SPR_{20\%SSB(F=0)}$ | 23% |

**Table NMLS-03.** Projected median values of WCNPO striped marlin spawning stock biomass (SSB, t), catch (t), and probability of reaching 20%SSB0 under five constant fishing mortality rate (F) and ten constant catch scenarios during 2018-2037. For scenarios which have a 60% probability of reaching the target of 20%$SSB_{F=0}$, the year in which this occurs is provided; NA indicates projections that did not meet this criterion. Note that 20%$SSB_{F=0}$ is 3,610 t and $SSB_{MSY}$ is 2,604 t.

| Year | 2018 | 2019 | 2020 | 2021 | 2022 | 2027 | 2037 | Year when target achieved with 60% probability |
|---|---|---|---|---|---|---|---|---|
| **Scenario 1: $F_{status\ quo}$; Long-Term Recruitment** | | | | | | | | |
| SSB | 1931.3 | 2605.3 | 3591 | 4288.3 | 4639.4 | 4893.4 | 4884.4 | |
| Catch | 2229.8 | 3089.8 | 3911.6 | 4412.8 | 4644.9 | 4797.2 | 4790.9 | |
| Probability of reaching 20% SSB | 0% | 4% | 44% | 70% | 79% | 84% | 84% | 2021 |
| **Scenario 2: $F_{status\ quo}$; Short-Term Recruitment** | | | | | | | | |
| SSB | 1932.4 | 2556.5 | 3080 | 2786.9 | 2422.3 | 2071.4 | 2072.1 | |
| Catch | 2224.6 | 2827 | 2871.7 | 2535.9 | 2260.7 | 2029.6 | 2030.4 | |
| Probability of reaching 20% SSB | 0% | 4% | 21% | 9% | 2% | <0.5% | <0.5% | NA |
| **Scenario 3: FMSY; Long-Term Recruitment** | | | | | | | | |
| SSB | 1935.1 | 2611.8 | 3650.5 | 4444 | 4860.6 | 5158.9 | 5203.5 | |
| Catch | 2228.1 | 3092.7 | 3705.2 | 4241.6 | 4498.9 | 4666.4 | 4711.5 | |
| Probability of reaching 20% SSB | 0% | 4% | 47% | 75% | 83% | 89% | 89% | 2021 |
| **Scenario 4: FMSY; Short-Term Recruitment** | | | | | | | | |
| SSB | 1932.9 | 2557.7 | 3126.3 | 2895.5 | 2552.2 | 2207 | 2197 | |
| Catch | 2230.8 | 2829.6 | 2724.6 | 2450.7 | 2209.9 | 1994.1 | 1984.9 | |
| Probability of reaching 20% SSB | 0% | 4% | 23% | 12% | 4% | <0.5% | <0.5% | NA |
| **Scenario 5: F 20%$SSB_{F=0}$; Long-Term Recruitment** | | | | | | | | |
| SSB | 1933.7 | 2611.9 | 3813.4 | 4943.7 | 5631 | 6358.1 | 6348.5 | |
| Catch | 2227.6 | 3091.3 | 2996.4 | 3588.7 | 3933.2 | 4271.7 | 4266.7 | |
| Probability of reaching 20% SSB | 0% | 4% | 55% | 85% | 93% | 97% | 98% | 2021 |
| **Scenario 6: F 20%$SSB_{F=0}$; Short-Term Recruitment** | | | | | | | | |
| SSB | 1934 | 2560.5 | 3276.3 | 3274.8 | 3030.2 | 2697 | 2690.2 | |
| Catch | 2224.9 | 2828.8 | 2211.6 | 2115.4 | 1969.7 | 1809.1 | 1804.7 | |
| Probability of reaching 20% SSB | 0% | 4% | 29% | 28% | 17% | 6% | 7% | NA |
| **Scenario 7: Highest F (Average F 1975-1977); Long-Term Recruitment** | | | | | | | | |
| SSB | 1932.8 | 2611.8 | 2739.8 | 2299.1 | 2102 | 2028.4 | 2036.2 | |
| Catch | 2226.4 | 3088.5 | 7520.7 | 6557.5 | 6184.4 | 6058 | 6084.1 | |

