FINAL

ISC/21/ANNEX/09

ANNEX 09

21st Meeting of the
International Scientific Committee for Tuna
and Tuna-Like Species in the North Pacific Ocean
Held Virtually
July 12-21, 2021

REPORT OF THE BILLFISH WORKING GROUP WORKSHOP

July 2021

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ANNEX 09

REPORT OF THE BILLFISH WORKING GROUP WORKSHOP

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

6-10, 13 April 2021 (JST)
Virtual Meeting

1. OPENING AND INTRODUCTION

1.1. Welcoming Remarks

Hirotaka Ijima, Billfish Working Group chair opened the Pacific blue marlin stock assessment meeting. Chinese Taipei, Japan, United States of America (USA), the Pacific Community Oceanic Fisheries Program, and the Inter-American Tropical Tuna Commission (IATTC) participated in the meeting. Attachment 1 lists participating scientists.

1.2. 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 virtual five-day meeting by webinar. The meeting conducted the stock assessment for Pacific blue marlin and agreed on stock status, future projections, and sensitivity analysis results. Based on these results, the BILLWG formulated conservation information.

1.3. Standard Meeting Protocols

The WG chair introduced protocols for the webinar meeting. The WG used Cisco Webex for this meeting, 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 four agenda items as follows:

Agenda item	day	Rapporteur
a. Base case model	6th April	Y-J Chang, Felipe Carvalho
a. Base case model	7th April	Felipe Carvalho, M Kanaiwa
a. Base case model	8th April	Y-J Chang, N D Barth
a. Base case model	9th April	Y-J Chang, N D Barth
b. Sensitivity analysis, c. Future projection	10th April	J Brodziak, M Kanaiwa

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. PACIFIC BLUE MARLIN STOCK ASSESSMENT MODELING

4.1. Base case model

Preliminary Base-case Models in Stock Synthesis 3.30 for Consideration in the 2021 Pacific Blue Marlin (Makaira nigricans) Stock Assessment. (ISC/21/BILLWG-02/01)

Dr. Michelle Sculley, who is the lead modeler of the WG, presented a "candidate" for the base case model (candidate model) of Pacific Blue marlin. 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

Two preliminary base-case models in Stock Synthesis 3.30 for Pacific blue marlin (*Makaira nigricans*) is described for consideration as the 2021 base-case model. The base-case model covers 1971-2016. It includes data from three International Scientific Committee for the Conservation of Tuna and Tuna-like Species (ISC) countries and from other countries in aggregate from the Western Central Pacific Fisheries Council (WCPFC) and Inter-American Tropical Tuna Commission (IATTC). This paper describes the data available for inclusion in the base-case model, a model using the biological parameters from the 2016 base-case stock assessment model (old growth) and a model using an updated growth curve presented to the ISC Billfish Working Group at the 2021 Data Preparatory meeting (new growth). Both models converge and appear to fit the data well. Initial diagnostics do not indicate major problems. Preliminary results from both models suggest the Pacific blue marlin stock is being fished below F_{MSY} and spawning stock biomass is above SSB_{MSY}.

Developing the base case model

The WG noted that the CV of the growth curve used in the working paper is slightly different. The presenter has clarified that during the March 2021 Working Group meeting, the WG decided to use the CV of the 2016 growth curve for the new growth model as well.

The WG recommended that the recruitment could be estimated by using the ASPM. However, this work would not be a priority diagnostic because of the meeting's time limitation.

The WG noted that the size composition of F14 EPO PS in 1990 and F12 during 1992-1993 were dropped in the previous Pacific blue marlin model. The WG considered these values are outliers. **The WG agreed to drop the size composition of F14 EPO PS in 1990 and F12 during 1992-1993** (Table 1. Runs 1 and 2).

