FINAL

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ANNEX 04

23rd Meeting of the
International Scientific Committee for Tuna
and Tuna-Like Species in the North Pacific Ocean
Kanazawa, Japan
July 12-17, 2023

REPORT OF THE PACIFIC BLUEFIN TUNA WORKING GROUP INTERSESSIONAL WORKSHOP

July 2023

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ANNEX 04

REPORT OF THE PACIFIC BLUEFIN TUNA WORKING GROUP INTERSESSIONAL WORKSHOP

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

March 21-24, 2023
Shinagawa, Tokyo JAPAN

1. OPENING AND INTRODUCTION

1.1. Welcome and introduction

The meeting was held in Shinagawa, Tokyo, Japan, allowing both in-person and online participation. S. Nakatsuka (Japan), Chair of the ISC Pacific Bluefin tuna Working Group (PBFWG or WG), welcomed participants from Japan, Korea, Mexico, Chinese Taipei, the United States of America, and the Inter-American Tropical Tuna Commission (IATTC) and opened the meeting.

1.2. Adoption of agenda

The adopted agenda is attached as Appendix 1, and the list of participants is provided in Appendix 2. The list of documents reviewed during the meeting is provided in Appendix 3.

1.3. Appointment of rapporteurs

Rapporteurs were assigned by the Chair as follows: Item 2: HH. Lee, Item 3: D. Tommasi, Item 4: N. Takahashi and Y. Tsukahara, and Item 5: SK. Chang.

2. DATA FOR THE PBF MSE AND STOCK ASSESSMENT

2.1. Catch

2.1.1. Retained catch

H. Fukuda from Japan presented the updated catch table for Japanese fisheries up to the 2022 calendar year. The total catch by the Japanese fleet in 2022 was about 10,000 tons and had been increasing since 2018 when the catch was 6,205 tons. The major reason for the increase was the increased catch upper limit for large PBF (>30 kg BW) following the adopted and implementing CMM in the WCPFC convention area in 2022.

Discussion

The PBFWG reviewed the recent amount of retained catch by Japanese fisheries, which showed an increase from 2021 to 2022 for most of fisheries, including Japan's longline, tuna purse seine, and troll fisheries. One member raised a question regarding the increase of catch for troll fisheries targeting age-0 PBF and whether it was associated with the change in the catch limit. It was clarified that the catch limit had not changed for 2021-2022, and the increase was due to better management practices implemented by the local government, resulting in a catch rate closer to the catch limit. Additionally, a question was asked about the historical landings during the U.S. occupation of Okinawa from 1945 to 1972. It was explained that efforts are being made to search for any records of PBF landings in the archived U.S. vessel landed in a foreign port data.

HW. Park from Korea presented ***Update on Korean fisheries information of Pacific bluefin tuna and size distribution by Korean offshore large purse seine fishery*** **(ISC/23/PBFWG-1/01).**

Total catch of Pacific Bluefin tuna (PBF) in 2022 was 881 tons caught by offshore large purse seine, set net, and trawl fisheries in Korean waters. The catch proportion of set net has been increasing in recent years and peaked in 2022. The catch proportion of large PBF in 2022 was 59% of the total catch. In 2022, most PBF were caught by purse seine from February to March in the eastern part of Jeju island, and some were caught by set net from June to September along the coast of the East Sea. As for the PBF size frequency, large size fish have increased since 2016 and were mainly caught in the 1st and 2nd quarters.

Discussion

The PBFWG noted that the Korean purse seiner catch in 2022 contained more relatively small size as well as large size of fish (>30kg) compared to 2021. A member asked whether the fishing operations (such as location or target species) had changed and affected the size of fish caught. Upon further investigation, it was clarified that set net size data had been combined with purse seiner size data. After separating the setnet size data that caught small PBF, the dominant small size mode disappeared. As most of the retained catch is from the Korean purse seiners, the difference in the size of fish caught will be captured in the stock assessment model with the time-varying selectivity for this fleet.

HH Lee from U.S. presented the latest catch information from U.S. commercial and recreational fisheries. The number of fish caught by recreational fisheries increased from 18,704 in 2019 to 57,198 in 2021 and remained stable in 2022, while the amount of fish caught in metric tons by commercial fisheries remained stable at around 206-269 mt from 2019-2021 and increased to 359 mt in 2022.

Discussion

It was clarified that the U.S. commercial fisheries operate in the U.S. EEZ, while the U.S. recreational fisheries operate in both U.S. and Mexican waters. PBF is not the major target for the purse seiners, and this likely accounts for the variability in their PBF catch. Many hook and line vessels that previously targeted Market Squid and other pelagic species have switched to targeting PBF since 2020, resulting in an increase in the catch. The increase is also observed in recreational fisheries after 2020, due to the increase in market price, higher demand, and greater availability.

M. Dreyfus from Mexico presented the latest catch information for Mexican fisheries. All catch of PBF is obtained by the purse seine fleet, which traditionally focuses on yellowfin tuna (YFT), but with 4 to 6 vessels participating in the PBF fishery. All catch is transported alive to pens located in Baja California. The catch in 2021 was 3,181 tons and in 2022, 3,400 tons.

Discussion

It was noted that the competition among the farming companies from purse seiners resulted in a change in the fishing season, with the season shifting from quarter 2 to quarter 1. As quota is not assigned to farming companies, the fish are harvested under competition among farming companies.

SK. Chang from Chinese Taipei presented the latest catch information of the Chinese Taipei fisheries. The total catch of PBF from Taiwanese coastal and offshore fisheries (mainly from the longline fishery) reached 3,089 mt in 1999 but continuously declined to the lowest record of 214 mt in 2012. Thereafter, the catch slowly recovered and remained at the level of 400–550 mt during 2014–2019. Then, the catch jumped up to 1,154 mt in 2020 and reached 1,475 mt in 2021 and 1,497 mt in 2022. The number of registered PBF vessels fluctuated between 480 to 560 in the last ten years. The average size of PBF was around 212–220 cm before 2008; thereafter, the average in the North region was stably maintained at 218–224 cm during 2008–2022. Meanwhile, in the South region, the average size gradually increased to 235 cm in 2012 and declined to about 210 cm during 2020–2022. From the size data, the substantial increase in average size in the South in the early 2010s was due to a decline in the catch of small adult fish, and the decrease since 2013 was a response to more small adult fish recruited to the region.

Discussion

The PBFWG reviewed the recent amount of retained catch by Chinese Taipei longline fisheries, which showed an increase in catch since 2020. The catch level for 2021 and 2022 was similar. One member raised a question regarding the reason behind the increase in longline catch and whether it was associated with a change in the catch limit. It was noted that the catch limit had not changed for 2020-2021 and had increased in 2022, and that the catch amounts were still much below the catch limit.

