NORTHERN COMMITTEE
TWENTY-SECOND REGULAR SESSION
11-19 August 2026
Apia, Samoa (Hybrid)

REPORT OF THE BILLFISH WORKING GROUP MODELING WORKSHOP

WCPFC-NC22-2026-IP04
13 July 2026

Submitted by ISC[1]

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

ISC/26/ANNEX/06b

ANNEX 06b

26th Meeting of the
International Scientific Committee for Tuna
and Tuna-Like Species in the North Pacific Ocean
Taipei City, Chinese Taipei
22-29 June 2026

REPORT OF THE BILLFISH WORKING GROUP MODELING WORKSHOP [1]

28 April – 4 May 2026
Honolulu, HI, USA

June 2026

[1] Prepared for the 26th Meeting of the International Scientific committee on Tuna and Tuna-like Species in the North Pacific Ocean (ISC) held June 22-29, 2026, in Taipei City, Chinese Taipei. Document should not be cited without permission of the authors.

Left Blank for Printing

REPORT OF THE BILLFISH WORKING GROUP WORKSHOP
International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean

28 April – 4 May 2026 (HST)

Honolulu, HI, USA

1. Opening and Introduction

a. Welcoming Remarks

Michelle Sculley, Billfish Working Group Chair opened the Pacific blue marlin (BUM) stock assessment meeting. Chinese Taipei, Japan, United States of America (USA), and the Inter-American Tropical Tuna Commission (IATTC) participated in the meeting. Attachment 1 lists participating scientists.

b. Introduction

The Billfish Working Group (WG) of the International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean (ISC) held a six-day meeting in Honolulu, Hawaii (HI). The meeting conducted the stock assessment for Pacific blue marlin (BUM) and agreed on stock status, future projections, and sensitivity analysis results. Based on these results, the BILLWG formulated conservation information.

c. Standard Meeting Protocols

The WG Chair introduced protocols for the meeting. A hybrid option included Cisco Webex for virtual participation, and working papers on the agenda were presented and discussed.

2. Adoption of Agenda and Assignment of Rapporteurs

Before the meeting, The WG adopted the draft agenda of the meeting (Attachment 2). The WG Chair distributed numbered working papers (Attachment 3). The WG Chair also assigned the rapporteurs for three agenda items as follows:

Agenda item	Day	Rapporteur
4. WCNPO SWO MSE	28th April	Michael Kinney, Marko Jusup, Janelle Morano, Jhen Hsu
5. Other Billfish Research	28th April	Yi-Jay Chang, Erin Bohaboy
6. Base case model	28th April	Mikihiko Kai, Michael Kinney
6. Base case model	29th April	Jon Brodziak, Jhen Hsu
6. Base case model	30th April	Michelle Sculley, Marko Jusup
6. Base case model	1st May	Yi-Jay Chang, Janelle Morano
6. Sensitivity analysis, Future projections	2nd May	Mikihiko Kai, Janelle Morano

3. Numbering Working Papers and Distribution Potential

The WG agreed to post the finalized papers on the ISC website and make them publicly available.

4. Western and Central North Pacific Swordfish Management Strategy Evaluation Progress (WCNPO SWO MSE)

a. Proposed workplan to NC22

The WG discussed the draft workplan for the WCNPO SWO MSE and the two options provided for the Northern Committee (NC) to consider. The WG also discussed the value in front loading the information provided by the NC to progress the MSE work. The WG noted that option 1, which requested NC provide draft operational management objectives, harvest control rules, performance indicators, and reference in 2026 would allow for preliminary results to be provided at NC23 in 2027. Option 2 would require NC23 to provide draft harvest control rules, performance indicators and reference points in 2027, and meet intersessionally between NC23 and NC24 to review the preliminary MSE results. Due to constraints in U.S. funding, the WG noted that all MSE work would need to be completed by March 2028 with the final results presented to NC24. The WG expressed a preference for Option 1 to enable earlier analytical progress **but agreed to provide both options to NC22 for their consideration.**

b. Progress on the operating model for WCNPO SWO MSE

Summary

The presentation provided an update on the progress of the MSE Framework for North Pacific Swordfish. The 2023 Base Case assessment, and the 25 sensitivity runs explored in the assessment, were imported as operating models (OMs) into the MSE framework. The key decision points for the development of OMs were highlighted, with particular emphasis on the need to define the boundary of the management area considered in the MSE, the importance of specifying the critical uncertainties to be explored in the analysis, and other assumptions regarding the management interval, management type, and fleet allocation. A set of 5 example candidate management procedures (cMPs) were introduced. These included two constant catch methods, used to explore the behavior of the fishery dynamics under various levels of fixed catch, and three versions of a model-free cMP that iteratively adjusts a total allowable catch (TAC) in response to the slope between the current index and a target level. The performance of these cMPs was demonstrated for the Base Case OM and two of the sensitivity OMs (High and Low M). The decision points related to the development of cMPs were presented to the group, particularly the questions of deciding which data would be made available to the cMPs. Further, performance metrics were discussed and the next steps for the MSE process were outlined to the group.

Last, the WG identified the key MSE development elements as defining the management area, specifying core uncertainties, selecting performance metrics, determining management parameters, and clearly defining CPUE indices used in candidate management procedures.

Discussion

The WG discussed some of the important axes of uncertainty that should be considered in the MSE operational OMs. The boundaries of the OMs and the stock being managed are important considerations and something the NC will need to provide input on. The NC report indicates it is a WCNPO SWO MSE, the 2023 stock assessment is a North Pacific assessment, and the Conservation Management Measure (CMM 2023-03) is for the WCPFC-CA north of 20°N. It was also pointed out that the large Vietnam and Indonesia catches of swordfish near the equator as well as the large swordfish "hotspot" in the EPO near the equator should be considered when exploring the uncertainty for the OMs.