The WG discussed the treatment of Taiwanese CPUE indices in the candidate model and recommended using the three separated standardized CPUE indices rather than using the time block approach for the one continuous CPUE index from the original standardized CPUE. The WG tested the three separate standardized CPUE indices model. The WG discussed the difference between two different approaches to treat Taiwanese CPUE and found separated indices were a better fit for the model. **The WG agreed to separate Taiwanese CPUE indices as S4_TWN_DWLL, S5_TWN_DWLL, and S6_TWN_DWLL** (Table 1. Run 3).

The WG noted that the start time of recruitment between old and new growth models is different. **The WG agreed to fix starting early recruitment in 1961 that is consistent with the old growth model** (Table 1. Run 4).

The WG noted that there was some conflict between CPUE fit and length composition data. To improve this issue, the WG tested the time-block selectivity model for the F1_JPN_LL_early and F7_US_HI_LL length composition before 1975 and 1994-2004, respectively. Because of the inconsistency of the likelihood profile, the WG tested that the down-weighting of the length composition for F1_JPN_LL_early and F7_US_HI_LL using a 0.5 variance adjustments value (50% down weight) (Table 1. Run 5 and 6). The WG discussed the down-weighting for length composition data of F1_JPN_LL_early. The WG noted that with the inclusion of time block selectivity for F1_JPN_LL_early, the new growth model had convergence issues because the initial F hit the lower boundary, which is very close to zero. The WG presented the new growth model's likelihood profile without including the time block selectivity for F1_JPN_LL_early. The profile results showed that generalized size composition data did not show good results in the profile compared to the MLE. The CPUE index and the length composition data generally appear consistent, but the generalized size data did not provide much information. The WG discussed that down-weighting JPN length composition data could not improve the profile. However, the better fit to CPUE appears more driven by the TW_DWLL CPUE index. The WG presented the profile for the new growth model without down-weighting length composition data for F1_JPN_LL_early. The profile suggested that the size composition data pushing for lower R_0 and agreement between total components. However, there are conflicts between the different indices. **The WG agreed that the down-weighting of F1_JPN_LL_early length composition was not enough to improve the likelihood fit.** In terms of effects of down-weighting and time block selectivity for F7_US_HI_LL, the WG recognized that likelihood improved but still had some conflict between data sets.

The WG also reviewed the effects of including an early time block on the early-period Japanese size composition data. The model results showed that one could not reliably estimate the initial F using a time block during 1971-1974 in the early-period Japanese size composition using either model. The WG agreed to exclude this time block, because it led to estimation problems with the initial F and also added 10 extra parameters to the number of freely estimated parameters. As a result, the WG also concluded that the initial F was estimable for models that excluded the 1971-1974 time block and also observed that the initial F estimation appeared to be estimable using either the new or the old growth model.

The WG tested the down-weighting and time block selectivity for F1_JPN_LL_early and F7_US_HI_LL at the same time (Table 1. Run 5 and 6). The WG found there is no issue for the model convergence, correlation, and high variance. The residual diagnostics suggested that the S1_JPN_LL_early had a relatively higher RMSE. However, the runs test failed, and the S2_JPN_LL_late had a higher RMSE but passed the run test. The WG also noted that in the last few years of the assessment, the estimated S2_JPN_LL_late CPUE index was significantly higher than the expected CPUE index. Three CPUE indices for TW_DWLL all passed the runs test. The joint residual plot of CPUE (RMSE=36.4%) suggested no significant conflicting information among CPUE indices and no residual autocorrelation pattern in general. The WG noted residual size composition runs test indicated that the fitness Japanese length composition data appears to pass. The WG pointed out that the yield curve of this model was in disagreement with Chang et al (2020), and the SSB_{MSY}/SSB_0 ~ 0.17 indicated the high per capita biomass production. In that paper, Chang *et al*. used the YPR analysis and assumed a stock-recruitment relationship. There are several differences between the two results. For example, the SS model just used the equilibrium selectivity pattern, the natural mortality was fixed across ages, and the growth model was a bit different. The values may not be directly comparable. The WG noted that the positive retrospective bias on productivity was found from high steepness and high natural mortality combination. The WG noted that the retrospective pattern is present only in the last few years. However, the pattern is consistent in the historical time-period. It might be caused by the interaction with growth curve and preferential fit to either S4_TWN_DWLL or S2_JPN_LL_late CPUE indices in the recent period. The WG noted the R_0 profile of the model suggested that the F1_JPN_LL_early had the biggest impact on the likelihood.