**Table NMLS-03** (continued)**.**

| Year | 2018 | 2019 | 2020 | 2021 | 2022 | 2027 | 2037 | Year when target achieved with 60% probability |
|---|---|---|---|---|---|---|---|---|
| **Scenario 17: 30% Reduction; Long-Term Recruitment** | | | | | | | | |
| SSB | 1947.6 | 2824.5 | 4381.5 | 5981.7 | 7356.2 | 10856.1 | 11783.5 | |
| Catch | 2150.6 | 2150.6 | 2377.8 | 2377.8 | 2377.8 | 2377.8 | 2377.8 | |
| Probability of reaching 20% SSB | <0.5% | 17% | 67% | 87% | 94% | 99% | >99.5% | 2020 |
| **Scenario 18: 30% Reduction; Short-Term Recruitment** | | | | | | | | |
| SSB | 1947.4 | 2733.8 | 3594 | 3479.2 | 3018.1 | 1736.6 | 1383.5 | |
| Catch | 2150.6 | 2150.6 | 2377.8 | 2377.1 | 2377.1 | 2365.6 | 2355.3 | |
| Probability of reaching 20% SSB | <0.5% | 15% | 45% | 42% | 29% | 5% | 2% | NA |
| **Scenario 19: 40% Reduction; Long-Term Recruitment** | | | | | | | | |
| SSB | 1949.2 | 2831.8 | 4486.8 | 6295.8 | 7868.9 | 11749.2 | 12851.3 | |
| Catch | 2150.6 | 2150.6 | 2038.1 | 2038.1 | 2038.1 | 2038.1 | 2038.1 | |
| Probability of reaching 20% SSB | <0.5% | 18% | 70% | 90% | 95% | >99.5% | >99.5% | 2020 |
| **Scenario 20: 40% Reduction; Short-Term Recruitment** | | | | | | | | |
| SSB | 1949.9 | 2737.3 | 3689.5 | 3756 | 3445.9 | 2444.2 | 2124.2 | |
| Catch | 2150.6 | 2150.6 | 2038.1 | 2038.1 | 2037.9 | 2037.6 | 2036.4 | |
| Probability of reaching 20% SSB | <0.5% | 15% | 48% | 49% | 41% | 16% | 10% | NA |
| **Scenario 21: 50% Reduction; Long-Term Recruitment** | | | | | | | | |
| SSB | 1950.4 | 2829.7 | 4548.9 | 6512.1 | 8259.1 | 12654 | 13799.3 | |
| Catch | 2150.6 | 2150.6 | 1698.4 | 1698.4 | 1698.4 | 1698.4 | 1698.4 | |
| Probability of reaching 20% SSB | <0.5% | 17% | 71% | 92% | 97% | >99.5% | >99.5% | 2020 |
| **Scenario 22: 50% Reduction; Short-Term Recruitment** | | | | | | | | |
| SSB | 1949.1 | 2737.4 | 3791.4 | 4065.7 | 3916.3 | 3214.4 | 3021.3 | |
| Catch | 2150.6 | 2150.6 | 1698.4 | 1698.4 | 1698.4 | 1698.4 | 1698.4 | |
| Probability of reaching 20% SSB | <0.5% | 15% | 51% | 57% | 53% | 35% | 29% | NA |
| **Scenario 23: 60% Reduction; Long-Term Recruitment** | | | | | | | | |
| SSB | 1949.9 | 2829.1 | 4631.3 | 6798.1 | 8741.1 | 13605.2 | 14857.1 | |
| Catch | 2150.6 | 2150.6 | 1358.7 | 1358.7 | 1358.7 | 1358.7 | 1358.7 | |
| Probability of reaching 20% SSB | <0.5% | 18% | 73% | 94% | 98% | >99.5% | >99.5% | 2020 |
| **Scenario 24: 60% Reduction; Short-Term Recruitment** | | | | | | | | |
| SSB | 1948.6 | 2737.7 | 3888.1 | 4364.3 | 4396.6 | 4110.1 | 3970.5 | |
| Catch | 2150.6 | 2150.6 | 1358.7 | 1358.7 | 1358.7 | 1358.7 | 1358.7 | |
| Probability of reaching 20% SSB | <0.5% | 15% | 53% | 65% | 67% | 63% | 59% | 2021* |
| **Scenario 25: 70% Reduction; Short-Term Recruitment** | | | | | | | | |
| SSB | 1948.7 | 2736.4 | 3979.8 | 4667.7 | 4886 | 4960.9 | 4977 | |
| Catch | 2150.6 | 2150.6 | 1019 | 1019 | 1019 | 1019 | 1019 | |
| Probability of reaching 20% SSB | <0.5% | 15% | 56% | 72% | 78% | 85% | 86% | 2021 |