Another important axis of uncertainty would be the biological parameters. Noting that the BILLWG is currently undertaking efforts to re-estimate the growth curve, maturity ogive, and consequently natural mortality and potentially steepness, the ability to account for uncertainty in the biological parameters could be a valuable component of the robustness OMs. In response to a question about the inclusion of the updated biological parameters expected to be available from the 2027 data preparatory meeting, it was noted that this uncertainty could be covered in the OMs.

The WG also discussed how the sample harvest control rules were implemented - as target indices. It was highlighted that the WG must be cautious using target indices and make sure the indices are clearly defined as it could turn the OM into a stock assessment model. How the harvest control rules are evaluated in the estimation model is a discussion that the technical team would need to have. The WG agreed to set up a follow-up meeting of the technical committee to work out some of the details about the axes of uncertainty and the estimation model.

5. Other BILLWG Research

Environmental variability shifts the trophic dynamics and ecological niche partitioning of billfishes using stable isotope analysis Ching-Tsun Chang, Wei-Chuan Chiang, Yi-Jay Chang, Nan-Jay Su, Chi-Lu Sun (ISC/26/BILLWG-02/01)

Summary

Climate-driven environmental variability is rapidly restructuring marine ecosystems, yet how these apex predators adjust their trophic dynamics and habitat uses remain poorly understood. Here, we used long-term stable isotope data (δ15N and δ13C; 2008 – 2024) to investigate trophic ecology and niche structure of five billfish species in the western Pacific under El Niño–Southern Oscillation (ENSO) variability and sea surface temperature anomalies (SSTA). Across all species, δ15N increased with body size, indicating an ontogenetic increase in trophic position (TP). However, species exhibited distinct responses to environmental variability. Black marlin and swordfish showed habitat driven responses; striped marlin demonstrated trophic flexibility; and sailfish and blue marlin exhibited coupled shifts in both habitat and feeding. Isotopic niche analyses further revealed that niche width and interspecific overlap varied across ENSO phases, indicating dynamic resource partitioning and potential competition. These findings suggest that environmental variability influences the habitat use, trophic dynamics, and interspecific interactions of billfishes, with implications for future stock assessments.

Discussion

The WG discussed if this work could evaluate seasonal changes in the distribution of billfish, noting these fish usually take long distance seasonal migrations across the ocean. The stable isotopes are extracted from muscle samples which have approximately one year turn-over, so seasonal changes in its distribution would not be able to be detected. The signals from these tissues are long term. Seasonal changes may be evaluated by other tissues such as blood or liver which have a faster turnover rate. The WG noted that an important aspect of this study is the scale over which conclusions could be drawn, both spatially and temporally. It was also noted that this study could not account for the difference in δ15N and δ13C in the vertical water column, which would be an important aspect for the billfish who make regular deep dives, especially swordfish. The WG also asked if there was a δ15N isoscape from the coastal waters of the Western Pacific, and if spikes in δ15N from river or agricultural runoff could be detected. It was answered that an isoscape does exist for the area from Japan to New Caledonia for phytoplankton, but that the scale of the billfish samples was too large to be able to detect it.

International Billfish Biological Sampling Updates

Japan provided an informal update on the progress of the aging study of North Pacific striped marlin in preparation for the 2027 stock assessment. It was reported that the aging of fish less than one year old based on otoliths had been completed, and that the aging of fish aged one year and older based on fin spines was underway. It was expected that a preliminary growth curve would to be available to consider for use at the November data preparatory meeting. Japan also indicated that efforts were underway to have annual ages from the MLS otoliths, but it was uncertain whether this information would be available for the assessment next year.

The USA indicated that work was underway to develop a preliminary epigenetic aging and close-kin mark recapture (CKMR) project for North Pacific SWO. The USA circulated Annex 1 of the MOU agreed to at the January 2026 meeting, which provides details of the study, prior to the end of the current meeting. The objectives of this study are to develop an epigenetic clock for North Pacific SWO, and to begin exploring kinship within this population to better understand what would be needed to establish a full Close-Kin Mark Recapture project capable of producing an independent estimate of abundance. The USA noted that CSIRO in Australia is currently undertaking CKMR work for southwest Pacific swordfish as well. IATTC also reported that there were preliminary discussions to investigate the possibility of using CKMR for S EPO SWO during June 2025 S SWO regional workshop. The WG agreed that it would be highly beneficial to coordinate these projects so that a clearer picture of the stock structure and population size of SWO in the Pacific Ocean could be obtained from these three studies.

6. Pacific Blue marlin stock assessment modeling

a. Base case model

Dr. Erin Bohaboy, who is the lead modeler of the WG, presented the progress toward a base-case model of Pacific BUM (ISC/21/BILLWG-02/02). The WG reviewed the model diagnostics and discussed how to improve the models. The lead modeler modified the candidate model based on the suggestions from the WG members and performed model diagnosis for the candidate models each time. The WG repeated this process multiple times until the WG agreed on a base case model. Table 1 shows the process up to the base-case model determination.

Summary

This working paper describes two preliminary base-case models in Stock Synthesis 3.30 for Pacific BUM (*Makaira nigricans*) for consideration as the 2026 base-case model. Both models cover the period 1971–2024 and incorporate data from three International Scientific Committee for the Conservation of Tuna and Tuna-like Species (ISC) members and other members in aggregate from the Western Central Pacific Fisheries Council (WCPFC) and Inter-American Tropical Tuna Commission (IATTC). The two preliminary base-case models have identical data inputs, with the exception of the catch per unit effort (CPUE) indices included: the “Japan” model excludes CPUE indices from Taiwan, whereas the “Taiwan” model excludes CPUE indices from Japan. Initial diagnostics reveal problematic performance of both models. Preliminary results from both models suggested that current (2024) spawning stock biomass was below SSB_{MSY}, whereas only the Japan model suggested that the BUM stock was being recently (2022–2024 average) fished above F_{MSY}.