The PBFWG members were interested in the mechanism leading to the decrease in the mean size of the longline catch in the southern fishing ground since the mid-2010s, as this area accounts for most of the catch for this fishery. It was pointed out that the recent fishing effort had been concentrated more in a smaller area in the southern fishing ground. Members asked if the shift in effort caused the decrease in the mean size. Further discussion was held under agenda 2.3.

2.1.2. Unseen Catch

Korea launched a new monitoring program this year to understand the discards from setnet fisheries. The results will be presented at the next meeting. Japan observed about 100 mt of discards in 2022. However, this amount of observation accounts for 1% of the national catch limit for Japanese fisheries and did not represent the whole sector. The estimates for dead discards in the WPO were assumed to be 5% of observed fish in the assessment model, and this will be the default approach for the next assessment unless further information is provided. The U.S. estimated the dead discards by using the reported number of fish released and mortality rate estimated using meta-analyses from national recreational fisheries. This will be the default approach in the next assessment. Discards are not an issue in Chinese Taipei’s longline fisheries as there is still a substantial amount of uncaught quota.

2.2. Abundance index

HW. Park presented ***CPUE standardization of Pacific bluefin tuna from Korean offshore large purse seine fishery*** **(ISC/23/PBFWG-1/04).** The CPUEs for Pacific bluefin tuna (PBF) from the Korean offshore large purse seine fishery (2004-2022) were standardized using Generalized Linear Models (GLMs). The data used for the CPUE STD included vessel id, fishing date, location (1 by 1 degree), effort (no. of hauls), and catch weight by species. We applied cluster analysis to address concerns about target change over time, which can affect CPUE indices. The standardized CPUEs had large fluctuations and have showed an increasing trend in recent years.

<u>Discussion</u>

It has been clarified that the same CPUE standardization method used in the last stock assessment for Korean purse seiners was used again. This CPUE index was included in the assessment model but was not fitted in the likelihood estimation. It was noted that the Korean purse seiners target small pelagic fish, and some vessels switch to PBF around March when PBF migrate to Korean waters depending on the amount, which explains the annual variability in the species composition. The fishing season for the common mackerel TAC has changed, starting in July and ending in June of the following year. The PBFWG suggested including size information in the CPUE standardization to account for the size change observed in 2022. **The WG agreed to treat the CPUE in the same manner as the last assessment.**

SK Chang presented ***CPUE standardization for Taiwanese PBF fisheries using delta-GLMM and VAST, incorporating SST and size data*** **(ISC/23/PBFWG-1/02).** Three model designs were applied for PBF CPUE standardization: traditional delta-GLMM with SST effect, VAST with SST effect, and VAST incorporating size data. The standardized CPUE series did not show obvious differences from traditional delta-GLMM with or without SST effect. The VAST incorporating size data (converted to seven age groups) suggested that the South region has a much higher density than the North, but the general trends are similar for both regions except for the latest one or two years for age groups older than 15 years old, and age group 9-11 was the most dominant fish, followed by the 6-8 age group. Relative CPUE series from GLMM and VAST with SST were compared and suggested that the two series in the South region have a similar trend, with the VAST series having a higher CPUE in the beginning of the series (2007) and in the later part of the series (after 2019). Relative CPUE from VAST incorporating size data showed a relatively smoother trend compared to VAST with SST and higher CPUEs in the latest two years (2021 and 2022). All the standardized CPUE series suggested a decreasing trend from the beginning of the data series to the lowest level in 2011–2012 and a recovery thereafter to the recent year.

<u>Discussion</u>

It was pointed out that the observed change in the fishing effort by longliners to more coastal waters in recent years was not correctly weighted using the GLMM method. Using the core area dataset in the GLMM would result in overweighting in this density area and is therefore not recommended. Instead, the spatial-temporal VAST method should be used to appropriately weight the CPUE by area.

The PBFWG suggested including the effect of the size change in the CPUE analyses as follows. The index developed using VAST should be based on the whole area to ensure local area trends do not bias the results. Investigations should be made into the reason for the two modes in the length composition data of the Chinese Taipei longline fishery. For example, clustering methods like the Tree analysis used in the IATTC. In particular, spatial, monthly, and spatial-seasonal interactions should be investigated to determine how the fisheries and index should be modeled. The following points may need to be re-evaluated: length compositions for the fisheries and the index should be developed separately, i.e., the fisheries' length compositions should be spatially weighted by catch, and the index composition data should be spatially weighted by the CPUE. Length composition data is not needed for the full period, but separate analyses may be required for the CPUE and for the length compositions. The WG encouraged the results of further analyses to be presented at the data preparatory meeting in the fall.

K. Fujioka presented ***Recruitment abundance index of immature Pacific bluefin tuna, derived from real-time monitoring survey data of troll fisheries*** **(ISC/23/PBFWG-1/03)**. In this study, we provided a recruitment abundance index of Pacific bluefin tuna using real-time troll monitoring (RTM) data instead of a traditional index based on sales slip data. The standardized CPUE based on RTM data was calculated by a Vector Autoregressive Spatio-Temporal (VAST) model, which is a delta-generalized linear mixed model that separately calculates the encounter probability and the positive catch rate, as described in Fujioka et al. (2021, 2022). The estimated index for 2011-2022 showed a similar trend to the index based on traditional sales slip data for the overlap period (2011-2016). In addition, the IQ-Independent scientific survey by monthly chartering of RTM vessels began from the 2021 fishing year (Fujioka et al., 2022). The estimated indices with and without this chartered RTM data were almost identical, and CV values were small when including the chartered RTM data. Therefore, the recruitment indices for two time periods presented in this study, 2011-2022 (the full RTM period) and 2017-2022 (the period of tightened fishing regulations), would be candidates for input into the stock assessment model in the next assessment.

Discussion

A member asked whether the regulation had any impact on the real-time monitoring survey, as well as the traditional troll index. The response was that both recruitment indices are subject to the regulation, but they use different data sources. The traditional troll fisheries use sales slips, which do not contain release information or zero catch records. Meanwhile, the real-time monitoring survey records release information and includes zero catch records. The data collection for real-time monitoring was strengthened through the introduction of the charter arrangement. It was suggested that the effect of the month and area interaction in VAST should be included in the catchability component rather than the component of the spatial-temporal variation of abundance.