**Table NMLS-03** (continued)**.**

| Year | 2018 | 2019 | 2020 | 2021 | 2022 | 2027 | 2037 | Year when target achieved with 60% probability |
|---|---|---|---|---|---|---|---|---|
| **Scenario 26: 80% Reduction; Short-Term Recruitment** | | | | | | | | |
| SSB | 1948.7 | 2736.2 | 4071.1 | 4971.3 | 5380.3 | 5909.1 | 5977.5 | |
| Catch | 2150.6 | 2150.6 | 679.4 | 679.4 | 679.4 | 679.4 | 679.4 | |
| Probability of reaching 20% SSB | <0.5% | 15% | 58% | 79% | 88% | 97% | 97% | 2021 |
| **Scenario 27: 90% Reduction; Short-Term Recruitment** | | | | | | | | |
| SSB | 1950.6 | 2740.5 | 4170.3 | 5284.1 | 5881.7 | 6836.7 | 7009.4 | |
| Catch | 2150.6 | 2150.6 | 339.7 | 339.7 | 339.7 | 339.7 | 339.7 | |
| Probability of reaching 20% SSB | <0.5% | 15% | 61% | 85% | 94% | >99.5% | >99.5% | 2020 |

* This scenario has a 60% probability of being at or above 20%$SSB_{F=0}$ in 2020 but drops slightly below 60% starting in 2035.