Developing the base case model

The WG discussed the use of three settlement periods for recruitment that were proposed at the data prep meeting. However, the size classes most affected using three settlement events are poorly represented in the data, suggesting that the number of settlement events has little practical impact on model results. The WG indicated that using a single settlement event would simplify the model and the WG recommended a single settlement event as the preferred approach given the limited effect of three settlement events. **The WG therefore agreed to set up the spawning event in July and the settlement event in August to avoid over-parameterization.** Because spawning occurs year-round but is concentrated from May to September, July was used as the representative spawning month, corresponding to the midpoint of the main spawning season. This assumption is intended to approximate the timing of peak reproductive output for calculating SSB, rather than implying that spawning occurs only in July. The assignment of the settlement event in August corresponds to the age of the fish in the first population bin (30cm EFL) in the model. The WG also agreed that the treatment of settlement events should be explored further through sensitivity runs in future analyses. The WG also noted that for future assessments, year-round spawning could be modeled using a quarters-as-years approach used for tropical tuna assessments.

It was noted that, for the purse-seine fishery length-composition data, there was a change in recording practices beginning around 2006. It was therefore suggested that data collected prior to this change should be excluded, or at least not fit in the model.

The WG noted that a significance level of 0.05 was used for the Runs tests; however, given that multiple tests were conducted, a Bonferroni correction should be applied. The WG pointed out that, if such a correction were used, some data sets (e.g., the Japanese length-composition data) might also pass the Runs test. The WG emphasized that this issue is primarily one of statistical power. In particular, for data sets with limited sample sizes or high variability, such as length-composition data, the Runs test may have low power to detect true departures from randomness. As a result, failures of the Runs test do not necessarily indicate substantive problems with model fit, but may instead reflect limitations of the statistical test itself. The WG discussed how to interpret the Runs test for CPUE and mean length, noting that its use in this context was to provide a diagnostic for potential model misspecification. The WG noted that a simple pass/failure may not capture all of the details of how the model fits the data and **agreed to include it with the RMSE and SDNR diagnostics to understand how well the model fits the data.**

The WG reviewed several models prepared for the assessment meeting: a model using a similar CPUE configuration to the 2021 model, where there was a single combined index for Japan for the whole Pacific and one for Chinese Taipei for the whole Pacific (Combined_63 and Combined_63_1971). Two other model runs included just the Japan or Chinese Taipei CPUE indices (Taiwan_57 and Japan_56), but splitting the late CPUE for both fleets into east and west of 170°W between 20°N and 20°S, to capture the core fishery area. An additional model was run with the full dataset excluding the Japan longline (LL) Late East index (Drop_59_JLE), which was inconsistent with the other CPUE indices, and indicated a large, long-term decline in CPUE. The WG discussed that this decline may reflect a shift of the Japan longline fleet in the eastern Pacific toward the central Pacific, which is characterized by a reduction in effort and mean size of catch over time. The WG noted this CPUE index was highly influential in the biomass trajectory of the model. In addition, a final model incorporating time-varying selectivity for the Japan LL Late (F2) fleet was also run.

After reviewing the available models, the WG agreed that a bridging analysis would be useful to understand how each change from the 2021 input data impacted the 2026 model results (Figure 1). The WG noted several major changes from the 2021 model: updated growth and natural mortality parameters (2026_bio), updated catch, size, and CPUE data (2026_data), and updated CPUE configuration (2026_CPUE), which included using size data to estimate selectivity of each CPUE index, and splitting the Japan and Chinese Taipei late CPUE indices into east and west regions in the core fishery area.

The first model run replaced the split CPUE with the single CPUE index for Japan and Chinese Taipei late longline fleets and removed the size data from the CPUE fleets, mirroring each index to its corresponding catch fleet (Continuity_1). This change reduced the conflict between the indices and the complexity of the model. The next two model runs ran the 2021 new growth base-case model with the 2026_bio parameters (Day2_2021_bridge), and the 2026_data model with the 2021 new growth base-case model biological parameters (Day2_2021_bio), to evaluate if the change in the data or the change in the biological parameters drove the differences between the 2021 model and the 2026 model. Results indicated that the larger L_{inf} from the 2026 biological parameters reduced the biomass per recruit, as at the same virgin recruitment levels, spawning biomass was larger due to the individual fish growing to a larger size. This resulted in a decrease in the overall scale of the population. The WG concluded that updated biological parameters primarily scale population size, while updated fishery data inputs drive differences in the depletion time series.

A final bridging analysis used the updated catch, size and biology data but the CPUE indices from 2021 (Day2_continuity_oldCPUE) to determine if the updated CPUE was driving the change in the model results, especially the estimate of initial depletion. The WG noted that the estimation of initial fishing mortality (F) resulted in a very large initial F value, and indicated a highly depleted stock. An additional model including catch data since 1950 indicated that the freely estimated initial F was much larger than the F estimated before 1971. These early catch data, obtained from the WCPFC public domain database, were excluded from the assessment because of concerns regarding possible species misidentification. The WG noted that the updated fishery data in 2026 were influential on the estimate of initial F, and that freely estimating initial F produced unstable and unrealistic depletion patterns, supporting anchoring initial F to the equilibrium catch. **The WG agreed that since catch was available for BUM prior to 1971, the average of 1968-1972 catch should be used to anchor the initial conditions, and that a sensitivity run using alternative catch and estimating F freely should be performed.** The WG also noted that pre-1971 data lack supporting indices and were not agreed upon at the data preparatory meeting, supporting a 1971 modeling start.

