Annex 9

REPORT OF THE PACIFIC BLUEFIN TUNA WORKING GROUP INTERSESSIONAL WORKSHOP

International Scientific Committee for Tuna and Tuna-Like Species
In the North Pacific Ocean

April 20-24, 2015
National Research Institute of Far Seas Fisheries, Shimizu, Shizuoka, Japan

1. Opening and Introduction
1.1. Welcome and Introduction
H. Nakano, Deputy Director-General of the National Research Institute of Far Seas Fisheries, Fisheries Research Agency, opened the meeting on 20 April 2015. He welcomed participants and hoped for a fruitful meeting. The Chair of the Pacific Bluefin Tuna Working Group (PBFWG), Z. Suzuki, highlighted the main objectives of the meeting on model and data improvements: review and discuss the 2014 Stock Assessment and CIE Review; review fishery data, biological parameters, model and model structure improvements, and stock status determinations.

1.2. Adoption of Agenda
The Chair introduced the draft agenda and proposed two additional items; New Agenda Items 3 "Recent information on PBF Fisheries" and 5 "Others" to have discussions on other matters on a broader term. The adopted agenda is provided as Appendix 1. A list of participants is provided as Appendix 2. The Chair noted that there were 10 Working Papers submitted and 10 oral presentations for discussion at the meeting (Appendix 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 2.1-Assessment (H. Fukuda); Item 2.2-CIE review (T. Carruthers); Item 3-Recent information (K. Fujioka); Item 4.1.1-Catch data (K. Oshima); Item 4.1.2-CPUE data (O. Sakai); Item 4.1.3-Length composition data (A. Aires da Silva); Item 4.2.1-Natural mortality and 4.2.2-Age and growth (M. Dreyfus); Item 4.2.3-Reproduction and 4.2.4-Migration (K. Piner); Item 4.3-Model improvement (H. H. Lee); Item 4.4-Model structure improvements (T. Carruthers); Item 4.5-Stock status determinations (Y. Kumegai); and Item 5-Others (K. Oshima).

2. Summary and Review of the 2014 Stock Assessment
2.1. Assessment
2.1.1. Review of the 2014 Pacific bluefin tuna stock assessment and
A sensitivity analysis of the 2014 stock assessment for Pacific bluefin tuna presented by H. Fukuda (ISC/15/PBFWG-1/02) (ISC/15/PBFWG-1/01)

The 2014 stock assessment of PBF was reviewed and the issues which were raised in the past assessments were highlighted. In the past assessments conducted in 2012 and 2014, the stock assessment model was unable to reconcile all key data sources while it represents the general conclusions about the status of stock. There were still some misfit among the model expectations and observation data, especially in the terminal abundance indices and the size composition data which was considered to be well sampled. The sensitivity analysis showed that one of the causes of the misfit to the abundance indices and size composition data was in the data conflicts among the input fishery data. Those conflicts of the input data should be resolved by the both aspects of data itself and the model setting such as relative weighting of the input data. Also, information about some life history parameters such as the maturity, growth, and natural mortality were becoming available after 2012 assessment. The presenter recommended that the PBFWG needs to review those information and consider the possibility of the change of those life history parameters in the stock assessment model during this meeting.

Discussion

A clarification was made that the reason for eastern Pacific Ocean (EPO) purse seine catch per unit of effort (CPUE) not being used for stock assessment was not because its fraction against total biomass is unknown but because search effort is conducted by small airplanes involved in PBF catch in farming activities and therefore there is still no good index to measure its effort level.