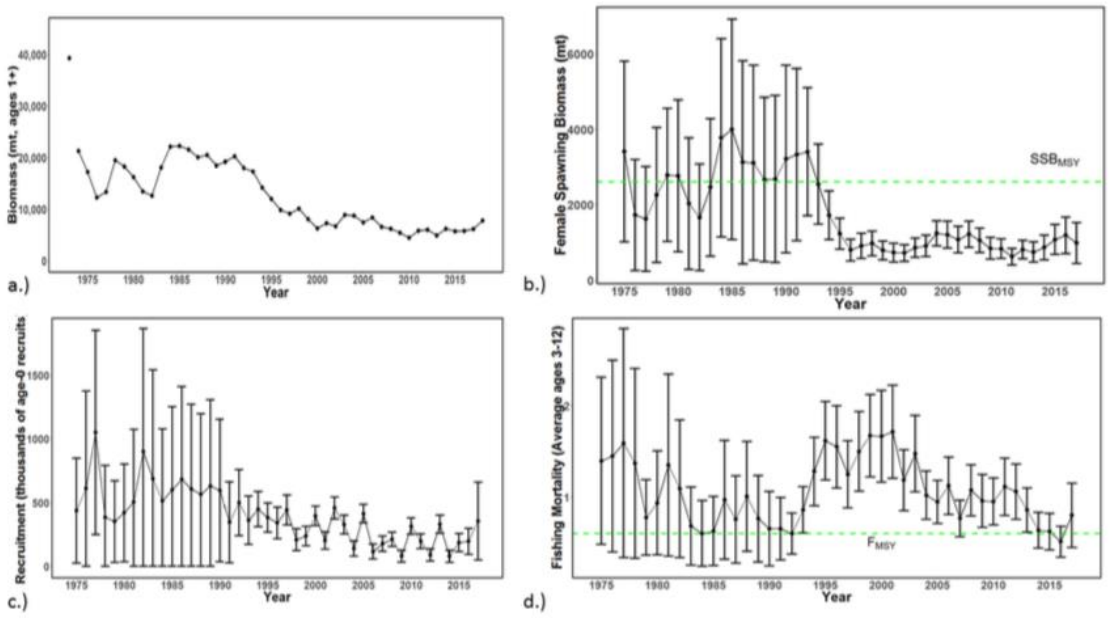



**Figure NMLS-01.** Time series of estimates of (a) population biomass (age 1+), (b) spawning biomass, (c) recruitment (age-0 fish), and (d) instantaneous fishing mortality (average for age 3-12, $year^{-1}$) for WCNPO striped marlin (derived from the 2019 stock assessment. The