# ANNEX 06

*25th Meeting of the*
*International Scientific Committee for Tuna*
*and Tuna-Like Species in the North Pacific Ocean*
*Busan, Republic of Korea*
*17-20 June 2025*

# REPORT OF THE BILLFISH WORKING GROUP WORKSHOP[1]

## June 2025

[1] Prepared for the 25th Meeting of the International Scientific committee on Tuna and Tuna-like Species in the North Pacific Ocean (ISC) held 17-20 June 2025, in Busan, South Korea. Document should not be cited without permission of the authors.

Left Blank for Printing

*ANNEX 06*

# REPORT OF THE BILLFISH WORKING GROUP WORKSHOP

*International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean (ISC)*

13-18 January 2025
Honolulu, HI, USA

## 1. OPENING AND INTRODUCTION

### 1.1. Welcoming Remarks

Michelle Sculley, the International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean (ISC) Billfish Working Group (WG) chair, opened the working group meeting. Participating scientists were from Chinese Taipei (TWN), Japan (JPN), United States of America (USA), the Inter-American Tropical Tuna Commission (IATTC), and the Pacific Community (SPC). The list of participating scientists is in Attachment 1.

### 1.2. Introduction

The WG met to discuss newly available research on North Pacific billfish stocks and the current progress of the International Billfish Biological Sampling (IBBS) program. The WG also participated in the ISC OpenScience workflows training held from Jan 13-16, 2025.

### 1.3. Standard Meeting Protocols

The WG chair introduced protocols for the hybrid meeting. The WG used Webex for this meeting, during which working papers and agenda presentations were discussed.

## 2. ADOPTION OF AGENDA AND ASSIGNMENT OF RAPPORTEURS

The WG adopted the meeting agenda before the meeting (Attachment 2). The WG chair also assigned the rapporteurs J Brodziak, M Kai, YJ Chang, C Castillo Jordan, W Chiang, and M Jusup.

## 3. NUMBERING WORKING PAPERS AND DISTRIBUTION POTENTIAL

Eight working papers and four presentations were submitted (Attachment 3). The WG agreed to post all working papers except WP05 and WP06 on the ISC website and make them publicly available.

## 4. RESPONSE TO EXTERNAL REQUESTS

### 4.1. Response to WCNPO MLS Peer Review

***On the Review of the Stock Assessment Results for Striped Marlin in the Western and Central North Pacific: Japan's Response and a Proposal to the BILLWG. Mikihiko Kai and Marko Jusup (ISC/25/BILLWG-1/03)***

This working paper summarizes Japan's response to the review of the stock assessment for striped marlin in the western and central North Pacific conducted in 2024. It also provides a proposal to the billfish working group to develop a detailed plan of tasks for each member country. This plan will be submitted to ISC Plenary 25 to address the short-term and long-term issues identified by the reviewers.

**Discussion**

The WG worked through the spreadsheet (Appendix 4) detailing their response to each of the recommendations from the WCNPO MLS peer review. Generally, the WG agreed to consider an ensemble model approach as a means to address many of the recommendations. The WG is prioritizing efforts to continue the IBBS program and develop a new growth curve for WCNPO MLS, and to create a unified CPUE index for JPN, TWN, and USA. **The WG recommended revisiting the spreadsheet, including the contents of this document, before and after the stock assessment-related meetings for the striped marlin in the western North Pacific.**

### 4.2. Climate vulnerability matrix (ISC Plenary request)

The WG developed the climate vulnerability matrix based upon the assumption that adult and sub-adult fish are highly migratory and will move to ideal habitat/food areas, but return to historical areas to spawn, and larvae are found in areas where they have historically been found. The WG noted that there is limited information on where billfish spawn and how or why they choose those areas to spawn. The WG noted that while most or all of the climatological changes in the matrix will likely have an effect on the billfish species, it remains to be seen whether these effects will be positive or negative, and that highly migratory species might adapt to climate changes in unknown ways. Further research is needed to evaluate these potential adaptations.

### 4.3. WCPFC Request for additional WCNPO MLS Rebuilding Scenarios

***Proposals for the Recovery Plan for Striped Marlin in the western and central North Pacific following the Implementation of Management Measures. Mikihiko Kai and Marko Jusup. (ISC/25/BILLWG-1/04)***

The 2023 stock assessment for striped marlin (*Kajikia audax*) in the western and central North Pacific (WCNPO) identified the stock as overfished and likely subject to overfishing. This stock status highlighted the need for a rebuilding plan, prompting subsequent future projections with the aim to restore spawning stock biomass to 20% of the unfished level within 10 years with at least a 60% probability of success. Finally, a management measure was adopted specifying a total annual catch limit of 2,400 metric tons for 2025–2027, with country-specific allocations. This working paper proposes three actions: clarifying catch allocations arising from management scenarios used in existing future projections, evaluating whether the rebuilding goal can be achieved under maximum allowable catches compatible with country-specific allocations, and determining necessary allocation adjustments for the second management phase post-2027 if current scenarios prove insufficient. These proposals aim to align management strategies with allocation constraints while ensuring the rebuilding goal is met.

**Discussion**

**The WG agreed to provide the comparison table between the catch allocated to each country in the 2024 WCNPO MLS rebuilding analysis and the new Conservation and Management Measure adopted by WCPFC in December 2024 (CMM 2024-06, Table 1). They also agreed to run three additional scenarios based upon the allocation in the new CMM (Table 2). The WG requested members to provide updated aggregated catch by country for 2021-2024 by Jan 31, 2024 and catch by fleet based upon the 2023 stock assessment fleet structure as soon as possible, noting that if catch was not available, the previous year's catch would be carried-over.** This work will be reviewed by the WG in a virtual meeting in April, and a report for that meeting will be appended to this report. (Appendix 5).

**Table 1.** Table of the catch by country for the WCNPO MLS rebuilding scenarios provided in 2024 based upon the average of 2018-2020 catch by country and the catch by country adopted in the 2024 Conservation Management Measure for WCNPO MLS at WCPFC21. The 2024 scenarios column indicate the expected catch for scenarios with a limit of 2400 mt in 2025-2027, CMM-2024-06 column is the agreed upon catch limits by country for 2025-2027.

| Fleet | 2024 Scenarios | CMM 2024-06 |
|---|---|---|
| JPN | 1558.6 mt | 1454.4 mt |
| TWN | 370.4 mt | 358.4 mt |
| USA | 324 mt | 228.4 mt |
| KOR | 59 mt | 214.8 mt |
| CHN | 51 mt | 68.8 mt |
| WCPFC Other | 36 mt | 75.2 mt |

**Table 2.** Table of proposed new scenario runs requested by WCPFC21 with the catch allocations by country in line with CMM 2024-06 in metric tons. TBD indicates projected annual catch determined to meet the rebuilding plan goals.

| Scenario 1 - TAC only | | | | |
|---|---|---|---|---|
| Fleet | 2025 | 2026 | 2027 | 2028 -2034 |
| JPN | 1454.4 | 1454.4 | 1454.4 | TBD |
| TWN | 358.4 | 358.4 | 358.4 | |
| KOR | 214.8 | 214.8 | 214.8 | |
| USA | 228.4 | 228.4 | 228.4 | |
| CHN | 68.8 | 68.8 | 68.8 | |
| WCPFC other | 75 | 75 | 75 | |
| Scenario 2 - Extra catch 2025 | | | | |
| Fleet | 2025 | 2026 | 2027 | 2028 – 2034 |
| JPN | 1619.4 | 1454.4 | 1454.4 | TBD |
| TWN | 523.4 | 358.4 | 358.4 | |
| KOR | 379.8 | 214.8 | 214.8 | |
| USA | 393.4 | 228.4 | 228.4 | |
| CHN | 233.8 | 68.8 | 68.8 | |
| WCPFC other | 75 | 75 | 75 | |
| Scenario 3 - Extra catch in 2025 and 2026 | | | | |
| Fleet | 2025 | 2026 | 2027 | 2028 -2034 |
| JPN | 1619.4 | 1619.4 | 1454.4 | TBD |
| TWN | 523.4 | 523.4 | 358.4 | |
| KOR | 379.8 | 379.8 | 214.8 | |

| | | | |
|---|---|---|---|
| **USA** | 393.4 | 393.4 | 228.4 |
| **CHN** | 233.8 | 233.8 | 68.8 |
| **WCPFC other** | 75 | 75 | 75 |

## 5. STRIPED MARLIN RESEARCH UPDATES

***CPUE standardization of striped marlin caught by Japanese longliners in the western and central North Pacific from 1977 to 2023. Shoma Takahashi, Mikihiko Kai*, Marko Jusup, and Minoru Kanaiwa (ISC/25/BILLWG-1/01)***

The nominal CPUE for striped marlin (*Kajikia audax*) caught by the Japanese coastal and distant water longline fisheries operating in the western and central North Pacific Ocean was standardized using a GLM with logbook data spanning the period from 1977 to 2023. Four explanatory variables—year, season, area, and fishing gear clusters—were used as main effects, along with their two-way interactions. Model selection revealed that a negative binomial model outperformed a Poisson model. According to AIC, the best model was the full model incorporating all combinations of two-way interactions, while BIC favored a full model excluding two-way interactions involving the year. Model diagnostics suggested that the best models fit the data adequately. For the AIC best model, the annual CPUE exhibited an upward trend until 1995 with significant annual fluctuations, followed by a downward trend until 2009, and then an increasing trend until 2022. For the BIC best model, the annual CPUE maintained a high level with significant annual fluctuations from 1977 to 1995, then showed a decreasing trend until 2010, followed by a slight increase, but remained at a low level until 2023. This study applied a simple method as a first step towards comprehensive CPUE standardization. It will be necessary to advance this work using more sophisticated methods in the future.