The assumption regarding the steepness in the model drew a considerable discussion. It was pointed out that the apparent lack of spawner-recruitment relationship does not equates with high steepness (h) and that h = 0.999 is unrealistically high and alternative methods for estimate spawner-recruitment relationship such as using virtual population analysis (VPA) or estimating h without using Stock Synthesis (SS), should be considered. Alternatively, methods to decouple the spawner recruit relationship from estimated recruitment inside the stock assessment model should be explored. It was noted that the implication of having a wrong assumption should be carefully evaluated. The WG agreed that the steepness is an important matter which needs careful consideration towards the next stock assessment. However, it was pointed out that the model does not converge with a smaller h because the current level of recruitment cannot be explained under a smaller h. It was also noted that the information regarding recruitment should be relatively reliable since there is substantial data available from a large fishery targeting it. It was also clarified that the current h = 0.999 was estimated independent of stock assessment model, by using life history parameters as described by Mangel et al. (2010) and that VPA application may have its own challenge.

2.2. CIE Review

Review of the 2012 Pacific Bluefin Tuna Stock Assessment is posted at the following NOAA site: https://swfsc.noaa.gov/2012_PBF_PeerReview/. The Chair introduced its summary (ISC/15/PBFWG-1/02) and explained its categorization; eleven recommendations have been done or partly done in the 2014 Stock Assessment Report, nineteen recommendations will be discussed at this workshop based on the working papers and presentations, eleven recommendations will be done as a future work, and additional explanations were given to two recommendations.

Discussion

The WG agreed that it is not necessary for the WG to respond to CIE review in a written form but rather it would be most effective that the WG discusses each agenda items while trying to incorporate or respond to the comments from CIE review.

3. Recent information on PBFT fisheries

3.1. Latest preliminary 2014 recruitment estimate

K. Oshima made an oral presentation. NRIFSF released preliminary estimations of recruitment abundance of the 2014 year class. Based on the preliminary estimations, both of CPUE of troll for farming and number of fish caught as seed for farming recorded the lowest in 2014. Recruitment from 2012 was thought to remain below the historical average levels. It was concluded that the 2014 recruitment was deemed to be at historically lower level, lower than that of the 2012 recruitment (the 8th lowest in 61 years).

Discussion

A question was posed regarding possible hypotheses for the causes of recent low recruitment but it was unclear at this stage. It was also emphasized by participants that the information provided in the presentation was only nominal CPUE data and it may not accurately reflect the true trend of recruitment; it may not be declining so much as indicated. For example, it was reported that recently very good fishing season is observed in EPO. It was agreed that the information presented in the presentation needs to be used with caution. At the same time, it was also emphasized not to miss an important warning sign since the information may truly reflect the recruitment trend.

In response to a question if there are any changes in operational environment of trolling for farming due to recent development of artificial hatching operation of PBF, it was clarified that the amount of artificial seed fish produced in Japan is rather stable recent years due to operational limitations and that farming companies usually prefer to natural seed fish because they are larger and stronger than artificial ones. Therefore, the demand for natural seed fish for farming is not considered to have declined recently. It was recommended to collect further information surrounding farming operation of PBF such as harvesting of seed fish, farming and artificial production of seed fish.

In response to a question regarding the operation of Korean purse seiners (usually catching age 0-3 fish), it was explained that the catch of 2014 and 2015 were about 1,300t and 600t respectively and that the size of fish is larger this year. It was requested that Korea would provide more information at the next meeting so that a comparative analysis with Japanese purse seine, which is catching the same age class, would be possible.

Recent information of PBF fisheries in EPO (usually targeting age 1-3 fish) was presented. In 2014, fishermen reported more fish than usual and the size of fish was larger than usual. It was noted that El Niño conditions were observed last year and that it might have pushed the fish north to areas more easily accessible for fishermen. It was also pointed out that management measures for the commercial fishery in EPO since 2011 could have resulted in more availability for sports fishermen. It was also noted that management measures by the Western and Central Pacific Fisheries Commission (WCPFC) were introduced from 2011 and that could have resulted in the protection of fish of younger ages, which is now age for the migration to EPO.

