NORTHERN COMMITTEE
FIFTEENTH REGULAR SESSION

Portland, Oregon, USA
3-6 September 2019

Report of the Pacific Bluefin Tuna Working Group Intersessional Workshop (ISC19 – ANNEX 8)

WCPFC-NC15-2019/IP-03

ISC[1]

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

FINAL

ISC/19/ANNEX/08

ANNEX 8

19th Meeting of the
International Scientific Committee for Tuna
and Tuna-Like Species in the North Pacific Ocean
Taipei, Taiwan
July 11-15, 2019

REPORT OF THE PACIFIC BLUEFIN TUNA WORKING GROUP INTERSESSIONAL WORKSHOP

July 2019

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Annex 08

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 18-22, 2019
Maison Glad Hotel
Jeju, Republic of Korea

1. OPENING AND INTRODUCTION

1.1. Welcome and introduction

S. Nakatsuka, Vice Chair of the ISC Pacific bluefin tuna working group (PBFWG), welcomed the participants and opened the meeting. He summarized the goal of the present meeting; The PBFWG has been tasked with completing a benchmark stock assessment of Pacific bluefin tuna in 2020. The primary objective of this meeting is to review the current assessment model and discuss improvements for the upcoming benchmark assessment. The PBFWG will also review the latest fishery information and evaluate whether unexpected changes in recruitment or biomass are occurring in PBF stock. In addition, the WG will respond to some requests to ISC from RFMOs relevant to PBF management, including implementation projection under additional harvest sceanrios.

1.2. Adoption of agenda

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

1.3. Election of chair

Shuya Nakatsuka of Japan was elected as the new PBFWG Chair. Gerard DiNardo was elected as the new Vice Chair of PBFWG on an interim basis.

1.4. Appointment of rapporteurs

Rapporteurs were assigned by the Chair as follows: Item 2: (M. Maunder), Item 3: (SK. Chang), Item 4: (G. DiNardo), Item 5: (Y. Tsukahara), Item 6: (H. Fukuda), Item 7: (M. Dreyfus).

2. REVIEW OF UPDATED INFORMATION

2.1. Catch information for CY 2018

The Data Manager (DM) of the PBFWG (H. Fukuda) presented the 2018 PBF catch by ISC member countries as well as revised catch information for 2017. He explained that because the WG will not have a half-day meeting in conjunction with the ISC 19 in July 2019, the WG needed to informally update the catch table to track the most recent information about fisheries. According to the catch information submitted by ISC members, the 2018 PBF catch is the lowest value since 1991. The DM also acknowledged that the catch information of the most recent year is considered provisional. Although PBF catches by all of ISC members in 2018 were below those of 2017, it was noted in particular that catches by set-net and purse seine in 2018 were below those of 2017.

Discussion
It was noted that there will be no PBFWG meeting in July, so the catch data will need to be approved by the Statistics Working Group. No authorization of catch data is required by PBFWG. It was somewhat surprising to note that the 2018 has the lowest catch since 2014 despite that there is much anecdotal information of high PBF abundance in 2018. Japan reported that due to strict implementation of the international catch limit, catch limits were allocated by the national government to local governments, from local governments to smaller management units such as local fishery cooperatives in finer scales and they were implemented strictly. This resulted in substantial amount of unused quota for the county as a whole. It was also noted that the US purse seine catch in 2018 was also low, which was considered to be resulted from the strict control by authority because they went over their quota in the previous year.

Sport catches of bluefin in the US come from two types of fleets: Commercial Passenger Fishing Vessels (CPFV) that take 15-25 passengers on each trip and a private vessel fleet that takes 1-5 passengers each trip. More than 90% of sport bluefin catches are from California fleets. The CPFV catch and effort are obtained from logbook data provided by California Department of Fish and Wildlife (CDFW). The private catch and effort are normally obtained from the Recreational Fisheries Information Network database (RecFIN, https://www.recfin.org/), however in 2019 the data had to be obtained directly from CDFW. Data from the two sources are not identical since 2015 so some differences in estimates are expected. Sport caught fish from both types of fleets are reported in numbers of fish which are converted to metric tons using the current length-weight regression adopted by the ISC PBF working group as described in ISC/15/PBFWG-1/03.

WG member asked if any new management measures were implemented in 2018. There were no new measures adopted at the international level. However, high catch rates in 2017 caused quotas to be exceeded in some countries and therefore they introduced stricter control, which apparently led to unused quota. Furthermore, the current restrictive management could result in higher discards and the WG noted that these should also be considered in the assessment. In case of Japan, it was informed that PBF are released in some fisheries, in particular the set net fishery (i.e. trap net, not gillnet), in order to comply with the allocation. The condition of released fish is not fully known and should vary depending on how the fish is released. For example, if PBF were released by opening the net, they would most likely survive after the release while there could be substantial mortality if fish were released by scooping with net. It was noted that US sports fishery has a bag limit of two PBF per person and captains are assumed to be responsible to ensure the rules.

The WG agreed that the impact of unaccounted mortality should be further investigated towards the 2020 assessment and members were requested to provide further information with respect to their fisheries in future meetings.

2.2. Review of updated CPUEs used for assessment

Japanese coastal longline CPUE and catch-at-length for Pacific bluefin tuna: Update up to 2017 fishing year; presented by Y. Tsukahara (ISC/19/PBFWG-1/01):

Y. Tsukahara presented updated CPUE for Japanese longline fishery up to the 2017 fishing year. In the 2017 fishing year, operation of longliners, whose data are used for standardization, stopped operation during their high fishing season because of fishing management. The nominal CPUE after stopping operation was the lowest value in "S1" CPUE time series (1993-2017 fishing year). Therefore, a separate standardization was conducted using the data before restriction only in 2017 fishing year, which was named "ad-hoc update". The CPUE from the "ad-hoc update" showed the continuously increasing trend since 2011 fishing year.

Presenter also showed two catch-at-length data series for Japanese longliners estimated and raised by two types of area strata: (1) prefecture strata, which is the same method as previous update, and (2) three area strata corresponding to areas used for CPUE standardization. There was little difference between the two and both showed a shift in accordance with the growth of PBF. Strong cohorts have been caught since 2011, and there were new cohorts of relatively smaller fish in longline catch at length in recent years. The area strata corresponding to the CPUE standardization will be an option for the next benchmark assessment.

Discussion

The main issue presented is that in 2018 the data from the second half of the fishing season is not representative due to the introduction of management restrictions resulting in the fishery reaching its quota. Therefore, an ad-hoc method was applied that only used data before this period for FY2017. The whole fishing season data were used for previous years. WG member noted that the length composition data continues to indicate targeting of cohorts by this fleet. This should be further investigated and also the difference between the two versions of the estimated catch at length data (one uses prefecture based data and the other uses area definition for standardization) should be further studied. WG member asked why PBF was not included in the clustering. It was explained that PBF is rarely targeted and is caught as a bycatch, and the WG advised not to use PBF as an effect in standardization to avoid double use of the data.

It was agreed that both the simple update and the ad-hoc indices would be recorded (Fig. 1). However, the WG considered that both indices have issues for the use in assessment; the simple update apparently does not track the trend of the stock abundance while ad-hoc index does not cover the historical fishing season. Therefore, the WG needs to further consider appropriate approach to deal with the effect of management restriction. It was noted that a time block may be used in future assessments to take account of the influence of management restrictions on the CPUE.

It was noted that there are currently no indices of abundance available based on data from the EPO. The US is investigating to create one from the recreational fishery data.

CPUE standardizations of Taiwanese PBF fisheries with/without geostatistical consideration; presented by SK. Chang (ISC/19/PBFWG-1/03):

Two sets of standardization models were designed to derive the relative CPUE series: The first was the same as the previous year with a revision of 2017 data and an addition of 2018 data, of which the CPUEs were standardized for north and south fishing grounds separately as well as for all fishing grounds combined, using delta-generalized linear mix model (delta-GLMM). The second model additionally included geostatistical component (residual of observed CPUE and interpolated CPUE from geostatistical ordinary kriging method) to the first model. Bootstrap-R2 suggested that the current practice of adding geostatistical component to the model (the second model) did not improve the model fitting. Therefore, standardized CPUE series for the southern fishing ground from the first model was recommended for representing the abundance index of PBF in this region which showed similar trend as the previous work presented in the 2018 ISC PBFWG meeting. In general, the relative CPUE declined continuously from 2001 to 2012 and then started to increase slowly since 2014. The 2018 CPUE level was almost the same as the 2017 level, indicating the increasing trend might have paused.

Discussion

It was noted that the index of abundance from the GLM without geostatistical component differed from that with geostatistical component in recent years, and WG member asked which index is most similar to nominal CPUE. It was confirmed that both standardized CPUEs and nominal CPUE showed very similar trends. It was explained that the choice of which Kriging method was better was based on eyeballing the fit and not based on a statistical criterion. It was also explained that the results do not differ much among the methods. It is observed that the fishery in southern area is consistently targeting the same size fish thus geostatistical aspect may be small for this index.

WG member asked about the distribution of effort over time between the north and south areas. The information was not immediately available, but it probably follows the catch, which showed a large decrease in the north area as the fleet shifted to south area. This is probably because the catch rates in the north area are lower in recent years and fuel costs are higher to go to the northern area.

It was noted that Taiwanese catch was decreasing in 2018, and WG member asked why and whether it affects CPUE. The decline in catch was mostly due to decreasing number of vessels resulted from the implementation of stricter regulations. For example, all vessels that have a PBF permit, including small vessels, are required to install VMS in 2018. Therefore, some vessels did not register for PBF permits while others registered but did not fish for PBF. It was explained that many vessels, including both small and large vessels, have moved from the northern area to the southern area in recent years. The inclusion of vessel size rather than vessel ID in the standardization may not account for ineffective vessels dropping out of the fishery. It was noted that the north area had higher proportion of the cohort currently dominant in 2014 compared to later years based on the length composition data, so this cohort may have moved to south resulting in reducing the CPUE in the northern area. After these discussions, the WG agreed to record the updated index for the south area, which was used for 2018 assessment, for the review purpose (Fig. 1).