circles represent the maximum likelihood estimates by year for each quantity and the error bars represent the uncertainty of the estimates (95% confidence intervals), green dashed lines indicate $SSB_{MSY}$ and $F_{MSY}$.

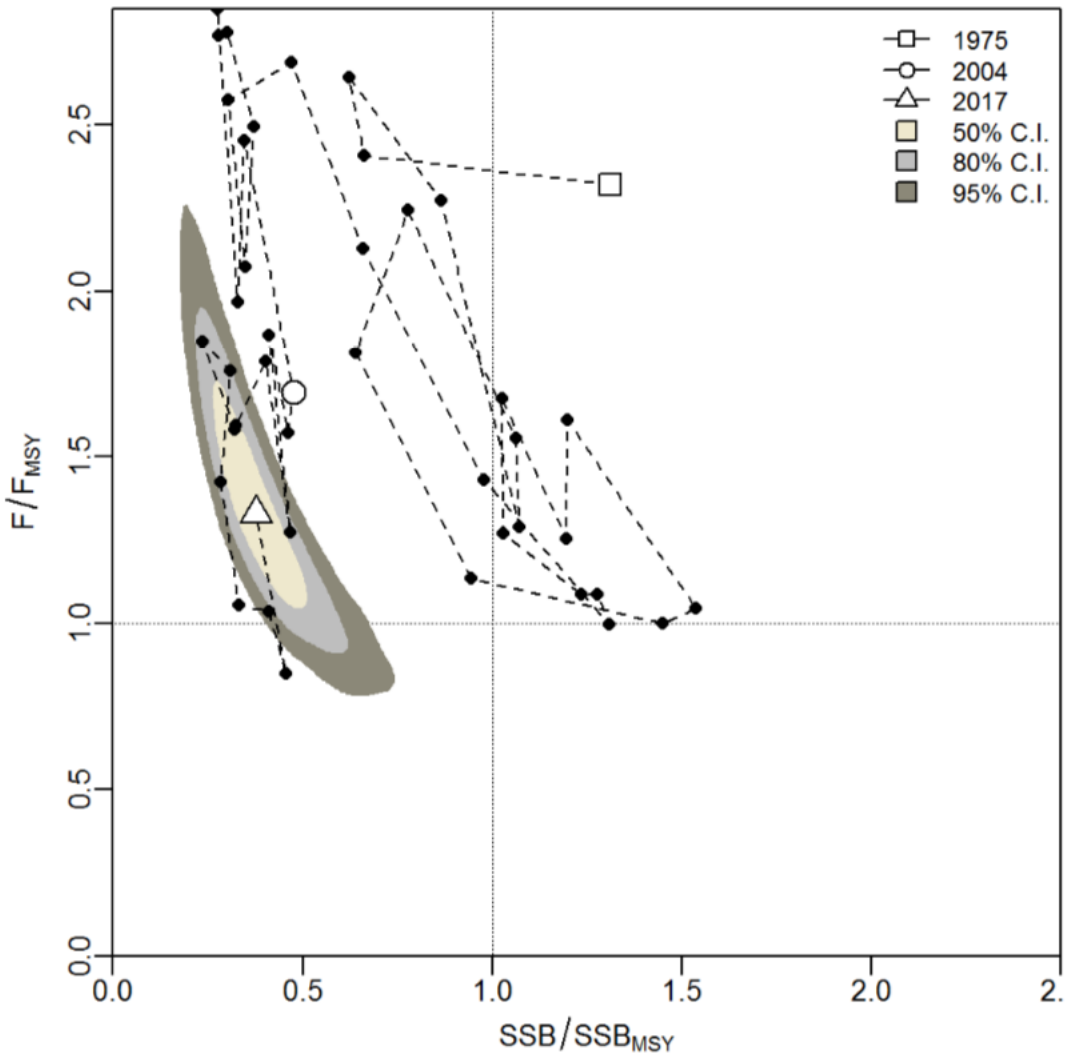
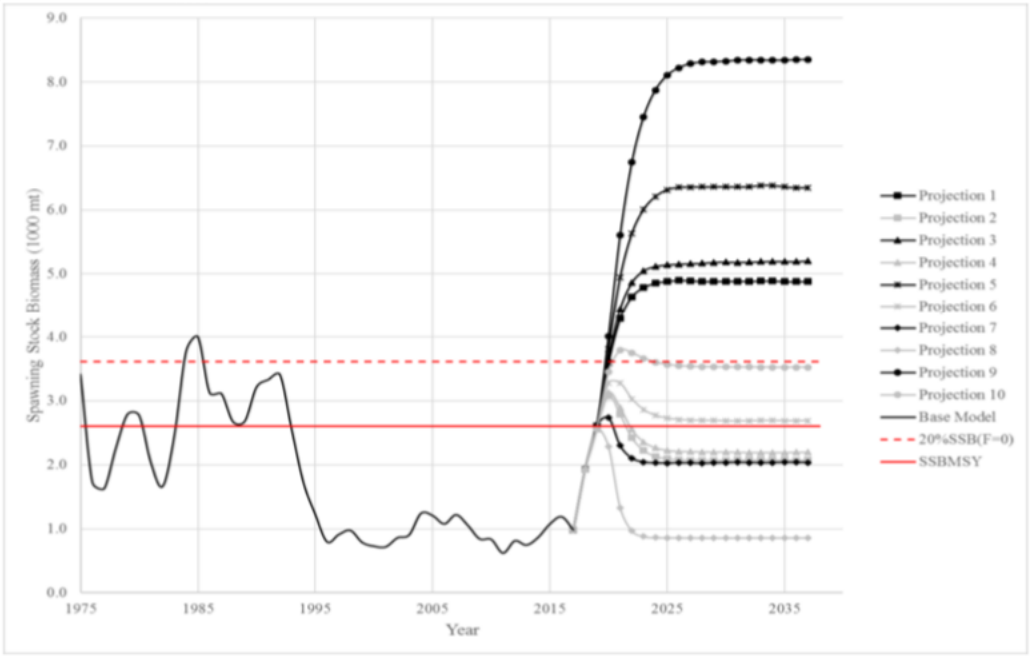