The WG tested the down-weighting model for length composition data of the F2_JPN_LL_late due to the conflict and misfit to the CPUE index in current years (Table 1 Run 7). The WG set 0.5 variance adjustments value that means 50% down weight for length composition data. The WG discussed the effects of changing the data weighting for F2_JPN_LL_late length composition data to improve model fit. The WG noted that down weighting the F2_JPN_LL_late length composition data did not make a practical difference or improve model fit. In particular, the likelihood profile showed no practical difference when the length composition data were down-weighted. Similarly, the estimated value of the initial fishing mortality rate was only slightly changed by the down-weighting length composition data. Overall the trends in model outputs were similar with or without down weighting the length composition data. **Considering this test model, the WG agreed to not down-weight for the F2_JPN_LL_late length composition data.**

To improve the misfit of the S2_JPN_LL_late index in recent years, the WG tested increasing the variance on the S2_JPN_LL_late index to help solve the retrospective patterns. The WG found that the 95% confidence interval of the S2_JPN_LL_late index misses the predicted value. **The WG agreed that adding the CV of 0.2 (based on the RMSE) to the S2_JPN_LL_late index did not improve the retrospective patterns** (Table 1 Run 8). The retrospective diagnostics results showed strong retrospective patterns with both growth models when S2_JPN_LL_late was down-weighted or when length composition data of F2_JPN_LL_late was down-weighted. The WG noted that this might be due to the misfit of the late-period Japanese CPUE index. The WG discussed whether the strong retrospective pattern in spawning biomass was being driven by the substantial decrease in late-period Japanese CPUE in the last six years of the assessment time-period (2014-2019). The WG noted that the decrease in CPUE appeared to be biologically implausible for a species with a longevity of at least 20 years. **The WG agreed not to down weight the S2_JPN_LL_late index because there is no apparent improvement to the model.**

The WG discussed the estimation of steepness in the candidate model and recommended changing the prior distribution of this parameter or the full beta prior. Moreover, the WG noted that it should consider the technique improvement for this key parameter, for example, estimation of steepness by using the probabilistic statement (MCMC). However, due to the time limitation of this meeting, the WG tested to change prior of steepness, mean 0.87, SD 0.05 using the full beta prior. The WG noted that the estimation of steepness does not really work in a statistical sense because of data conflicts. Most of the CPUE indices are consistent with a steepness of h=1. This result suggested that there is no observable relationship between spawning potential and recruitment in the CPUE indices, except for the S2_JPN_LL_late index, which was consistent with a lower steepness. The WG also noted that the size composition data indicated a steepness of h=1. Thus both CPUE and size composition data suggested that the steepness parameter estimate would be driven by the highly informative prior. **The WG agreed not to estimate the steepness parameter because the likelihood profiles over unfished recruitment were inconsistent, and there was not enough information to estimate steepness in the abundance indices or size compositions** (Table 1. Run 9).

The WG discussed whether removing the S2_JPN_LL_late index would improve the model fits based on the retrospective patterns. In this context, the WG noted that both the new and old growth models had problems fitting the last few years of the S2_JPN_LL_late index. The WG concluded that it would be important to understand the effects of removing the S2_JPN_LL_late index on the strong retrospective patterns. The WG discussed some possible reasons for the decrease in the S2_JPN_LL_late index in recent years. The WG noted that the Japanese longline fleet exhibited a different spatial distribution of fishing effort in the past decade. In particular, graphs of fishing efforts showed that the Japanese longline fishing grounds in the EPO had a decreasing pattern starting around 2010 (Ijima 2020). The WG discussed how to treat the S2_JPN_LL_late index from 2010-2019 and whether it would be appropriate to split the CPUE index prior to and after the year 2010. Some WG members noted that if the index was not a consistent abundance index, then it should be excluded, while others pointed out that there was probably useful information on abundance trends in the index at least prior to 2010. Overall, it was suggested that there were two options for developing the base case model relative to the treatment of the S2_JPN_LL_late. These were:

(1) Drop the S2_JPN_LL_late index and assess the model diagnostics using both the new and old growth models.