**Discussion**

The working paper focused on standardizing Japanese longline CPUE for striped marlin in the western and central North Pacific from 1977 to 2023, ensuring no temporal break around 1993–1994. Using the same area definition as the 2023 stock assessment, CPUE standardization employed four subregions and gear strata (3–4, 5–14, 15–23 HBF). Negative binomial (NB) models were selected based on AIC and BIC, with year effects being predominant. The CPUE pattern aligned with the 2023 spawning stock biomass trend, highlighting seasonal size composition as a key issue for the fitted CPUE indices. The study identified no clear time trends in HBF for MLS catch and emphasized using models without interaction terms for practical application.

The Working Group discussed the challenges such as data variability, the need for operational-level data, and refining models for seasonal and spatial patterns. **The importance of robust CPUE indices for reliable stock assessments was discussed and it was recommended that further spatio-temporal modeling and complementary approaches be considered to address data gaps and to align CPUE indices more closely with stock dynamics and changes in fishing effort impacting WCNPO striped marlin.** The WG discussed the species composition in the cluster analysis on species targeting, and noted that there was no clear pattern for targeting of striped marlin.

***Preliminary spatio-temporal CPUE standardization for the Japanese longline fishery in the North Pacific from 1975 to 2023. Marko Jusup and Hirotaka Ijima (ISC/25/BILLWG-1/05)***

This study presents a multi-species spatiotemporal statistical model to produce standardized catch per unit effort (CPUE) series for albacore tuna, bigeye tuna, and striped marlin in the North Pacific. The model incorporates interspecies interactions to reflect the effects of targeting practices. Using data from 1975 to 2023, standardization was performed for both the North Pacific and Western and Central North Pacific Ocean regions. Significant spikes in the standardized CPUE were observed for albacore and striped marlin, which may indicate overfitting to high-CPUE years. Computational challenges arose when incorporating vessel license numbers due to their large number and potential reassignment across vessels. An alternative approach using vessel names was considered but also requires substantial preprocessing due to inconsistent recording formats. The effects of hooks between floats (HBF) were found to be statistically significant, though potential confounding factors related to material changes around 1994 need to be considered. Preliminary spatiotemporal CPUE distributions reveal species-specific abundance hotspots, with some exhibiting strong seasonal patterns. Further research, including related species such as blue marlin or black marlin, may enhance the understanding of these patterns.

**Discussion**

The WG discussed HBF's significant influence on CPUE while cautioning against over-interpretation due to confounding effects. Spatial analyses revealed distinct abundance hotspots with both stable and variable seasonal patterns. Recommendations included expanding the model to include related species like blue and black marlin, addressing data preprocessing challenges, and refining the interpretation of latent variables as predictors of species abundance.

The WG appreciated the efforts from Japan to produce a single CPUE index without splitting it in 1993. There were several questions about aspects of the analysis. There was discussion on if it would be useful to include the correlation between the latent variables for different species. There was also discussion among WG members about how to manage the changes to the data before and after 1994, and how it may be possible to quantify the differences in the data quality and operational characteristics that may not be measured. It was noted that precision has not been calculated for these indices yet, as the work is still in progress. The integration of additional explanatory variables, such as vessel ID as a random effect, was suggested to improve analysis.The authors indicated that some attempts were made to incorporate more variables but ran into computational limitations.

The WG asked what the explanation was for the large spike in striped marlin CPUE around 1990. It was responded that there was actually a big spike in nominal CPUE at this time as well and that the model likely needs more explanatory variables to help resolve this issue.

***Preliminary joint CPUE standardization of Western and Central North Pacific striped marlin using the spatio-temporal modelling approach. Zi-Wei Yeh, Jhen Hsu, Yi-Jay Chang*, Wei-Chuan Chiang (ISC/25/BILLWG-1/07)***

A joint CPUE standardization was conducted for striped marlin in the Western and Central North Pacific Ocean using longline data from Japanese and U.S. fleets (sourced from the WCPCF Public Domain Aggregated Catch/Effort Data) and Taiwanese fleets (derived from aggregated logbook data) for the period 1995–2022. Using a spatio-temporal delta-generalized linear mixed model (sdmTMB), which explained 63% of the variation, the analysis revealed distinct spatial patterns between encounter probability and positive catch rates. The standardized abundance indices showed high values during 1995-1997, followed by a declining trend before stabilizing at lower levels from 2008 onwards, with higher seasonal abundance in the first quarter. This preliminary analysis of joint standardization demonstrates the potential for developing comprehensive abundance indices with wider spatial coverage and consistent methodology across multiple fleets.

**Discussion**

The WG noted the value of combining datasets and using a unified modeling approach to resolve data inconsistencies that complicated stock assessments. The model explained 63% of data variation and effectively captured spatial dynamics, showing that high encounter areas did not always align with high catch rates. However, residual patterns suggested the need for further refinements, particularly to account for fleet-specific biases. **The WG requested that Japanese data not only prior to 1995 and but also full seasons and areas be considered in future analyses, as the spatio-temporal coverage of the current analysis is limited. The WG also requested the inclusion of other CPUEs, such as those from Korea and China.** When asked about the computational cost, it was noted that the data are in monthly 5°x5° aggregate and not computationally intensive.

## 6. SWORDFISH RESEARCH UPDATES

***Movement patterns of striped marlin (Kajikia audax) and swordfish (Xiphius gladius) in the northwestern Pacific Ocean. Wei-Chuan Chiang, Shian-Jhong Lin, Michael K. Musyl, Yi-Jay Chang, Chi-Lu Sun, Yuan-Shing Ho (ISC/25/BILLWG-1/06)***

Understanding the movements and ecology of billfish is essential for improving their management and gaining insights into the basic life history of these migratory predators. Traditional harpoon and longline fishing gears were employed to deploy pop up satellite archival tags (PSATs) on striped marlin and swordfish in the waters off southeastern Taiwan (Taitung). These tags recorded depth, temperature, and ambient light data, enabling detailed analysis of movement patterns. From December 2008 to June 2024, a total of five striped marlin and five swordfish were tagged. The tags remained affixed to the animals for durations ranging from 13 to 360 days. Linear displacements from deployment to pop up locations ranged from 279 to 1,605 km, with average speeds between 3 and 107 km/day. Horizontal movement tracks, determined using the Kalman filter (Most Probable Tracks), revealed no distinct seasonal movement patterns. The tagging locations in eastern Taiwan corresponded to pop-up locations extending northward to the East China Sea, southwest to the South China Sea, and southeast to waters off the Philippines. Diving depths and water temperatures ranged from the surface to ~258m (14.4°C to 34.4°C) for striped marlin, and from the surface to ~915m (4.9°C to 32.9°C) for swordfish. A significant difference in time spent at depth was observed between daytime and nighttime diving behaviors. Striped marlin predominantly occupied the surface mixed layer down to ~50 m during the day, often exhibiting basking behavior, and remained confined to the surface at night. Swordfish, on the other hand, displayed pronounced diel vertical movement patterns, descending to depths greater than 400 m during the day and returning to the surface mixed layer (<100m) at night. For striped marlin, depth distribution appeared to be constrained by a water temperature difference of ~8° C relative to the warmest surface waters, even when sea surface temperatures (SSTs) ranged from 24°C to 35°C. Striped marlin and swordfish exhibited a broad depth and temperature range in their habitats, with striped marlin occupying areas from the surface to the epipelagic zone. In contrast, swordfish were observed diving into the mesopelagic zone during both daytime and nighttime. These findings provide valuable information to support effective fisheries management.

**Discussion**

The WG asked if there were any differences between the striped marlin that moved north as opposed to those that moved south. The authors indicated that they had looked at size and tagging time but neither was able to explain the split in movement behaviors. The group expressed interest in being able to collect tissue samples from tagged fish in order to get information on sex, which may shed light on this north south movement as it may be related to spawning, or post spawning behavior. The authors indicated that this was of interest and that efforts will be made into trying to collect tissue from tagged fish.

The WG was interested in the size of tagged animals and if it was easy for Taiwan to catch fish over 200cm EFL, but sizes of animals in this study were estimated from body weight. The WG asked how many billfish tags were recovered. It was answered that none of the tags for billfish had been recovered and that all data presented on them was transmitted data. The WG was interested in why tags seemed to be popping off prior to the date they were programmed to. The author responded that due to the nature of tagging from fishing vessels it was difficult to get tags attached well and that perhaps this may improve in the future when they are able to tag from research vessels.

***Incorporating climate indices into stock assessment projections: A case study using WCNPO swordfish. Michelle Sculley, Hirotaka Ijima, Phoebe Woodworth-Jefcoats, Yi-Jay Chang. Presentation 1.***

It is becoming increasingly important to consider climate when managing fish stocks, with climate change poised to play a major role in the sustainability of fisheries into the future. This can be challenging for highly migratory species due to the difficulty of collecting fisheries independent data and large−scale environmental data beyond the remote sensing data available. Furthermore, the value of including environmental data is lessened if we are unable to propagate those data into future short-term projections to provide management advice. The 2018 western and central North Pacific swordfish stock assessment was modified to include environmental covariates to inform recruitment deviations in using Stock Synthesis and into future projections using the projection software SSFutures. We tested several climatological indices for which it was possible to obtain short-term (< 5 years) future estimates including a phytoplankton size composite, the Southern Oscillation Index (SOI), the Pacific Decadal Oscillation (PDO) Index, and the ENSO Oceanic Nino Index. Of these, the SOI has been shown to correlate strongly with swordfish recruitment for the western and central North Pacific stock. We compare multiple climate scenarios to show how environmental variables can change future projections of the WCNPO stock, and highlight the value of continuing work on near-term climatological prediction models.