The WG next discussed the change in the size composition data included for the Chinese Taipei fleets from the 2021 assessment. The WG noted that the 2021 assessment model included length data for the TWN Large-scale-Tuna-Longline (LTLL) Late fleet and mirrored the selectivity for the TWN Small-scale-Tuna-Longline (STLL) fleet. At the January Data Preparatory meeting, the WG agreed to use the weight data for the TWN LTLL and STLL fleets, noting that the length data was estimated and the weight data was measured and therefore more precise. Upon further discussion, there were concerns with the accuracy of the weight data, as the data are dressed weight and converted to whole weight by a constant factor of 1.2. The WG discussed the possibility of the weight data being biased. A model run to compare the impacts of including the length data instead of the weight data was conducted

(Continuity_1_TWNLength). The WG noted that the size of the fish caught were different between the length and weight data, with the weight data suggesting much smaller fish were caught than the length data. The WG concluded that length data produced more consistent selectivity patterns and avoided bias associated with converted weight data. **The WG agreed to use the TWN LTLL length data instead of the weight data due to their concern about the possibility of bias in the weight data.** The WG also considered the length data for the TWN STLL fleet, but noted that these data were poorly sampled. Due to the concern about the bias in the weight data, **the WG agreed to exclude all size data for the TWN STLL fleets and mirror the fleet to the LTLL fleet.**

The WG explored the impact of the log scaled standard error (SE) of the CPUE indices on the model. The WG discussed the input SE for the TWN_LTLL_Late index, as the CPUE standardization likely underestimated the true SE and suggested it should be scaled to at least 0.2. The WG ran a model increasing the SE of each CPUE index based upon the RMSE calculated from the SS3 model (Day3_1). **The WG agreed to add additional SE to four indices: 0.01 to the JPN_LL_early index, 0.176 to the TWN_LTLL_mid index, 0.058 to the US_LL index, and 0.066 to the TWN_LTLL_Late index, as recommended by the RMSE estimated in the model.** The WG also explored allowing the model to estimate additional SE to be added to each CPUE index (Day3_2e). The model results showed that additional SE was added to the TWN_LTLL_Mid and TWN_LTLL_late indices, although they did not substantially improve the fit to the rest of the data in these models. The WG continued to explore estimating additional SE in subsequent iterations.

A model run was performed using the Francis method to down weight the size data thereby reducing the influence of the size data and increasing the relative influence of the CPUE indices on the likelihood (Day3_2a). The Francis method estimates the effective weights of the size data among various fleets within the model; these were rescaled onto a log-scale, and then normalized to sum to one. This approach maintains the relative importance of each time series while down weighting the overall contribution of size data to the likelihood. The final weights for each fleet were between 0.1 and 0.2. **The WG agreed to down weight the size data in the model because the model run improved the fits to the CPUE data.** The WG suggested including sensitivity runs for the model with alternative weights for the size data.

The WG explored two additional models to reduce the influence of the variability of the recruitment deviations (Rec-dev) on model results. This work was motivated by concerns that the likelihood component associated with Rec-dev was contributing disproportionately to the likelihood profile on R_0. First, a model with sigmaR = 0.6 was run (Day3_2b). Although this increased the magnitude of the Rec-devs, it did not improve the overall model fit, and the WG therefore concluded to continue using sigmaR = 0.4. The second model modified the timing of the Rec-dev, shifting the start of the main Rec-devs to 1990 and the early Rec-devs to 1976 (Day3_2c). This change resulted in the Rec-devs in the early period of the model (before 1990) having substantially different trends compared with a model in which the main Rec-devs begin in 1975. This effect was driven primarily by the model estimating recruitment during 1971-1975 directly from the stock recruitment relationship, which produced larger recruitment estimates than those obtained when early Rec-devs were estimated for that period. After 1990, the change in the timing of Rec-devs had little effect on the model results. The WG continued to explore the timing of the main Rec-devs, but noted that estimating recruitment from the stock-recruitment curve represents a strong assumption for a time period when both length and CPUE data are available to inform the model. As such, this configuration should perhaps be a sensitivity run rather than a candidate base-case model.

The WG discussed the fit to the length composition data for the Japan LL Late fleet. The WG noted that in the 1990s-early 2000s, the Japanese LL fleet contracted from the eastern Pacific Ocean to the central and western Pacific Ocean. As a result of that shift, the mean size of the fish caught for that fleet decreased, as larger fish are generally caught in the east as compared to the west. The WG had attempted to account for that shift by splitting the Japanese and Chinese Taipei fleets into an East and West component, but challenges in fitting those data resulted in a single index for the whole ocean from each fleet instead of two indices. In order to account for the shift in the fleet's distribution, **the WG agreed to put a time block on the Japanese LL Late size data from 1994-2003 when the fleet caught larger fish (Day3_4d).** The WG also explored including a time block to account for the very small fish caught in 2021-2024, but ultimately the model did not fit the data well and a single time block was used.

