Annex 7

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)

February 15-20, 2017
National Research Institute of Far Seas Fisheries
Shimizu, Shizuoka, Japan

1. OPENING AND INTRODUCTION

1.1. Welcome and Introduction

An intercessional workshop of the Pacific Bluefin Tuna Working Group (PBFWG) of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC) was convened in Shimizu, Shizuoka, Japan, from 15-20 February 2017. H. Nakano, the PBFWG Chair, welcomed the participants and opened the WG meeting. He introduced the tasks of the present WG meeting. The work schedule adopted at the last ISC plenary meeting was to update the assessment in two years and conduct a full assessment in four years. Between assessments, like this year, research to advance stock assessments is to be conducted. However, at the first Joint Meeting of the Northern Committee of the Western and Central Pacific Fisheries Commission (WCPFC-NC) and Inter-American Tropical Tuna Commission (IATTC) in September 2016 the ISC was requested to conduct additional stocks projections (on more scenarios) to assist **Discussions** on the next rebuilding target and present the projection results at an April 2017 ISC PBF Stakeholders meeting in Japan. It was decided that the PBFWG would conduct the analyses and finalize the results of the February 2017 PBF Working Group Workshop.

G. DiNardo, the ISC Chair, confirmed the importance to complete the assigned tasks by the Joint Meeting, and highlighted the challenge to prepare a presentation that can be understood by the expected audience at the stakeholder meeting. The WG agreed to prepare an executive summary to be provided to the stakeholder meeting. Participants included scientists from Chinese-Taipei, IATTC, Japan, Korea, Mexico, and the United States. In addition, a subject matter expert, Joel Rice, was invited to present recent research on PBF projections.

J. Rice a consultant hired by PEW was introduced as an invited expert.

1.2. Adoption of agenda

The adopted agenda is attached as Attachment 1. A list of participants is provided as Attachment 2. The list of documents is provided as Attachment 3.

1.3. Appointment of rapporteurs

S. Nakatsuka was appointed as the lead rapporteur for the meeting and support rapporteurs were assigned by the Chair as follows: Item 2. (H. Fukuda); Item 3. (O. Sakai); Item 4. (K. Piner); Item 5. (S.K. Chang); Item 6. (M. Maunder).

2. REVIEW OF FY 2015 INDICES

2.1. Longline CPUE (JPLL and TWLL)

Japanese longline CPUE and catch-at-length for Pacific Bluefin tuna; presented by O. Sakai (ISC/17/PBFWG-1/01)

O. Sakai presented updated Japanese coastal longline CPUE and catch-at-length from 1993-2015 (fishing year). The CPUE was standardized using the agreed procedure in the ISC PBFWG. In the standardization, the effect of target shift was addressed by the indicator from cluster analysis. The cluster indicator was based on the species composition, except for PBF, by fishing trip, and it was used as an explanatory variable in the standardization model. A zero inflated negative binomial (ZINB) model was applied to standardize the CPUE, which was aggregated by fishing trip. The final model selected by the Bayesian information criterion (BIC) included the main effect and some first-order interactions of the cluster indicator. The standardized CPUE showed a consistent increase after the 2011 fishing year (Fig. 1). Catch-at-length data indicated a new mode of smaller fish in the catch since the 2014 fishing year. The presenters concluded that these results are positive information for the PBF stock status: the strong cohorts are still remaining, new cohorts are coming, and as the result, the adult population is recovering gradually.

Discussion

It was pointed out that the results may be biased since the 1 degree x 1 degree geographical cells which do not have PBF catch history at least for 10 years since 1994 are excluded from the standardization. It was suggested that a spatio-temporal model may handle such information more effectively. In response, the author explained that PBF is generally a rare by-catch species and the effort targeting yellowfin covers a wide range of area. It was agreed to discuss the improvement of standardization further under agenda 3.

The WG discussed whether the model should be adapted for the proposed update (i.e., different covariates used depending on the selection process.) Some members disagreed, but others thought it was fine as long as the method to select the covariates followed the same procedures as the previous assessment. At the request of the WG, the author conducted a simple update with the same covariates used and only adding new data to the old model.

The author presented a comparison of CPUE indices between the best model in the present analysis and the model in the last assessment. The WG noted that the result was almost exactly the same. The WG discussed potential causes for the observed changes in the early years of the new index and determined that the filtering and clustering algorithms used in the analysis caused the observed differences.

Standardized PBF CPUE Series for Taiwanese Longline Fishery up to 2016; presented by SK. Chang (ISC/17/PBFWG-1/02):

PBF has long been an important seasonal target species in the Taiwan offshore longline fishery. However, prior to 2010 only market landing data from a small number of logbooks was available. Therefore, several alternative procedures were adopted to estimate the standardized PBF CPUE series: using of voyage data recorder (VDR) data and trip data (from the Coast Guard Administration) to estimate fishing effort, using landing data and CDS data for estimating catch (in number), and using a delta-generalized linear mix model (delta-GLMM) to estimate CPUE. The current work is an update to the work of ISC/16/PBFWG-1/02 (revised), including a revision of the 2015 data and addition of 2016 data. In general, standardized CPUE declined from 2001 to 2010, stayed at low level for two years (2011-2012) before increasing in 2013 (Fig. 1).

Discussion

It was confirmed that the updated model included the same covariates as the last assessment and is reasonable since the model has relatively few variables. A version of the model that included revised 2015 data (more complete VDR data than that used in the 2016 assessment) was presented and the WG concluded that using the updated 2015 data is informative and should be included in the 2018 assessment. Group members decided that the past data should be updated if more information is available and requested that the author include the result using the updated 2015 information. The WG also concluded that comparing Japanese-Tawainese-South- CPUE is informative.

It was noted that the two CPUE series are similar (Fig. 1), even though the fish targeted by Taiwanese vessels are slightly larger than those of Japanese vessels, and that the similarity may result from an overlap in fishing areas between Japanese and Taiwanese vessels. .