**Discussion**

The WG discussed how to account for various sources of uncertainty, including observation error, process error, and climate scenarios in projections, etc. Additionally, model selection and the evaluation of model performance were addressed. Another topic of discussion was why recruitment is higher under negative SOI (El Niño conditions) and the biological mechanisms underlying this phenomenon. Finally, the WG discussed how this climate-informed study can be translated into management advice.

***Progress on the SWPO Striped Marlin Stock Assessment. Claudio Castillo Jordan. Presentation 4.***

A short update on the current progress of the SWPO striped marlin stock assessment was presented. Current challenges were highlighted for the WG to provide feedback and advice. The WG provided several comments on potential steps to take to help reduce conflict between data sources in the assessment. These included: increasing the CV on early time period CPUE values when there is high interannual variability that is unlikely to be related to relative abundance, exploring using weight data in place of the less reliable length data, potentially converting weight to length data outside of the model (following a recommendation from the WCPNO MLS review), exploring the use of age-specific selectivity to address some of the seasonal patterns, dropping data that are not representative of the population, and exploring the use of age-specific CPUE indices. Japan also noted that for JPN weight data, total weight is collected for each set, regardless of how many fish are caught (i.e., if there are 10 fish the weight is the total for all 10 fish) which, if they are using the operational data to extract weight data, may be unrepresentative as it is an average weight.

## 7. BLUE MARLIN RESEARCH UPDATES

There were no working papers or presentations on Pacific Blue Marlin.

## 8. INTERNATIONAL BILLFISH BIOLOGICAL SAMPLING PROGRAM UPDATES

***Progress on Japan's Biological Sampling of Three Billfish Species caught in the North Pacific from 2019 to 2024. Yuki Ishihara, Marko Jusup and Mikihiko Kai (ISC/25/BILLWG-1/02)***

In 2020, Japan, the United States, and Taiwan initiated International Billfish Biological Sampling Program (IBBS) to accurately estimate the key life history parameters, such as maturity and growth, of three billfish species—swordfish, striped marlin, and blue marlin—across the North Pacific Ocean. This working paper summarizes the current progress of the biological sampling undertaken by Japan and the number of samples shared with the United States and Taiwan. The total number of gonads, otoliths, and fin rays collected by Japan from swordfish and striped marlin in the western North Pacific Ocean between January 2019 and November 2024 has reached the predetermined target. However, swordfish samples were biased towards females, and striped marlin samples were highly biased in terms of length bins and sampling locations. The number of swordfish gonad samples per length bin analyzed by Japan, including samples provided by the United States and Taiwan, is relatively evenly collected, although some bins do not reach the target. On the other hand, striped marlin otolith and fin ray samples have significantly fewer small and large specimens. Additionally, there are a few large geographic areas where very few samples of either swordfish or striped marlin have been collected. A more efficient sampling plan will be required to collect effectively these missing samples in the future.

***Progress on Taiwan's Biological Sampling of three Billfish Species caught in the Pacific. Yi-Jay Chang, Zi-Wei Yeh, Jhen Hsu (ISC/25/BILLWG-1/08)***

The International Billfish Biological Sampling (IBBS) program, launched by the ISC Billfish Working Group in 2020, aims to improve stock assessments of highly migratory billfish species by reducing uncertainties in key biological parameters. Taiwan has contributed to the program by collecting biological samples of blue marlin (*Makaira nigricans*), striped marlin (*Kajikia audax*), and swordfish (*Xiphias gladius*) from longline fishing vessels between 2020 and 2024. Samples include muscle tissue, fin spines, gonads, otoliths, vertebrae, and eyeballs, with muscle tissue being the most frequently collected. Spatial analysis showed distinct distribution patterns among species, with gaps noted in the Eastern Pacific. International sample exchanges began in 2023, enhancing collaboration among Taiwan, the United States, and Japan. Identified gaps in size and spatial coverage highlight the need for targeted sampling to better support stock assessments. This study demonstrates the importance of international cooperation in managing billfish populations.

***International Billfish Biological Sampling Project - 3-year update. Michael Kinney. Presentation 3***

The current progress of the efforts from the USA were presented to the working group. Efforts are currently underway to work with the West Coast Region of the US to get samples between Hawaii and the mainland. To date, the US has collected over 1100 samples from swordfish, striped marlin, and blue marlin, with over 3500 samples collected for the sampling program. The US noted that samples were being collected and processed, but funding is still pending to begin analyzing the swordfish samples.

**Discussion**

The WG discussed the current progress of biological sampling from all three countries. Taiwan indicated the growth curve for blue marlin was in preparation to be submitted for publishing. This work is just from samples from Taiwan and previously published data, but they will be keeping the samples collected as part of IBBS to analyze further in the future. There was some discussion on how the maximum age of blue marlin was estimated, and the WG noted that it was from a bomb-radio carbon dated fish aged by Allen Andrews.

The WG also discussed how fin spines are being stored by each country and if there were concerns about discoloration of the fin spines. All three labs are processing and storing fin spines using similar methods, and at this time, no discoloration has been noticed. However, a yellowing phenomenon was observed in some slides that had been stored for a long time.

The WG also discussed the challenge of reading billfish otoliths, amid concerns that aging using fin spines could lead to biased growth curves. Taiwan is currently reading daily otolith rings through age one, while fin spines are being used for determining the ages of older fish. It was noted that ageing younger fish otoliths was simpler, but that after establishing a baseline by ageing enough samples of younger fish, it may become easier to read more difficult to age otolith samples from older fish. It was suggested that a reference collection may be needed. The presenter responded that there are few aged samples available at this time, but that sample size should increase in the future.

The WG also discussed the storage of eye lenses and gonad tissue, clarifying that if age-validation was to be performed on eye lenses, they needed to be frozen. All three WG members indicated that they were freezing samples, but at different temperatures. There was discussion on whether the temperature mattered or if being frozen was enough. For genetic samples, it is likely that the storage temperature matters, but not for eye lenses and potentially not for gonad samples.

The WG discussed the challenges associated with the genetic analyses proposed by the group to explore stock structure in the future. It was noted that some preliminary work has been done in the US to start identifying the quality of the genetic samples in different storage conditions, and how subsampling the tissues may impact the quality of the genetic samples. Japan has indicated a willingness to take the lead on analyzing striped marlin genetic information, as they have the in-house expertise to do so. The WG emphasized that this would mean Japan would also need to do these preliminary explorations of sample degradation if they wanted to be the first group to tackle a genetic analysis. It was noted that Taiwan has started collecting shortbilled spearfish genetic samples and encourages other countries to do so as well. Overall, the WG noted the importance of genetic analysis for identifying stock structure for billfish assessments.

***The Preliminary report of age estimation for striped marlin in the Western North Pacific by Japanese samples. Ayumu Furuyama, Yuichi Arai, Miwako Funabara, Yuki Ishihara Mikihiko Kai, Minoru Kanaiwa*. Presentation 2.***

In this study, daily age determination using otoliths and age determination using spines were conducted for striped marlin in the western North Pacific, and the growth curves were estimated. Otolith cross-sections were prepared for 158 striped marlin caught in the North Pacific.

Since the otoliths of striped marlin become bent perpendicular to the cross-section at the margin as they develop, making daily rings unclear, daily age determination was conducted on only 96 individuals, excluding those with unclear rings. The sampling areas for the 96 individuals were 75 from the western region, 19 from the central region, and 2 from the eastern region.

The early growth (eye fork length: EFL) was estimated against daily age using linear regression on logarithmic values. The 365-day-old EFL of striped marlin in the western region was 135.57 cm, and the estimated curve was consistent with previous findings. Early growth of striped marlin in the central region showed large variability, resulting in unrealistic estimates.

Based on the 365-day-old EFL of striped marlin in the western region and its 95% prediction interval (112.74-163.03 cm), the first annulus of the dorsal fin spine was determined. Age determination was performed on 184 individuals. Although no apparent decrease in the MIR of the annuli of the spines was observed, the von Bertalanffy growth curve was estimated with a birth date of July 1 according to the standard method. $L_{\infty}$ was estimated to be 207.065, k was 0.408, and t0 was -1.423. The growth curve of striped marlin in the western North Pacific estimated in this study showed faster growth than that around Taiwan, as shown by Sun *et al.*, (2011). This difference is thought to be due to the decrease in the count of false annuli during early growth by determining the first annulus from the early growth equation obtained from otolith daily ages.

Samples have been insufficient for many months. Therefore, it is necessary to add samples from Taiwan and the United States for this analysis.

**Discussion**

The WG discussed the sampling of striped marlin, noting that few samples have been collected below 100 cm (EFL) and above 200 cm. Japan mentioned that it might be possible to collect large samples over 200 cm this year, so the WG would like the US to collect small samples below 100 cm (EFL) if possible. The US responded that three options could be considered: 1) not setting a specific target eye-fork length for sample collection, 2) collecting samples from both large and small individuals, or 3) collecting samples from only large or only small individuals. At this time no target lengths are being used and it will take a few months for target lengths to be implemented.

The current aging study is based only on Japanese data collected from the Western and Central Pacific. However, the growth curve estimated from otolith samples collected in the Central region has shown that older individuals are smaller than younger individuals, so additional work is needed to address the patterns observed in the Central region, which might be due to mixing of multiple stocks in this region. .