The PBFWG also discussed how to handle the overlapping years between the traditional troll index and the real-time monitoring index in the assessment model. **The PBFWG agreed to validate the real-time monitoring recruitment index during the 2024 benchmark stock assessment, and the handling of the overlapping years will be decided accordingly.**

Discussion of Japan longline CPUE:

It was clarified that the time series of the Japan longline CPUE index was used till 2019 after which the IQ introduction changed the operation strategy. Japanese scientists are currently working to investigate additional information to develop another Japan longline index based on interview data. During the discussion, it was suggested that the CPUE index should include the size of the fish caught in the standardization process. However, due to data constraints, logbooks do not have any record of individual size data. Therefore, incorporating size data in the CPUE standardization is not feasible. It was suggested that including the average size in the CPUE analysis should be considered.

A. Tawa presented ***Annual indices of Pacific bluefin tuna larvae standardized by the Vector Autoregressive Spatio-Temporal model based on 2011 to 2021 larval survey*** **(ISC/23/PBFWG-1/05)**. The larval abundance obtained by the larval survey from 2011 to 2021 was standardized by the Autoregressive Spatio-Temporal (VAST) model to create a fishery-independent index of the spawning stock biomass of Pacific bluefin tuna in the Nansei area. Length frequency data showed a clear bimodal shape. The size of sampled individuals has large influences on larval abundance due to the high mortality rate during the larval stage. Therefore, the VAST model considered catchability by larval size (large and small larvae separated at the threshold of 4.55mm). The scaled abundance index for large larvae has the lowest value in 2012FY, and after that it showed a gradual increasing trend until 2020FY and a remarkable drop in 2019. On the other hand, that for small larvae showed a relatively unstable trajectory with two peaks, one in 2013FY and one in 2018FY. Due to a smaller number of collected samples in small size and the fluctuating trend, only the index for large larvae was compared to the abundance indices currently used for the assessment. The general increasing trend since around 2010FY coincided with that in current indices (Japanese and Chinese Taipei longline CPUE), but the degree of increase was more noticeable for the larval index. Also, the large increase from 2018 to 2020 is somewhat concerning. The current standardization by VAST did not take into consideration the timing of the survey or the environment. This may disturb the estimation of spatial effects. Discussion on how to incorporate the larval index into the assessment model is necessary. For example, whether the relationship between the SSB abundance and larval abundance is linear or not. The selectivity issue should be discussed as well.

Discussion

The question was raised as to whether there are other factors that should be considered when standardizing the Japan larval index to explain the drastic fluctuation from the 2018 to 2020 FY value. It was recommended that further research be carried out to investigate this matter.

2.3. Size data

Discussion of Japan longline size

It was observed that the catch at size by Japan longliners was divided into two groups: the southern part of Japan, which catches larger PBF, and the northern part of Japan, which catches smaller adult PBF. A question was raised regarding whether catch records can be sorted by port to match the size patterns. It was clarified that the logbook does not contain landing port information.

Discussion of Korea purse seine size

A member asked if there are differences in size composition by quarter. The response was that the major fishing season for Korean purse seiners is in quarter 1 and some of quarter 2, while the common mackerel fishing seasons are in quarters 3 and 4. Additionally, it was noted that the PBF fishing season for Korean purse seiners differs from that of Japan's small purse seiners, which occurs in quarter 2 starting in May.

In response to questions about size sampling methodology and whether information on sample sizes is available, it was explained that the size composition data are measured by 1 cm, but the figure is drawn using size bins of 10 cm. Sampling was conducted by port samplers and fish purchased at the market, and the samplers attempted to measure all PBF.

Discussion of U.S. commercial and recreational size

HH. Lee presented ***Length and Weight Data Analyses for Commercially Landed Pacific Bluefin Tuna in the U.S. West Coast EEZ*** **(ISC/23/PBFWG-1/06)**. This study aims to analyze the size compositions of U.S. commercial fisheries by examining the length and weight data collected by both the California Department of Fish and Wildlife for the purse seine (PS) fishery and the West Coast Region observer program for the large-mesh drift gillnet (DGN) fishery. The length frequencies of the U.S. PS and DGN fisheries were compared to the recreational length samples, while the catch-at-size data of the Mexican PS was used to compare the size frequency of the U.S. commercial landings. Results show that the U.S. PS and DGN fisheries caught more similar fish sizes to each other than those caught by the Mexican PS fleet (when overlapping). Comparing U.S. commercial fisheries to the recreational fishery revealed that similar size classes were landed, but the relative importance varied over time and there was no consistent pattern. Regularly monitoring the importance of the U.S. commercial fisheries ensures the assessment model reflects the size of fish caught by the important fisheries.

Discussion

The PBFWG acknowledges the new information on the commercial size data and agrees with the recommendation made by the authors that the U.S. commercial size data will not be included in the stock assessment unless the importance of the fisheries increases. How to model the size composition for US commercial fisheries will be further considered in the upcoming assessment. A member asked about the larger size of PBF caught by U.S. recreational fisheries in 2022 compared to 2021. It was clarified that the mechanism behind this pattern is unknown, but it is not related to the sampling methodology.

Discussion of Mexico purse seine size

The sampling method has not changed for Mexico. Size data are obtained using underwater stereoscopic cameras. Based on preliminary results, the average size across 5,000 samples in 2022 was 123 cm (45 kg).

Discussion of Chinese Taipei longline size

The PBFWG inquired whether the change in mean size had any spatial effect. Additional analyses were conducted by dividing the south region into two parts: one between 20N-24N and another south of 20N during 2010-2022. These analyses suggested the change in size is not associated with latitude. More analyses suggested by the member described in the previous section will be provided in the next meeting.

3. POSSIBLE AREAS OF CHANGE IN THE ASSESSMENT MODEL

3.1. Input data

3.2. Assessment Model assumption and structure

3.3. Future Projection

S. Asai presented ***Alternative input data bin format of length-composition from Japanese longline fishery for robust estimation of its selectivity*** **(ISC/23/PBFWG-1/07)**. This document discusses an alternative input data bin format for the length-composition from the Japanese longline fishery used in the PBF stock assessment model. In the alternative input data, the bin width was changed from the current one to a 2 cm width for all bins, 16-290 cm FL. The uncertainty in selectivity parameters estimated by the Pacific bluefin tuna SS3 short model using this alternative input data showed results similar to the current base case in terms of standard deviations, and those were not sufficient improvements. The results in this document suggest that using input data with a finer length bin can improve the fit to the data, but more consideration is needed for optimal parameter estimation.