2.2. Troll CPUE (JPTroll)

Updated standardized CPUE for 0-age Pacific Bluefin tuna caught by Japanese troll fisheries: Updated up to 2015 fishing year; presented by Y. Fukuda (ISC/17/PBFWG-1/03):

To estimate an index of relative abundance for age zero, the Japanese troll fishery operating in the East China Sea (coastal area around Nagasaki Prefecture) was standardized for the period 1980-2015 (fishing year). A generalized liner model (GLM) with lognormal error distribution was used for the standardization, which was accepted and used in the 2016 stock assessment. The standardized CPUE of the 2015 fishing year is slightly larger than the 2014 fishing year, but is still at a low level (Fig. 2).

Discussion

The utility of the GLM approach as opposed to say a ZINB approach was discussed given the large number of trips with small catches (1-2 fish). It was noted that efforts are currently underway to improve the standardization model for the next assessment. The WG also noted the importance of determining whether the increase of catch for farming influences these results.

A question was raised whether oceanographic conditions impacted the CPUE. It was clarified that even though SST information is collected by the survey vessels, the analysis using such information is a future task.

2.3. Presentations on Other relevant fisheries information

Mexican fisheries from 2009 to 2016

M. Dreyfus presented data from the Mexican fisheries for the period of 2009 to 2016, including the number of vessels and trips related to its PBF catch. It was shown that the number of vessels has decreased and is expected to stay low. In 2016, the commercial catch in the EPO remained below the 3300 ton quota, however Mexican fisheries had to release 195 tons of PBF to remain below their voluntary measure of 2750 tons.

Discussion

A question was posed if there is any change of size composition towards larger fish as in the case of recreational fisheries in the EPO. M. Dreyfus responded that the size information of 2016 catch has not yet been analyzed. It was noted that Mexican commercial purse seiners target larger fish for commercial reasons, but recreational fisheries do not.. It was further questioned if size information from stereo video camera is obtained after 2014 and it was confirmed that the information was obtained but was not yet been analyzed. It was also reported that no sexually mature females were found in the recent survey by the U.S. even though the size of the fish is increasing, confirming the current understanding that no spawning is occurring in the EPO.

Japanese Recruitment Indices

O. Sakai made an oral presentation regarding the CPUE based on the Japanese real-time troll monitoring program. The CPUE has recruitment information for the most recent year-class (2016 recruitment). In the real-time troll monitoring, data loggers and transmitters are equipped on cooperative fishermen's boats. The fishermen input their catch number of age-0 PBF into the data logger during the fishing operation. The catch information with geographic position data are sent to the NRIFSF via a cellular network in real-time. The CPUE from July to August on the Pacific side (data from Nagasaki, Miyazaki, Kochi, Wakayama, and Mie prefectures) is thought to represent the recruitment from the Nansei-island spawning area. The CPUE from September to November in the Sea of Japan (data from Shimane prefecture) is thought to represent the recruitment from the spawning area in Sea of Japan. These CPUE series were standardized using a zero-inflated negative binomial model for the Pacific and a Negative binomial for Sea of Japan because zero-catch information were included in the data. The standardized CPUE suggested that the recruitment level in 2016 was higher than that of 2015, possibly similar to or higher than the 2013 level.

Discussion

It was suggested that conducting a standardization using a ZINB model for both indices may be beneficial to see the impact on the results.

The WG discussed whether the ultimate goal of the new recruitment indices should function as new inputs to the assessment model or to inform the management as an early indicator of recruitment. The WG determined the latter should be the first priority, but also decided that their use as a new model input should also be evaluated by incorporating the new indices in the assessment model.

Other information from Japan

H. Fukuda described the recent operation of the Japanese fisheries, including some good observations that took place in 2016. Purse seine targeting juvenile PBF caught some age 1 fish in addition to the usual catch of age 0 fish. Catch rates from purse seine vessels targeting adult fish both in the Sea of Japan and in the Pacific are generally good, as well as coastal fisheries targeting age 0 fish.

Y. Akatsuka reported on the recently discovered unreported PBF catch by Japanese coastal fisheries. The total amount of unreported catch found so far was 89 tons, of which 82 tons was in the 2016 fishing season. Most of the unreported catch was juveniles and it is probably due to the improvement of fishing conditions, although the exact cause is under investigation. As an indication of improvement of the fishing conditions, the catch in the 2016 fishing season increased at a much faster rate than the 2015 fishing season. He emphasized that the Japanese government is making every effort so that the total Japanese catch does not exceed the level authorized by WCPFC. He also explained the intention of the Japanese government to introduce a voluntary measure to transfer the limit for small fish to large fish, as recognized by the new WCPFC CMM, for the purpose of expediting the recovery of the stock. Specifically, Japan is considering transfering 200-300 tons of the catch limit from small to large fish.

2.4. Possible conservation advice

The WG reviewed the newly available information (updated CPUE for Japanese and Taiwanese longline vessels [Fig. 1] and Japanese troll vessels [Fig. 2]), all of which were higher than those of the 2014 fishing year. The WG concluded that nothing unexpected occurred during the 2015 fishing year and thus the WG considered that it was not necessary to change the conservation advice from 2016.