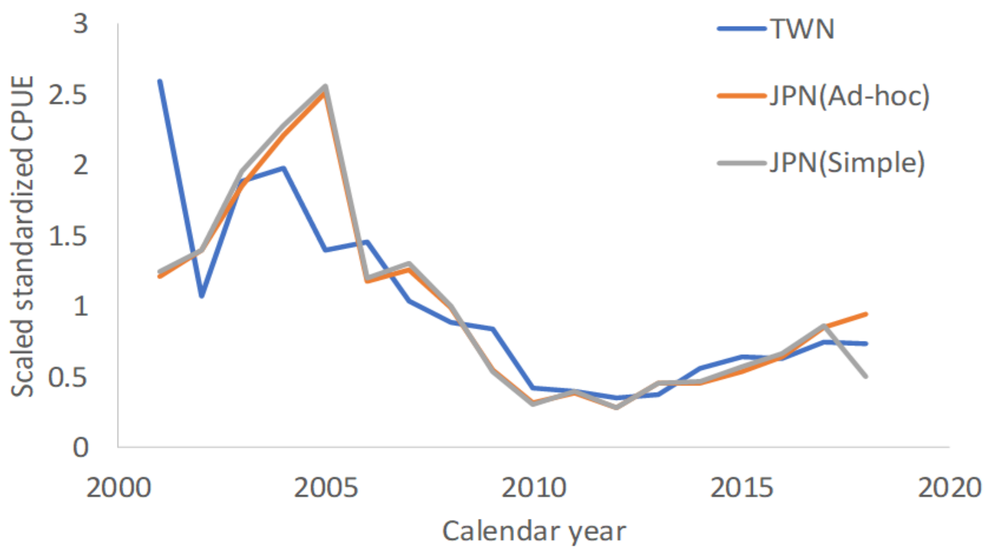

Fig. 1. Trajectory of standardized CPUEs of Japanese longline and Taiwanese longline South fleets (Japanese ad-hoc: orange, Japanese simple update: grey, Taiwanese: blue).

Updated standardized CPUE for 0 age Pacific Bluefin Tuna caught by Japanese troll fisheries: Updated up to 2017 fishing year; presented by K. Nishikawa (ISC/19/PBFWG-1/03):

To estimate the recruitment abundance index for Pacific bluefin tuna, Japanese troll CPUE in the East China Sea (coastal waters of western Kyushu) was standardized for the period of 1980-2017 fishing year. Generalized liner model (GLM) with lognormal error distribution was applied for the standardization, which was the same method as used for the previous stock assessment. The "best model" was the same model as used in the previous assessment. The standardized CPUE in the 2017 fishing year was lower than the one in 2016 and similar to the historical average with relatively wider confidential intervals because of artificial constraint by fishery management. In addition, a revised version of this CPUE, to better align with the fleet definition of the assessment, is presented. The best model of the revised CPUE was also the same as the best model for the present standardized CPUE and showed a similar trend. The data used for the standardization of the revised CPUE (FM4-12) reflects more accurately the fleet definition in the current stock assessment. Thus, it is recommended that the revised CPUE (FM4-12) be used as abundance index of recruitment in the next benchmark assessment.

Discussion

WG member asked if there was a difference between the fishing methods used for the farming and fresh markets. It was clarified that the fishing method is the same, but fish destined for the farms need a tank on the vessel so the amount that can be caught in a trip may be smaller than those for the fresh market. It was asked why port was used as an explanatory variable. It was explained that fishermen in each port may use slightly different gears, different fishing methods, and the fishing grounds differ. They catch similar size fish, but the catch amount may be different. WG member asked why there was no bluefin caught for farming in 2017. It was explained that the purse seiners got better to catch bluefin for the farms, so there is a trend to use purse seine catch for the farms.

The WG noted that the revised CPUE was one requested by the WG. Therefore, it was agreed to record the update as well as revised CPUE for the review purpose (Fig. 2). At the same time, the WG noted that it needs to continue to discuss how the index can be improved.

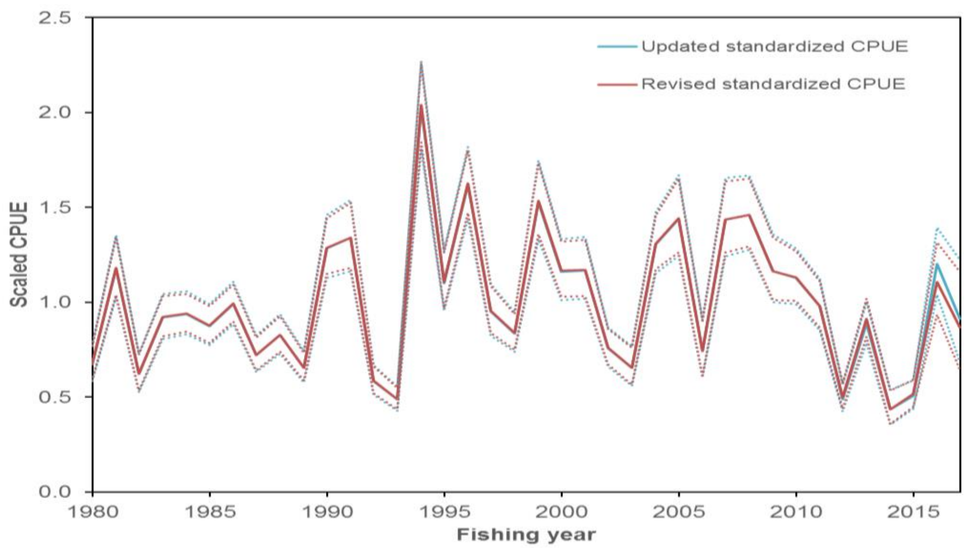

Fig. 2. Trajectory of update (blue) and revised (red) standardized CPUEs of Japanese troll vessels operating in the East China Sea.

2.3. Review of Japanese recruitment monitoring programme

Real-time recruitment monitoring for Pacific bluefin tuna using CPUE for troll vessels: Update up to 2018 fishing year; presented by Y. Tsukahara (ISC19/PBFWG-1/04):

Y. Tsukahara presented updated CPUE for recruitment levels using real time monitoring system, that has been conducted by Japan since 2011 fishing year. This monitoring system can obtain the recruitment information in most recent year, 2018 fishing year in the Pacific side and the Sea of Japan side, respectively (Fig. 3). The point estimates were both higher than the respective historical average, but lower than those in the previous year. On the other hand, the limited amount of data due to some management factors, such as catch limit, led to increased uncertainty in standardization, thus recruitment levels should be monitored continuously with multiple information, such as sales slips and catch at subsequent ages.

Discussion

WG member asked what proportion of the vessels are monitored. It was explained that there are 74 vessels participating the survey so only a small proportion are monitored. However, there only needs to be an adequate sample size of vessels that represent the abundance and many of the vessels are probably not reliable for use in the CPUE index.

The troll fishery CPUE that is used in the assessment does not use data from the zero catch trips because catch invoices are not created in those cases. On the other hand, the monitoring program shows that the proportion of zero catch has changed over time, suggesting that the CPUE index could be biased and the monitoring program might provide a better index.

A discrepancy between troll CPUE (Fig. 2) and monitoring CPUE (Fig. 3) was noted; in troll CPUE, 2017 estimate was lower than that of 2016 but in monitoring CPUE, 2017 estimate was much higher than that of 2016. The WG considered that monitoring CPUE is possibly more desirable as it properly accounts for zero-catch information. However, the Japanese monitoring program has not been documented for the working group to be adopted for the use in assessment. The WG noted that it should be considered for the next assessment. A table should be created showing the data available, the proportion of catch covered, etc., so that the monitoring program can be compared with the troll CPUE index.

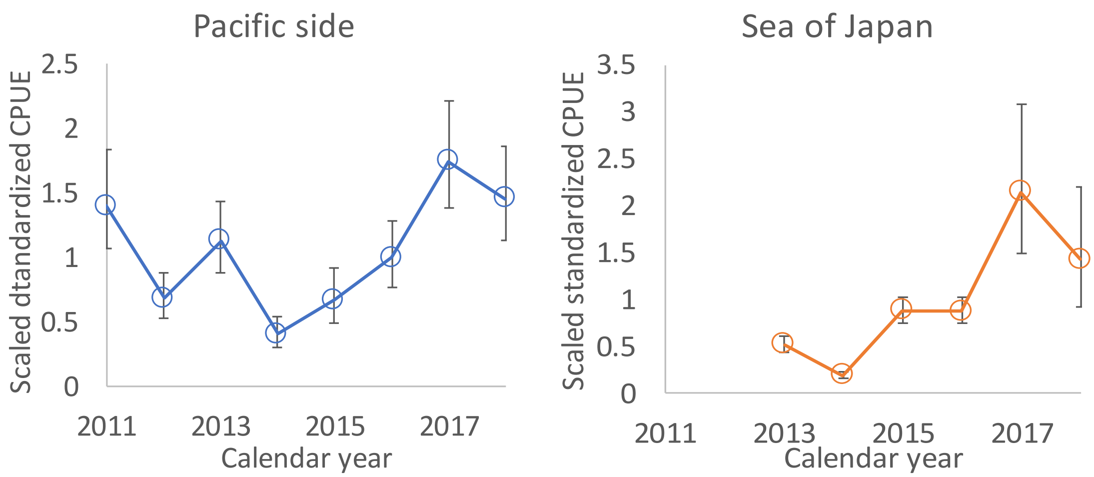

Fig. 3. Trajectory of standardized CPUE from Japanese recruitment monitoring programme in Pacific side (left panel) and Sea of Japan (right panel).