Discussion

A working group member asked if the stock assessment with the finer length bin resolution has a longer estimation time. The author replied that the assessment run time is the same as for the coarser length bin model. It was also clarified that the analysis used the short assessment model starting in 1983, and that it still needs to be assessed if using a finer length bin resolution would result in a longer run time for the early start assessment model.

Another WG member asked if the increased spikiness of catch-at-size estimates from the finer length bin resolution model is real or an artifact. It was noted that it is expected that using a finer length bin would lead to noisier but more informative data. It was also clarified that the analysis was carried out to improve the selectivity estimation of the longline fleet in the assessment. The descending limb for the Japanese longline selectivity curve is quite uncertain due to limited observations of very large bluefin, and one aim of the analysis was to increase the number of data points to improve the estimation of the selectivity parameters. Since the analysis did not improve the selectivity parameter estimation, the WG discussed potential causes and alternative solutions.

It was noted that around 2015 the size composition data showed a second mode of larger fish of ~210 cm in size. A WG member noted that if there are spatial differences in selectivity because of ontogenetic changes in the availability of fish, use of time-varying selectivity could be considered, but then use of this fleet as an index of abundance becomes problematic. **The WG group agreed that the Japanese longline index is an important source of information on population scale in the model, and that use of the index is prioritized over fits to the size composition data.** It was also clarified that there is no spatial composition data for the Japanese longline fleet so that the size composition data cannot be weighted by the CPUE. However, the size data was assigned to 5 prefecture strata to partially reflect spatial differences in the size of fish caught. **The WG encourages further analysis of the selectivity issue for the Japanese longline fleet.**

H. Fukuda made an oral presentation entitled Some considerations about the abundance index related matters for PBF assessment. This ongoing research evaluates the suitability of the relative index of abundance for large PBF in an objective manner. The consistency between catch-at-age and each terminal index of adult PBF abundance was evaluated using an age-structured production model, which was fitted to catch and an adult terminal index from either Japanese longline CPUE, Chinese Taipei longline GLMM CPUE, or Chinese Taipei longline vast CPUE. Also, likelihood profiles over the fixed size selectivity parameters (peak of the double normal or inflection of the asymptotic selectivity) were calculated to evaluate consistency between the index trend and selectivity. The Japanese longline index showed consistency with catch-at-age data given estimated selectivity based on observed size data. On the other hand, the indices of abundance from Chinese Taipei longline CPUEs were somewhat inconsistent with catch-at-age, although this showed some improvement when selectivity was assumed as smaller size than estimated based on the observed size composition data. Given the range of the fish size caught by the Chinese Taipei longline, the index of abundance standardized by the vast model might be more suitable than that of the traditional GLMM index. Since the analysis shown was not fully structured, further analysis based on hypotheses, modeling, and performance measurement is required.

Discussion

A WG member suggested that the RMSE metric should be computed over the same time frame. It was also suggested that the analysis be re-run using ASPM-R rather than ASPM, as the lack of fit might be due to recruitment variability. Finally, it was advised that the analysis be re-run with a time-varying selectivity for the Japanese longline fleet while the models are fit to the Chinese

Taipei longline. It was also suggested to try using dome-shaped selectivity for the Chinese Taipei longline after 2016 by using a time block to address the inconsistency between the index and size composition. However, using the new spatio-temporal standardization for the Chinese Taipei index integrating the size data might remove the need for using a dome-shaped selectivity. It was also discussed that having a plus group from age 20 onwards reduces the information to inform the shape of the selectivity curve (dome-shaped or asymptotic). Finally, it was suggested that potential MSE uncertainty scenarios could look at alternative selectivity formulations in the operating model to generate different hypotheses for the recent lack of large fish in the Chinese Taipei longline (e.g. fished out or availability change) and test the robustness of the management procedure to those changes.

General discussion

The WG also noted that CPUE indices developed with updated spatio-temporal modeling methods will be used for the Chinese Taipei longline fleet.

There was a discussion of the tradeoff between better fit to the size composition data from different fleets and increasing the number of selectivity parameters. It was also suggested that the next benchmark be based on the short assessment model. It was noted that while the population scale does not change when using the short model, some required management outputs such as the median SSB reference point are derived from the early start model timeseries. However, now that the stock appears to be rebuilt past the second rebuilding target, there might be no need to estimate this reference point in the future. It was also highlighted that the future projections re-sample recruitment derived from the early start model. **The WG agreed that more discussion on the potential use of the short assessment model is needed.**

A WG member suggested that the future projections could be done with Stock Synthesis rather than the current PBF-specific projection software. **The WG agreed that undertaking further analysis to compare SS3 projections with the SSFuture program would be useful.** For instance, one could compare the prediction skill of both methods for some period in the past. It was also noted that SS3 assumes that the full quota is caught, and that further discussion on which recruitment option to select when using SS3 is also needed.

A WG member also mentioned that in preparation for the assessment meeting, the WG could assess if the best practices for tuna assessments presented at the recent CAPAM meeting are being met and use those to make recommendations for future work. The report from the workshop will be ready for the IATTC SAC meeting in May. **The WG agreed to present diagnostics at the next meeting for the short assessment, according to best practices, and to review if best practices are met.**

4. WORK PROGRESS IN PBF MSE

4.1. Operating Model

4.1.1. Uncertainty Grid

HH. Lee presented ***Evaluating productivity parameter uncertainty using the age-structured production model diagnostic with recruitment*** **(ISC/23/PBFWG-1/09)**.

Management strategy evaluation (MSE) evaluates how robust a feedback-control management strategy is to uncertainties using forward simulation. These uncertainties include process uncertainty, parameter uncertainty, model uncertainty, data and observation systems error, and implementation uncertainty. Among these uncertainties, the productivity parameters, length at age 3, natural mortality for age 2 and older, and steepness of the stock-recruitment relationship, greatly impacted the historical trajectory of Pacific bluefin tuna spawning stock biomass in the 2022 assessment. Potential combinations for the values of these parameters are enormous, and some combinations may not be plausible for the stock, given the fishing history and life-history traits. A plausible uncertainty grid for productivity parameters was selected based on the following steps. We first selected the range of productivity parameters based on the data and life-history information. We then showed that the age-structured production model diagnostic with recruitment (ASPM-R) is a valuable tool for selecting productivity combinations. The PBF model prefers larger length at age 3 and higher natural mortality for age 2 and older than the base values. The larger the length at age 3 and natural mortality for age 2 and older are, the broader range of potential steepness parameters selected. Last, we eliminated low productivity assumption that created low depletion levels not consistent with the history of the PBF fishery. The final combinations were candidates for the uncertainty grid for the MSE operating model(s).