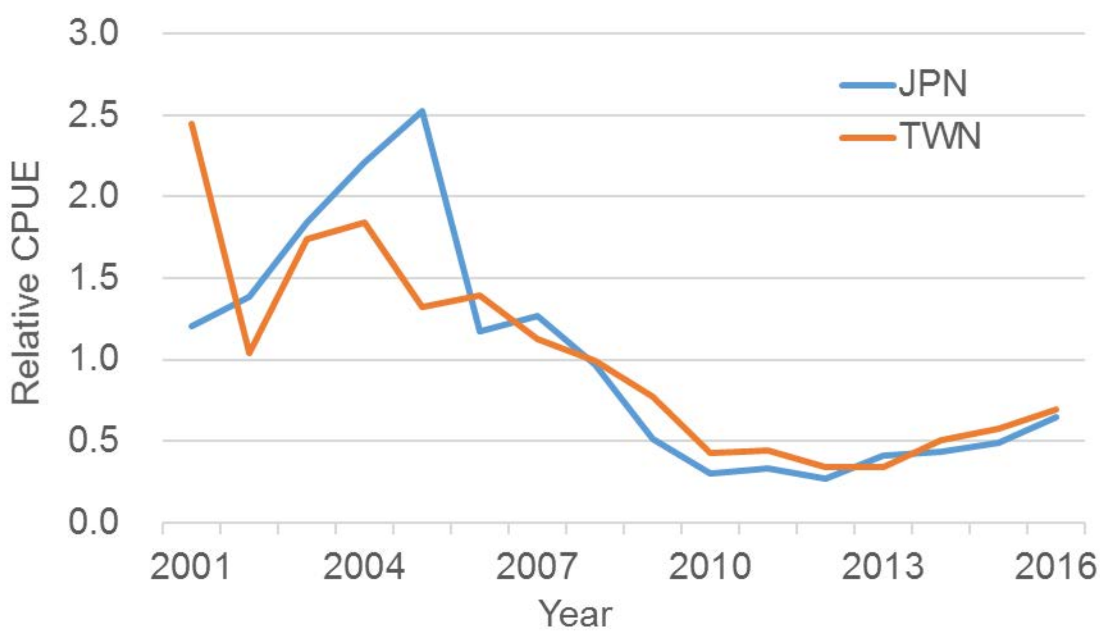

Fig. 1. Trajectory of standardized CPUE of Japanese longline and Taiwanese longline (South) fleets.

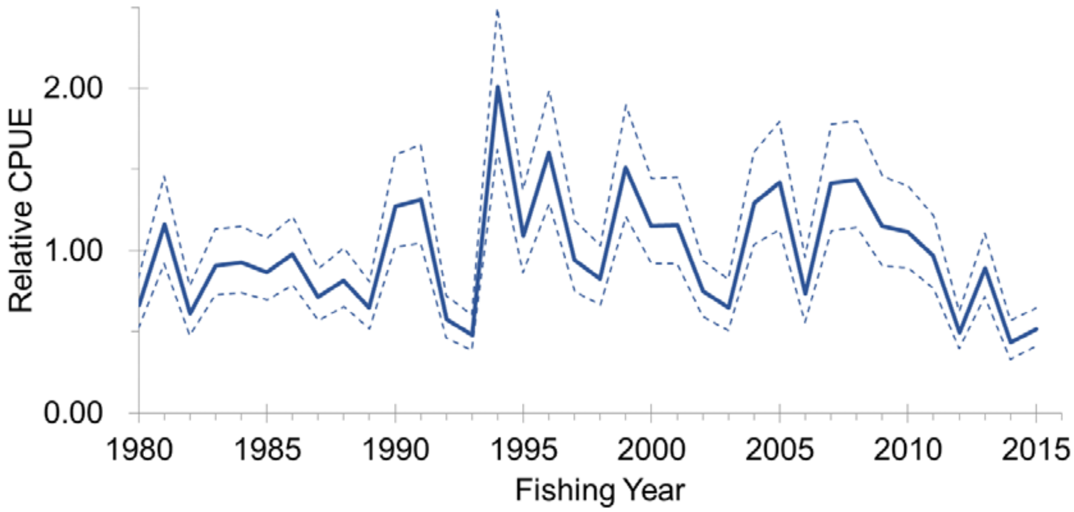

Fig. 2. Trajectory of standardized CPUE of Japanese troll vessels operating in the East China Sea.

3. REVIEW OF THE 2016 STOCK ASSESSMENT

3.1. Summary of 2016 stock assessment

H. Fukuda made an oral presentation summarizing the 2016 stock assessment. A stock assessment model created for the 2016 Pacific bluefin tuna assessment was reviewed and some points, which potentially need to be improved for the future benchmark assessment, were discussed. The highlights of the presentation were; 1) the information about abundance and recruitment trend, and abundance scale was derived from catch, size, and CPUEs; 2) the assessment model fits these data generally well; 3) each data component generally was consistent regarding population scale estimates in the stock assessment model; 4) the retrospective diagnostics suggested that the base case model would be robust to the data update. A systematic misfit in the annual size composition data was pointed out and is possibly due to the misspecification of the fishing and/or biological process such as growth. Finally, the possible areas to improve the stock assessment model were introduced.

3.2. Possible areas of improvements towards the next benchmark assessment

-fishery data

Geographical characteristics of CPUE; presented by Y. Tsukahara (ISC/17/PBFWG-1/04)

It is considered that the CPUE for PBF caught by Japanese coastal longliners has a geographical trend. Ignoring these geographical effects might lead to a misunderstanding of the annual stock status fluctuation. This study applied a GAM to the CPUE data in order to evaluate the geographical effect. An interaction term of longitude and latitude showed a positive effect on CPUE around Nansei Islands, a somewhat belt-like geographical effect was additionally found offshore. For detailed analysis, a year effect was included in the interaction term of the geographical effect to investigate the geographical differences by year. The results indicated that annual fluctuations are spatially correlated, but the year effects varied regionally. This analysis shows the potential for development of a geo-statistical model. Considering the causations of different catchability by area with several perspectives (e.g., length composition of catch by area, migration, etc.) will lead to a deeper understanding of geographical effects on PBF abundance.

Discussion

A question was raised how it was decided to divide the coastline into three clusters, not four. The author explained that it is an arbitrary decision and considered the presented clustering easier to explain.

It was also pointed out that the composition of the "other" cluster in the current CPUE standardization potentially included multiple target species and that none of the clusters focused on PBF targeting. It was explained that since PBF are so rare, fishers generally target other species with the secondary intent of catching PBF as a "bonus."

It was noted that the core area has relatively large fluctuations and that may have reduced the splines ability to describe the data.

It was pointed out that the presented approach presumed the same smoothness across areas, though it could be different by area. Therefore, it may be beneficial to analyze the three areas separately.

A question was raised about what caused the difference in the area definition between the current model and the GAM model. It was clarified that the data sources to cluster the areas are different. It was noted that there are unclear aspects of the area definition in the current standardization model. It was again pointed out that the cluster analysis included in the current model should take into account some spatial effects. The WG determined that the current area definitions need to be reviewed for the next benchmark assessment.