2.4 Possible conservation advice

After reviewing updated CPUE indices as well as Japanese recruitment monitoring, the WG recommends to maintain the conservation advice from ISC18 (in 2018). In addition, the WG noted that some positive signs of PBF stock were observed after the last assessment. In the 2018 assessment it was noted that optimistic but relatively more uncertain 2016 recruitment made the projection results more optimistic than previously. The projection assumed the low recruitment scenario for 2017 and onwards. New positive information this year includes that the troll CPUE recruitment index in 2017 is similar to its historical average, that Japanese recruitment monitoring indices in 2017 and 2018 are higher than 2016 and that larger fish are apparently becoming more abundant in EPO, although this information needs to be confirmed through stock assessment in the future.

3. UPDATE OF INFORMATION REGARDING CANDIDATE REFERENCE POINTS

H. Fukuda presented ISC/19/PBFWG-1/07, a review of biological reference points with specific recommendations for Pacific bluefin tuna to respond the request of ISC18 to update candidate reference points (RPs) that was presented at ISC10 (ISC/10/Plenary/04). The recommended RPs, both F-based and SSB-based, were compiled based on the results of the 2018 stock assessment. Compared to the original table in ISC10, complicated simulation-based RPs were removed while new candidate RPs were added that reflect the current improvements in stock assessments or the usage by RFMOs.

Discussion

It was noted that generally a limit reference point (LRP), which should be developed based on scientific information, should have low probability to be exceeded. However, the level of a LRP, the probability to exceed the LRP, and anticipated management response in such case are all interlinked. For example, if a LRP is relatively high (e.g. 20%B0) and allowable risk are relatively low (e.g. 5%), management implication would be great if anticipated response is drastic such as cessation of fisheries. Therefore, it was suggested that consideration of a threshold reference point, instead of or in addition to LRP, may be advisable. It was also noted that, although theoretically the LRP is a level not to be breached to avoid irreversible harm to a stock, it is usually difficult to identify such a level. In the case of a F-based reference point, the application of the reference point itself can be management action; however, this approach may cause confusion to managers when a stock was considered subject to overfishing according to the LRP but at the same time was recovering.

It was also noted that the PBF stock is currently managed under a management plan agreed by RFMOs, with rebuilding targets and associated timeline. The WG felt that it might be premature to decide the long-term target reference point (TRP) because there still are many uncertainties involved in the current knowledge on PBF stock (e.g, B0 is unknown, many parameters were adopted from other species) and that the stock is at a progressively rebuilding phase.

The WG confirmed the format and content of the table of candidate reference points to be presented to the ISC19 (Appendix 4).

4. POSSIBLE IMPROVEMENT OF STOCK ASSESSMENT

4.1. Review of 2018 assessment

H. Fukuda presented the results of diagnostics and sensitivity analyses in the 2018 Pacific bluefin tuna assessment model to review the performance, robustness and pliability of the model. The model performed generally well in terms of the model fit to the data, internal consistency among the data and model assumptions, and robustness. Because of the high robustness of the current model, in particular for the removal process and recruitment estimates, some of the changes of model assumptions in the next full stock assessment will likely be done without any fatal issues.

On the other hand, 5 out of 21 sensitivity runs (e.g. lower h, lowest M) were not considered converged. In terms of the pliability, the very rigid removal process imposed by given parameterization might be causing the current model of losing some pliability to the alternative assumptions. It would be more desirable in principle if a similar performance can be achieved by less number of parameters, and it may help to solve the convergence issue. The WG may want to investigate the effect of the parameter reduction for the future stock assessment.

Discussion

It was noted that catch @ age is very rigid regardless sensitivity settings. It was also noted that natural mortality schedule is more influential than maturity schedule. It was suggested that length-weight relationship may need to be reviewed using EPO data. The WG agreed that the current length-weight relationship should be revisited by incorporating new data both from WPO and EPO.

The approach to deal with the inconsistency between Japanese and Taiwanese longline CPUEs was discussed. One suggested approach is to apply time-varying selectivity to Japanese longline CPUE as it seems to follow strong cohorts while size distributions of Taiwanese longliners are more consistent over time. Another approach is to apply geostatistical model in the CPUE standardization. However, at this stage it is uncertain if CPUE series derived from geostatistical model can be smoothly incorporated into the assessment model. In particular, how to fit to the length data is unclear.

It was noted that the growth curve for age 0 old fish used in the model is inconsistent with the daily otolith data. Therefore, fitting to length compositions for fisheries that catch age 0 might cause a bias. This could be minimized by either 1) using cohort slicing method to turn the catch-at-length into catch-at-age for those fleets catching age 0, and fit to the catch-at-age using an age specific selectivity or 2) just take out all the catch assuming they are age zero. This will work best for fleets that report catch in numbers. For those fleets that report catch in weight will require additional work to convert from weight to numbers based on the size of fish caught, not the growth curve. The WG recognized the importance to improve the fit for such fleets and more work is necessary to identify appropriate solution.

It was pointed out that resampling from bootstrapped results is based on input sample size of size composition data, possibly causing bias, and that this needs to be reviewed at the time of assessment. It was also considered necessary to investigate the magnitude of unaccounted mortality by bycatch and the impact should be evaluated through assessment.

Areas to improve for 2020 Pacific bluefin tuna stock assessment; presented by H. Lee (oral presentation):

This presentation provided three aspects of model improvement in selectivity to be considered for the 2020 Pacific bluefin tuna stock assessment. Selectivity was used in two ways for highly migratory Pacific bluefin tuna in the 2016 and 2018 stock assessments: (1) length-based contact selectivity (the probability that a fish of a given size is caught by the fleet) and (2) age-based selectivity as proxy of the age-based availability (the probability that a fish of a given age is available to the fleet). Time-invariant length-based selectivity was estimated assuming asymptotic pattern or domed-shape for the fleets catching non migrating age-classes (ages 0 and ages 6 and older). For the fleets catching migrating age-classes (ages 1-5), both time-invariant length-based contact selectivity assuming either asymptotic pattern or domed shape and time-varying age-based selectivity were estimated or only time-varying length-based contact selectivity assuming domed shape were estimated to account for both contact selectivity and the annual spatial age-class availability due to movement.

The first model improvement is to address the misfit of size composition data for fleet 2 and 6 catching age 0 bluefin tuna. Misfit was reduced by estimating the selectivity at last bin (P6) of the double normal function that describes domed shape for length-based contact selectivity for fleet 2 and allowing age 0 to 3 to be fully selected. For fleet 6, misfit was reduced by estimating both selectivity at the first bin (P5) and the last bin (P6) of the double normal function that describes domed shape for length-based contact selectivity and allowing age 0 to 2 to be fully selected.

The second improvement is to fit the size composition data for the US recreational fisheries (F15) to account for increased size classes observed in the eastern Pacific Ocean since 2014. All six parameters of the double normal function that describes domed shape for length-based contact selectivity were estimated. Four out of six parameters (beginning size for the plateau (P1), width of plateau (P2), descending width (P4) and selectivity at last bin (P6)) were assumed to be time-varying to account for change of annual spatial age-class availability due to movement for 2014-2016 and contact selectivity.

The third model improvement is to reduce the number of parameters estimated. For the fleets catching migrating age-classes (ages 1-5), time-invariant length-based contact selectivity assuming either asymptotic pattern or domed shape and shared time-varying age-based selectivity were estimated to account for both contact selectivity and the annual spatial age-class availability due to movement. The time-varying age-based selectivity was shared among all fleets in each side of ocean (i.e. fleet 4, 5, 8, 9, 10, and 18 for the western Pacific Ocean and fleet 13 and 14 for the eastern Pacific Ocean). Selectivity at age 3 to 6 was assumed to be time-varying in the western Pacific Ocean and age 2 to 5 in the eastern Pacific Ocean. The number of parameters were reduced from 316 to 285. The difference in number of parameters will be enlarged in future assessments due to increased observations of size composition data from new data points and new fisheries. Further scrutiny would have to be taken on the robustness of the model.

Discussion

The WG generally agreed with the direction towards reducing the number of estimated parameters in the current model and considered the approach proposed to have some fleets to share time varying selectivity. It was agreed to further investigate its merit and drawbacks and to decide if it is beneficial in future meeting. With regards to the development of a spatial assessment model, although conceptually it is considered a right direction, the WG felt it would probably be a very complex undertaking and be unrealistic to expect it be completed for the assessment in 2020. However, it was also recognized that the WG needs to show that it considers it as an important task and is working towards it. Therefore, research towards that end is encouraged. It was also pointed out that the spatial model will need to be investigated once MSE process formally starts.

Possible consideration for stock-recruitment relationship for the benchmark assessment; presented by S. Nakatsuka (oral presentation):

First, he described the results of analysis on the relationship between recruitment and stock as well as environment (SST) using empirical dynamic modeling, which is currently under review. It was found that SST in certain areas in certain period has causality on recruitment. It was also found that SSB of 8 and 9 years old fish has causal effects on recruitment. It was also shown that a model to reconstruct recruitment based on SST and biomass over age of 8 years old performed significantly better than current assumption. Another study on the stock-recruitment relationship is a simple application of the hockey-stick SRR. It can provide another possible approach on the SRR, but he noted that the estimation of the hinge point has a substantial uncertainty. Those examples could be considered for possible use in the upcoming assessment.

Discussion
The WG appreciated the information and noted that age 8 years old roughly corresponds to the age when PBF starts being caught around the Nansei spawning area. However, the WG considered it is premature to incorporate this approach into the next stock assessment. It was considered more appropriate to test the uncertainty related to SRR by applying different levels of steepness.

4.2. Possible areas of improvement towards 2020 assessment

The WG reviewed thoroughly the list of model settings of the current stock assessment and discussed what improvement can be made item by item. The WG compiled the possible changes to model setting, their priority and responsible members as Appendix 5. Main issues discussed are as follows.

<u>Version of SS</u>
It was recognized that the WG should update the model to the new version of SS (3.3). However, it is necessary to check if the transition to the new version can be properly done before the assessment and it was agreed that Japan and US will conduct exercise before the data preparatory meeting.

<u>Sigma R</u>
The WG recognized that, from the analyses by H. Fukuda, current setting of 0.6 is apparently not causing a significant problem for the assessment but nonetheless agreed to review it based on the results of the new assessment.