A model run incorporating all of the changes agreed to at this time was run and the model diagnostics (likelihood profiles, runs test, ASPM, and retrospective analysis) were considered (Day3_3). The WG agreed this model fit the data reasonably well. This model was used for the next set of model explorations. The first was to evaluate how reducing the contribution of the Rec-devs would change the model results. Model Day3_4a started main Rec-devs in 1990 instead of 1975 and early Rec-devs in 1980. Recruitment prior to 1980 was estimated from the stock-recruitment curve. The model fit a larger spawning stock biomass prior to 1990 due to the larger recruitment estimated during that time period. After the main Rec-devs began in 1990, the model results were the same. The WG agreed this would be an interesting sensitivity run, but felt the strong assumption that recruitment prior to 1980 was estimated from the stock-recruitment curve was inconsistent with the data available for that time period. The WG also discussed how many years early Rec-devs should be estimated in the model. The WG noted that previously, approximately one life-span were used, 14 years. The WG discussed using a mean generation time of 8 years for BUM, noting the female maximum age for the 2026 assessment was increased from 20 to 27 based upon the updated biological parameters.

The WG also explored how the additional SE was different between calculated values from the RMSE table and those estimated as a parameter in the model. Model Day3_4b estimated additional SE parameters for five survey fleets (excluding JPN LL Late), although only two estimated values were greater than zero: TWN_LTLL_Mid and TWN_LTLL_Late. The SE estimated as parameters were slightly lower than those calculated from the RMSE table, and the model fits were not improved. The WG agreed this would be a good sensitivity run.

The WG noted the length composition in the 2000s for F10 from the IATTC purse seine fleet was poorly fit in the model. IATTC provided information that after 2006 observers were provided a specific form to report the length of all billfish caught. Prior to 2006, it is unclear how consistently observers measured the billfish caught, and there was concern that these data may be unreliable or unrepresentative of the catch. Model Day3_4c dropped the F10 length data prior to 2006, and improved the fits to the F10 size data and the CPUE and other size composition fleets. **The WG agreed to remove the F10 size data prior to 2006 for subsequent models.**

The WG then explored estimating initial conditions freely in the model, first by allowing the model to estimate it without prior information (Day3_4d) and then with a somewhat informative prior (Day3_4e). Both of these runs indicated that estimating F freely and with a prior allowed the model to fit a much larger F (0.7 or greater) and correspondingly large equilibrium catch than the models using the 1968-1972 average catch to calculate F. The model accounted for this high depletion by estimating large negative early recruitment deviations. The WG compared these results with the model run starting in 1950 with additional catch from 1950-1969, and noted that the freely estimated Fs and associated catch were substantially higher than any observed prior to 1970, and despite catch in that early period being lower than catch in the model, the initial F estimate was more than 3 times higher than F estimated for any other year in the model. The WG agreed that this would be a useful sensitivity run, but felt that using the 1968-1972 catch data to inform the initial conditions of the model was a more robust option.

The WG explored using a time block on the US length composition data to account for the positive residuals in the first half of the time series and negative residuals in the second half of the time series (Day4_1). This time block improved the model fits to the US size composition data and the US CPUE index, but at the cost of poorer fits to the Japan LL Late CPUE data. The WG agreed that the improvement to the US data did not offset the degradation of fits to other data.

The WG accounted for the spatial heterogeneity of the length composition data and the retraction of the Japanese longline fleet from the EPO. The JPN and TWN LL Late indices were split at 170°W and constrained to 20°N and 20°S based on the conceptual model described in the data preparatory workshop report (Day4_2). The model selectivities clearly showed that fish caught in the EPO were around 20cm larger on average than those caught in the western Pacific. There was some improvement to the fits of the CPUE indices and the length composition data for those fleets. However, there was concern about a strong decline in the SSB in the 1990s which coincided with sharp declines in the US and JPN LL Late East CPUE indices, but were not associated with a decline in catch or mean length of fish caught. The WG hypothesized that this decline in the JPN LL Late East index may be an artifact of the contraction of the fleet further west, however noted that more research was necessary to fully explore the impact of this trend on the model. The WG also recommended that the CPUE standardization for the next assessment should explore the impact of this changing spatial pattern on the Japanese CPUE in this region.

The WG noted that, overall, the retrospective analysis produced a relatively low Mohn’s rho, however, it tended to overestimate SSB and underestimate fishing mortality (F). It was pointed out that for the last year peel, SSB tends to be markedly underestimated, while F tends to be markedly overestimated, and that this issue requires careful consideration. The hind-cast cross-validation diagnostic indicated limited predictive ability.

The ASPM diagnostic indicated that the model contains sufficient information to adequately explain the biomass trends and a clear production function, because the trend was almost identical to that of the base-case model.

For the likelihood profile of R_0 based on CPUE, the CPUE likelihood was primarily driven by the Japanese late longline, mid Taiwan longline, and U.S. longline indices. For the total likelihood as well, the maximum CPUE likelihood, the maximum length composition likelihood, and the maximum total likelihood occurred at similar R_0 values. The WG noted that this indicates the model sufficiently relies on CPUE information to estimate biomass trends.

Some of the Runs tests failed, but the WG noted that Runs tests alone rarely identify major problems in model diagnostics. Instead, the WG emphasized that model evaluation should be based on an integrated assessment of multiple diagnostics, including CPUE residual patterns, ASPM results, retrospective analyses, and R_0 likelihood profiles, etc.