Spatial-temporal modeling of CPUE; presented by M. Maunder (ISC/17/PBFWG-1/05)

Standardizing for spatio-temporal distribution of the fishing effort has been a main issue in CPUE analysis. Of particular concern is the change in spatial distribution over time due to movement of the stock, recruitment dynamics, or local depletion. A simple GLM including area as a factor and no interaction terms assumes that the year effect (or relative year-to-year variability in catch rates), which is assumed to represent relative abundance, is the same in each area and just the average catch rates differ among areas. The assumptions underlying this model can cause bias in the estimated index of relative abundance if the stock or fishery spatial distributions change over time. In addition, a somewhat overlooked component of using indices of relative abundance in stock assessment models is the component of the population that is represented by the index with respect to age or size. Typically, this is modelled using a selectivity curve that is estimated by fitting to composition data. The selectivity curve represents both the catch and the index of abundance. Naively, this makes sense, since both catch and the index of abundance are derived from the same gear. However, selectivity in the stock assessment model does not simply represent contact selectivity, but also represents availability, which is a consequence of the spatial structure of the fleet relative to the stock. Therefore, due to the index representing abundance in each area and the fishery catch representing catch in each area, if the composition differs among areas then the selectivity in the stock assessment differs between the survey and the catch. The index and the composition data should both be derived using the same spatio-temporal model. The use of spatio-temporal models for standardizing CPUE and composition data were outlined, and the issues using PBF as an example were discussed. A workshop is proposed for the first half of March 2018 in La Jolla, California, to discuss the issues.

Discussion
The WG agreed it was challenging to capture targeting effects in a geo-statistical model. It was pointed out that only using hooks per basket and spatial effect may not be sufficient to capture targeting effects. It was also pointed out that there are seasonal changes within a year, which may need to be taken into account. It was clarified that the WG has flexibility to decide which model is most appropriate in the course of development of such a model. In response to a question, it was clarified that environmental information such as SST can also be incorporated.

The WG noted that use of the available data for such a fine scale analysis is an important consideration. It was noted that Taiwanese data has high-resolution spatio-temporal information. The WG encouraged Taiwan to conduct such spatio-temporal analysis collaboratively with WG members or make this data available for the WG for calculation with appropriate conditions.

Spatio-temporal variation in size-structured populations using fishery data: an application to shortfin mako (Isurus oxyrinchus) in the Pacific Ocean

M. Kai made an oral presentation on a novel length-disaggregated spatio-temporal delta-generalized linear mixed model (GLMM), and its application to fishery-dependent catch rates of shortfin mako sharks in the North Pacific Ocean. The spatio-temporal model may provide an improvement over conventional time-series and spatially stratified models by yielding more precise and biologically interpretable estimates of abundance. Including length data may provide additional information to better understand life history and habitat partitioning for marine species. Nominal catch rates were standardized using a GLMM framework with spatio-temporal and length composition data. The best fitting model showed that most hotspots for “immature” shortfin mako occurred in the coastal waters of Japan, while hotspots for “subadult and adult” occurred in the offshore or coastal waters of Japan. It was also found that size specific catch rates provide an indication that there has been a recent increasing trend in stock abundance since 2008.

Predicting the spatio-temporal distributions of pelagic sharks in the western and central North Pacific
M. Kai made an oral presentation on analyses of the seasonal spatio-temporal distribution of pelagic sharks in the western and central North Pacific Ocean using fishery catch rates and a generalized linear mixed model with spatio-temporal effects. Different spatial distribution patterns were observed between two shark species. The hotspots of shortfin mako (SFM) appeared in the vicinity of the coastal and offshore waters of Japan and the Kuroshio-Oyashio transition zone (TZ), while the hotspots of blue shark (BSH) were widely distributed in the areas from the TZ to the waters of the Emperor Seamount Chain. SFM distribution changes seasonally with clear north-south movement, which follows higher sea surface temperatures (SST). However, preferred spring and summer water temperature was still colder than those in fall and winter, but not as cold as for BSH, which did not show seasonal north-south movement. BSH

exhibits seasonal east- west movement apparently unrelated to temperature. The spatial fishing effort by season generally follows the seasonal movement of temperature possibly making SFM more vulnerable to the fishery than BSH

Discussion

A question was raised about whether discard information was included in the analysis. It was clarified that since the data used is from longline vessels of Kesennuma that target sharks, discarding is likely to be low. However, it was noted that if such analysis is to be conducted for general longline vessels, the discard information needs to be taken into account because the vessels would be releasing sharks due to strict international regulations.

With regard to the future application of such analysis, it was noted that the available data only allows the method based on size-information to go back to 2006, thus it may be difficult to directly incorporate the resulting index in an assessment model. The model using SST may provide a longer time series. However, even for a short period, information provided from such spatio-temporal model could be useful.

It was questioned if targeting has an impact on the results. The presenter clarified that when he included the impact of fishing strategies to target swordfish or sharks, it was not significant.

The coverage of skipper notes that provide fish size information was questioned and if such a data collection framework is possible for PBF fisheries. The presenter did not have the exact coverage, but it was noted that a substantial portion is covered by the skipper notes. It was noted that the vessels involved in the PBF fisheries come from many different ports, thus it is difficult to have dialogue with fishermen and would make an application of this nature especially difficult. In this regard, the WG considered that it might be useful for standardization to include the home port of each vessel's data.

It was noted that by including various data (e.g., SST), spatio-temporal modeling would be able to fill the gaps, but if the overall coverage is shrinking due to the decrease of fishing vessels, that cannot be covered by such an approach. The WG discussed various ideas to improve the standardization method and agreed to continue discussing towards the next benchmark assessment.

a. biological information

It was noted that there are indications that the growth rate, which is currently assumed to be time-invariant, may be variable. In the current model, change in selectivity and change in growth rate are hard to distinguish. Length based selectivity could be an option to deal with the issue, but further research is required.

b. assessment model

The WG determined that reviewing the CPUE is the highest priority for the next benchmark assessment. It was also discussed whether it is possible to obtain an abundance index in the EPO. The WG recalled that it discussed the matter in the past, but could not come up with a feasible approach. It was suggested that an aerial survey may provide an index. If such an index is available, it may be possible to move to a spatially structured assessment model.