<u>Natural mortality</u>
It was recommended to test a variation of M. One of them would be to try Lorenzen curve. It was agreed that it should be tested on current assessment prior to the data preparatory meeting.

<u>Maturity</u>
It was agreed to test other settings, particularly one with more late maturity schedule.

Growth
It was recognized important to review the various aspects of growth; growth function, how the CV is calculated, etc. The WG members agreed to work collaboratively using up-to-date otolith data to review the current model and also to endeavor to develop a growth function using Richard model. It was recommended as well to examine the feasibility of conditional @ length approach. The results of the new approach as well as their preliminary sensitivity tests should be available at data preparatory meeting for the use in the benchmark assessment. As these are substantial undertakings, the relevant members were encouraged to collaborate well.

Length-Weight relationship
It was recommended that the L/W relationship should be reviewed with updated data. Members agreed to gather all available data to prepare to review the result and its implication at the data preparatory meeting.

Unaccounted mortality
It was recognized important to evaluate the impact of possible unaccounted mortality from bycatch. Each member is requested to provide available information about unaccounted mortality at data preparatory meeting. The WG then will explore ways to account for unaccounted catch in the assessment.

Construction of fleets
It was agreed to separate Japanese small purse seine for farming because the size of their catch is different from the catch for fresh market and catch information is available in number.

Selectivity for fleets
It was agreed to investigate the benefit of applying shared time-varying selectivity to some of the fleets which share geographical distribution. It was recommended to present preliminary results to data preparatory meeting.

Korean PS fleet
It was agreed that the Korean PS fleet will be fit to its own size compositions.

US PS fleet
It was pointed out that currently the US purse seine mirrors the Mexican purse sein selectivity, but they may actually be different. Therefore, it was recommended that the USA would endeavor to collect size information from its purse seine fleet.

US Sport fleet
It was agreed that the US sport fleet will be fit to its own size compositions.

CPUE standardization
It was agreed that Japan and possibly Taiwan, with consultation with experts, would further investigate the plausibility of geostatistical standardization with size information for respective longline CPUE. Preliminary results should be provided to data preparatory meeting. It was also noted that sufficient information to compare the two indices of recruitment, current troll index and monitoring based index, should be provided to data preparatory meeting.

4.3. Workplan towards 2020 assessment

The WG agreed that a data preparatory meeting will be held in fall and a stock assessment meeting will be held in early 2020 to complete the benchmark assessment. It was agreed in principle that the data preparatory meeting will be in La Jolla, USA in November and the assessment meeting will be in Japan in late February to early March 2020. The hosting countries will consider the specific date and consult with the WG members.

5. REQUESTS FROM RFMOS

5.1. Review the updated abundance indices, including recruitment index, up to 2017 to evaluate the need to change its scientific advice in 2018

The WG considered the request from the IATTC – WCPFC NC Joint Working Group and agreed to provide the response based on the conservation advice in Agenda 2.

5.2. Conduct additional projections of harvest scenarios based on 2018 assessment and provide probability of achieving initial and 2nd rebuilding targets

Additional projections based on 2018 assessment as requested by WCPFC and IATTC; presented by S. Nakatsuka (ISC/19/PBFWG-1/08):

S. Nakatsuka presented the document, which provides the results of additional projections under scenarios requested by the RFMOs based on the 2018 assessment. It was clarified that for the sake of simplicity, the Korean fleet is assumed to be catching solely small PBF (<30kg) and the increase of large PBF is split between Japan and Taiwanese catch proportionately.

Discussion

The WG agreed to provide the results contained in Tables 2 and 3 to managers. It was clarified that in projections of future assessments the catch of Korean fleet will be calculated based on their recent size compositions including large fish.

5.3. Provide information regarding candidate LRP and TRP

The topic was discussed under agenda item 3.

Based on the discussion, the WG developed a draft response to requests from IATTC-WCPFC NC Joint Working Group in Appendix 6. The WG recommended that it will be provided to IATTC SAC following appropriate steps within ISC. The WG requested Chair to forward the request the ISC Chair.

6. MANAGEMENT STRATEGY EVALUATION

6.1. Review of the results of 2018 PBF MSE Workshop and possible feedback

Possible Feedback on "Basic Structure of PBF MSE"; presented by S. Nakatsuka (ISC19/PBFWG-1/04):

In May 2018, ISC hosted PBF MSE Workshop in Yokohama, Japan. Total 70 participants including managers, scientists and stakeholders attended the meeting and started discussion on elements necessary for management strategy evaluation (MSE) of PBF. The Workshop developed a document titled "Basic Structure of PBF MSE" as a living-document to keep track of MSE development of PBF. For particular relevance to PBFWG, the document includes potential operational management objectives, which are expected to be quantitively evaluated through MSE. ISC needs to comment on their relevance and feasibility. Here, possible feedbacks from ISC on the document, which should be provided to the next PBF MSE Workshop planned in May 2019 in USA, are proposed.

Discussion

Proposed performance indicators for the operational management objectives which were listed by mangers were reviewed. For sustainability category, it was considered possibly useful to examine threshold reference point in addition to TRP and LRP. For "responsiveness", it was noted that this can be evaluated through the trade-off between "yield" and "stability"; usually the higher the yield, the lower the stability, i.e. more responsive, and vice versa. It was suggested that annual fishing mortality of recruitment could also indicate responsiveness. For socio-economic objectives, they were generally considered difficult to quantify. However, it was suggested that information regarding yield per recruit might be a useful indicator.

As to the general structure of the MSE related work in ISC, it was recognized that PBFWG will naturally be the lead group but a small subgroup should be established to conduct MSE technical work as the WG has its own research priorities. Japan and the USA indicated that they may be able to provide personnel for the technical subgroup. The WG recognized that close cooperation is essential for the technical subgroup for the MSE to be successful. In terms of work schedule, the WG considered that it is difficult to engage in MSE related work in a substantive manner while preparing for the benchmark assessment. Therefore, the WG considered that the progress of MSE work will be small until the next benchmark assessment is completed.

6.2. Preparation of 2019 PBF MSE Workshop

The WG was informed that the USA is planning to host the 2nd PBF MSE workshop in May in San Diego. The announcement will be circulated shortly though ISC, WCPFC and IATTC circular. The aim of the workshop is to build upon the discussion so far, in particular following up the discussion at the first workshop, with a focus to enhance involvement of the stakeholders in EPO. A draft agenda will also be prepared by the USA and be circulated to PBFWG members for comments.

6.3. General discussion on the work schedule of PBF MSE

H. Fukuda presented a basic idea for the development of an Operation Model (OM) for the Management Strategy Evaluation (MSE) of Pacific Bluefin tuna (PBF). The formal MSE using the full range of uncertainties are requested from the joint working group of WCPFC NC and IATTC in 2016. Since the PBFWG developed a stock assessment model using fully integrated assessment package (Stock Synthesis V3) for a long time, the knowledge accumulated in the WG about the stock, fishery and modelling will be an advantage to develop OM. However, the presenter mentioned that since even the current Management Measures of the relevant RFMOs were more complicated than that can be dealt with by the existing MSE package such as SS3sim, the WG may need to develop own OM package for the PBF MSE. He added that the development of the OM should be led by a particular person with high transparency and understandability under the support of the WG.

Discussion

Some advantages to use SS3-based operating model (OM) package (SS3sim) were pointed out such as the convenience to handle the spatial structures, advanced time-varying parameterization, and flexible observation error structure. The presenter responded that although the choice of the OM package could depend on the requirement in the harvest strategy and performance indicator mainly requested by the management bodies, he believes that current management measures are too complex to handle in the stock synthesis and it would better to use both of the original OM and SS3-based estimation model (EM). The uncertainties to be incorporated into the OM were discussed and it was noted that the migration of the animal was already suggested by the ISC Chair and some other things such as the stock recruitment relationship also will need to be incorporated if it is technically possible.

The WG discussed at length the benefits of conducting MSE for PBF. Generally speaking, a management strategy proven through MSE to be robust against perceived uncertainties is desirable for management. However, because mangers have established a rebuilding target to be achieved by 2034 for PBF and the stock assessment conducted every 2 years including projections is relatively coherent and robust, the WG considered that MSE might not be urgently needed.

6.4. Preparation of feedback to RFMOs

The WG amended "Basic Structure of PBF MSE" to reflect the discussion (attached as Appendix 7) and recommended it to be forwarded to the 2nd PBF MSE workshop. The WG requested the Chair of PBFWG to contact ISC Chair to take appropriate process.

7. OTHER MATTERS

7.1. New scientific information

Updated statistics and CPUE standardization of Pacific bluefin tuna from Korean coastal and offshore fisheries; presented by SI. Lee (ISC/19/PBFWG-1/10):

In Korean waters, the annual catch of PBF showed less than 1,000 ton until the 1990s except 1997. The catch sharply increased to 2,401 ton in 2000 and was recorded at its highest of 2,601 ton in 2003, and then the catch decreased with a fluctuation thereafter. PBF in Korean waters has been caught by offshore large purse seine fishery which accounted for about 99% in total catch. The main fishing ground of PBF of purse seine fishery is formed around Jeju Island. However, it expanded to the Yellow Sea and the East Sea depending on the migration patterns of PBF. The PBF CPUE standardization of purse seine fishery was conducted using Generalized Linear Models (GLMs) for the whole and the core area, and the CPUE series for the core area was chosen as the base due to the lower value in AIC. The standardized CPUE from 2004 to 2011 showed a steady trend, and after 2012 it increased until 2014, but decreased in 2015 and 2016. However, it increased again in 2017 and showed the highest level.

Discussion
It was asked if catch included all range of sizes of PBF (1 to 3 years old). Since this was the case, it was suggested that further work needs to be done since CPUE is mixing several cohorts. The definition of lunar effect (night or day) was clarified since Korean operations for PBF are operating at night, similar to Japanese operations targeting mackerel but not PBF that are targeted during the day in Japanese fleet. The authors will check this information as well as the significance of that variable in the model. It was suggested to use other targeted species in this fishery as explanatory variables. It was also noted that CPUE starts in 2004 because there is lack of data previously although the PBF fishery operated earlier. It was considered interesting to compare the estimated CPUE and abundance trend of target age PBF when the next assessment is completed.