4. Status and Work Plan for 2016 Stock Assessment

4.1. Fishery Data Improvement

4.1.1. Catch Data

4.1.1.1. Preliminary fishery data from Japanese troll fishery for farming

K. Oshima made an oral presentation. This presentation was intended to provide preliminary fishery data of troll fishery for farming to establish a new fleet for this fishery in the stock assessment model. Lengths of fish caught by troll for faming were apparently smaller than those of fish caught by conventional troll. It is possible that there are differences in size selectivity between troll for farming and conventional troll. Preparation of quarterly catch data of this fishery was feasible using appropriate catch statistics. The fishery data from this fishery would support to establish a new fleet in the coming stock assessment, if needed.

Discussion

Since the measurement of fish for farming was conducted by using dead or injured fish, the possibility of sampling bias was raised. Nonetheless, the WG agreed that the result of this analysis is an important information, which revealed a possibility of underestimation of recruitment due to overestimate of the size of fish in the troll catch for farming, and that it need to be taken into account in the future assessment. In order to do so, several options were suggested, namely, (i) change the selectivity to reflect the size of troll catch for farming, (ii) split the troll catch for farming and establish another fleet, and (iii) take out the troll catch for the farming from troll fleet and treat that they are all age-0 fish. It was pointed out that changing the selectivity to accurately reflect the portion of troll catch for farming would be difficult due to annual variability. On the other hand, it was also noted that adding another fleet will create further complexity to the assessment model and might not be desirable. Concern was raised that creating a new fleet specifically targeting age-0 fish may overly influence the recruitment estimate but it was clarified the recruitment estimate is not directly tied to catch data.

4.1.1.2. Revision of estimates of catch in weight from the US recreational fishery from 1993 to 2014 presented by S. Teo (ISC/15/PBFWG-1/03)

The US recreational fishery for Pacific bluefin tuna (PBF) has been the most important US fishery for PBF in recent years. Although the most recent stock assessment uses catch in number of fish for this fishery, the US also submits the estimated catch in weight (metric tons) to the ISC and tuna RFMOs. The catch in weight was estimated by multiplying the monthly average weight of PBF caught by the US recreational fishery with the monthly number of PBF caught. The average weight of PBF caught by the US recreational fishery was estimated from the measured lengths of PBF sampled at the dock. In this paper, we revise the monthly average weights used in the catch in weight calculation because we simplified the algorithm used to calculate the monthly average weight, and used a length-weight relationship that is consistent with the stock assessment. There are three main periods of size sampling on the CPFV (commercial passenger fishing vessel) fishery: (1) 1993-2012 – IATTC sampling; (2) 2013 – No sampling; and (3) 2014 onwards – NOAA sampling. The monthly mean weights using the current algorithm are mostly within 10% of the previous algorithm, if actual size samples were used in the calculation instead of substitutions. When substitutions were used by the current or previous algorithm, this can result in large differences in monthly mean weight. However, the small amount of catch in those months limits the impact on the estimated annual catch in weight. Nevertheless, some future research is needed to improve on the current substitution method, taking into account the intra-annual seasonal variability and inter-annual variability in the size of PBF caught. The revised catch in weight for the US recreational fishery from 1993 to 2014 is shown, and this time series is considered to be the best currently available scientific information on the catch in weight for this fishery. It is important to note that this revision in the catch in weight does not affect the results of the stock assessment because the assessment uses the number of fish caught for this fishery, not the estimated catch in weight.

Discussion

It was pointed out that the catch in weight estimated by the new method is generally smaller than past methods. The author responded that, although the reason is unclear, it is probably because of the length-weight relationship but also mentioned that the past method is undocumented and cannot be verified. In response to a question regarding the amount of released and discarded PBF, the author clarified that the information of release and discard is provided by captain but its survival rate is unknown. It was also pointed out that the releases of PBF will likely increase because of the stricter bag limit newly introduced (reduced from 10 fish to 2 fish per trip per person). It was pointed out that commercial fishing in Mexico prefers larger fish while US vessel prefers smaller fish due to its operational characteristics (up to 30 customers on board on a single vessel and hooking of a large fish can disrupt other customers). In response to the question about the coverage of survey, the author responded that he did not know. He further noted that the US will collect more information from different type of sports fishing vessels and conduct further study if finer stratified analysis would be warranted.