The WG mentioned that the MLS caught in the waters around Hawaii may consist of a mixture of stocks, based on past genetic studies. Japan proposed to lead the genetic study to resolve this issue; however, the WG expressed concerns about the sampling treatments because the sample preservation methods differ among countries. The US and Taiwan store samples in freezers at -80°C and -20°C, respectively, while Japan stores samples at room temperature using a urea buffer. Additionally, the WG has no established rules on how to handle the samples to prevent contamination and ensure optimal DNA extraction. **The WG agreed to develop a sampling protocol to properly treat the samples, specifying the condition (frozen, preservation solution, etc.), quantity, and type of packaging for transportation to other countries. The WG determined that Japan will lead the genetic research on the stock structure of striped marlin, provided that Japan creates the sampling protocol based on the opinions of genetics experts and that the protocol is acceptable to the relevant countries.**

The WG noted that the new growth curve in the new analysis of striped marlin growth indicates faster growth compared to the one used in the previous stock assessment (Sun *et al.*, 2011). The WG considers that this could potentially impact the assumption about longevity. The WG also noted that this issue might be resolved by collecting large specimens, but there is a problem with underestimating age due to the vascularization in the fin spines of larger individuals.

The WG asked whether the lack of samples in certain months observed in Japan is also present across the entire IBBS samples. Upon checking the data for all IBBS samples, the WG noted fewer samples in October and December in the western region. The WG also inquired if the samples include tissue samples from all the tissues targeted by IBBS (e.g, eye-lenses, muscle tissue, otoliths, fin spines, gonads, etc.). It was noted that the US always collects all tissues, but this is not the case for Japan and Taiwan.

## 9. OTHER ITEMS

**The WG agreed to conduct a stock assessment of Pacific blue marlin in 2026.** A data preparatory workshop is tentatively scheduled for November 11-17, 2025, in Yokohama, with a stock assessment workshop planned for April 2026.

## 10. CIRCULATE WORKSHOP REPORT

The WG Chair made a draft of the workshop document and distributed it to the WG members. The WG members reviewed the draft.

## 11. ADOPTION

The WG Chair adjourned the working group meeting at 12:00PM on January 18, 2025 (HST).

## 12. REFERENCES

Sun, C.L., Hsu, W.S., Chang, Y.J., Yeh, S.Z., Chiang, W.C., and Su, N.J. (2011) Age and growth of striped marlin (*Kajikia audax*) in waters off Taiwan: A revision. Working paper submitted to the ISC Billfish Working Group Meeting, 24 May-1 June 2011, Taipei, Taiwan. ISC/11/BILLWG-2/07: 12p.

## ATTACHMENT 1. LIST OF PARTICIPANTS

**Chinese Taipei**

Yi-Jay Chang
Institute of Oceanography National Taiwan University, Taipei, Taiwan
yjchang@ntu.edu.tw

Wei-Chuan (Riyar) Chiang
Eastern Fishery Research Center, Fisheries Research Institute, Taitung, Taiwan
wcching@mail.tfrin.gov.tw

**Japan**

Yuki Ishihara
Fisheries Resources Institute,
Fisheries Stock Assessment Center
2-12-4 Fukuura, Yokohama
Kanagawa, Japan 236-86
ishihara_yuki13@fra.go.jp

Mikihiko Kai
Fisheries Resources Institute,
Fisheries Stock Assessment Center
2-12-4 Fukuura, Yokohama
Kanagawa, Japan 236-8648
kai_mikihiko61@fra.go.jp

Marko Jusup
Fisheries Resources Institute,
Fisheries Stock Assessment Center
2-12-4 Fukuura, Yokohama
Kanagawa, Japan 236-8648
jusup_marko00@fra.go.jp

Minoru Kanaiwa
Mie University
1577 Kurima-Machiya, Tsu, Mie
JAPAN,514-8507
kanaiwa@bio.mie-u.ac.jp

**United States**

Jon Brodziak
NOAA Fisheries, NMFS
Pacific Islands Fisheries Science Center,
1845 Wasp Blvd.,
Honolulu, HI, 96818
jon.brodziak@noaa.gov

Michael Kinney
NOAA Fisheries, NMFS
Pacific Islands Fisheries Science Center,
1845 Wasp Blvd.,
Honolulu, HI, 96818
michael.kinney@noaa.gov

Felipe Carvalho
NOAA Fisheries, NMFS
Pacific Islands Fisheries Science Center,
1845 Wasp Blvd.,
Honolulu, HI 96818
felipe.carvalho@noaa.gov

Michelle Sculley
NOAA Fisheries, NMFS
Pacific Islands Fisheries Science Center,
1845 Wasp Blvd.,
Honolulu, HI, 96818
michelle.sculley@noaa.gov

**The Pacific Community (SPC)**

Claudio Castillo-Jordan
Pacific Community
Fisheries Scientist
claudioc@spc.int

**Inter-American Tropical Tuna Commission (IATTC)**

Carolina Minte-Vera
8901 La Jolla Shores Drive,
La Jolla, CA 92037, USA
cminte@iattc.org

## ATTACHMENT 2. MEETING AGENDA

**BILLFISH WORKING GROUP (BILLWG)**
***International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean***

**INTERSESSIONAL MEETING**
**January 13-16 and 18, 2025**
**NOAA National Marine Fisheries Service Pier 38**
**Honolulu, HI, USA**

**Meeting time: 1:00PM-4:00PM HST**

**AGENDA**

1. Opening of Billfish Working Group (BILLWG) workshop
    a. Welcoming remarks
    b. Introductions
    c. Standard meeting protocols
2. Adoption of agenda and assignment of rapporteurs
3. Numbering working papers and distribution potential
4. Response to external requests
    a. ISC Climate Change Vulnerability Assessment
    b. ISC request for prioritization of WCNPO MLS peer review recommendations
    c. COM21 request – review of updated WCNPO MLS projections based upon CMM 2024-06
5. **Striped Marlin research updates**
6. **Swordfish research updates**
7. **Blue Marlin research updates**
8. **International Billfish Biological Sampling program update**
9. **Other matters**
10. **Clearing of Meeting Report**
11. **Adjournment**

## ATTACHMENT 3: WORKING PAPERS

| WP number | Author(s) | Title |
|---|---|---|
| WP01 | Shoma Takahashi, Mikihiko Kai, Marko Jusup, and Minoru Kanaiwa | CPUE standardization of striped marlin caught by Japanese longliners in the western and central North Pacific from 1977 to 2023. |
| WP02 | Yuki Ishihara, Marko Jusup, and Mikihiko Kai | Progress on Japan's Biological Sampling of Three Billfish Species caught in the North Pacific from 2019 to 2024. |
| WP03 | Mikihiko Kai and Marko Jusup | On the Review of the Stock Assessment Results for Striped Marlin in the Western and Central North Pacific: Japan's Response and a Proposal to the BILLWG |
| WP04 | Mikihiko Kai and Marko Jusup | Proposals for the Recovery Plan for Striped Marlin in the western and central North Pacific following the Implementation of Management Measures. |
| WP05 | Marko Jusup and Hirotaka Ijima | Preliminary spatio-temporal CPUE standardization for the Japanese longline fishery in the North Pacific from 1975 to 2023. |
| WP06 | Wei-Chuan Chiang, Shian-Jhong Lin, Michael K. Musyl, Yi-Jay Chang, Chi-Lu Sun, Yuan-Shing Ho | Movement patterns of striped marlin (*Kajikia audax*) and swordfish (*Xiphius gladius*) in the northwestern Pacific Ocean. |
| WP07 | Zi-Wei Yeh, Jhen Hsu, Yi-Jay Chang, Wei-Chuan Chiang | Preliminary joint CPUE standardization of Western and Central North Pacific striped marlin using the spatio-temporal modelling approach. |
| WP08 | Yi-Jay Chang, Zi-Wei Yeh, Jhen Hsu | Progress on Taiwan's Biological Sampling of three Billfish Species caught in the Pacific. |
| **Presentation Number** | **Author(s)** | **Title** |
| P01 | Michelle Sculley | Incorporating climate indices into stock assessment projections: A case study using WCNPO swordfish |
| P02 | Minoru Kanaiwa | The Preliminary report of age estimation for striped marlin in the Western North Pacific by Japanese samples |
| P03 | Michael Kinney | International Billfish Biological Sampling Project – A 3-year update |
| P04 | Claudio Castillo Jordan | Progress on the SWPO Striped Marlin Stock Assessment |