Trial analysis of standardized CPUE for Japanese Purse seine fishery; presented by K. Nishikawa (oral presentation):

For considering abundance index of intermediate age between recruitment and large adult, trial CPUE standardization from the purse seine fisheries in the Sea of Japan targeting young adults PBF was conducted. As effort, searching time or distance obtained from ship position information were used. Catches are calculated from logbook data and used that of over 30kg fish. GLM with log normal error distribution was applied. The preliminary results showed that standardized CPUE using distance as effort performed better than the standardized CPUE using time.

Discussion
It was clarified that distance (effort) is search distance based on an algorithm that uses vessel position data. It was noted that further improvement is needed since several cohorts are represented in the catch. It was considered that CPUE fluctuations from young adult PBF (3-5 years old) in the Sea of Japan might not necessarily represent abundance but variations in migration proportion. The group considers this to be useful when a spatial model is implemented.

Preliminary analysis of Spatial-temporal modeling for Japanese longline CPUE (Oral presentation):

Y. Tsukahara presented preliminary analyses and results of geostatistical model for Japanese longline (fleet 1). This presentation focused on how to incorporate the size information into geostatistical model. The weight data in logbooks was used for size information in this standardization. The results showed that CPUEs using geostatistical approach showed similar trend overall with the current CPUE used in the stock assessment, although CPUEs using geostatistical approach exhibited peculiar spikes in some years. It is necessary to work further for investigating the spatial and size specific effects on the catchability.

Discussion

Various suggestions were made to improve the standardization method. In general, the group considered this as a good approach that might be used in the next assessment and suggested more analyses to be conducted till their results were satisfactory. The presenter was encouraged to consult to with experts further.

Current status and future subject of research on PBF spawning grounds; presented by Y. Tanaka (oral presentation):

This presentation reviewed 6 papers regarding PBF spawning grounds. Particularly, the presenter focused on Ohshimo et al. (2018) which reported that matured PBF occurred off the northeastern off the Pacific coast of Sanriku-Joban area, northeastern Japan in addition to two known spawning grounds, Sea of Japan and Nansei Island area. The presentation showed that the spawning adults in the Sea of Japan are 3–6 years old, 6–8 years old in Sanriku-Joban area and over 8 years old in the Nansei Islands area. The relevant researches on the PBF spawning grounds study were also introduced, which were the larval survey conducted in Sanriku-Joban area and the estimation of the natal origin by using the vertebrae.

Discussion

The difference of proportion of spawning adults from the two spawning grounds caught in the two spawning grounds were observed; the proportion of adults born in Nansei spawning ground is high in Nansei spawning ground. Possible explanations, such as that there are residential group of younger adults in the Sea of Japan, were discussed but there was no sufficient information to confirm. Nonetheless it was considered that the information from alumni on vertebrae supports that PBF consist of one stock.

Batch fecundity seems higher in the Sea of Japan with smaller animals than in Nansei area but the effect of this is not known (survival rate of larvae or total amount of egg production). Japan is conducting vertebrae analysis of PBF animals from EPO exported to Japan to understand spawning ground origin. It was asked if there is variation is size of egg between the spawning grounds but the presenter considers there is more within area variation depending on month. About the third spawning ground, more work is considered to be needed to know the significance of this spawning ground.

7.2. Report of ad-hoc Close-kin Workshop

The results of ad-hoc Close-kin Workshop, which was held on March 16-17, was briefly introduced by one of participants to the workshop. It was noted that no clear timeline has been agreed to complete the assessment based on close-kin analysis. However, it was pointed out that the qualitative information on life cycle of PBF which could be obtained through close-kin analysis, such as movement and spawning behavior, would be very helpful for the future discussion of stock assessment. At the same time, the WG generally felt that it would be unfeasible to envision that the WG would take initiative to analyze close-kin data and to develop fishery independent abundance estimate based on it.

7.3. Report of ad-hoc Tagging Workshop

The WG was informed that the ad-hoc Tagging Workshop originally scheduled in conjunction with the WCPFC15 was not held.

8. ADOPTION OF THE REPORT

The PBFWG reviewed, discussed, and amended the draft Working Group meeting report prepared by the rapporteurs. The report was adopted by consensus.

9. ADJOURNMENT

The meeting was adjourned on March 22, 2019.

APPENDIX 1

THE PACIFIC BLUEFIN TUNA WORKING GROUP INTERSESSIONAL WORKSHOP
March 18-22, 2019

Agenda

1. Opening and Introduction
    - 1.1. Welcome and introduction
    - 1.2. Adoption of agenda
    - 1.3. Election of chair
    - 1.4. Appointment of rapporteurs

2. Review of updated information
    - 2.1. Catch information for CY 2018
    - 2.2. Review of updated CPUEs used for assessment
    - 2.3. Review of Japanese recruitment monitoring programme

3. Update of information regarding candidate reference points

4. Possible improvement of stock assessment
    - 4.1. Review of 2018 assessment
    - 4.2. Possible areas of improvement towards 2020 assessment
    - 4.3. Workplan towards 2020 assessment

5. Requests from RFMOs
    - 5.1. Review the updated abundance indices, including recruitment index, up to 2017 to evaluate the need to change its scientific advice in 2018
    - 5.2. Conduct additional projections of harvest scenarios based on 2018 assessment and provide probability of achieving initial and 2nd rebuilding targets
    - 5.3. Provide information regarding candidate LRP and TRP

6. Management Strategy Evaluation
    - 6.1. Review of the results of 2018 PBF MSE Workshop and possible feedback
    - 6.2. Preparation of 2019 PBF MSE Workshop
    - 6.3. General discussion on the work schedule of PBF MSE
    - 6.4. Preparation of feedback to RFMOs

7. Other matters
    - 7.1. New scientific information
    - 7.2. Report of ad-hoc Close-kin Workshop
    - 7.3. Report of ad-hoc Tagging Workshop
    - 7.4. Others

8. Adoption of the report
9. Adjournment

Appendix 2. List of Participants

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APPENDIX 3: LIST OF DOCUMENTS

Index	Agenda	Title	Author	Contact	Website availability
ISC/19/PBFWG-1/01	2.2	Japanese coastal longline CPUE and catch-at-length for Pacific bluefin tuna: Update up to 2017 fishing year	Y. Tsukahara, Y. Ohashi and S. Nakatsuka	tsukahara_y@affrc.go.jp	Yes
ISC/19/PBFWG-1/02	2.2	CPUE standardizations of Taiwanese PBF fisheries with/without geostatistical consideration	H.-I Liu and S.-K. Chang	skchang@faculty.nsysu.edu.tw	Yes
ISC/19/PBFWG-1/03	2.2	Updated standardized CPUE for 0-age Pacific bluefin tuna caught by Japanese troll fisheries: Updated up to 2017 fishing year	K. Nishikawa, Y. Tsukahara and S. Nakatsuka	kiraranishi@affrc.go.jp	Yes
ISC/19/PBFWG-1/04	2.3	Real-time recruitment monitoring for Pacific bluefin tuna using CPUE for troll vessels: Update up to 2018 fishing year	Y. Tsukahara, K. Chiba	tsukahara_y@affrc.go.jp	Yes
ISC/19/PBFWG-1/05	4.1	Review and test for performance, robustness and pliability of 2018 PBF stock assessment model	H. Fukuda	fukudahiromu@affrc.go.jp	Yes
ISC/19/PBFWG-1/07	5.1	Review of biological reference points with specific recommendations for Pacific bluefin tuna.	H. Fukuda and S. Nakatsuka	fukudahiromu@affrc.go.jp	Yes
ISC/19/PBFWG-1/08	5.2	Additional projections based on 2018 assessment as requested by WCPFC and IATTC	S. Nakatsuka, K. Nishikawa and H. Fukuda	snakatsuka@affrc.go.jp	Yes
ISC/19/PBFWG-1/09	6.1	Possible Feedback on “Basic Structure of PBF MSE”	S. Nakatsuka	snakatsuka@affrc.go.jp	Yes
ISC/19/PBFWG-1/10	7.1	Updated statistics and CPUE standardization of Pacific bluefin tuna from Korean coastal and offshore fisheries	S. I. Lee, D. N. Kim, M. K. Lee and H. J. Jo	k.sungillee@gmail.com	Yes

Appendix 4: List of candidate biological reference point

Ps	Definition	Limit/ Target	Type of overfishing that can be Diagnosed	Pros/Cons and Comments	Calculation	Reference year	Estimate		
							Base case	M_{old}_ high	M_{old} _low
F_{msy}	Fishing mortality (F) that maximize average yield sustainably under existing environmental condition	either	Recruitment and Growth	Consistent with management goals; Difficult to estimate because of uncertain stock recruitment relationship for PBF	F_{RY}/F_{msy} ($1/FAAmult_{msy}$)	2015-2016			
F_{max}	F that maximize yield from a recruitment	either	Growth	Concept of maximum yield; Does not consider recruitment overfishing	F_{RY}/F_{max} ($1/FAA\mathrm{mult}_{max}$)		1.36	1.20	1.57
$F_{0.1}$	F at which slope of Y/R is 10% of value at origin	either	Growth	Does not directory consider recruitment overfishing but its more precautional than F_{max}	$F_{RY}/F_{0.1}$ ($1/FAA\mathrm{mult}_{0.1}$)		1.98	1.77	2.28
F_{med}	F corresponding to the median observed recruit/SSB ratio	either; not suitable for TRP of PBF	Recruitment	Depend on the narrow range of the historical observation of SSB and Recruitment	F_{RY}/F_{med} ($1/FAA\mathrm{mult}_{med}$)		0.77	0.75	0.81
$F_{10\%SPR}$	F that produces given % of the unfished spawning potential (biomass) under equilibrium condition	either	Recruitment	Independent from the Stock-Recruitment estimates; Does not consider about yield; Choice of percentage is difficult	$(1\text{-}SPR_{RY})/(1\text{-}SPR_{xx\%})$		1.02	1.00	1.04
$F_{20\%SPR}$							1.15	1.13	1.17
$F_{30\%SPR}$							1.32	1.29	1.34
$F_{40\%SPR}$							1.54	1.5	1.57