Discussion

It was asked if model tuning, e.g., jitter analysis, was conducted for each run in the presentation. The author responded that each run was not tuned in detail because the aim of this analysis was to see overall trends when having alternative parameter values. However, it was investigated whether each model converged or not.

T. Ishihara presented ***Estimation of confidence intervals for the von Bertalanffy growth function parameters using the bootstrap method with a data set of direct age estimates from otoliths*** **(ISC/PBFWG-10).** To evaluate the uncertainty in the growth of Pacific bluefin tuna, we estimated 95% confidence intervals (CI) for each parameter of the von Bertalanffy growth function (VBGF) and the estimated body length at 3 years of age using the bootstrap method, based on length-at-age data from otolith observations. Three different procedures for two sets of samples, totaling six cases, were tested in the bootstrap method, including stratification of the data set and trimming of infrequent data. The results showed that the 95% CI for the asymptotic length and the fork length (FL) at 3 years of age were within ± 2 cm for all cases. These results indicated that the length-at-age data used for the estimation of the growth of Pacific bluefin tuna provided consistent information regarding the growth rate and asymptotic length and the procedure of the sampling (resampling) did not affect critically the growth parameter estimation.

Discussion

It was clarified that the observation data for this analysis have precise age data with the first decimal digit by including birth date information.

Discussion on uncertainty on growth

The WG discussed how to incorporate the uncertainty in the growth curve based on the two presentations. Although the log-likelihood values showed a preference for having larger L2 values, e.g., 126 cm, and thus larger Linf values, e.g., 267.2 cm, it was questioned whether such larger L2 values are plausible in terms of the biological study. Based on the actual observations by otolith, there are few fish which are larger than 260 cm. A participant suggested using the Richards curve as a growth function, as it is generally flexible for fitting the data. It was clarified that using the Richards curve would be a possible way to consider the uncertainty in growth, but the Richards curve had been applied during the 2016 assessment process, and the results showed no difference from the current growth curve with the von Bertalanffy function. It was noted that there could be aging errors in the growth curve, but the age assessment conducted by multiple aging readers to verify the results can reduce the aging error. The author later presented the results of a comparison between the estimated growth curve and mean length-at-age data calculated quarterly. It was confirmed that the mean length at age conformed to the current von Bertalanffy curve. **The PBFWG concluded that neither the alternative growth curve function nor the current von Bertalanffy curve is a major source of uncertainty for this assessment and agreed not to include it as one of the uncertainty axes for the MSE.**

Uncertainties in natural mortality (M) and steepness (h)

It was recommended that the estimated M proposed by Hamel's empirical approach based on the maximum age should be used as the basis of uncertainty in M. The oldest observed PBF to date is 28 years old, and hence, M of 0.193 for older ages was the candidate value as the basis of uncertainty. **It was agreed to apply the Hamel method (2023), and a detailed analysis will be reported in the future.** It was pointed out that the exercises using ASPM-R showed that models with low M were less likely to be selected under various uncertainty settings. Because the suggested range will evaluate only lower M than the current setting, it was pointed out that the higher M may need to be evaluated to make the uncertainty grid acceptable to people outside of the PBFWG.

The PBFWG also discussed the uncertainty in the current M schedule and the potential use of the Lorenzen curve to estimate M at younger ages in the OM. The setting for M and steepness (h) will be related to the setting in the assessment model, and diagnostics in the assessment model with current M and h assumptions did not show any remarkable negative signs except for the retrospective analysis. **The PBFWG, therefore, will continue the discussion for those uncertainties**.

Uncertainties other than Parameter uncertainty

The PBFWG also discussed uncertainties derived from sources other than parameter uncertainty, i.e., process uncertainty, model uncertainty, errors in observations and implementation error. A participant clarified that some of those uncertainties have already been taken into account in the MSE framework by using future recruitment deviations (process uncertainty), error structure in the data generation routine, and the use of an estimation model (observation error). The implementation error will be related to the calculation of the MP, and hence it is not necessary to consider it for OM development.

The uncertainties related to selectivity and data were further discussed. It was discussed whether the base-case selectivity setting for the Chinese Taipei longline operating in the South should be asymptotic (status quo) or dome-shaped (see section 2.3). A participant pointed out that the selectivity setting will be addressed in the next base-case assessment, and the setting in the MSE should follow the decision for the base-case model. It was clarified that current simulation runs to evaluate the HCR did not use the recruitment monitoring index but assumed that the old sales slip index would remain available in addition to the Japanese and Chinese Taipei SSB longline indices. Because the performance of the recruitment monitoring index is not fully evaluated in the assessment model due to its short time series, it was recommended that when it is included in the MSE, an OM having a larger CV for this index should be considered as a robustness test.

Uncertainty grid and OM weighting.

The PBFWG discussed the width of the envelope consisting of multiple OM trajectories and the number of OMs within the envelope, which relates to the OM weighting. The removal of implausible assumptions for the uncertainty grid would make the envelope narrower. On the other hand, the inclusion of many assumptions with equal weight for all OMs would lead to relatively low weights for every OM. A participant suggested that the log-likelihood (LL) in the conditioning period and other diagnostics for each OM can be used to select plausible models and for the discussion of OM weighting. It was also pointed out that the correlation of future trajectories between the OMs can be an indicator to reduce the weight of OMs which have similar information. The PBFWG recognized the importance of diagnostics, e.g., R0 profile, to select a candidate set of OMs. However, the OM weighting will be subjective unless the criteria to decide whether each diagnostic is good or not are agreed prior to conducting the diagnostics. **The PBFWG tentatively agreed that OMs to be included in the MSE should show satisfactory diagnostic performance with the assumption that they will be used with equal weighting and requested that a suite of diagnostics be conducted for models in the proposed uncertainty grid.**

K. Nishikawa presented ***Cause of the high fluctuation of SSB in base case OM*** **(ISC/23/PBFWG-1/11)**. In the PBFWG meeting held in November 2022, the calculation results from the base case OM were shown. The PBFWG raised concerns regarding larger than expected fluctuations in the future trajectories of TAC and SSB. To clarify the cause of these large fluctuations in the base case OM, the output of the base case OM was examined. During the assessment period, the number-at-age time-series showed that a stronger cohort was more heavily caught at a young age than weaker cohorts. It suggested that a strong year class was exposed to stronger fishing mortality than weaker cohorts, and thus it disappeared quickly. On the other hand, the catch in the projection period was assigned to each fleet to be consistent with the currently introduced catch upper limit. Due to the constant catch scenario without time-varying selectivity, F during the projection period was negatively correlated with the recruitment size. Therefore, recruitment fluctuations during the projection period can be maintained even at age 10.