## APPENDIX 4 - ISC BILLWG RESPONSE TO RECOMMENDATIONS FROM THE WCNPO MLS PEER REVIEW

| **TOR 1** | Review the information available on Pacific MLS stock structure and conceptual model and provide any recommendations for changing WCNPO MLS stock boundaries or to the fleet structure. | | | | |
|---|---|---|---|---|---|
| Recommendation | Priority | Time Frame | Effort | WG Response | Next Assessment? |
| Simplify the Japanese fleet structure. The panel recommends not using the CPUE component in the current finite mixture model as a primary determinant for fleet structure. More focus should be given to operation level information to define the fleet structure as the primary objective should be to ensure a consistent fleet-specific selectivity. The key determinant of the fleet structure should be the size structure of the catch. Any fleet categorization should not simply be determined by the model output. | High | Short Term | High | In the most recent WCNPO MLS assessment, there were more than 10 Japanese fleets, Japan plans to stop using finite-mixture modelling to determine fleet structure, and will attempt to simplify the Japanese fleet structure based on the MLS size data caught by the Japanese longliners for the next assessment. | Yes |
| For all fleets, a better understanding of the spatial and temporal structure should be explored to more fully understand the patterns of CPUE, size, targeting, fleet structure and vessel turnover. | High | Short Term | medium | The WG will aim to show the spatial and temporal changes in CPUE, size, targeting, fleet structure, and vessel turnover in the future work. | Yes |
| Continue to pursue genetic research to more fully understand mixing between the genetically distinct population. This research should encompass the whole Pacific. There is an opportunity to utilize the genetic samples from the current IBSS program. This may require some modifications to the current sampling programs to ensure that genetic samples meet the requirements for the questions being pursued. | Medium | Long Term | high | The WG agreed that pursuing further understanding of stock mixing and structure in the whole Pacific using genetic samples from the current IBBS program and the other Tuna RFMOs in the future work, is an important future research area. Japan has offered to lead efforts in this area. | No |
| The WG should explore the use of an index fishery approach which would link to an exploration of a unified CPUE analysis (Maunder et al 2020, Xu et al 2023). | high | Long Term | high | Efforts are currently underway to work with WCPFC to give the WG access to confidential fisheries data to develop the unified CPUE index | Yes (probably) |
| | | | | | |

| **TOR 2** | Model inputs, commenting on the adequacy and appropriateness of data sources and data inputs to the stock assessment. |
|---|---|

| **Growth** | | | | | |
|---|---|---|---|---|---|
| Recommendation | Priority | Time Frame | Effort | WG Response | Next Assessment? |
| The WG should explore the possibility of fitting the growth model within the assessment, together with the inclusion of conditional length-at-age data. There is the option to use a fleet currently in the assessment for selectivity or to create another fleet for this purpose. | High | Short Term | Medium | The WG plans on exploring this option for the next assessment if possible. | Yes |
| The panel notes that the current IBSS project is a significant step in resolving growth uncertainty and this project should continue to be well supported. The spatial evaluation of growth is supported by the panel and careful consideration to how spatial growth applies to fleet structure and the interpretation of length data is needed. | High | Short term | High | The WG intends to continue efforts to collect samples and analyze data from IBBS | No |
| Should there be delays in the production of a new growth curve then effort needs to be put into resolving the potential age bias of using spines to produce the growth curve. | High | Short term | High | If we have good characterization of aging-bias, we will address this directly, otherwise we intend to use an ensemble approach. | Yes |
| There needs to be continuing effort to resolve growth curves across space, sex, time, and genetic origin. | High | Long term | High | This work is ongoing. | No |
| **Catch** | | | | | |
| Recommendation | Priority | Time Frame | Effort | WG Response | Next Assessment? |
| Efforts should be made to continue to improve the full historical time series of catch and associated uncertainty, even if the full catch time series is not used in the model. This would include an evaluation of the reported catch by other nations and whether or not reported catches make sense given fleet effort and area specific catch rates of reference nations. As an example, given the fishing effort of one nation in specific locations, if the CPUE of another nation was used would you estimate the same scale of catch. | High | short term | low | WG members plan to review the catch data for longline and high seas driftnet fisheries and, if necessary, revise the catch amounts before the 2027 stock assessment. | Yes |
| Efforts to improve the characterization (spatial location) and associated uncertainty in the driftnet data would increase confidence in these data and should be pursued. | Medium | Short Term | high | WG members plan to review the catch data for longline and high seas driftnet fisheries and, if necessary, revise the catch amounts before the 2027 stock assessment. | Maybe |

| | | | | | |
|---|---|---|---|---|---|
| Efforts should be taken to more fully understand discarding in all fleets. A potential starting point is the comparison of discarding between observed / training vessels and logbooks. | Medium | short term | medium | The WG notes that the new CMM for WCNPO MLS requires countries to provide discard estimates for their fleets and how discards are estimates. | Maybe |
| The reporting of MLS may not have been consistent across vessels and fleets. Efforts should be made to more fully understand if there are reporting biases in all fleets. A potential starting point is the comparison of MLS reporting rates between observed / training vessels and logbooks, at a reasonable spatial and temporal resolution. | medium | short term | medium | WG members plan to undertake this kind of research before the 2027 stock assessment. | |
| **Size data** | | | | | |
| Recommendation | Priority | Time Frame | Effort | WG Response | Next Assessment? |
| Length frequency should be explored in detail at the national level for full historical time series. Methodologically this would include the application of a standardization method to understand the factors that cause spatial and temporal variability in the size data. This would allow a more complete understanding of the spatial and temporal nature of the data, how it relates to population size structure and fleet structure, and the standardization of size data should an index fishery be used. | High | Short term | medium | Japan plans to raise the length-frequency data using catch data before the 2027 stock assessment, other WG members intend to explore similar approaches for the treatment of size data. | Yes |
| The US shallow set longline length data should be removed from the length composition data to resolve the discontinuity in the selectivity as a result of the fishery changes that occurred in the early 2000s. | High | Short term | low | The WG intends to follow this recommendation. | Yes |
| Weight data should be used for the Taiwanese fleet instead of the length data since the length data may not always be measured, but can be estimated. The conversion from weight to length should be done outside the model using the fleet-specific length weight relationship. The panel acknowledged that the length-weight relationship in the model is the Taiwanese fleet's relationship but still recommended doing this conversion external to the assessment model. Consider inputting these data as generalized compositions to allow for bin sizes that can span potentially rounded weights. | High | Short term | medium | The WGs intend to explore including the TWN weight composition data. | Yes |
| Bootstrapping or a model-based approach should be used to establish initial sample sizes external to the model to account for the properties of the underlying data (Thorson et al. 2017, Stewart et al. 2014) | medium | Short term | medium | If upon further examination this method is proven to be effective, its future use could be considered by the WG. | Maybe |
| **CPUE** | | | | | |

| Recommendation | Priority | Time Frame | Effort | WG Response | Next Assessment? |
|---|---|---|---|---|---|
| Make every effort to not split CPUE series (see discussion in Hoyle et al. 2024). | High | Short term | high | The WG is making efforts to produce a unified CPUE index which would address this concern | Yes |
| If the time period of the assessment includes the period with high seas driftnet fishing as early longline fishing, effort should be made to standardize Japanese longline CPUE without splitting its time series since this could be a data source of the population dynamics bridging before and after 1994. | High | Short term | high | The WG is making efforts to produce a unified CPUE index which would address this concern | Yes |
| Investigate the potential for monofilament branch-lines and other technological advances that may have affected Japanese CPUE during the 1980s. | medium | Short term | medium | Japan plans to investigate if such information is available in the fishery data from the 1980s. | |
| Use the annual variance estimates from the CPUE standardization as a starting point for model inputs. These can be rescaled but should reflect the differences in precision among years within each series. Where necessary, either iterate or estimate additional variance such that the model fit (RMSE - root mean squared error) is consistent with the average input standard error by fleet. | High | Short term | low | The WG intends to follow this recommendation. | Yes |
| For the Taiwanese CPUE series, omit data before 2006 until there is confidence that these data can be used to provide reliable information. Explore the data for the period prior to 2006 to identify factors that may have caused the jump in CPUE 2003-2005. | high | Short term | low | The WG intends to follow this recommendation. | Yes |
| When there are conflicting CPUE series covering the same period, and these conflicts cannot be resolved, they should be included in alternative model scenarios rather than combining them in the same model (Francis 2011, Schnute and Hilborn 1993, Hoyle et al 2024). This assumes that consideration has been given to the nature of the conflict and that the conflict is not due to a model misspecification (e.g., an error in the fleet designation) | High | Short term | medium | The WG recognizes that an ensemble approach may be most appropriate for the next WCNPO MLS assessment. | Yes |
| Provide full diagnostics for all CPUE series that may be included in the assessment, including residual plots, effect plots (i.e., the effect of the covariate on the expected CPUE), and influence (i.e., the impact of the covariate on the index over time) plots. | High | Short term | medium | The WG is developing a template for working papers with minimum requirements for plots, tables, and diagnostics for data inputs. | Yes |

| | | | | | |
|---|---|---|---|---|---|
| Develop joint CPUE series across nations and multiple fleets, to address the following issues: 1. Provide indices that cover the majority of the stock across the whole time series. Such an approach would help to limit the effect of contracting spatial coverage in some of the fleets. It is unclear what impact declining spatial coverage has on the estimation of annual random fields even when only a portion of the random fields are used in standardization. 2. Provide a single series using consistent methods for data cleaning and model fitting, rather than multiple series that may conflict. 3. Develop a shared understanding among the collaborators | High | long term | high | The WG is making efforts to produce a unified CPUE index which would address this concern | Maybe |
| **Data inputs** | | | | | |
| Recommendation | Priority | Time Frame | Effort | WG Response | Next Assessment? |
| As previously mentioned, continue to improve the full historical time series of catch, regardless of whether the full catch is used in the model, more fully understand and characterize discarding in all fleets, more fully understand and account for reporting discrepancies in all fleets. | High | Short term | medium | WG members are currently undertaking these efforts | Yes |
| The range contraction of some of the fleets highlights the importance of information sharing across fleets and nations. Consideration is needed to ensure that biological information used to make inferences at the population level has the appropriate spatial coverage. | High | Long term | high | The IBBS program was undertaken to address these types of concerns and is ongoing. | No |
| Age sampling for a fleet could provide better estimates of population scale. | Low | Long term | high | Th WG believes there are higher priorities that should be address first. | No |
| **Other Inputs** | | | | | |
| Recommendation | Priority | Time Frame | Effort | WG Response | Next Assessment? |
| There have been developments in how to estimate life-history parameters. New life history data has been and is being collected. Revisiting the life history values used in the model in light of this new information and approaches should be considered, with the goal of internal consistency across the development of the full suite of parameters used in the model. | High | Short term | medium | The WG plans to revisit the estimation of life history parameters prior to the next assessment, including steepness and natural mortality. | Yes |