SSB_{msy}	Spawning stock biomass (SSB) associated with maximum sustainable yield	either	Recruitment and growth	Consistent with management goals; Difficult to estimate because of uncertain stock recruitment relationship for PBF	SSB_{RY}/SSB_{msy}				
SSB_{med}	SSB at the median of observed time period	either; not suitable for TRP ofPBF	Recruitment	Relatively robust to the structural uncertainty such as natural mortality assumption; Depend on the narrow range of the historical SSB observation and recruitment	SSB_{RY}/SSB_{med}		0.52	0.54	0.5
10%SSB_0	SSB at given % of the estimated unfished level under equilibrium condition	either	Can consider Recruitment overfishing depend on percentage chosen	Consistent SSB_{MSY} proxi with the other RFMO; Does not consider about yield; Choice of percentage is difficult	SSB_{RY}/10% SSB_0	2016	0.33	0.42	0.25
20%SSB_0					SSB_{RY}/20% SSB_0		0.17	0.21	0.13
30%SSB_0					SSB_{RY}/30% SSB_0		0.11	0.14	0.08
40%SSB_0					SSB_{RY}/40% SSB_0		0.08	0.10	0.06
$SSB_{0.5R0}$	SSB associated to 50% of the unfished recruitment (R0) with assuming a stock-recruitment relationship steepness of 0.75. Interim LRP for Tropical tuna in IATTC	limit	Recruitment	Consider Recruitment overfishing explicitly; Choise of the steepness is difficult; percentage of R0 is arbitral choise	SSB_{RY}/7.7 %SSB_0 in the condition of (h=0.75 and 50%R_0)		0.43	0.54	0.32

SSB_{1stReb_tgt}	SSB at the median during 1952-2014; Initial rebuilding target for PBF in the WCPFC/IATTC	Current Rebuilding target	Recruitment	Easy to understand the concept as a rebuilding target; time period is an arbitral choice	SSB_{RY} /$SSB_{\mathrm{med1952\text{-}2014}}$		0.50	0.53	0.48

Appendix 5: list of possible model setting of 2020 assessment and related tasks

	Full stock assess. in 2016	**Full stock assess. in 2020 (Idea by ISC19PBFWG01)**	Prioritization	Corresponding person
SS version	SS-V3.24f	SS-V.3.3 (comparison w/ V3.24 nesessary)	High	HH Lee, H. Fukuda
Year definition	July to June (Fishing year)	July to June (Fishing year)		
Time step	Quarter	Quarter		
Stock(spawning population)	Single spawning population	Single spawning population		
Area	Single for assessment	Single for assessment (try spatial model as sensitivity)	Long term	HH Lee, K. Piner
Number of age class	21(0-20) -default; 21- lumped	21(0-20) -default; 21- lumped		
Ngender	sex-combined	sex-combined, WG recommended to collect sex specific size comp	Long term	Each member
SRR	B-H (h=0.999) w/ Appropriate sensitivity runs	B-H (h=0.999) w/ sensitivity runs (Nakayama et al., 2019; and other scenarios)		
R0	estimated	estimated		
SigmaR	0.6	0.6 (need a diagnostics)	High	HH Lee, H. Fukuda
R0 offset	estimated	estimated as a regime shift parameter		
Natural mortality	Age specifc M M0=1.6 M1=0.386 M2+=0.25	Age specifc M M0=1.6 M1=0.386 M2+=0.25	High	Provide Lorenzen curve; C. MinteVella,

	w/ Appropriate sensitivity runs	w/ Appropriate sensitivity runs including Lorenzen curve		Test it at Data prep; HH Lee
Maturity	Age specific Maturity Age3.75=0.2 Age4.75=0.5 Age 5.75+=1.0 w/ Appropriate sensitivity runs	Age specific Maturity Age3.75=0.2 Age4.75=0.5 Age 5.75+=1.0 w/ Appropriate sensitivity runs including BRPs, projection	High	H. Fukuda will test it at the assessment meeting
Growth curve	Fukuda et al. (2015) vBertalanffy form	Fukuda et al. (2015) vBertalanffy form Try Richard growth function Growth cessation model (available in SS Beta version) Test in the data prep meeting	High	H. Fukuda gather data, update vB curve, create Richard curve, growth cessation model, sensitivity at data prep, Conditional approach inside and outside model
#of growth patterns	1	1		
#of morphs, sub-morphs	1	1		
Functional form of CV growth	CV=F(L)	Subject of WP in data prep meeting		
Amin	0	Subject of WP in data prep meeting		
Amx	3	Subject of WP in data prep meeting		

L-W	Kai et al., 2007	Kai et al., 2007, review L/W relationship with the latest info.	High	SK Chang, K. Nishikawa, MK Lee, G. DiNard Results, which include comparison with Kai (2007), test using 2018 model, will be provided at Data prep.
Length bin definition	2cm bin for 16-58 cm FL, 4 cm bin for 58-110 cm FL, 6cm bin for 110-290 cm FL	same assumption, or try effect of cutting out a maximu bin ?	Medium	Assessment meeting
Weight bin definition	0,1,2,5,10,16,24,32,42,53,65,77,89,101,114,126,138,150,161,172,182,193,202,211,220,228,236,243,273	0,1,2,5,10,16,24,32,42,53,65,77,89,101,114,126,138,150,161,172,182,193,202,211,220,228,236,243,273		
Population length bin	2cm, 1cm, 2cm	2 cm for all	High	Check by HH Lee
Catch unit	weight for most of fisheries except US sports (numbers) troll for pen(numbers)	weight for most of fisheries except US sports (numbers) troll for pen (numbers) Jpn PS for pen (number)	High	H. Fukuda will provide WP to Data prep meeting about Jpn PS for Pen

Catch error	0.1	0.1 for fishing fleets, a larger value for unaccounted mortality (catch)	High	Each member will provide info about unaccounted catch at data Prep. WG explores the way to account unaccounted catch. H. Fukuda, HH Lee, and M. Maunder will try to establish the discard Fleets in the model.
F-method	3 (solve catch eq) - catch exact	3 (solve catch eq) - catch exact		
upperF	10	10		
Fishery definition	19 Fleets for fisheries, 5 Surveys for abundance indices, no discard fleets	20 Fleets for fisheries, one or several Discard fleets for unaccounted catch, 5 Surveys for abundance indices		

Selectivity for fishery	Type 1 Time-invariant size based Double normal/Asymptotic; Type 2 Combination of Time-invariant size based Asymptotic and Time-invariant age specific non-parametric; Type 3 Time variant size based Double normal (Time-block); Type 4 Combination of Time invariant size based Asymptotic and Time variant age specific non-parametric; Type 5 Combination of Time invariant size based Double normal and Time variant age specific non-parametric; Type 6 Share with other fleet (not fitted to comp data) Type 7 Given Age specific non-parametric (not fitted to comp data)	Type 1 Time-invariant size based Double normal/Asymptotic; Type 2 Combination of Time-invariant size based Asymptotic and Time-invariant age specific non-parametric; Type 3 Time variant size based Double normal (Time-block); Type 4 Combination of Time invariant size based Asymptotic and Time variant age specific non-parametric; Type 5 Combination of Time invariant size based Double normal and Time variant age specific non-parametric; Type 6 Share with other fleet (not fitted to comp data); Type 7 Given Age specific non-parametric (not fitted to comp data); Type 8 Combination of Time-invariant size based Asymptotic and Sharable Time variant age-based (fitted to comp data); Type 9 Combination of Time-invariant size based Double normal and Sharable Time variant age-based (fitted to comp data).	High	HH Lee will provide WP about shared selectivity. Modelers should conduct preliminary examinations on selectivity options by data prep.
Fleet 1	Japanese Longline; Catch in weight; Length comp data available; Selex Type3 (-1992, 1993-);	Japanese Longline; Catch in weight; Length comp data available; Selex Type3 (-1992, 1993-); Options: time varying selex for recent years; Geostatic composition data (Documentation necessary)		
Fleet 2	Japanese Small Pelagic Fish Purse Seine (Season 1, 3, 4); Catch in weight; available Length	Japanese Small Pelagic Fish Purse Seine for market (Season 1, 3, 4); Catch in weight; available Length Comp. ~~of Fleet 2 and 3 were combined~~; Selex type 1 or 9		