Discussion

It was clarified that cohort targeting is not being considered, not only for the MSE but also for projections in the current assessment. It was questioned if cohort targeting occurs even when fishing mortality is low due to strict management. It was responded that the relatively strong 2016 year class was targeted after strict management and that the cohorts after 2017 have not been appropriately evaluated because the recruitment index was not available for that period in the assessment. The PBFWG recognized that the projected trajectory by Stock Synthesis in the MSE simulation does not take cohort targeting into account, and therefore, the variation of SSB tends to be larger than what is expected.

It was noted that future recruitment in the MSE simulation is randomly generated in accordance with the value of sigma R, which is set at 0.6 in the assessment. It was asked if autocorrelation is introduced into future recruitment. It was responded that in the past analysis, it was found that there is no clear autocorrelation structure in estimated recruitment to date. Therefore, it is unnecessary to consider autocorrelation in future recruitment. The PBFWG recommended continuing to monitor the size frequency data in the future to evaluate whether cohort targeting occurs.

4.1.2. Data Generation

There was no discussion.

4.1.3. OM Output

D. Tommasi presented ***Calculation of Fishery Impact Performance Metric for the Pacific Bluefin Tuna Management Strategy Evaluation*** **(ISC/23/PBFWG-1/12)**. The Western and Central Pacific Fisheries Commission of the Northern Committee (WCPFC NC) and the Inter American Tropical Tuna Commission (IATTC) requested, via the Joint Working Group (JWG), that the ISC PBF working group develop a Management Strategy Evaluation (MSE) to help inform the development of a long-term management strategy for PBF (JWG 2022). As part of the MSE process, the JWG proposed a list of operational management objectives and performance metrics with which to evaluate the performance of potential management strategies for Pacific Bluefin tuna (JWG 2022, Annex E). One of the proposed objectives for yield was to "Maintain a proportional fishery impact between the WCPO and EPO similar to the average proportional fishery impact from 1971-1994". Here we detail how this performance metric is calculated for the PBF MSE and present preliminary results of the fishery impact metric for one of the proposed management strategies for PBF.

<u>Discussion</u>

Showing impact plots from OM output is important to facilitate the discussion of one of the candidate management objectives. It was clarified that the impact by area can be changed by adjusting the relative Fs, which refers to Fs during 2017-2019. It was noted that there are few differences in the future impact by area across the current HCRs. The increase in calculation time is negligible because a calculation for the impact plot is conducted after the final iteration. It was noted that the future impact will be affected by the change in selectivity, which might be expected with increasing TAC. Hence, the evaluation of future impact should be done carefully in terms of the selectivity change. If the future impact ratio is specified by stakeholders, appropriate adjustment for relative Fs for WPO and EPO needs to be sought and then simulated.

4.2. Management Procedure

4.2.1. Estimation Model

N. Takahashi presented ***Considerations of the Use of SS3 ASPM-R as an Estimation Model in PBF MSE*** **(ISC/23/PBFWG-1/13)**. This document is a discussion paper that briefly reports simple comparisons of performance between full SS3 and ASPM-R when using these models as the estimation model (EM) in the PBF MSE. The use of ASPM-R and ASPM-R fitting to size composition data can reduce computation time (1/5 by ASPM-R fitting to size data and 1/20 by ASPM-R). Although trajectories of future TAC based on results from the EM of ASPM-Rs somewhat diverged from that of full SS3, TACs appeared to be determined according to the SSB trend. ASPM-R showed better performance than ASPM-R fitting to size in this regard. For the exploratory purpose of testing candidate management procedures, the use of ASPM-R as a tentative EM merits consideration to reduce computation time in the course of the PBF MSE process.

<u>Discussion</u>

The ASPM-R usually estimates stock dynamics using catch and indices without size frequency data. However, SSB levels estimated by the usual ASPM-R over the conditioning period differed from the assessment result estimated by the full Stock Synthesis model primarily due to changes in the estimation of recruitment deviations. This is why the ASPM-R with a log-likelihood function of size frequency data (ASPM-R w/ size) was tested: to enable the estimation of recruitment deviations using both index and size data as in the base case model. The ASPM-R w/ size showed similar SSB levels to the base case model. Also, while the usual ASPM-R showed different SSB levels for past stock dynamics, the TAC levels and SSB from the OM in the future did not diverge when the base case model (SS) or ASPM-R was used as an EM.

It was noted that the composition data influenced the estimates of absolute abundance. Therefore, it would be useful to include EMs with and without the composition data. It was suggested that the ASPM-R fitting to composition data (with fixed selectivities) could be used as a computationally efficient representation of the full SS model to reduce run times. Using only the Chinese Taipei longline composition would be preferable if the model produces results similar to the full SS model; otherwise, further investigation is needed to determine what composition data needs to be included. Japanese scientists continue exploring better specifications of ASPM-R while waiting for the decision regarding the number of HCRs.

4.2.2. Harvest Control Rule

D. Tommasi presented ***Performance of Candidate Model-based Harvest Control Rules for Pacific Bluefin Tuna* (ISC/23/PBFWG-1/14)**. The Western and Central Pacific Fisheries Commission of the Northern Committee (WCPFC NC) and the Inter American Tropical Tuna Commission (IATTC) requested, via the Joint Working Group (JWG), that the ISC PBF working group develop a Management Strategy Evaluation (MSE) to help inform the development of a long-term management strategy for PBF (JWG 2022). As part of the MSE process, the JWG proposed a set of candidate reference points and associated model-based harvest control rules (HCRs) to be evaluated using MSE (WCPFC 2019, Annex F). The total number of candidate HCRs to be tested is 115. It would not be feasible to timely evaluate all these HCRs in an MSE simulation that includes an estimation model due to long run times. We therefore evaluate the performance of these HCRs in a faster MSE simulation with no estimation error to guide the selection of a subset of HCRs for evaluation in an MSE simulation with an estimation model.