**Figure NMLS-02.** Kobe plot of the time series of estimates of relative fishing mortality (average of age 3-12) and relative spawning stock biomass of WCNPO striped marlin during 1975-2017. The white square denotes the first year (1975) of the assessment, the white circle denotes 2004, and the white triangle denotes the last year (2017) of the assessment.

a.)




b.)

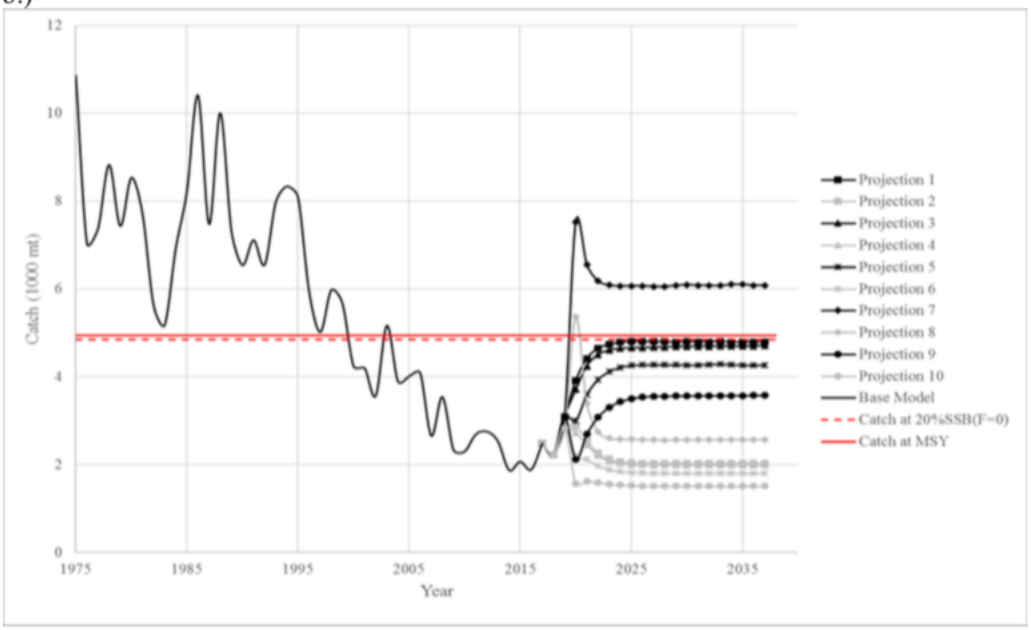
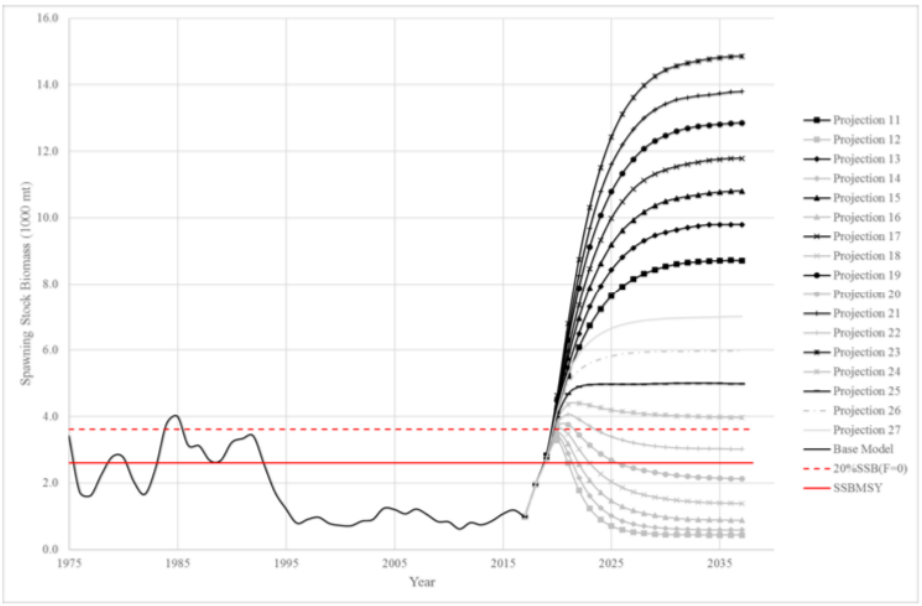



**Figure NMLS-03.** Historical and projected trajectories of spawning biomass and total catch from the WCNPO striped marlin base case model based upon F scenarios (projection 1-10): (a) projected spawning biomass and (b) projected catch.

a.)




b.)


**Figure NMLS-04.** Historical and projected trajectories of spawning biomass and total catch from the WCNPO striped marlin base case model based upon constant catch scenarios (projections 11-15): (a) projected spawning biomass; and (b) projected catch.

Note on Figure NMLS-3 and Figure NMLS-4: Black lines are the long-term recruitment scenario results; grey lines show the short-term recruitment scenario results. The red dashed line shows the catch or spawning stock biomass at $20\%SSB_{F=0}$ and the solid red line is the catch or spawning stock biomass at $SSB_{MSY}$. The list of projection scenarios can be found in Table NMLS-03.