| | | | | | |
|---|---|---|---|---|---|
| There is evidence to suggest a west to east difference in maturity. Note also that samples from spawning areas may not be representative of the population-level maturity ogive. Consideration should be given to addressing these differences by establishing a CPUE-weighted maturity ogive (Farley et al. 2014). | Medium | Short term | high | This question may be addressed during development of the maturity ogive as part of the IBBS program. | No |
| The IBBS project collecting information on growth, maturity, and genetics is a significant step to helping understand the spatial distribution of the underlying life history characteristics and needs continued support to ensure success. | High | Short term | high | The WG plans to continue this work. | No |
| The steepness prior should be updated to take into account changes in the input parameters. It is important to allow for uncertainty in the values of all input parameters and uncertainty about the structure of the stock recruitment relationship, which may result in a flatter prior. | Medium | Short term | medium | The WG plans to explore the use of a prior distribution on steepness in the next assessment, | Yes |
| New information on growth and maturity will require natural mortality to be updated. Given the potential for spatially varying life history values, spatial consideration will need to be given to how to weight such information appropriately in the estimation of these values. | Medium | short term | high | This may be undertaken as part of the estimation of life history parameters prior to the next assessment. | Yes |

| | | | | | |
|---|---|---|---|---|---|
| **TOR 3** | Model configuration, assumptions and settings | | | | |
| **Selectivity** | | | | | |
| Recommendation | Priority | Time Frame | Effort | WG Response | Next Assessment? |
| The population level size bins should be reduced from 5 cm (to 1 or 2 cm) as this has the potential to provide a smoother likelihood surface where selectivity is highly dome-shaped. This does not mean that the bins for the fleet specific length frequency data need to be reduced. | High | short term | low | This can be completed for the next assessment. | Yes |
| Consider setting the parameter defining the width of the top of domed selectivity curves to span at least 2 population size bins. | High | short term | low | This can be completed for the next assessment. | Yes |
| Given the structure of the area-implicit assessment model, a fleet assumed as an asymptotic selectivity should be chosen based on the observed data (i.e. empirical selectivity method). The panel recommends fleet 18, the TWN DWLL, as this fleet has the largest observed fish, though this may be revisited after the data source has been changed from length frequency to weight frequency observations. | High | short term | low | This can be completed for the next assessment. | Yes |

| | | | | | |
|---|---|---|---|---|---|
| Aim to remove time blocks from the selectivity parameterization of the Japanese and US fleets. | Low | short term | low | This can be considered for the next assessment. | Yes |
| Explore more flexible selectivity for the US longline fleet in order to better fit the bimodal size-composition information. There is also the potential to use an age-based selectivity of this fleet given the apparent length-based modal progression seen in the data. | Low | short term | medium | The US fleet is a small component of the fishery, and other changes may resolve the issue. | Yes |
| Review parameter and asymptotic variance estimates from all selectivity curves and reparametrize where there is no apparent information (e.g. Size_DblN_descend_se_F16_US_LL(16) in the 2023 base case model). | Low | short term | Low | This can be considered for the next assessment. | Yes |
| Consider reducing the range of the lower and higher bounds for selectivity parameters (especially those that are logistic transformed) and adjusting the phasing to achieve more reliable convergence. Ideally this would reduce/remove the need for a .par file and assist profile and jitter analysis convergence. | Low | short term | low | This can be considered for the next assessment. | Yes |
| **Initial equilibrium conditions** | | | | | |
| Recommendation | Priority | Time Frame | Effort | WG Response | Next Assessment? |
| As in the 2023 assessment, the initial conditions should be estimated. This includes recruitment deviations for the initial age structure and initial F | Low | short term | low | The WG intends to continue this. | Yes |
| **Uncertainty** | | | | | |
| Recommendation | Priority | Time Frame | Effort | WG Response | Next Assessment? |
| The panel recommends the adoption of an ensemble model approach. The ensemble should consider: growth, assessment start year, steepness, catch uncertainty, and conflicting time series. Growth should be ensembled based on observed spatial differences in growth if they are identified to exist. Model start date should be ensembled if there is no possibility of linking the early and late parts of the CPUE time series. (A 1977 + and a 1994+ model). Steepness could be ensembled by selecting three steepness values that represent a plausible range of steepness for the species. Uncertainty in catch should be incorporated by including ensembles with high/low, and best estimates. Should conflicting (e.g., | Medium | short term | medium | The WG agrees that an ensemble approach may be most appropriate to address the many sources of uncertainty for WCNPO MLS. | Yes |

| | | | | | |
|---|---|---|---|---|---|
| JPN vs. TWN) CPUE time series not be resolved the assessment should be ensembled over these conflicting time series. | | | | | |
| The full time series (a 1952+ model) of catch should be included at least as a sensitivity run. | Medium | short term | low | The WG will explore this as a potential sensitivity run. | Yes |
| Some simulation work would be required to understand the details of how, if it is present, spatial differences in life history characteristics should be accounted for within an assessment model. Best practices have not been determined. | Medium | long term | high | Some work addressing this recommendation has already be completed within the framework of IBBS program. | No |
| **Start year** | | | | | |
| Recommendation | Priority | Time Frame | Effort | WG Response | Next Assessment? |
| The panel would prefer the model to begin in 1977, combined with improved long-term catch time series, and with a CPUE series the same length as the assessment period. If discrepancies are not resolved between early and late assessment periods then a model such as the one starting in 1994 was recommended for inclusion in an ensemble approach. | Medium | short term | low | The WG will consider this recommendation for the next assessment. | Yes |
| **Alternative models** | | | | | |
| Recommendation | Priority | Time Frame | Effort | WG Response | Next Assessment? |
| The review panel supports the use of an age-structured production model to provide a good diagnostic tool for the current assessment framework. | low | short term | low | The WG intends to continue using the ASPM as part of the suite of diagnostics for assessments. | Yes |
| There is a notable reality that the reliance of the assessment on length composition data and the nature of the growth pattern results in challenges in determining the scale of the population. Consideration should be given to the use of close-kin approaches to estimate population scale. | Low | long term | high | The WG hopes to explore the possibility of CKMR in the future. | No |
| | | | | | |
| **TOR 4** | Model diagnostics | | | | |

| Recommendation | Priority | Time Frame | Effort | WG Response | Next Assessment? |
|---|---|---|---|---|---|
| Check convergence of all models, to avoid incorrect inferences from models that have not converged. The results of models that have not converged should not be reported, or included as sensitivity runs. | High | short term | low | The WG intends to address this recommendation in the next assessment. | Yes |
| Given that stock rebuilding has been evaluated based on future projection, longer term (i.e., an assessment cycle or generation time) hind-casting could be conducted to determine the prediction skill of the model. | Medium | short term | low | The WG can explore longer-term hindcasting as part of the next assessment. | Yes |
| Continue to use a broad suite of metrics to characterize model suitability. | Low | short term | low | The WG will continue this practice. | Yes |
| Consider the absolute scale of the residuals from diagnostic plots and reweight data sets accordingly (e.g., some of the size data residuals were notably larger than others). | Medium | short term | low | The WG will address this in the next assessment. | Yes |
| As noted earlier, data sets that are in conflict such as CPUE time series should not be included in the same model but accounted for in an ensemble approach. | Medium | short term | low | The WG intends to explore the use of an ensemble approach in the next assessment. | Yes |
| The flat CPUE through the high catch period is scaled independently of the later period where length frequency data is fit. This appears to have forced the model into a domain where it needs to be highly responsive to recruitment deviations as well as fishery removals to fit the data. The adoption of the review panel's recommendations related to selectivity and continuity of time series should change this pattern. The response of the model to these changes as demonstrated by the additional runs requested suggest these are productive areas of exploration. | Medium | short term | low | The WG believes addressing many of the recommendations provided will solve some of the concerns with the patterns in recruitment and fishing mortality. | Yes |
| | | | | | |

| | |
|---|---|
| **TOR 5** | Comment on the proposed reference points and management parameters (e.g., MSY, FMSY, SSBMSY, 20%SSBF = 0); if possible and feasible, estimate values for alternative reference points or alternative methods of determining the appropriate reference years for the dynamic B0 calculations. |

| Recommendation | Priority | Time Frame | Effort | WG Response | Next Assessment? |
|---|---|---|---|---|---|
| Recommend calculating and reporting both the 20-year moving average as well as the annual dynamic B0 so that the trends can be compared. | Low | short term | low | The WG can provide additional information about the dynamic B0 calculated during the assessment. | Yes |
| Recommend averaging relative Fs over the last 3-5 years but not including the terminal year for the calculation of FSSB20% rather than using the terminal year. | Low | short term | low | The WG can address this in the next assessment | Yes |
| The panel suggests continued reporting of additional status metrics such as %SPR or 1-SPR. | Low | short term | low | The WG already provides this information | Yes |
| The panel recommends reviewing the standards outlined by the WCPFC and considering the adoption of the same approach. | High | short term | Medium | The WG intends to provide stock status and conservation information using the template adopted by WCPFC | Yes |

| **TOR 6** | Suggest research priorities to improve our understanding of essential population and fishery dynamics, necessary to formulate best management practice, with the identification of priorities to improve future assessments. | | | | |
|---|---|---|---|---|---|
| Recommendation | Priority | Time Frame | Effort | WG Response | Next Assessment? |
| The development of an age validated growth curve is essential to improve the reliability of the assessment model. | High | short term | high | Work is ongoing to address this recommendation. | Maybe |