	Comp. of Fleet 2 and 3 were combined; Selex type 1			
Fleet 3	Korean Offshore Large Purse seine Catch in weight; Length comp. available (combined w/ F2); Selex Type 6	Korean Offshore Large Purse seine Catch in weight; Length comp. available ~~(combined w/ F2)~~; Selex Type 1 or 9		
Fleet 4	Japanese Tuna Purse Seine operating in the Sea of Japan; Catch in weight; Length comp available; Selex type 4	Japanese Tuna Purse Seine operating in the Sea of Japan; Catch in weight; Length comp available; Selex type 4 or 8 or 9		
Fleet 5	Japanese Tuna Purse Seine operating in the Pacific coast; Catch in weight; Length comp available; Selex type 4 (Timeblock)	Japanese Tuna Purse Seine operating in the Pacific coast; Catch in weight; Length comp available (new data will be available for recent years); Selex type 4 (Time block) or 8 or 9	High	Japan will provide a WP to Data prep
Fleet 6	Japanese troll (Season 2-4); Catch in weight; Length Comp. available; Selex Type 1 (Double Normal)	Japanese troll (Season 2-4); Catch in weight; Length Comp. available; Selex Type 1 (Double Normal) or 7		
Fleet 7	Japanese Pole and Line; Catch in Weight; Length Comp. available; Selex Type 6	Japanese Pole and Line; Catch in Weight; Length Comp. available; Selex Type 6		
Fleet 8	Japanese Setnet Season 1-3; Catch in weight; Length Comp. available; Selex Type 2	Japanese Setnet Season 1-3; Catch in weight; Length Comp. available (subject of reconsider); Selex Type 2 or 8 or 9	Medium	Japan may consider its fleet definition and way to raise the composition
Fleet 9	Japanese Setnet Season 4; Catch in weight; Length Comp. available; Selex Type 2	Japanese Setnet Season 4; Catch in weight; Length Comp. available (subject of		

		reconsider); Selex Type 2 or 8 or 9		
Fleet 10	Japanese Setnet in Hokkaido and Aomori Catch in weight; Weight Comp. available and combined w/ F11; Selex Type 2	Japanese Setnet in Hokkaido and Aomori Catch in weight; Weight Comp. available ~~and combined w/ F11~~; Selex Type 8		
Fleet 11	Japanese Other fishery (mainly in Hokkaido and Aomori) Catch in weight; Weight Comp. available and combined w/F10; Selex Type 6	Japanese Other fishery (mainly in Hokkaido and Aomori) Catch in weight; Weight Comp. available ~~and combined w/F10~~; Selex Type 8		
Fleet 12	Taiwanese Longline South fishing ground Catch in weight; Length Comp. available; Selex type 1	Taiwanese Longline South fishing ground Catch in weight; Length Comp. available; Selex type 1		
Fleet 13	1952-2001; US com PS; Catch in weight; Length Comp. available; Selex type 3	1952-2001; US com PS; Catch in weight; Length Comp. available; Selex type 3 or 8 or 9		
Fleet 14	2002-; Mexican PS for pen (include US catch) Catch in weight; Length Comp. available; Selex type 3	2002-; Mexican PS for pen (include US catch) Catch in weight; Length Comp. available; Selex type 3 or 8 or 9 * WG Recommend to collect the US PS size data, which may be smaller than Mexican PS catch for penning.		
Fleet 15	US recreational; Catch in number of fish; Length comp. available; Selex Type 6	US recreational; Catch in number of fish; Length comp. available; Selex Type 8 or 9		

Fleet 16	Japanese troll for pennning Catch in number of fish, No size comp. available; Selex type 7 (Fix the age-0 selectivity as full selection)	Japanese troll for pennning Catch in number of fish, No size comp. available; Selex type 7 (Fix the age-0 selectivity as full selection)		
Fleet 17	Taiwanese Longline North fishing ground; Catch in weight; Length Comp. available; Selex type 1	Taiwanese Longline North fishing ground; Catch in weight; Length Comp. available; Selex type 1		
Fleet 18	Japanese Small Plagic Fish Purse Seine (Season 2); Catch in weight; Length comp. available, Selex Type 5	Japanese Small Pelagic Fish Purse Seine (Season 2); Catch in weight; Length comp. available, Selex Type 5		
Fleet 19	Japanese Troll (Season 1); Catch in weight; Length comp. available; Selex Type 1	Japanese Troll (Season 1); Catch in weight; Length comp. available; Selex Type 1 or 7		
Fleet 20		Japanese Small Plagic Fish Purse Seine (Season 4); Catch in number of fish; Length comp. available; Selex Type 1		H. Fukuda WP
CPUE S1	Standardized Japanese longline CPUE (terminal) by the zero-inflated negative binominal model	Standardized Japanese longline CPUE (terminal) by the zero-inflated negative binominal model Longline CPUE by Geo-stat standerdization	High	Y. Tsukahara will provide geo-stat standardization to Data prep.
CPUE S2	Standardized Japanese longline CPUE by the log-normal model	Standardized Japanese longline CPUE by the log-normal model		
CPUE S3	Standardized Japanese longline CPUE by the log-normal model	Standardized Japanese longline CPUE by the log-normal model	Medium	Japan may provide review of CPUE to Data prep.

CPUE S5	Standardized Japanese longline CPUE by the log-normal model	Japanese Troll CPUE by the log-normal model; Japanese monitoring CPUE	High	Japan will provide a comparison between Japanese Troll and Monitoring
CPUE S9	Standardized Taiwanese LL CPUE Delta-lognormal GLMM	Standardized Taiwanese LL CPUE Delta-lognormal GLMM; further improvement is considered	High	Eric-san, Mark-san
CPUE (JLL) selectivity	Same as Fleet 1	Same as Fleet 1		
CPUE (Jp Troll) selectivity	Same as Fleet 6	Same as Fleet 6		
CPUE (TWLL) selectivity	Same as Fleet 12	Same as Fleet 12		
CPUE likelihood	lognormal	lognormal		
CPUE lambda	1	1		
CPUE CV	Lowest is 0.2, use observation error if it is above 0.2.	Lowest is 0.2, use observation error if it is above 0.2.		re-reviewed at the assessment
Input sample size for LenComps	Number of haul well measured/ Number of fish measured/Number of landing well measured/Number of total month of well sampled port	Number of haul well measured/ Number of fish measured/Number of landing well measured/Number of total month of well sampled port Subject of reconsider		
1st year of main Rdev	1953	1953		

SR auto correlation	no	no (try to evaluate the effect of regime shift or other possible environmental effect)	Medium	M. Maunder
Initial F	Estimate without fitting to EqC	Estimate without fitting to EqC		
	Fleet 1, Fleet 8	Fleet 1, Fleet 8	High	re-reviewed at the assessment
Diagnostics of the model	ASPM model, Jitters, retrospective analysis, Likelihood profile relative to R0, model fits to the data	ASPM model, Jitters, retrospective analysis, Likelihood profile relative to R0, model fits to the data, residual analysis		

APPENDIX 6: RESPONSE TO REQUESTS FROM IATTC-WCPFC NC JOINT WORKING GROUP

ISC PBFWG
2019

The following requests were made to ISC by the IATTC-WCPFC NC Joint Working Group meeting in September 2018 at NC14 (see Attachment E of NC14 Report (https://www.wcpfc.int/system/files/0_NC14%20Summary%20Report%20rev.1%20%2810Dec2018%29_0.docx)). Responses from ISC PBFWG are provided below the requests.

Request 1: review the updated abundance indices, including recruitment index, up to 2017 to evaluate the need to change its scientific advice in 2018.

Response from ISC PBFWG
The WG noted that some positive signs for the PBF stock were observed after the last assessment. In the 2018 assessment, the projections were considered optimistic because they were influenced by a high but uncertain recruitment in the terminal year (2016). The WG notes that the Japanese troll recruitment index value estimated for 2017 is similar to its historical average (1980-2017), that Japanese recruitment monitoring indices in 2017 and 2018 are higher than the 2016 value and that there is anecdotal evidence that larger fish are becoming more abundant in EPO, although this information needs to be confirmed for the next stock assessment expected in 2020.

After reviewing the updated CPUE indices as well as the Japanese recruitment monitoring results, the PBFWG recommends maintaining the conservation advice from ISC18 (in 2018) that the projection mimicking the current management measures under the low recruitment scenario resulted in an estimated 98% probability of achieving the initial rebuilding target (6.7%SSBF=0) by 2024 and that of achieving the second rebuilding target (20%SSBF=0) 10 years after the achievement of the initial rebuilding target or by 2034, whichever is earlier, is 96%.

In the projections reported here, the projected future SSBs are the medians of the 6,000 individual SSB calculated for each 300 bootstrap replicates (i.e. catch, CPUE and size) to capture the uncertainty of parameter estimations followed by 20 stochastic simulations based on the different future recruitment time series. The projection assumes that each harvesting scenario is fully implemented and is based on certain biological or other assumptions of base case assessment model. If conditions change, the projection results would be more uncertain.

Request 2: Conduct projections of harvest scenarios shown below based on 2018 assessment and provide probability of achieving initial and 2nd rebuilding targets in accordance with paragraph 2.1 of HS2017-02.

Scenarios for catch increase

West Pacific		East Pacific
Small fish	Large fish	
0	600t	400t
5%	1300t	700t
10%	1300t	700t
5%	1000t	500t
0	1650t	660t
5%		5%
10%		10%
15%		15%

* 250t transfer of catch limit from small fish to large fish by Japan is assumed to continue until 2020.

Response from ISC PBFWG

PBFWG conducted projections in the same manner as in the 2018 assessment. The recruitment scenario followed paragraph 2.1 of WCPFC Harvest Strategy 2017-02; and was kept at a low level (re-sampling from 1980-1989) until the initial rebuilding target is achieved and then changed to the historical average level.

The projection results are shown in Table 2 and Figure 1. The results show that increasing the catch limit of small PBF (<30 kg) in the WPO has the largest impact on the probability of achieving the interim and 2nd rebuilding targets. In addition, an overall increase in catch from the current limits, particularly a 15% increase, has the largest impact on achieving rebuilding targets.

Scenario #	Fishing mortality	Catch limit					Catch limit Increase		
		WPO		EPO			WPO		EPO
		Small	Large	Small	Large	Sport	Small	Large	
Base case	F2002-2004	4725	6582	3300		-	0%		
Current catch limit	F2002-2004*2	4725	6582	3300		-	0%		
1	F2002-2004*2	4725	7180	3699		-	0%	600	400
2	F2002-2004*2	4960	7880	4000		-	5%	1300	700
3	F2002-2004*2	5196	7880	4000		-	10%	1300	700
4	F2002-2004*2	4960	7580	3800		-	5%	1000	500
5	F2002-2004*2	4725	8231	3960		-	0%	1650	660
6	F2002-2004*2	4960	6909	3465		-	5%		
7	F2002-2004*2	5196	7238	3630		-	10%		
8	F2002-2004*2	5433	7567	3794		-	15%		

Table 2: Probability of achieving targets under projection scenarios for Pacific bluefin tuna Future projection scenarios for Pacific bluefin tuna and their probability of achieving various target levels by various time schedules based on the 2018 base-case model.