4. REQUEST FROM IATTC – WCPFC-NC JOINT WORKING GROUP

4.1. Results of projection analysis

Preliminary analysis of additional future projections; presented by T. Akita (ISC/17/PBFWG-1/06)

T. Akita presented the results of thirty-two stochastic projections requested by the Joint Meeting between WCPFC-NC and IATTC and WCPFC Commission Meeting in August and December 2016, respectively. The projections were based on the 2016 PBF stock assessment and contained alternative harvesting (several combinations of fishing mortality and catch limit) and recruitment (randomly resampled from the whole stock assessment period or from the relatively low recruitment period) scenarios. Performance measures were examined for all scenarios, such as achieving probabilities of rebuilding targets (SSBMED1952-2014 in 2024, 150%SSBMED1952-2014 in 2030, 200%SSBMED1952-2014 in 2030, 20%SSBcurrent, F=0 in 2030, and 20%SSB0 in 2034) and expected annual yield by flag or area. Trajectories of spawning stock biomass and total yield during 2015-2035 were graphically shown, and compared between all scenarios, as well as presented in a table of performance measures, providing material for further **discussion** on the next conservation and management measures. The results are expected to be presented to the ISC PBF stakeholder meeting in April.

Projections based on the 2016 Pacific Bluefin tuna assessment; Information Paper presented by Joel Rice (ISC/17/PBFWF-1-/IP)

Joel Rice (Invited Expert) presented alternative projections based on the reference case model of the ISC's 2016 PBF assessment. The projections are stochastic forward projections run using SSFUTURES (Akita et al. 2015) as described in the 2016 assessment (ISC, 2016). Scenarios considered included modifications made to the harvest levels found in the ISC assessment in order to compare the effect of alternative catch limits. The results indicate that the catch of smaller fish (less than 30kg) in the western Pacific Ocean is highly impacting the stock. All scenarios considered had a nearly 100% chance of reaching the WCPFC "historical median" rebuilding target by 2024, and multiple scenarios would give a high likelihood of rebuilding to 20%SSB0 by 2024. It was pointed out that WCPFC agreed a definition of SSBmed, which resulted in 41,000 t.

4.2. Preparation of response to the RFMOs.

Discussion

The WG determined that it should not comment on the performance of each scenario because the requested information is provided and the importance of performance criteria would differ depending on perspective. The WG discussed possible additional scenarios that may further inform the **discussion** at the stakeholder meeting in April. It discussed if an additional recruitment scenario might be necessary given that the result is totally different depending on the recruitment scenario. Several ideas were suggested, including a recruitment scenario in the middle of the current two, one that uses stock recruitment relationship, or one that uses 10 years low recruitment followed by average recruitment, as done previously. The WG agreed to include the third option for reference. The WG also considered that a 20%SSB0 based on low recruitment would be necessary because the performance should be evaluated against the same recruitment scenario (i.e., a target based on low recruitment should be used to evaluate the low recruitment projection). The WG agreed to add the following scenarios and performance measures.

1. Runs with zero catch for both recruitment scenarios.
2. Change the threshold of small/large fish to 85kg in Scenario 1.
3. Scenario 1 using a recruitment scenario of 10 years of low recruitment and average recruitment thereafter.
4. Additional performance indices of the probability (i) to achieve 20% of SSB0 of low recruitment in 2034 and (ii) the stock going below the median of 2014 in 2024.

The WG considered that it would be also useful to have performance criteria based on dynamic B0. However, it was reported that such a performance criterion is not possible to calculate in the current projection model. The WG therefore decided the model should be revised to have a capability for doing such calculations in future meetings.

The WG discussed the concern raised regarding Korean vessels not being able catch any large fish in scenarios 11 and 12 due to the lack of historical fishing mortality for large fish associated with Korean vessels in the prescribed period. It was clarified that fishing mortality in the projection is directly drawn from the assessment result, and because there is no history of Korean vessels catching larger fish over the projection period, it is currently not possible to ascribe a fishing mortality. It was agreed to explain the situation in the reporting document.

The WG agreed that Appendix 4 would be forwarded to the stakeholder meeting.

5. RESEARCH ACTIVITIES BY MEMBER

Japanese larval survey

S. Ohshimo presented “Horizontal distribution and habitat of Pacific Bluefin tuna larvae in the waters around Japan,” which compared survey data with historical data collected from 1979 to 1988 (“early period”). A total of 9192 individual PBF larvae were collected from 1979 to 2015, and body lengths ranged from 2 mm to 11 mm. In the early period, the relatively higher probability area for the presence of PBF larvae in the Pacific, as determined by a GAM (generalized additive model), was wider than that in the Sea of Japan. However, in the late period, the relatively higher probability area for presence in the Sea of Japan was wider than in the early period. The spline function of sea surface temperature for PBF larvae was lower in the early period than in the late period, though large uncertainty in the Pacific in the late period was observed. These results suggest that the change in the distribution pattern of PBF larvae was caused by ocean warming. Clarification was requested on the gear and area selections, as well as relationships between recruitment index and number of sampled larvae. It was clarified that gear had not changed, and survey area in the recent years was fixed. The final goal of this survey is to estimate the recruitment index.

Discussion

The Group questioned the possible cause of the large catch of larvae in the Sea of Japan. The presenter responded that it could be due to a variety of reasons, including an increase of young adults in the spawning ground, the vessel hitting the right place by coincidence, etc. It was also questioned if larvae have been caught in the area between the two fishing grounds. The presenter responded that PBF larvae had not been found in the East China Sea presumably due to its shallowness. It was further asked if there is a correlation between larval abundance and recruitment. The presenter commented that it would be difficult to find connection between larval abundance and recruitment due to a very high mortality before recruitment, although the ultimate goal of the research is to predict recruitment through the larval survey. There was support for a more collaborative approach on larval surveys and Taiwan expressed interest in working collaboratively with the NRIFSF on this survey.