<u>Discussion</u>

The PBFWG expressed concern about the large number of HCRs and attempted to propose a reduction in the next JWG based on the performance indicators. To facilitate this reduction, a cluster analysis or principal component analysis might be useful to identify groups of HCRs with similar performance in terms of multiple axes of performance indicators. It was pointed out that HCR 1b, which is assumed to be more stable in terms of TAC variation, was not really stable compared to HCR 1a. **The PBFWG agreed to suggest the exclusion of HCR 1b in the JWG.**

Regarding the biomass status performance indicator, a participant suggested that the indicator should be biomass values corresponding to target F levels in each OM. It was also suggested to output a probability of SSB falling below a certain biomass level, which is biologically undesirable (e.g., 5 or 7.7%), as an indicator of safety. It was pointed out that the performance in safety was not affected by the difference in minimum F. **Therefore, the PBFWG also agreed to encourage the JWG to choose one minimum F.**

For further reduction of HCRs, the PBFWG requested the author to compare the results of HCR1 and HCR2 under the same management objective, i.e., the same target, threshold, limit, and minimum F. It was questioned if the 5% limit reference point is plausible for the stock. It was responded that this stock historically experienced such low status, and it is recovering, and therefore 5% is acceptable as a limit reference point. On the other hand, the PBFWG recognized that some combinations of reference points, e.g., target and threshold that are the same, would be impractical as they will induce frequent TAC changes.

In terms of the HCR3 requested by the JWG, which is a combined MP with a model-based HCR for large fish and an empirical approach for small-sized fish using a recruitment index, it was noted that this HCR can have the advantage of taking the most recent recruitment into account. However, it was pointed out whether the inclusion of one data point from the recruitment index would help to determine a TAC for 3 years. Also, the validity of the recruitment index from real-time monitoring has not yet been evaluated in terms of consistency with the other data sources. Considering also that introducing HCR3 needs further coding and that there is plenty of work to be completed for the MSE, the PBFWG will not develop HCR3 unless there is a strong instruction from the JWG.

A participant suggested that additional performance indicators for yield showing catch amount by small or large fish are important. **The PBFWG agreed to add catch by size as one of the yield performance indicators.**

The WG noted that ISC needs to provide an update of MSE work to the JWG to be held prior to ISC23. The WG reviewed the draft presentation for the JWG, aiming to introduce the MSE development to date by showing preliminary results and advancing discussion related to narrowing down possible HCRs. The WG will further refine the presentation intersessionally and asked the chair to contact the ISC Chair for his instruction on how the presentation will be authorized to be presented to the JWG before ISC23.

5. OTHER MATTERS

5.1. New Scientific Information Relevant to PBF

Y. Tsukahara presented the recent progress of Close-kin Mark Recapture (CKMR) in Japan. Japanese scientists have been conducting this study since 2015, and more than 20 parent-offspring pairs and 400 half-sibling pairs have been found in the samples so far. The kinship identification method for this analysis is now in preparation for publication. Finally, the CKMR data were evaluated using Stock Synthesis with CKMR data, which was modified from the original SS code.

Discussion

The WG congratulated the Japanese scientists for their development of CKMR for PBF to date. It was questioned how errors are included in kinship, and it was responded that currently no error structure is assumed for kinship data. However, the presenter is investigating approaches to address errors in kinship detection. The PBFWG encouraged Japan to continue its research.

5.2. Others

The PBFWG noted that the PBF catch table to be presented at ISC23 by the STAT WG needs to be quickly checked during the week of the Plenary.

SK Chang was elected as Vice-Chair of the PBFWG for his second term (2023-2026).

The WG tentatively agreed on the meeting schedule for 2023 as follows:

Data preparatory meeting: November 27-December 1, 2023, online

Stock assessment meeting: February 29-March 7, 2024, Taiwan or US

6. ADOPTION OF THE REPORT

The WG reviewed the draft report and adopted it after review.

7. ADJOURNMENT

The meeting was adjourned on March 24.

APPENDIX 1

INTERNATIONAL SCIENTIFIC COMMITTEE FOR TUNA AND TUNA-LIKE SPECIES IN THE NORTH PACIFIC OCEAN (ISC)

PACIFIC BLUEFIN TUNA WORKING GROUP INTERSESSIONAL WORKSHOP

21 March to 24 March 2023
Shinagawa Tokyo, Japan

INFORMATION AND DRAFT AGENDA

Meeting Objectives

The ISC Pacific Bluefin tuna working group (PBFWG) is planning to develop a package of Management Strategy Evaluation for Pacific bluefin tuna stock and fishery until early spring of 2025. In the previous intersessional meeting, the PBFWG developed a prototype framework of the PBF MSE, and listed several technical issues to be developed by the WG and management issues needed to be discussed at the IATTC-WCPFC NC Joint working group. In the present meeting, the PBFWG will confirm work progresses for those issues and develop a draft progress report of MSE to be submitted to the JWG meeting through the adoption by the ISC Plenary. The PBFWG is also scheduled to conduct the benchmark stock assessment in the early 2024. For that, the PBFWG review and discuss about the current model to list and prioritize the areas to be improved for the next assessment.

Draft agenda

1 Opening and Introduction
- 1.1 Welcome and introduction
- 1.2 Adoption of agenda
- 1.3 Appointment of rapporteurs

2 Data for the PBF MSE and Stock assessment
- 2.1 Catch
  - 2.1.1 Retained catch
    - *- The formal submission of input data for assessment is scheduled on December 31 2023. This is an opportunity for WG to informally go over the updated catch data (CY 2021 and 2022). Please, if possible, submit PBF catch in CY 2022 to Hiromu Fukuda.*
  - 2.1.2 Unseen Catch
- 2.2 Abundance index
  - *- Please present updated abundance indices with up to FY2021.*
- 2.3 *Size data*

-Please present updated size comps with up to FY2021 (if available)

3 Possible areas of change in the assessment model

-The next assessment is pl anned as a benchmark and, in principle, all aspects of the model structure, assumptions or data preparation method will be reviewed and changed for improvement. In the previous intersessional meeting, the WG recognized that several changes are obviously beneficial for the assessment model. This is an opportunity for WG to confirm the assessment model structure including possible areas of subject to changes.