| | | | | | |
|---|---|---|---|---|---|
| Consider exploring requirements for CKMR. | Low | short term | high | The WG hopes to explore this possibility in the future. | No |
| Continue to develop a more comprehensive understanding of the genetic structure of the entire Pacific as well as the genetic composition of the removals. | medium | long term | medium | The WG agrees better understanding of the genetic composition of removal relative to the stock structure is an important area of future research. | No |
| Implement CKMR approaches should they prove to be tractable for the population. | Low | long term | high | The WG hopes to explore this possibility in the future. | No |
| Simulation work to understand the best assessment approaches to deal with a complex fishery and life history spatial structure. | Low | long term | high | This is an area of future exploration in collaboration with other Pacific stock assessors | No |

| **TOR 7** | Comment on whether the stock assessment methods, results, and assessment decision process are clearly and accurately presented in the detailed report of the stock assessment. | | | | |
|---|---|---|---|---|---|
| Recommendation | Priority | Time Frame | Effort | WG Response | Next Assessment? |
| Some of the supporting documentation in the working group papers would benefit from greater detail in the decisions made and well as the diagnostics used. It would be helpful to have this information within these documents. This is important for the development of both CPUE time series and size data. Encourage analysts to follow standard guidelines for documenting these analyses, and development of standards for data areas without them. We also encourage coordination across groups so that they follow similar approaches. | Medium | short term | medium | Efforts are being made to develop templates for working papers which would identify which analyses, diagnostics, figures, and tables should be included at a minimum | Yes |

## APPENDIX 5 – REPORT OF THE ISC BILLFISH WORKING GROUP VIRTUAL MEETING MAY 12/13, 2025.

### 1. INTRODUCTION

The WG convened a virtual meeting May 12, 2025 14:00-16:00 HST to discuss outstanding topics from the January 2025 meeting. These included a response to the NC20 request about the feasibility of a NPO SWO MSE and the results of the additional projections for WCNPO MLS requested by the WCPFC. WG participants included M. Sculley (USA, Chair), Y.J. Chang (TWN, Vice chair), M. Kai (JPN), M. Jusup (JPN), J. Brodziak (USA), M. Kinney (USA), and C. Minte-Vera (IATTC).

### 2. RESPONSE TO NC20 REQUEST.

NC20 requested the ISC to explore the feasibility of implementing an MSE for NPO SWO, including its potential timeline and needs for human and financial resources, and present its views at NC21. In light on this request, the WG discussed their capacity to produce an MSE for NPO SWO, and came to the following conclusions:

At this time, none of the ISC WG member countries have the capacity to dedicate staff to the development of an MSE for NPO SWO. The WG agreed that the best option for producing an MSE for NPO SWO would be to hire a contractor specifically to undertake the work under the guidance of the WG. It is estimated that an initial MSE that is ready to be used to guide harvest control rule evaluation would be complete within 5 years under this scenario. The first two years would be focused on stakeholder engagement and development of the management strategies to be included, and 3 years for the model development and testing. Throughout these five years we would expect the contractor to meet with the WG regularly to provide updates and get feedback, as well as present progress annually at each NC meeting. Additional time could be required after the initial model development is completed should the stakeholders or NC request changes or additional components to be evaluated. The WG also agreed that it could be possible to hire only a model development expert for approximately 3 years if the WCPFC or NC managed the stakeholder engagement process before model development begins.

### 3. WCNPO MLS REBUILDING ANALYSIS ADDITIONAL PROJECTION RUNS

***Stock Projections to Rebuild WCNPO striped marlin under WCPFC CMM 24-06. Jon Brodziak (ISC/25/BILLWG-02/01).***

This working paper analyzes three alternative rebuilding scenarios under CMM 2024-06 which provides for carryover allowances if WCNPO striped marlin catch limits are not exceeded in a year. In particular, if the annual catch limit of 2,400 metric tons of striped marlin is not fully utilized in a given year, then CCMs may carryover up to 165 metric tons of their individual quota to the following year. CMM 24-06 states that "*In 2023, there was an 826 mt underage of the TAC of 2400 mt that will be available to CCMs fishing in 2025. Any underage from 2024 will be available to CCMs in 2026, and any underage from 2025 will be available to CCMs in 2027.*" Potential catch underages in 2024 and 2025 would lead to carryover catches in 2026 and 2027, respectively. However, no CCM may exceed a 165 metric ton increase in any carryover year, and any overage of an individual limit would be deducted from that country's catch limit in the subsequent year. This working paper describes rebuilding projections to analyze three scenarios for potential catch underages and subsequent carryover of striped marlin catches during 2025-

2027. Overall, the goal is to show how projected striped marlin rebuilding outcomes would change under different carryover catch scenarios.

**Discussion**

The WG noted one important difference between the projections run in 2024 and those run in 2025, the treatment of the catch assumed for 2021-2024. In the 2024 projections, catch was assumed to be consistent with the average fishing mortality for 2018-2020, whereas in 2025, catch in 2021-2024 was reported or estimated catch from the WCPFC yearbook, with the exception of the US and Japan, which provided fleet specific catch. When catch in 2024 was not yet available, catch was assumed to be equal to catch in 2023. This resulted in a decrease in catch in each year by ~50% compared to the 2024 projections (Table A1, Figure A1)

The WG noted that due to the lower-than-expected catch in 2021-2024 and the above recent average recruitment in 2018-2020, the projections estimate that the rebuilding target was reached in 2023 for all three scenarios. For all three scenarios, catch would need to be reduced below the 2400 mt limit starting in 2028 to maintain female spawning stock biomass above the rebuilding target with a 60% probability. For scenario one, where there is no carryover catch above 2400mt, catch would need to be reduced to 2300 mt in 2028-2031, and 2200 mt in 2032-2034 to reach the target. For scenario 2 where all countries take the maximum carryover catch (165mt) in 2025 only, catch would need to be reduced to 2200 mt for 2028-2034 to reach the target. For scenario three where all countries take the maximum carryover catch in 2025 and 2026, catch would need to be reduced to 2150mt in 2028-2034 to reach the target.

The WG noted that these projections could be considered pessimistic if the strong recruitment seen in 2018-2020 persists into subsequent cohorts and increases recruitment above the low levels observed in the last 20 years and that the stock may recover faster than predicted from these projections.

**Table A1.** Comparison of observed catch biomasses (mt) from WCPFC Tuna Fishery Yearbook 2024, Japan, and the U.S. and projected catches from assuming recent average fishing mortality in the 2024 rebuilding projections.

| Year | Observed Catch | F-Based Catch | % Change from 2024 |
|---|---|---|---|
| 2021 | 1540 | 2970 | -48% |
| 2022 | 1474 | 3420 | -57% |
| 2023 | 1685 | 3380 | -50% |
| 2024 | 2157 | 3080 | -30% |
| Total | 6856 | 12850 | -47% |
| Source: | Scenario 1 from CMM 2024-06 projections | Scenario 6 from 2024 rebuilding projections | |

**Table A2.** Estimated catch (mt), female spawning stock biomass (mt), probability of reaching the rebuilding target, and instantaneous Fishing mortality ($^{-yr}$) for each of the three projection scenarios: Scenario 1 with no carryover catch in 2025-2027, Scenario 2 with carryover catch in 2025, and Scenario 3 with carryover catch in 2025 and 2026. Values are median estimates for each year.

| | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scenario 1 - No carryover catch | | | | | | | | | | | | | | |
| Catch | 1540 | 1474 | 1685 | 2157 | 2400 | 2400 | 2400 | 2300 | 2300 | 2300 | 2300 | 2200 | 2200 | 2200 |
| SSB | 2638 | 3973 | 5521 | 5716 | 5414 | 5015 | 4707 | 4515 | 4390 | 4275 | 4197 | 4167 | 4165 | 4191 |
| Probability of reaching rebuilding target | 0.06 | 0.67 | 0.94 | 0.92 | 0.85 | 0.77 | 0.71 | 0.67 | 0.64 | 0.62 | 0.61 | 0.6 | 0.6 | 0.6 |
| Fishing Mortality | 0.33 | 0.23 | 0.23 | 0.25 | 0.28 | 0.3 | 0.32 | 0.32 | 0.32 | 0.33 | 0.34 | 0.32 | 0.32 | 0.32 |
| Scenario 2 - Carryover catch in 2025 | | | | | | | | | | | | | | |
| Catch | 1540 | 1474 | 1685 | 2157 | 3225 | 2400 | 2400 | 2200 | 2200 | 2200 | 2200 | 2200 | 2200 | 2200 |
| SSB | 2640 | 3972 | 5514 | 5718 | 5081 | 4460 | 4234 | 4184 | 4213 | 4223 | 2431 | 4245 | 4248 | 4249 |
| Probability of reaching rebuilding target | 0.06 | 0.67 | 0.94 | 0.92 | 0.79 | 0.67 | 0.62 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 | 0.62 | 0.61 |
| Fishing Mortality | 0.33 | 0.23 | 0.23 | 0.4 | 0.33 | 0.35 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 |
| Scenario 3 - Carryover catch in 2025 & 2026 | | | | | | | | | | | | | | |
| Catch | 1540 | 1474 | 1685 | 2157 | 3225 | 3225 | 2400 | 2150 | 2150 | 2150 | 2150 | 2150 | 2150 | 2150 |
| SSB | 2640 | 3975 | 5526 | 5722 | 5074 | 4121 | 3690 | 3743 | 3894 | 4021 | 4108 | 4195 | 4258 | 4306 |
| Probability of reaching rebuilding target | 0.06 | 0.67 | 0.94 | 0.91 | 0.79 | 0.6 | 0.51 | 0.52 | 0.55 | 0.57 | 0.59 | 0.61 | 0.62 | 0.63 |
| Fishing Mortality | 0.33 | 0.23 | 0.23 | 0.25 | 0.4 | 0.48 | 0.39 | 0.35 | 0.34 | 0.33 | 0.32 | 0.31 | 0.31 | 0.31 |