Evidence of westward transoceanic migration of Pacific bluefin tuna in the Sea of Japan based on stable isotope analysis

A. Tawa made an oral presentation on emerging research to identify PBF migrations (PBF is a highly migratory species, with some individuals migrating) between the western Pacific Ocean (WPO) and eastern Pacific Ocean (EPO). In this study, stable isotope analysis is used to identify PBF that had recently undergone westward transoceanic migration to the Sea of Japan. A total of 155 PBF individuals were examined. Their ages ranged from 2 to 17 years, with most individuals being 2 to 7 years of age. Individuals from each year class were classified as WPO residents or recent EPO migrants using cluster analysis of $\delta15N$ values. Individuals aged 2, 6, and 7+ years had unimodal distributions of $\delta15N$ values, while individuals aged 3, 4 and 5 years showed a bimodal distribution with high- and low- $\delta15N$ groups. Due to the overall higher baseline of $\delta15N$ values in the EPO, high $\delta15N$ individuals were considered to represent PBF that had migrated from the EPO. Though individuals aged 6 and 7+ years showed unimodal distributions in the cluster analysis, discriminant analysis indicated that these PBF also included some migrants from the EPO. Researchers preliminary estimated the percentages of migrants and residents in the Sea of Japan but recognize that significantly more samples are required. Such information can improve stock assessments models for PBF and contribute to the sustainable stock management of this species.

Preliminarily estimation of catch composition from two natal origins based on catch at length data of age-0 fish caught in 2008-2014

Y. Hiraoka made an oral presentation on recruitment mechanisms for PBF. In this study, the catch composition of two natal grounds (northwestern Pacific Ocean and Sea of Japan) during 2008 and 2014 for age-0 fish were estimated using the same procedure as a previous study (Itoh, 2009) and hatch date, growth parameters, and catch at length were re-estimated and used in subsequent analyses. Monthly catch-at length by fishery (troll, set net, and small pelagic purse seine in the East China Sea) and landing area (Sea of Japan side or Pacific Ocean side) were decomposed into two sub-cohorts ("SC1" or "SC2") groups and an "unknown" group, then aggregated by year and landing area. From the results, updated compositions of "SC2", which is assumed as juveniles from Sea of Japan, caught in Sea of Japan side were substantially higher percentage than the values estimated by previous study (40-78% in 2008-2014, 5-40% in 1993-

1997). Verification of the results by other methods such as otolith chemistry analysis would provide a good opportunity of interesting **discussion**s in the future.

Discussion
The WG discussed if it is possible to model the different growth of the two spawning grounds and recalled that the group discussed options in the November 2015 meeting. It was also pointed out that the group once discussed separating CPUE for recruits from two spawning grounds but did not proceed further because catch information cannot be divided into two groups. The WG noted that the current recruitment index from Nagasaki Prefecture presumably captures the signal from both recruitment groups, so the strength of the two groups are considered in the model to some extent.

It was noted that the Japanese catch composition data showed that the proportion of recruits from the Sea of Japan fishing ground is quite substantial (around 50%) of age-0 catch by Japan. However, it was difficult to conclude if it is because the actual recruitment from the Sea of Japan ground is higher than expected or whether this is a sampling artifact.

Relationship between large PBF catch and oceanographic condition in Korean water

D. Kim briefly presented the results of a study on the relationship between large PBFs catches and sea surface temperatures. Results suggested that catches of larger PBF fluctuate depending on the extension of the 15℃ isothermal line in Korean waters. A greater number of PBF were caught from March through April 2016, when 15℃ isothermal line extended further north, than had been in previous years However, in order to obtain reliable results, it is necessary to understand the spatio-temporal distribution of PBF in the Korean waters through appropriate statistical analysis considering environmental changes over time.

Discussion
The WG noted a higher proportion of large PBF catch in the Korean fishing grounds in 2016 that had not occurred before. The WG could not identify the cause but it could be an environmental effect or the emergence of a large cohort. It was suggested to seek further historical information to see if a similar oceanographic condition was observed in the past.

Energy budget model

H. Ijima and M. Jusup introduced a new modeling approach for PBF population dynamics. This new model combines population dynamics model and a dynamic energy budget model that considers the energy flow of tuna. They plan to evaluate the environmental effects against tuna population dynamics by using this model to portray the changing effects of food and water temperature for individual tuna.

Discussion
It was asked how the model can improve assessment models. The presenter explained that the model will become capable of portraying environmental changes by modeling parameters currently assumed to be static.

Progress in the Japanese Close-Kin project in 2016

N. Suzuki made an oral presentation on the progress of PBF tissue sampling in Japan to advance close-kin research, project member, and their tasks. Since 2014, Japan has collected tissue samples from PBF for close-kin analyses to estimate the absolute abundance of PBF SSB. In 2016, the number of juvenile and adult samples collected are in excess of 3,000 individuals. RAD sequencing succeeded in finding approximately 260,000 SNPs, which were screened by automated and manual filtering based on bioinformatics, in the process of developing SNP markers for genotyping individuals. To date, researchers obtained more than 200 SNP markers enabled to be genotyped by the simple protocol (Ampliseq) via a multiplex PCR and NGS, processing per sample is approximately $40-$80 USD. Based on the allele frequency data observed in 45 wild PBF, among 3 families, computational simulations assuming a virtual ideal reproductive process were performed to validate how many SNP markers should be analyzed. According to both accuracies for identifying or misidentifying POPs, 150 SNP markers should be sufficient to find POPs accurately. In contrast, simulations also indicated that more than 1400 SNPs should be analyzed to distinguish half-sib pairs from non-relatives, if researchers want to use sibling information to evaluate stock size.

Discussion

It was clarified that the current plan is to provide a rough estimate of absolute biomass in 2020. The challenge of the program is the cost; even the cheapest genetic analysis costs about U.S. $40 per sample. It was also noted that individually-based operating models created to incorporate close-kin analysis are still in development. It was questioned if the current schedule by Japan assumes international collaboration. The presenter responded that the current schedule has been developed to use Japanese data only.

It was noted that Taiwan is considering collaborating with ISC members to ease the burden of cost for genetic analysis of collected samples. Korea also noted that for the past two years they have secured some funding to analyze the collected samples.

Even though Japan is leading the process, the WG confirmed the importance of international collaborations to advance close-kin analysis. In doing so, the WG determined that it is important for the Plenary to hold a workshop on close-kin and discuss matters such as the standardization of analytical methods.