4.1.2. CPUE Data

4.1.2.1. Standardized CPUE for Pacific bluefin tuna caught by Japanese coastal longliners, by zero-inflated negative binomial model using cruise aggregated data presented by Y. Hiraoka (ISC/15/PBFWG-1/04)

In order to handle data with many zero-valued observations, set by set data set for Pacific Bluefin Tuna caught by Japanese coastal longline fishery was aggregated by each cruise. The cluster analysis for species composition by cruise was conducted to identify the target species, especially

PBF and YFT, and the three clusters were used as the target indicator in this study. The negative binominal model (NB model) was firstly applied to select the explanatory variables by aggregated data. Subsequently the zero-inflated negative binomial model (ZINB model) was applied and this model converged successfully owing to the aggregated data. The two area definitions were applied as sensitively analysis. As the target shift was fully considered, it was suggested that the annual CPUE trend of Model B2 (ZINB model with three areas) would be the best available index of population trend for adult PBF.

Discussion

The WG noted that the effect of target shift could not be adequately addressed at the previous stock assessment but it is known that fishermen do change target while maintaining the target on a single cruise. Hence, the data were aggregated to identify the target. A participant expressed concern that the proposed method might be using the dependent variables as the explanatory variable, leading to a flattening of trend. The WG requested the authors to investigate the result of analysis without using cluster although the result may not be so different given the similarity of the result with nominal CPUE. Another participant pointed out that it is a valid point but the method used here is a standard one and such an impact could be taken into account. It was also explained by the author that the result without cluster analysis did not show much difference.

4.1.2.2. Data preparation for PBF CPUE analyses for Taiwanese longline fishery

S.K. Chang presented the data preparation for PBF CPUE analyses for Taiwanese longline fishery. Due to lack of sufficient logbook data, alternative data sources are considered to calculate CPUE index. For catch estimate, detail market landing data and PBF catch documents (CDS, since 2010) that containing information on each PBF catch are available. CDS data was compared and consequently showed high consistency with landing data. For effort estimate, logbook data can be useful only in estimating number of hooks per day due to its low coverage rate. Alternatively, coast guard records on vessels leaving and returning port can be used to estimate the days at sea. Data from vessel monitoring system (VMS) and voyage data recorder (VDR) that are available since 2007 could be used to identify fishing days by several approaches including the methods described in Chang and Yuan (2014) for each vessel and then cross-referencing its landing data to develop catch and effort statistics.

Comparisons between the resulted data set with the coast guard data for the same period since 2007 might be able to draw a correlation which can be applied to the coast guard data before 2007 for obtaining fishing-days estimate of each trip for data before 2007. Whether there is a need to convert the fishing-day estimates to number of hooks will be considered in the future. GLM/GLMM or ZINB models are to be used for standardizing the CPUE. Factors considered in the model include year, half-month, vessel size and area. Only the major fishing ground (120-126°E, 20-26°N) will be considered in the analyses. Due to lack of fishing area information for whole data series, the area factor will be represented by information of landing port since landings in different ports were noted generally coming from different fishing areas based on CDS data.

Discussion

It was reconfirmed the importance of the evaluation Taiwanese CPUE data due to its conflict with other abundance indices. A participant pointed out that the sharp increase in the previous Taiwanese longline CPUE in the terminal 2 years (2011 and 2012) had a strong influence in the results of the last assessment, and the WG hoped Taiwan to look into the matter. The author explained that the VMS/VDR data that they are going to use have high resolution to resolve the concerns on the actual fishing grounds implied from landing port information. In response to a question of the annual change of the landing individual weight, the author responded that it was stable in 2010-2012. There was also a question regarding the reason of excluding the data of larger fish (>300kg) in the calculation of average weight for converting landing weight to catch in number before 2010, and the author responded that it is to avoid contamination in the estimation with the assumption that record with landing weight over 300kg may come from more than one fish. The WG noted that this assumption may need further investigation.