After reviewing the overall diagnostics, the WG agreed that the base-case model for the 2026 BUM stock assessment would be model Day3_4c with the following settings: set initial conditions to calculate F using the mean of 1968-1972 catch; use the whole ocean (combined) CPUE indices for the Japan and Chinese Taipei longline late indices; mirror the selectivity of the CPUE indices to their corresponding fleets; include the TWN LTLL length composition data and exclude the TWN LTLL and STLL weight composition data; include a time block on JPN LL Late selectivity; drop the F10 IATTC purse seine length composition data prior to 2006; start main Rec-devs in 1975 and estimate early recruitment deviations starting in 1961; and additional variance for CPUE indices would be calculated from the RMSE table. The WG considered this base-case model configuration to provide the best balance of data quality, model stability, and biological realism.

b. Sensitivity analysis

The WG drafted a set of proposed sensitivity runs based upon the major sources of uncertainty identified during the data preparatory meeting (Table 2). In addition, the WG identified several other data sources, model configurations, and model assumptions during the development of the base-case model that should be explored in a sensitivity analysis. **The WG agreed to include:**

- **the split east/west JPN and TWN LL Late CPUE indices model;**
- **an analysis including the TWN weight data instead of the length data;**
- **an analysis estimating additional SE for the CPUE indices except JPN LL Late;**
- **a time block on TWN LL Late catchability starting in 2012;**
- **an analysis on growth by using the 2021 new growth base-case model biological parameters;**
- **estimating F freely in the model;**
- **setting equilibrium catch to ½ the average catch from 1968-1972;**
- **setting equilibrium catch to two times the average 1968-1972 catch; and**
- **starting main recruitment deviations in 1990.**

c. Future projections

Using the deterministic recruitment, 10-years projections for 2025-2034 were performed using the forecast file within SS3, based upon 100 bootstrap runs of the base-case model. The WG conducted the future projections after the stock assessment meeting and reviewed the results via email. Consistent with the 2021 stock assessment, the WG defined four constant F scenarios and predicted future spawning biomass for the base-case model (Table 3).

7. Other Matters

a. Chair Elections

Elections for the next Billfish Working Chair will take place at the BILLWG Meeting prior to the ISC Plenary meeting on June 21, 2026.

b. Next Meeting

A BILLWG meeting will be held before the ISC Plenary meeting on June 21, 2026 in Taipei, Taiwan. The BILLWG data preparatory meeting for the 2027 WCNPO striped marlin stock assessment will be held November 10-17, 2026 in Yokohama, Japan. Virtual meetings will be held intersessionally to prepare for the data preparatory meeting.

8. Circulate workshop report

The WG Chair prepared a draft of the workshop report and reviewed it with the WG members. The provisional report was editorially revised by the WG Chair and distributed via email for WG members to finalize.

9. Adoption

The WG adjourned the stock assessment meeting of Pacific BUM stock assessment at 02:42 PM on 4 May 2026 (HST). The WG Chair expressed appreciation to the participating scientists for their collaboration in the stock assessment work.

Table 1. The list of test models.

Model Run	Description
All_35D	All Data included, start in 1971
Combined_63	Combined East and West indices for JPN and TWN, start in 1950
Combined_63_1971	Combined East and West indices for JPN and TWN, start in 1971
Drop_59_JLE	Drop only the JPN LL Late East CPUE index, start in 1971
Japan_56	Include only the US and JPN CPUE indices (Indices split east and west)
Tawian_57	Include only the US and TWN CPUE indices (indices split east and west)
TimeVarSel_67	All_35D but with time varying selectivity on F2
Continuity_1	Combined east and west indices for JPN and TWN, start in 1971, estimate initial F, mirror survey fleets to corresponding catch fleets
Continuity_1_TWNLength	Continuity 1 but replacing the TWN LTLL and STLL weight composition data with length data
Day2_2021_bridge	Use the 2021 new growth base-case model but with 2026 updated biological parameters
Day2_2021_bio	Use the 2026 data but 2021 new growth base-case model biological parameters
Day2_continuity_oldCPUE	Use continuity 1 model (2026 data, 2026 biological parameters) but use the TWN and JPN CPUE indices from 2021, and turn off US LL index (i.e., update catch and size only)

Day3_1	Include TWN LTLL length data, mirror TWN STLL catch to LTLL fleet, inform initial F using average catch from 1968-1972, increase CPUE CVs based upon RMSE table
Day3_2a	Day3_1 plus down weight all length and size data
Day3_2b	Day3_1 plus set sigmaR to 0.6
Day3_2c	Day3_1 plus start main rec devs in 1990
Day3_2d	Day3_1 plus time block on F2 JPN LL length data for 1994-2003
Day3_2e	Day3_1 plus estimate additional variance for all CPUE fleets except JPN LL Late
Day3_3	Day3_1 plus down weight all length and size data, add time block on JPN LL Length data for 1994-2003
Day3_4a	Day3_3 plus start main rec devs in 1990
Day3_4b	Day3_3 plus estimate additional variance on CPUE except for JPN LL Late
Day3_4c	Day3_3 plus drop pre-2006 size data for F10_VAR_PS_Other
Day3_4d	Day3_3 plus estimate initial F freely
Day3_4e	Day3_3 plus estimate initial F freely with a prior
Day4_1	Day3_4c plus time block from 2004-2014 for US Size comp
Day4_2	Day3_4c plus splitting JPN and TWN CPUE indices into east and west, and JPN catch from east to west, with corresponding length comp data

Table 2. The list of sensitivity runs.