6. OTHER MATTERS

Response to request from WCPFC13

The WG discussed the request from WCPFC13 to define “drastic drops in recruitment and associated risks.” The WG determined that it is difficult to define an arbitrary level of a drastic drop in PBF recruitment. The WG noted that the best estimate of recruitment is only available through the assessment, and any emergency rule has to rely on more uncertain recruitment indicators (i.e., surveys), such as those currently performed by Japan. Therefore, the WG questioned the effectiveness and necessity of such an emergency rule when an assessment is scheduled to be conducted every two years. However, it is possible to suggest a framework for the emergency rule if it is still considered useful. For example, it may be possible to evaluate a framework such that when recruitment is considered to be lower than the current low recruitment scenario based on the new Japanese recruitment index, a preliminary projection is conducted using the estimated recruitment to evaluate whether the probability of achieving a target decreases to a level for which additional measures are required. The required measures to achieve the target under such a situation can also be calculated. A detailed description of such a management framework follows:

Quantification of the impact of the recent recruitment level, as implied by a new age-0 troll fishery CPUE data point, could be calculated by evaluating how a single recruitment in the most recent year would affect the probability of the stock rebuilding to the interim rebuilding target within the specified time period. The estimate of the proportionality (catchability) of the troll fishery CPUE series to the age-0 abundance (scaling) and the reliability of the index in predicting recruitment (precision) would be used to calculate the recruitment and its uncertainty. Estimates of both precision and scaling can be taken from the stock assessment model (conducted in a previous year) if the age-0 troll fishery CPUE series is included in the assessment. Precision can be measured by the mean squared error of the residuals of the fit of the stock assessment model to the age-0 troll fishery CPUE index of abundance. The uncertainty in the estimate of the scaling factor would have to be added to this precision estimate to determine the total uncertainty in the recruitment estimate. With these measures a new projection can be conducted that includes the estimate of recruitment and its uncertainty implied by the troll fishery CPUE index value for the new year. The bootstrap projection could include the uncertainty by resampling recruitment from a distribution described by the estimate and its uncertainty. The effect of this level of recruitment would be expressed as a new probability of rebuilding to the interim target within the specified period. Because the index of age-0 is expected to have information on recruitment, this new projection would be better than simply resampling historical recruitments for the single new year. Management measures that would restore the probability of rebuilding to the interim target in the given time period to the desired level could be calculated.

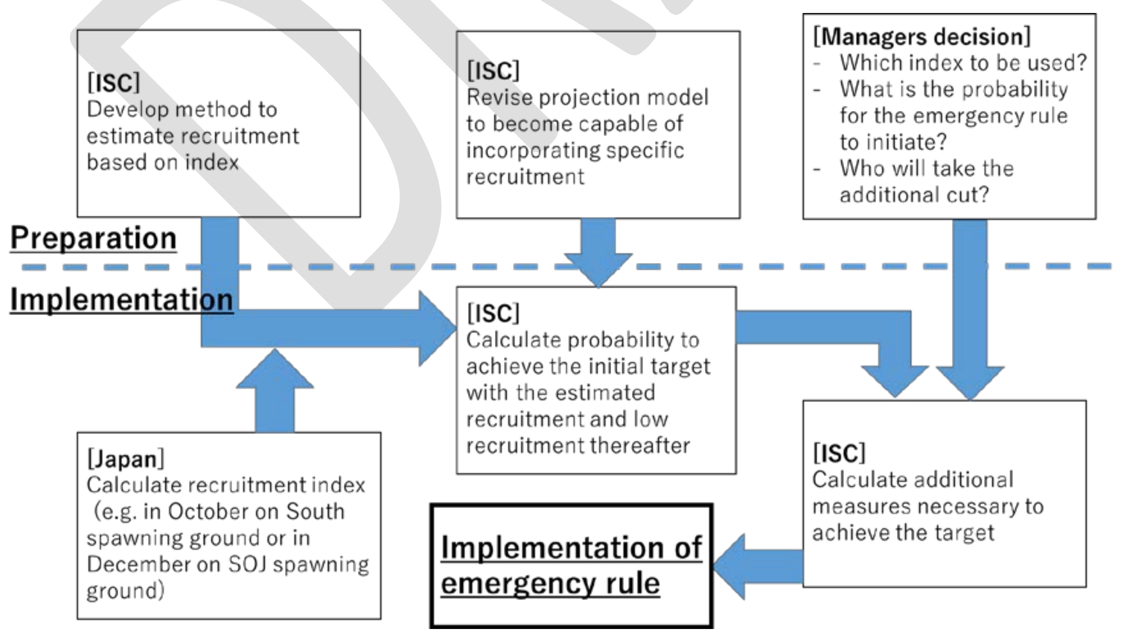

Fig. 3. An example of flowchart of development and implementation of an emergency rule based on recruitment index.

If such a framework is considered useful, the WG can discuss the specific details of this framework in collaboration with managers (Fig. 3). The development of this framework would require a certain amount of time to properly evaluate the ability of the new Japanese index to predict recruitment level, develop a procedure to convert the index to recruitment, and revise the projection model to become capable of the calculation suggested here. It should also be noted that since the new Japanese recruitment index has a relatively short data series, this framework should be approached cautiously and the uncertainty taken into account.

Limit reference point of PBF
S. Nakatsuka introduced a recently published paper entitled, "A limit reference point to prevent recruitment overfishing of Pacific Bluefin." It argues that a limit reference point (LRP) for PBF could be developed by determining a biomass level that would prevent recruitment overfishing. First, it reviews the development of LRPs for various tuna species and demonstrates that most of these limits are not necessarily based on biological information on the respective species. Then, a variety of simple analyses of the stock–recruitment relationship of PBF are conducted to find a biomass level that would prevent recruitment overfishing (i.e. an LRP below which stocks should not fall.) It concluded that defining such an LRP for PBF is possible (about 30 thousand tonnes or 5% of estimated unfished spawning stock biomass.) The LRP is both based on actual experience and the logic would also be more understandable to stakeholders than the theoretical LRPs used elsewhere. This LRP should be useful in future more comprehensive management frameworks, such as one developed through management strategy evaluations, in which stakeholder involvement in decision-making is crucial.

Discussion
It was questioned if the uncertainty associated with each stock-recruitment data point is taken into consideration. It was clarified that the analyses did not specifically deal with the uncertainty of data.