Scenario #	Catch limit Increase				Initial rebuilding target			Second rebuilding target		Median SSB (mt) at 2034
	WPO		EPO		The year expected to achieve the target with >60% probability	Probability of achiving the target at 2024	Probability of SSB is below the target at 2024 under the low recruitment	The year expected to achieve the target with >60% probability	Probability of achiving the target at 2034	
	Small	Large	Small	Large						
Base case	0%				2020	99%	0%	2028	96%	262,952
Current catch limit	0%				2021	97%	0%	2028	96%	264,748
1	0%	600	400		2021	95%	0%	2028	95%	256,252
2	5%	1300	700		2021	88%	0%	2029	91%	236,691
3	10%	1300	700		2021	81%	1%	2030	88%	224,144
4	5%	1000	500		2021	89%	0%	2029	92%	240,739
5	0%	1650	660		2021	92%	0%	2029	94%	246,593
6	5%				2021	93%	0%	2029	94%	248,757
7	10%				2021	86%	1%	2029	90%	232,426
8	15%				2021	76%	2%	2030	85%	215,385

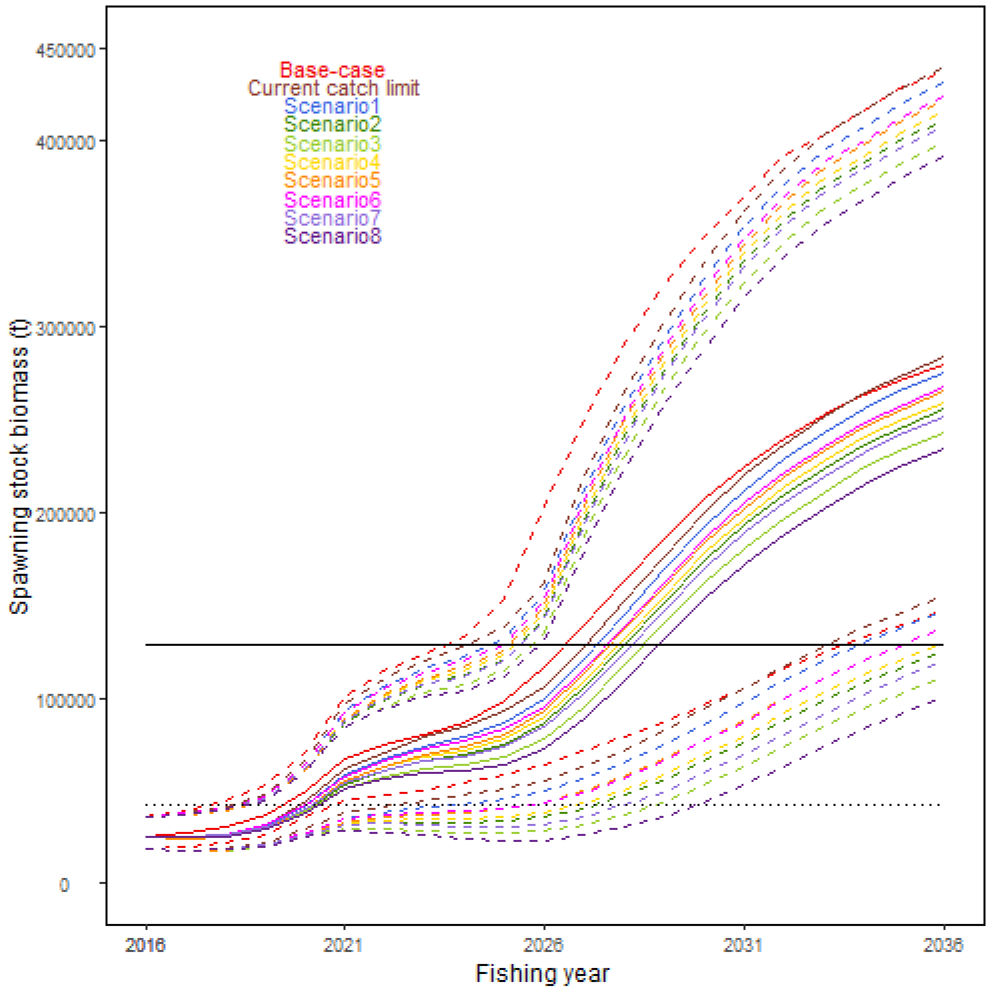

Figure 1: Time series of the projected spawning stock biomass by various harvest scenarios listed on the Table 1. Each colored solid and broken lines indicate the median spawning stock biomass and its 95% confidence intervals, respectively. The black dotted and solid lines are corresponded to the spawning stock biomasses of the initial and second rebuilding targets of Pacific bluefin tuna, respectively.

APPENDIX 7: FEEDBACK ON "BASIC STRUCTURE OF PBF MSE"

ISC PBFWG

Summary

In May 2018, the ISC hosted a PBF MSE Workshop in Yokohama, Japan. Some 70 participants including managers, scientists and stakeholders attended the meeting and started discussion on elements necessary for management strategy evaluation (MSE) of PBF. The Workshop developed a document titled "Basic Structure of PBF MSE" as a living-document to keep track of MSE development of PBF. The ISC PBFWG reviewed the document in its meeting in March 2019 and provides the attached feedback.

Basic structure of PBF MSE Process (as of March 2019)
This document will continuously be updated as MSE develops.
Modification in this version in red is made by ISC PBFWG in March 2019.

1. **The Purpose of MSE of PBF**: "To develop long-term management strategies of PBF robust to perceived uncertainties including environmental impacts while also evaluating the current rebuilding strategy to rebuild the stock to 20%$SSB_{F=0}$ by 2034"

2. Management objectives, operational management objectives and corresponding performance indicators:

(1) Suggested possible additions to the current (aspirational) management objectives in the WCPFC Harvest Strategy (for further discussion at WCPFC NC-IATTC joint WG)

- Minimize negative impacts of increased PBF on other fisheries not targeting PBF
- Minimize negative impacts of management measures on sustainability of small-scale fisheries

(2) Possible operational management objectives (should be able to be evaluated quantitatively through MSE)

Sustainability:

- Rebuilding: achieve 2nd rebuilding target (20%$SSB_{F=0}$) by 2034 with probability of at least 60%.
- Target: maintain the stock above TRP (B-base and/or F-base) (TBD) with relatively high probability (TBD)
- Risk: maintain the stock above LRP (B-base and/or F-base) (TBD) with (very) high probability (TBD). If the stock falls below LRP, rebuild the stock above LRP (TBD) within TIME (TBD) under the long-term management strategy (after 2034). (add recruitment related objective?)

Harvest:

- Yield: maximize yield (possibly including changing size of fish caught)
- Stability: ensure management changes are relatively small (TBD)
- Responsiveness: Respond more timely to biomass trend including recruitment variability

Socio-economics:

- Maximize revenue to fisheries (trade-offs among fisheries? Increase Yield/Recruit?)
- Maximize social benefit from PBF fisheries (economic size of related industry?)

(3) Performance indicators **suggested by ISC based on the proposed management objectives in 2. (2)**

Category	Management objective	Suggested performance indicator	Comments/questions from ISC
Sustainability	Rebuilding	Probability to achieve the 2nd rebuilding target by 2034.	A target probability needs to be specified, i.e., what level of certainty is needed to achieve rebuilding?
	Target	Probability to stay above the target (or to stay in a certain area on Kobe chart).	TRP needs to be specified.
	Risk	- Probability to breach LRP. - Time required to rebuild the stock above LRP.	LRP and acceptable risk need to be specified. Need Threshold RP?
Harvest	Maximize yield	Expected average yield.	Timeframe needs to be considered. For example, short, medium, and long-term.
	Stability	Expected annual variance in catch.	Will managers set duration/amount of TAC change?
	Responsiveness to abundance	None. (or expected annual variance in fishing mortality of age 0 fish)	"Responsiveness to abundance" can be inferred to some extent from the combination of "Maximize yield" and "Stability". The higher the yield and variance, the more responsive. In addition, variance in fishing mortality of age 0 fish can show how responsive the catch is to the strength of recruitment
Socio-economics	Maximize revenue	None. (or CPUE or Y/R can be useful?)	Yield can be provided. Trade-offs among fisheries should be investigated by the comparison of candidate Management Strategies.
	Maximize social benefit	None. (or CPUE or Y/R can be useful?)	At this stage, economic model is not anticipated for MSE. However, CPUE or Y/R may be used as proxy for economic indicators.

3. Features of candidate management strategies to be advised by managers: options could to be evaluated through MSE. Some of them could be automatically filled as operational management objectives will be specified more.

Features	**Status**	**Additional instruction**
Rebuilding targets	Specified (SSBmed and 20%$SSB_{F=0}$, including timeframe)	
Risks (probability)	Specified only for rebuilding strategy	Risk to go below LRP, no more than 20% usually in WCPFC
Type of Management Strategy	Not specified. Empirical or Model based?	
Reference points	Not specified. Not indispensable, but low limit is desirable to evaluate MSs	Threshold RP may need to be considered.
Duration of TAC	e.g. 2 or 3 years	
Change of TAC	e.g. 10%, 20% or absolute value (e.g. maximum or minimum)	Minimum change can also be specified.
General guidance of TAC change	Proportional, different among CCMs, among fisheries?	
Any other features	e.g. Area-wise, size-wise, country-wise TAC? Any other?	

4. **Organizational structure for advancing PBF MSE**: Organizations responsible for various aspects to advance MSE, including decision-making and steering of MSE related work, scientific work and outreach, need to be clearly specified. Advice further discussion in this regard at NC-IATTC joint WG meeting.

5. **Timeframe and structure of computational aspects of PBF MSE**: It is expected that technical work on MSE on PBF would be conducted by a small group of experts, who would be work under the instruction from ISC PBFWG. However, it is difficult for PBFWG to engage in MSE related work extensively while simultaneously conducting assessment work. As the WG plans to conduct assessment in 2020 (2019-2020 March), the progress in MSE related work in 2019 could be relatively small.