(2) Drop the most recent 10 years from the S2_JPN_LL_late index (2010-2019) and assess the model diagnostics using both the new and old growth models.

Based on the agreement of the best available input CPUE data at the data preparation meeting, the WG agreed to go forward with option (1) (Table 1. Run10). In this context, the modeling choice would be whether to include the S2_JPN_LL_late or not based on objective measures of goodness of model fit. The results using the old growth model showed that there were minor differences in spawning biomass and fishing mortality. As might be expected, the R_0 profile of the old growth model without the CPUE index was driven by the S6_TWN_DWLL_late index. The WG noted that dropping S2_JPN_LL_late under the old growth model reduced the retrospective patterns in spawning biomass and fishing mortality but did not remove the patterns. Similar results were obtained using the new growth model with and without S2_JPN_LL_late. Dropping S2_JPN_LL_late under the new growth model led to a more rapid increase in spawning biomass in recent years but did not appreciably change the R_0 likelihood profiles for individual CPUE indices or size composition data. The WG also noted that excluding the S2_JPN_LL_late index using the new growth model slightly improved the retrospective patterns but did not remove them.

The WG discussed the inclusion of the S2_JPN_LL_late index in the base case model. The WG noted that excluding the S2_JPN_LL_late index did not improve model fit and removed information on relative abundance trends. Excluding the S2_JPN_LL_late index would also imply the recent abundance trends were only dependent on the S6_TWN_DWLL_late index. The WG noted that the retrospective patterns were only slightly improved by excluding the S2_JPN_LL_late index. **Overall, the WG reached a consensus to include the S2_JPN_LL_late index in the base case model.**

Considering the development of the base case model, the WG agreed on the changes in Runs 1 through 7. Furthermore, the WG discussed whether the old growth curve or the new growth curve is more suitable as a base case model using this model.

The WG agreed that if either the old or new growth model clearly had better model diagnostics, then the choice of the base case was also clear. The WG looked at the results of model runs comparing the impacts of down weighting the F1_JPN_LL_early and F7_US_HI_LL length composition data. The results showed no practical difference in model diagnostics or results between down weighting only the F1_JPN_LL_early length composition data and down weighting both the Japanese and the Hawaii length composition data sets.

The WG also compared the likelihood profiles over the logarithm of the unfished recruitment parameter (R_0). Comparing likelihood profiles among the alternative models showed that the old growth models produced slightly better likelihood profile fits compared to the new growth models. This result suggested that the old growth models provided somewhat better fits to the data than the new growth models but also showed that the differences in the goodness of fit were not substantial.

The WG discussed the modeling choice of using either the new or the old growth model. The WG noted that the old growth model produced slightly better likelihood profiles but that this was a not major difference between models. It was suggested that the WG consider using model averaging to combine results of the old and new growth models as is commonly done in SPC assessments when there are major axes of uncertainty.

The WG discussed the possible causes for the persistent retrospective patterns in model results for spawning biomass and fishing mortality regardless of the scenario or growth model. The WG noted that there were no substantial retrospective patterns in the 2016 BUM stock assessment model. The WG discussed the probable impacts of misreporting of BUM catch, and the WG noted that underreporting of BUM catch could lead to an overestimation of biomass. The WG also discussed the impact of different CPUE standardizations and data weighting in the current assessment and concluded that these changes from the 2016 benchmark assessment were also possible causes of a retrospective pattern. The WG also suggested that the misspecification of life-history parameters could be another cause of retrospective patterns. However, the WG pointed out that the life history parameters under the old growth model were identical to those used in the 2016 benchmark assessment. Since the 2016 benchmark assessment model did not exhibit a retrospective pattern, it seemed unlikely that life-history parameter misspecification was a substantial factor in the strong retrospective patterns in the current old growth model. **Overall, the WG concluded that there were several possible causes for the observed retrospective patterns.**

The WG noted that the uncertainty in the initial estimates of spawning biomass under the old growth model was relatively high and included the estimated spawning biomasses under the new growth model.