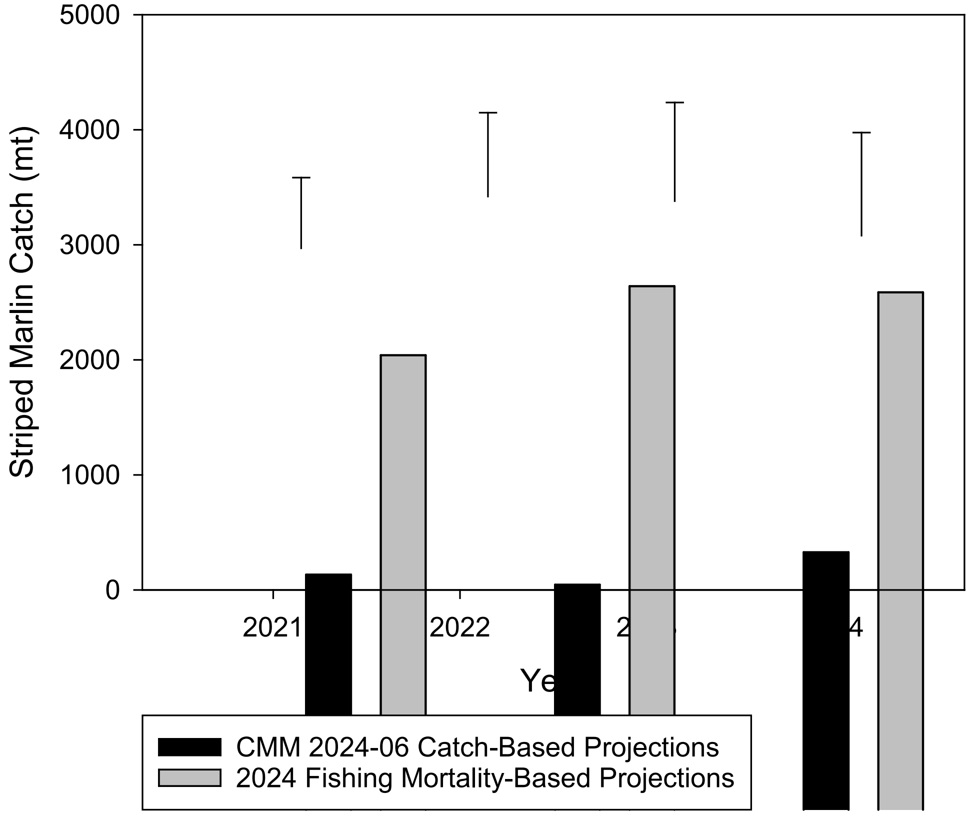


**Figure A1.** Comparison of observed WCNPO striped marlin catch biomasses in 2021-2024 used in the CMM 2024-06 projections and predicted catch biomasses used in the 2024 rebuilding projections with 80% confidence whiskers.

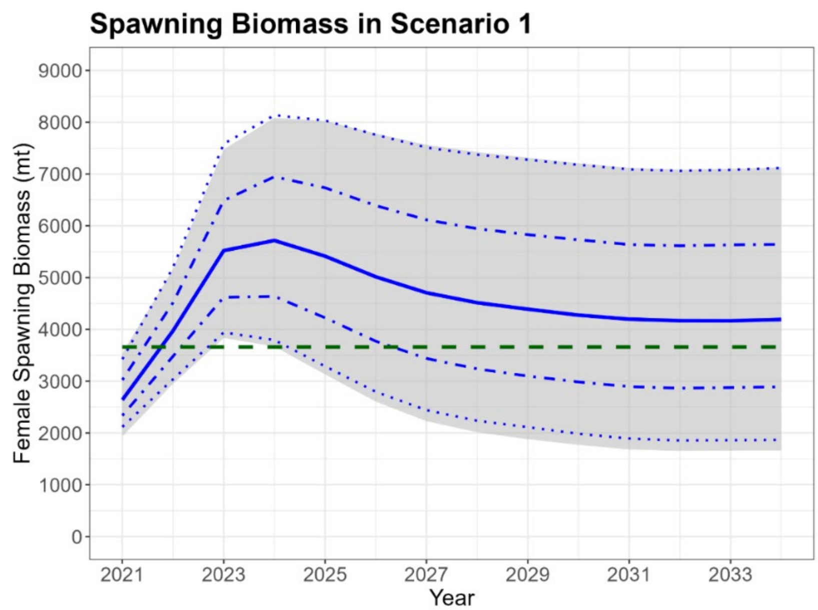


**Figure A2.** Projected distributions of WCNPO striped marlin female spawning biomass <u>under Scenario 1 with no carryover catch</u>. Median (solid blue lines), interquartile range (dot-dashed lines), 10th and 90th percentiles (dotted blue lines), target biomass (green dashed line), and approximate 80% confidence intervals (gray shaded region).

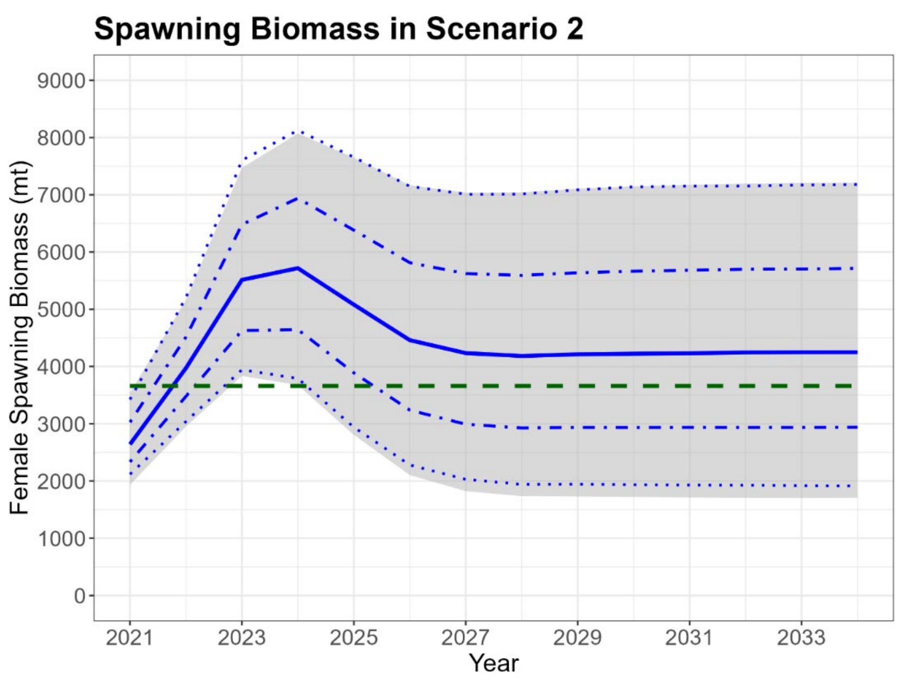


**Figure A3.** Projected distributions of WCNPO striped marlin female spawning biomass <u>under Scenario 2 with 825 mt of carryover catch in 2025</u>. Median (solid blue lines), interquartile range (dot-dashed lines), 10th and 90th percentiles (dotted blue lines), target biomass (green dashed line), and approximate 80% confidence intervals (gray shaded region).

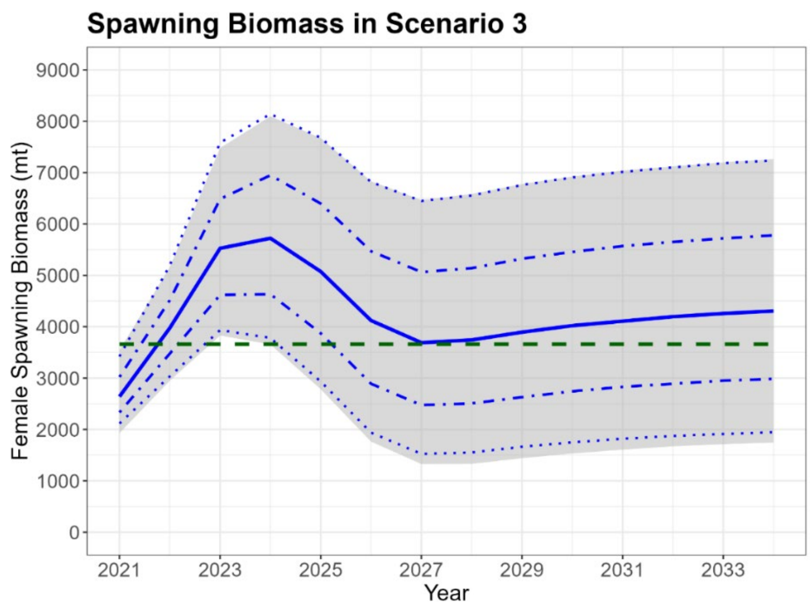


**Figure A5.** Projected distributions of WCNPO striped marlin female spawning biomass under Scenario 3 with 825 mt of annual carryover catch in 2025-2026. Median (solid blue lines), interquartile range (dot-dashed lines), 10th and 90th percentiles (dotted blue lines), target biomass (green dashed line), and approximate 80% confidence intervals (gray shaded region).