Correction of the 2016 Assessment results
H. Fukuda reported that a miscalculation was found in the previous assessment report. The mistake only affects a small portion of the assessment results and does not impact management advice. The WG agreed to revise the assessment report with revision note and have it publicized after authorization by the Plenary.

Update assessment in 2018
The WG tentatively agreed to hold a one-week update assessment in late February 2018. The venue will be discussed further.

In principle, the data for an update assessment would be only updated for the additional two years and the terminal year in the previous assessment. Model diagnostics will be conducted and if not satisfactory, the projections should be conducted using the previous model. A simple report will be prepared.

Revision of the projection model

Given that many different projection scenarios will likely be requested by managers, it is beneficial to revise the projection model so that it can deal with a variety of harvesting or recruitment scenarios. The WG noted that the new features would be useful, including those that show the trajectory of fishing mortality, to incorporate arbitral fishing mortality or recruitment, calculation of dynamic B0 based reference points, and implementation of feedback control based on recruitment or biomass.

7. ADOPTION OF REPORT

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

ATTACHMENT 1. AGENDA

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

PACIFIC BLUEFIN TUNA WORKING GROUP
INTERSESSIONAL WORKSHOP
February 15-20, 2017

Draft agenda

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

2. Review of FY 2015 indices
2.1. Longline CPUE (JPLL and TWLL)
2.2. Troll CPUE (JPTroll)
2.3. Other relevant fisheries information
2.4. Possible conservation advice

3. Review of the 2016 Stock Assessment
3.1. Summary of 2016 stock assessment
3.2. Possible areas of improvements towards the next benchmark assessment
- fishery data
- biological information
- assessment model

4. Request from IATTC – WCPFC-NC Joint Working Group
4.1. Results of projection analysis
4.2. Preparation of response to the RFMOs.

5. Research Activities by Member

6. Other Matters

7. Adoption of Report

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ATTACHMENT 3. LIST OF DOCUMENTS

3.1 Working Papers

No.	Agenda	Title	Authors	Contact
ISC/17/PBFWG-1/01	2.1	Japanese coastal longline CPUE and Catch at length for Pacific bluefin tuna: Update upto 2015 fishing year	Osamu Sakai and Yohei Tsukahara	sakaios@affrc.go.jp
ISC/17/PBFWG-1/02	2.1	Standardized PBF CPUE Series for Taiwanese Longline Fishery	Shui Kai Chang and Hung-I Liu	skchang@facultynsysu.edu.tw
ISC/17/PBFWG-1/03	2.2	Updated standardized CPUE for 0-age Pacific Bluefin tuna caught by Japanese troll fisheries: Updated up to 2015 fishing year	Yoshiaki Fukuda and Osamu Sakai	yoshif@affrc.go.jp
ISC/17/PBFWG-1/04	3.2	Geographical characteristics of CPUE for Pacific Bluefin Tuna caught by Japanese coastal longliners.	Yohei Tsukahara and Osamu Sakai	tsukahara_y@affrc.go.jp
ISC/17/PBFWG-1/05	3.2	The need for spatial-temporal modeling of catch-per-unit-effort data when used to derived indices of relative abundance to include in stock assessment models	Maunder, M.N., Thorson, J.T., Lee, H.H., Kai, M., Chang, S.K., Kitakado, T., Albertsen, C.M., Piner, K.R.	mmaunder@iattc.org
ISC/17/PBFWG-1/06	4.1	Future projections of Pacific bluefin tuna requested from Northern committee	Tetsuya Akita, Hiromu Fukuda, and Shuya Nakatsuka	akitatetsuya1981@affrc.go.jp

3.2 Presentations

No.	Title	Presentators	Contact
2.3	Real-time troll monitoring CPUE for 2016 recruitment	Osamu Sakai, Yaoki Tei, Nobuaki Suzuki	sakaios@affrc.go.jp
2.3	Mexican fisheries from 2009 to 2016	Michel Dryfus	dreyfus@cicese.mx
2.3	Other information from Japan	Hiromu Fukuda and Yujiro Akatsuka	fukudahiromu@affrc.go.jp
3.1	Summry of the 2016 stock assessment	Hiromu Fukuda	fukudahiromu@affrc.go.jp
3.2	Predicting the spatio-temporal distributions of pelagic sharks in the western and central North Pacific	Mikihiko Kai, James T. Thorson, Kevin R. Piner, Mark N. Maunder	kaim@affrc.go.jp
3.2	Spatio-temporal variation in size-structured populations using fishery data: an application 1 to shortfin mako (Isurus oxyrinchus) in the Pacific Ocean	Mikihiko Kai, James T. Thorson, Kevin R. Piner, Mark N. Maunder	kaim@affrc.go.jp
4.1	Projections based on the 2016 Pacific Bluefin tuna assessment	Joel Rice	joelrice@uw.edu
5	A limit reference point to prevent recruitment overfishing of Pacific bluefin tuna	Shuya Nakatsuka, Yukimasa Ishida, Hiromu Fukuda, Tetsuya Akita	snakatsuka@affrc.go.jp
5	Relationship between large PBF catch and oceanographic condition in Korean water	Doo Nam Kim	doonam@korea.kr
5	Horizontal distribution and habitat of Pacific bluefin tuna Thunnus orientalis (Temminck & Schlegel, 1844) larvae in the waters around Japan	Seiji Ohshimo, Atsushi Tawa, Tomoko Ota, Satoru Nishimoto, Taiki Ishihara, Mikio Watai, Keisuke Satoh,Toshiyuki Tanabe, Osamu Abe	oshimo@affrc.go.jp
5	Evidence of westward transoceanic migration of Pacific bluefin tuna in the Sea of Japan based on stable isotope analysis	Atsushi Tawa, Taiki Ishihara, Yuki Uematsu, Tsuneo Ono, Seiji Ohshimo	atawa2015@affrc.go.jp
5	Preliminarily estimation of catch composition from two natal origins based on catch at length data of age-0 fish caught in 2008-2014	Yuko Hiraoka	yhira415@affrc.go.jp
5	Energy budget model	Hirotaka Ijima	ijima@fra.affrc.go.jp
5	Progress in the Japanese Close-Kin project in 2016	Nobuaki Suzuki	suzunobu@affrc.go.jp