It was pointed out that if there are different numbers of data points among areas this may have a large impact on GLM CPUE standardization in general and a possible solution in a published paper (Campbell 2004) was introduced. With regard to the logbook system in Taiwan, it was noted that the submission of logbook is voluntary and coverage is not enough to derive a reliable index. The WG pointed out that the comparison between standardized effort and hook number recorded in logbook could be informative. The Chair encouraged further discussion and improvement towards the next PBF WG workshop for data preparation.

4.1.2.3. Estimation of annual stock indices for Pacific bluefin tuna using catch data at Sakai-minato Port presented by M. Kanaiwa (ISC/15/PBFWG-1/05)
For highly migratory pelagic fishes like Pacific bluefin tuna (PBF: *Thunnus orientalis*), commercial fishery data is important and Sakai-minato Port is one of the biggest fishery ports for PBF. Purse seine is one of the major fisheries for PBF in Japan but no abundance indices of this fishery were provided to use in the past stock assessment (Anon. 2012). Kanaiwa et al. (2012) provided the nominal CPUE by this fishery and mentioned the annual differences in length distribution were problem to standardize it. In this document we tried to explain catch at age per each set of purse sine by latitude, longitude, sea surface temperature, salinity, water current, year, day from July. 1st and ages estimated from growth curve used for current stock assessment with length using Random forest. We provided the annual trend by using marginal mean of year from this model for each age. Because statistically there was no problem on this standardization, this standardized CPUE could become one of candidates as abundance indices to be used in stock assessment. Standardized CPUE for all ages became smoother than nominal CPUE. For all age, decreasing trend appeared between 2003 and 2006. For age 3- and 4, increasing trend was observed during most recent few years. At the same time, this trend has conflict with other information e.g. standardized CPUE of trolling fishery in the East China Sea. Therefore, careful consideration was required when these indices would be included.

Discussion
In response to a question, the author noted that in a trial application of the assessment model, the standardized CPUE for age 5 as presented demonstrated less conflict than nominal CPUE for age 5. However, it was clarified that it was not applicable universally to all age CPUEs. Regarding the operation of the Sea of Japan purse seine, it was clarified that each fleet has 3-5 vessels including one purse seiner and transfer vessels and that transfer vessels engage in searching activities when they are not transferring catch.

4.1.3. Length Composition Data
4.1.3.1. Body size of Pacific bluefin tuna caught by Japanese purse seine off the Pacific coast of Japan
Y. Ishida made an oral presentation. In the 2014 PBF stock assessment, catch at size in 1997-1998 were used for all years from 1952 to 2012. They examined if catch at size in 1995-2005 and body weight compositions in 1957-1961 can be used for the future stock assessment. In length compositions in 1997-1998 and 1995-2005, small-sized fish less than 70 cm was 9% and 17%, medium-sized fish in 70-146 cm was 76% and 60%, and large-sized fish greater than 146 cm was 15% and 23%, respectively. Comparing these length compositions, there is no clear reason to use only catch at size in 1997-1998 for stock assessment. In body weight compositions in 1957-1961, small-sized fish less than 7 kg was 0%, medium-sized fish in 7-65 kg was 0-78%, and large-sized fish greater than 65 kg was 22-100%. In conclusion, the average percentage of large-sized fish is 76% in 1957-1961, higher than 15% in 1997-1998, so it may not be appropriate to apply the catch at size in 1997-1998 to those in 1957-1961. A correction in small-sized fish in 1957-1961 and a missing size data from 1962-1994 are future works.