The WG also discussed the biological realism of the old and new growth models. Here the WG suggested that the old growth model might be somewhat biased at younger ages while the new growth model may be somewhat biased at the older ages. These apparent biases were due to differences in the growth parameter estimates under both models. The WG noted that the old growth model had an estimated Brody growth coefficient (K) that was too low, while the new growth model had an estimated asymptotic length (L_{inf}) that was too low. As a result, there was no clear basis to choose between the growth models based on biological realism.

The WG noted that the estimated initial F under the old growth model was relatively high, while the initial F under the new growth model seemed relatively low.

The WG also noted that both models showed a decline in spawning biomass during the 1970s-1980s but that the decline from unfished spawning biomass was much higher under the new growth model, about a 6-fold reduction, likely because the new growth model does not include very large fish (female L_{inf} is 250 cm EFL) in the initial population. The old growth model has an L_{inf} of 305 cm EFL, therefore to reach the same size structure from the size composition data, a much higher F on large fish in the old growth model is required. Given that catches increased to a peak in the late-1980s, it was difficult to explain the relative stability of the spawning biomass time trend subsequent to the peak catches.

Given this information, **the WG agreed that there were some problematic issues with both growth models and concluded that it would be best to consider a base case that provided information on both models**. Some WG members suggested using model averaging to combine the results of the old and new growth models for the provision of scientific advice. After further discussion about the relative merits of using different weights for averaging the old and new growth models, **the WG reached consensus that the base case model would be an equally weighted average of the old and new growth models. The WG also agreed to show the results of the old and new growth models separately as well to provide transparency in how the best scientific information available was derived in this case.**

4.2. Sensitivity analysis

After determining the base case models, the WG discussed what sensitivity analyses should be performed (Table 2). **The WG agreed that all sensitivity runs would be performed on both the old growth and new growth models.**

To explore alternative data hypotheses, **the WG agreed to carry out (1) an analysis excluding the F1_JPN_LL_early index and (2) an analysis excluding the S6_TWN_DWLL_late index** because these CPUE indices in recent years showed the poor fitting and retrospective analysis indicated the overestimation of spawning biomass in recent years. **The WG also agreed to perform the exact down weighting for length composition data as in the F1_JPN_LL_early and F7_US_HI_LL and confirmed the impact of down weighting other fleets.**

The WG agreed to confirm the effect of the alternative biological assumptions on natural mortality, growth curve, maturity, and stock-recruitment relationship. These alternative assumptions were the same explored in the 2016 stock assessment, exploring 10% higher and 10% lower plausible parameter values.

The WG confirmed the biggest change in the present stock assessment was to estimate the initial equilibrium F instead of fixing equilibrium catch. To explore the change due to a different model configuration, **the WG agreed to fix equilibrium catch at the 2016 assessment level and not estimate initial F as an alternative model structure assumption.**

4.3. Future projection

Using the deterministic recruitment, projections were performed using the forecast file within SS. The WG ran the future projections after the stock assessment meeting and reviewed them by email. Consistent with the 2016 stock assessment in, the WG defined four constant F scenarios and predicted future spawning biomass for the old growth and the new growth models (Table 3).

5. CIRCULATE WORKSHOP REPORT

The WG Chair made a draft of the workshop document and distributed it to the WG members. The WG members browsed and proofread the draft on an e-mail basis.

6. ADOPTION

After the circulation of the adopted workshop document by e-mail, the WG adjourned the Pacific blue marlin stock assessment meeting on 21^{th} May 2021 (JTS).