Run name	Description
Alternative input data (based on the base case model)	
base_case_catch_1950	Model start 1950s (as early as possible); complete catch estimates for all fleets
base_case_catch_TWNearly	TWN_LTLL estimate missing catch from foreign ports.
base_case_catch_misID	Adjust catch for discards and species mis-ID - decrease catch by 10% for all years/fleets
base_case_catch_discards	Adjust catch for discards and species mis-ID - increase catch by 10% for all years/fleets
base_case_estimateCPUEVar	Estimate additional CPUE variance within the model
base-case_eastwestSplit	Split TWN and JPN CPUE indices into East and West
base_case_TWNcatchability	Use time block on catchability for S10 starting in 2012
base_case_TWNweight	Use weight composition data for TWN STLL and LTLL
Alternative life history parameters	
base_case_lowM	Updated Lorenzen NatM vectors -1stddev
base_case_highM	Updated Lorenzen NatM vectors +1stddev
base_case_metaanalysis	Updated meta-analysis

Alternative life history parameters: stock recruitment steepness	
base_case_h065	Alternative stock-recruitment steepness, lower h, h = 0.65
base_case_h075	Alternative stock-recruitment steepness, lower h, h = 0.75
base_case_h095	Alternative stock-recruitment steepness, higher h, h = 0.95
Alternative life history parameters: growth curve (depend on the base case model)	
base_case_75growth	25th percentile posteriors from Chang et al. 2025
base_case_25growth	75th percentile posteriors from Chang et al. 2025
base_case2021NewGrowth	Use biological parameters from the 2021 New Growth model
Alternative life history parameters: maturity ogives	
base_case_high_L50	Alternative maturity, +10%(base): L50 = 197.7 cm
base_case_low_L50	Alternative maturity, -10%(base): L50 = 161.8 cm
Alternative life history parameters: L-W	
base_case_betahigh	Brodziak (2013) meta-analysis beta high - increase by 10%
base_case_betalow	Brodziak (2013) meta-analysis beta low - decrease by 10%
base_case_beta3	beta = 3
Alternative Initial conditions	

base_case_FreeF	Estimate F freely in the model
base_case_LowCatch	Set equilibrium catch to 0.5x 1968-1972 average
base_case_HighCatch	Set equilibrium catch to 2x 1968-1972 average
base_case_MainRecDevs	Start main rec devs in 1990, early rec devs 1980

Table 3. The list of future projection scenarios.

No	Scenario	Time period
1	F_{High}	2025-2034
2	F_{MSY}	2025-2034
3	$F_{2021-2023}$	2025-2034
4	$F_{30\%}$	2025-2034

Figures

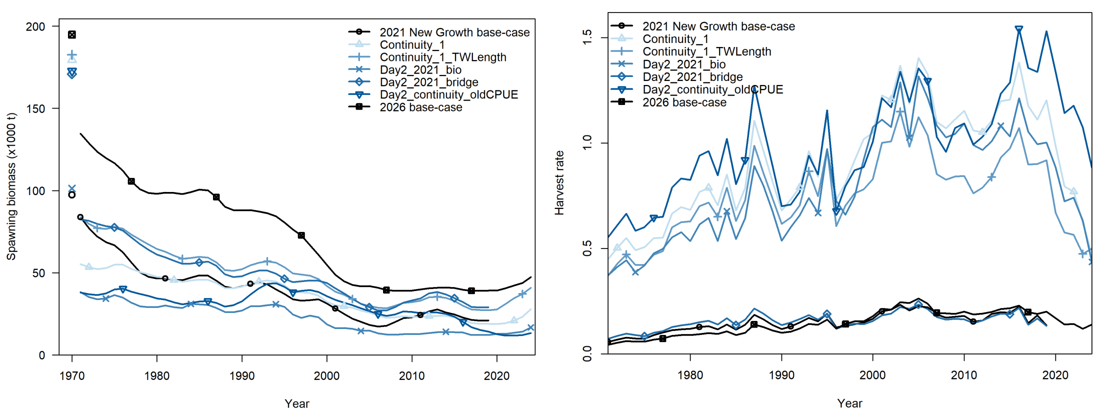


Figure 1. Plot of spawning stock biomass (left) and fishing mortality (right) for each model change from the 2021 new growth base-case model to the 2026 base-case model. Descriptions of each model can be found in Table 1.

Attachment 1. List of participants

Chinese Taipei

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

Ching-Tsun Chang
Eastern Fishery Research Center, Fisheries Research Institute, Taiwan
ctchang@mail.tfrin.gov.tw

Japan

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

United States

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

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

Erin Bohaboy
NOAA Fisheries, NMFS
Pacific Islands Fisheries Science Center,
1845 Wasp Blvd.,
Honolulu, HI, 96818
erin.bohaboy@noaa.gov

Jhen Hsu
NOAA Fisheries, NMFS
Pacific Islands Fisheries Science Center,
1845 Wasp Blvd.,
Honolulu, HI, 96818
jhen.hsu@noaa.gov

Janelle Morano
NOAA Fisheries, NMFS
Pacific Islands Fisheries Science Center,
1845 Wasp Blvd.,
Honolulu, HI, 96818
janelle.morano@noaa.gov

Kristen Dahl
NOAA Fisheries, NMFS
Pacific Islands Fisheries Science Center,
1845 Wasp Blvd.,
Honolulu, HI, 96818
kristen.dahl@noaa.gov

Adrian Hordyk
Blue Matter Science, Ltd
2150 Bridgman Ave,
North Vancouver, BC, V7P 2T9
adrian@bluematterscience.com

Rebecca Scott
The Ocean Foundation
1320 19th St, NW, Suite 401,
Washington, DC 20036
rscott@oceanfdn.org

IATTC

Carolina Minte-Vera
Inter-American Tropical Tuna Commission
Ecosystem Program
8901 La Jolla Shores Drive, La Jolla, CA,
92037, USA.
cminte@iattc.org

Attachment 2. Meeting agenda

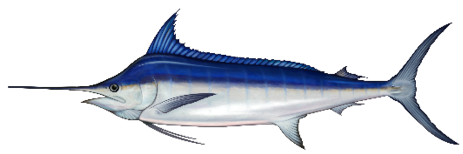
INTERNATIONAL SCIENTIFIC COMMITTEE FOR TUNA