- 3.1 Input data
- 3.2 Assessment Model assumption and structure
- 3.3 Future Projection

4 Work Progress in PBF MSE

- 4.1 Operating Model
  - 4.1.1 Uncertainty Grid
  - 4.1.2 Data Generation
  - 4.1.3 OM Output
- 4.2 Management Procedure
  - 4.2.1 Estimation Model
  - 4.2.2 Harvest Control rule

5 Other matters

- 5.1 New scientific information relevant to PBF
- 5.2 Others

6 Adoption of the report

7 Adjournment

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APPENDIX 3 LIST OF DOCUMENTS

Index	Title	Author
ISC/23/PBFWG-1/01	Update on Korean fisheries information of Pacific bluefin tuna and size distribution by Korean offshore large purse seine fishery	Hee Won Park, Haewon Lee, Sung IL Lee
ISC/23/PBFWG-1/02	CPUE standardization for Taiwanese PBF fisheries using delta-GLMM and VAST, incorporating SST and size data	Tzu-Lun Yuan, Shui-Kai Chang, Yi Chang
ISC/23/PBFWG-1/03	Recruitment abundance index of immature Pacific bluefin tuna, derived from real-time monitoring survey data of troll fisheries	Ko Fujioka, Saki Asai, Yohei Tsukahara, Hiromu Fukuda and Shuya Nakatsuka
ISC/23/PBFWG-1/04	CPUE standardization of Pacific bluefin tuna from Korean offshore large purse seine fishery	Hee Won Park, Haewon Lee, Sung IL Lee
ISC/23/PBFWG-1/05	Annual indices of Pacific bluefin tuna larvae standardized by the Vector Autoregressive Spatio-Temporal model based on 2011 to 2021 larval survey	Atsushi Tawa, Yohei Tsukahara, Hiroshige Tanaka, Taiki Ishihara, Hiroshi Ashida, Yosuke Tanaka
ISC/23/PBFWG-1/06	Length and Weight Data Analyses for Commercially Landed Pacific Bluefin Tuna in the U.S. West Coast EEZ	Huihua Lee, Heidi Dewar, Kelsey James, Michelle Horeczko, and Yuhong Gu
ISC/23/PBFWG-1/07	Alternative input data bin format of length-composition from Japanese longline fishery for robust estimation of its selectivity	Saki Asai, Yohei Tsukahara and Hiromu Fukuda
-	Withdrawn	
ISC/23/PBFWG-1/09	Evaluating productivity parameter uncertainty using the age-structured production model diagnostic with recruitment	Huihua Lee, Desiree Tommasi, Fukuda Hiromu, Kevin Piner
ISC/23/PBFWG-1/10	Estimation of confidence intervals for the von Bertalanffy growth function parameters using the bootstrap method with a data set of direct age estimates from otoliths	Taiki Ishihara, Hirosige Tanaka, Hiromu Fukuda, Atsushi Tawa, Hiroshi Ashida, Yosuke Tanaka
ISC/23/PBFWG-1/11	Cause of the high fluctuation of SSB in base case OM	Kirara Nishikawa, Norio Takahashi, Hiromu Fukuda
ISC/23/PBFWG-1/12	Calculation of Fishery Impact Performance Metric for the Pacific Bluefin Tuna Management Strategy Evaluation	Desiree Tommasi, Huihua Lee, Kevin Piner
ISC/23/PBFWG-1/13	Considerations of the Use of SS3 ASPM-R as an Estimation Model in PBF MSE	Norio Takahashi, Yohei Tsukahara, Hiromu Fukuda
ISC/23/PBFWG-1/14	Performance of Candidate Model-based Harvest Control Rules for Pacific Bluefin Tuna	Desiree Tommasi, Huihua Lee, Kevin Piner

APPENDIX 4

PBF MSE Stocktaking
March 2023

- **Bold** means generally agreed

1) Timeline for development
- **March 2023: Drafting feedback from the PBFWG to JWG.**
- **November 2023: Decide general structure of OM and Grids.**
- **(March 2024: Benchmark stock assessment, which is also to be used for OM)**
- **November 2024: Decide all the specifications (Model weighting, MP(s), performance indicators…)**
- **April 2025: Confirm the results of MSE**

2) Data for MSE (will be discussed and evaluated through the 2024 stock assessment)
- **Data for OM Conditioning: Data up to 2022FY (basically identical data set with 2024 stock assessment) will be used.**
- **Data for 2026 TAC calculation by MP: Data up to 2023 FY (for model-based approach) ~~and 2024 FY (for index-based approach; if available)~~ will be used.**
- Deadline of the data submission will be similar with an assessment schedule.

3) Specification of operating model including uncertainty grid
- **Using short-term model starting from 1983 fishing year**
- Elements for uncertainty grid: Biological assumption (~~Growth: VB and Richards,~~ Natural mortality based on maximum age + Lorenzen curve, various steepness => use model with satisfactory diagnostic performance)
- Recruitment index and adult SSB index variation to be tested as robustness test.
- Observations (Index) and Implementation (unseen mortality) errors to be tested in MP implementation.
- Elements for robustness test (selectivity change or shape, recruitment drop)
- OM plausibility weighting: will be discussed after agreement of uncertainty grid (tentatively equal weighting for equally plausible OMs with satisfactory diagnostics)
- **Catch in number in data file will be replaced by the estimated catch in weight**
- Assume time in-variant selectivity for conditioning OM with time blocks
- Reference year for the fishing pattern in the future projection: use the recent period, e.g. 2017-2019 (to be updated for final presentation). ~~Consider adding time varying selectivity?~~

4) Estimation model regarding the type of models and management procedure
- Type of estimation model: ASPM-R for early sorting of HCRs and maybe full SS3 (or ASPM-R fitting to size data (large adult only?)) model for final analysis?
- Type of management procedure: model-based. Empirical approach is not considered at this time. ~~Features of two types of MPs be presented to stakeholders for their input.~~

5) Exceptional circumstances.
- Further consideration is necessary together with OM grid. In general, situation which is not evaluated in MSE, e.g. lack of index and cohort targeting.

6) HCR

- HCR procedure will be implemented as specified rather than using as tuning target to avoid complication.
- Less than 10 MPs is desirable for the scientists to prepare the materials for introduction in time.
- Inform stakeholders sigmoid HCR (HCR-1b) would likely not perform differently from HCR-1a. Also inform stakeholders HCR-1 and HCR-2 with a same target would not perform differently.
- JPLL not used for MP testing.

7) Impact

- ~~If fishery impact is a control parameter to allocate TAC in the feedback loop, further modules will be required outside of current feedback loop.~~
- ~~Some derivatives from the estimation model, e.g., fleet specific SPR, could be an indicator of fishery impact, which can be calculated in the current framework~~.
- WPO/EPO impact plot can be prepared post-hoc of MP implementation but not as tuning criteria.

8) Performance indicators

- Safety: Probability of SSB < SSB_{LRP}[5-20%]
- Status: Probability of F <= F_{target}[50%]
- Stability: Less than [15%] change of catch limit. Since most of current HCRs show larger change in TAC than 15% at least once, stakeholders need to consider if a built-in limit for change in TAC is necessary.
- Yield: Impact ratio [SPR/Traditional impact] and expected annual yield for size and area (large fish/small fish and WPO/EPO)

Safety and Status indicator will work as a cutoff level.

9) Management cycle

- **Tentative default: Projection period: 24 years (roughly corresponding to 3 generation cycle for PBF)**
- **Interval of TAC change: 3 year**