7. REFERENCES

Chang, Y.J., Winker, H., Sculley, M., Hsu, J., 2020 Evaluation of the status and risk of overexploitation of the Pacific billfish stocks considering non-stationary population processes. Deep Sea Research Part II: Topical Studies in Oceanography, 175, 104707.

Ijima, H., 2020 Update Japanese catch and length-frequency data of Pacific blue marlin (*Makaira nigricans*) during 1971-2019. ISC/20/BILLWG-03/05 rev1.

Table 1. The list of test models.

Base-case	Run	Model Change
Yes	1	Drop 1990 size comp for F14 EPO PS
Yes	2	Drop 1992-1993 (first two years) of F12 other LL
Yes	3	Keep TWN as scaled to mean, split into three indices
Yes	4	Start new growth early recruitment at 1961
Yes	5	Down weight JPN LL length composition using 0.5 variance adjustment value, use time block 1971-1974.
Yes	6	Down weight HI LL length composition using 0.5 variance adjustment value, use time block 1994-2004.
No	7	Down weight JPN LL late length composition using 0.5 variance adjustments value.
No	8	Down weight (add variance to) JPN LL Late CPUE (add ~0.2 based upon RMSE) – based on Francis method
No	9	Change prior of steepness, mean 0.87, sd 0.05, Full Beta prior
No	10	Drop JPN S2

Table 2. The list of sensitivity runs.

Alternative data	
CPUE	Drop JPN LL Late CPUE time series (S2) Drop TWN LL Late CPUE time series (S6)
Size composition	Bias adjustment for length composition data set to 0.5 for each fleet (at the same time).
Alternative biological assumption	
Natural mortality	Increase/decrease M at age by 10%
Growth curve	Alternative growth curves, 10% smaller maximum size for each sex, change K to be consistent with size at age-1 from the base case model Alternative growth curves, 10% larger maximum size for each sex, change K to be consistent with size at age-1 from the base case model
Maturity	lower: L50=161.8cm, higher: L50=197.7cm
Stock-recruitment steepness (h)	lower: h=0.65, middle: h=0.80, higher: h=0.95
Alternative model structure assumptions	
Initial F	Fix initial catch at levels = 2016 assessment

Table 3. The list of future projection scenarios.

No	Scenario	Time period
1	F2003-2005	2020-2029
2	FMSY	2020-2029
3	F2016-2018	2020-2029
4	F30%	2020-2029

ATTACHMENT 1. LIST OF PARTICIPANTS

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ATTACHMENT 2. MEETING AGENDA

INTERNATIONAL SCIENTIFIC COMMITTEE FOR TUNA AND TUNA-LIKE SPECIES IN THE NORTH PACIFIC

BILLFISH WORKING GROUP (BILLWG)

INTERSESSIONAL WORKSHOP ANNOUNCEMENT and AGENDA

Meeting Style: Webinar meeting using Webex
The WG chair will inform the link at the day before the meeting.

Meeting Dates:
9:00-13:00, 6-10th, 13th April (Japan Time)
8:00-12:00, 6-10th, 13th April (Taiwan Time)
11:00-15:00, 6-10th, 13th April (New Caledonia Time)
14:00-18:00, 5-9th, 12th April (US Hawaii Time)
16:00-20:00, 5-9th, 12th April (US San Diego Time)

Meeting Goals: The ISC BILLWG will conduct the stock assessment for Pacific blue marlin and agree on stock status, future projections, and sensitivity analysis results. Based on these results, the BILLWG will formulate conservation information.

Meeting Attendance: Please respond to Hirotaka Ijima (Email: ijima@affrc.go.jp) if you plan on attending this meeting

Working Papers: Submit working papers to Hirotaka Ijima by April 5th.

BILLWG Contact:
Hirotaka Ijima (Ph.D, ISC BILLWG Chair)
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ATTACHMENT 3. THE LIST OF WORKING PAPERS.

ISC/21/BILLWG-02/01	Preliminary Base-case Models in Stock Synthesis 3.30 for Consideration in the 2021 Pacific Blue Marlin (*Makaira nigricans*) Stock Assessment. michelle.sculley@noaa.gov