AND TUNA-LIKE SPECIES IN THE NORTH PACIFIC

BILLFISH WORKING GROUP

STOCK ASSESSMENT MEETING FOR THE PACIFIC BLUE MARLIN STOCK ASSESSMENT

ANNOUNCEMENT AND AGENDA



Meeting Site:	NOAA Offices on Pier 38 1139 N. Nimitz Highway, Suite 220 Honolulu, HI 96817
Virtual Option:	A virtual option via WebEx is linked under each day's agenda items. Please note these is a different link for each day.
Dates:	April 28 – May 4, 2026
Goals:	The Billfish Working Group will be holding a meeting to complete the stock assessment for Pacific blue marlin (*Makaira nigricans*). The goal is to complete a 2026 benchmark stock assessment at this meeting, including projections and sensitivity runs.
File Distribution:	Working papers, presentations, and other files will be available on the BILLWG *Google Drive*.
Working paper deadline:	Working papers must be submitted **one week** in advance to be considered at this meeting. Submit papers to Michelle Sculley (*michelle.sculley@noaa.gov*) by **Tuesday, April 21, 2026** for distribution.
Attendance:	Please email Michelle Sculley (*michelle.sculley@noaa.gov*) if you plan on attending the meeting in person or online.
Contact:	Michelle Sculley (ISC BILLWG Chair) Oceanic Fisheries Stock Assessment Program, Pacific Islands Fisheries Science Center National Marine Fisheries Service, NOAA

Email: *michelle.sculley@noaa.gov*
TEL: +1 808-725-5705

Draft Agenda

1. Opening of the Billfish Working Group Meeting
    a. Welcoming Remarks
    b. Introductions
    c. Standard meeting protocols
2. Adoption of Agenda and assignment of rapporteurs
3. Numbering of working papers
4. WCNPO SWO MSE
    a. Proposed workplan to NC22
    b. Progress on the operating model for WCNPO SWO MSE
5. Other BILLWG Research
6. Pacific Blue Marlin stock assessment modeling
    a. Base model consideration
    b. Key uncertainties
    c. Sensitivity Analysis
    d. Future Projections
6. Other Matters
    a. Chair Elections
    b. Next meeting
7. Clearing of the meeting report
8. Close of meeting

Attachment 3. The list of working papers.

ISC/26/BILLWG-02/01	Environmental variability shifts the trophic dynamics and ecological niche partitioning of billfishes using stable isotope analysis. *ctchang@mail.tfrin.gov.tw*
ISC/26/BILLWG-02/02	Progress towards a Base-case Model in Stock Synthesis 3.30 for the 2026 Pacific Blue Marlin (Makaira nigricans) Stock Assessment. *erin.bohaboy@noaa.gov*

Attachment 4: Draft Workplan for the WCNPO Swordfish MSE

The following is a proposed work plan for developing a long-term Harvest Strategy (including MSE) for Western and Central North Pacific Swordfish:

Option 1:

2025 (NC21):

- NC requested that the ISC develop a workplan for the MSE process that will be presented to NC in 2026, outlining steps and timeline to conduct and complete an MSE.
- NC requested the ISC to begin technical work on an MSE.
- NC tasked itself to discuss candidate operational management objectives for WCNPO swordfish in 2026

2026 (NC22):

- ISC to provide an overview of their workplan and any progress on the MSE, including but not limited to clarifications needed.
- NC22 provides guidance on candidate operational management objectives, performance indicators, reference points and harvest control rules to ISC
- If additional information is requested by the ISC from the NC relevant to the MSE, the NC should task its members to solicit input from its stakeholders and task itself to address this at NC23 in 2027, as appropriate.

2027 (NC23):

- ISC provides feedback on inputs and preliminary MSE results in 2027 to NC23
- NC23 reviews preliminary MSE results and may provide feedback to refine inputs to MSE in 2027
- If additional information is requested by the ISC from the NC relevant to the MSE, the NC should task its members to solicit input from its stakeholders and task itself to address this at NC24 in 2028, as appropriate.

2028 (NC24):

- ISC presents results from the MSE to NC24 in 2028.
- ISC presents a new benchmark stock assessment for WCNPO SWO to NC24.
- NC considers and recommends revisions to HS 2016-01 and/or CCM 2023-03 based upon MSE results to the WCPFC for adoption.

Option 2:

2025 (NC21):

- NC requested that the ISC develop a workplan for the MSE process that will be presented to NC in 2026, outlining steps and timeline to conduct and complete an MSE.
- NC requested the ISC to begin technical work on an MSE.
- NC tasked itself to discuss candidate operational management objectives for WCNPO swordfish in 2026

2026 (NC22):

- ISC to provide an overview of their workplan and any progress on the MSE, including but not limited to clarifications needed.
- NC discusses candidate operational management objectives for WCNPO swordfish for use in an MSE process.
- If additional information is requested by the ISC from the NC relevant to the MSE, the NC should task its members to solicit input from its stakeholders and task itself to address this at NC23 in 2027, as appropriate.

2027 (NC23):

- NC provides candidate performance indicators, reference points and harvest control rules.
- If additional information is requested by the ISC from the NC relevant to the MSE, the NC should task its members to solicit input from its stakeholders and task itself to address this at NC24 in 2028, as appropriate.
- ISC provides feedback on inputs and preliminary MSE results as part of an intersessional meeting in 2027/2028

2028 (NC24):

- ISC presents results from the MSE to NC24 in 2028.
- ISC presents a new benchmark stock assessment for WCNPO SWO to NC24.
- NC considers and recommends revisions to HS 2016-01 and/or CCM 2023-03 based upon MSE results to the WCPFC for adoption.

Funding for technical support for MSE is time limited and must be completed by 2028