Discussion
The WG noted that this is an important study which could have a large implication to the assessment results. Several points were raised; how reliable are data? What is the explanation of sudden change of target size? Operation changed or fish changed? The author responded that he believed that the fishing operation is not so different and that data should be reliable since it is collected by the industry and their research institute. He added that since they used to measure individually only large fish, it is important to analyze the composition of small fish which were measured in a bulk.

The Chair asked for the opinion of the WG how to use the information from this analysis. The common view was that it is an important issue that warrants further work but probably preliminary to be incorporated in the next assessment. Some participants suggested using the information as sensitivity analysis in the next assessment.

4.1.3.2. Re-estimation of length frequency for Pacific bluefin tuna caught by Japanese coastal longliners for 1994-2013 presented by Y. Hiraoka (ISC/15/PBFWG-1/06)
There are clear differences in length frequencies of Pacific bluefin tuna at northern and southern ports landed by Japanese coastal longline fishery. However, the only influence on length frequencies by month was considered to estimate the catch at size data in the latest stock assessment. Therefore, we re-estimated the catch at size data considering the influence on length frequency by port/quarter and port/month. There is no clear difference between the catch at size data used in the latest stock assessment and the re-estimated catch at size data in the fourth quarter of fishing year between 1994 and 2012 in the present study. This may be due to the proportional shift in the main sampling port and the effort for measurement from Wakayama to Okinawa corresponding to the shift of main fishing ground from south of the main island (off Honshu) to off Okinawa and Yaeyama islands. Since the proposed method would enable length frequency estimation to reflect the operational characteristic more accurately, it is recommended to adopt this method.

Discussion
The WG considered the new method is an improvement and supported the method to be used in the next assessment.

4.1.3.3. Estimation of length frequency for Pacific bluefin tuna caught by Japanese set net with modified method presented by Y. Hiraoka (ISC/15/PBFWG-1/07)
Due to the complex structure of catch and size data for the PBF caught by Japanese set-net, a modification of previous method was considered. We developed a new procedure, which could keep the assumption about the random sampling as much as possible while reducing the bias such as spikes of the length frequency. Appropriate data stratification and priority for the data aggregation were decided based on GLM analysis. In order to eliminate the spikes, the selection of strata was determined by sensitivity analysis. As a result, it is suggested that the strata with observation of more than 10 and coverage rate of more than 50% would be the best for the estimation of catch at size of this fishery. Set net fleet is suggested to be categorized by size of fish caught rather than area and quarter.

Discussion
The WG agreed the proposed method more accurately reflects the catch at size and should be used in the next assessment.

It was pointed out that, since the set net fleet does not provide abundance index, what is important in the model is to remove the right catch at age. Having more fleets does not always improve the model and, in this case, it might be possible to combine all the set net catch but to try to have accurate selectivity. The author responded that their method is intended to achieve the same purpose. In a larger discussion, it was suggested to combine all the catch data which does not provide abundance index into one data set while have a time-varying selectivity in the next assessment. It was pointed out, however, that estimating an accurate time-varying selectivity can be challenging. In any event, the WG noted the possible value of having less fleet and agreed to consider the option as sensitivity at the next assessment.

4. 2. Biological Parameters Improvement

4.2.1. Natural Mortality

4.2.1.1. The seasonality of natural mortality for age-0 fish of the Pacific bluefin tuna using 1996-2012 mark-recapture data in Tosa Bay presented by S. Iwata (ISC/15/PBFWG-1/08)

This document studied about a quarterly change of natural mortality for age-0 fish of the Pacific bluefin tuna, *Thunnus olientalis* using limited data (only using recapture data at one port up to 9 months after the release) from mark-recapture experiments in 1996-2012 at Tosa Bay and the operational data for troll fishery by using a tag attrition model. When we applied the whole recapture and effort data set, we could not detect quarterly factors. On the other hand, by applying a part of the recapture and effort data (by selecting year with normal fishing mortality), quarterly change appears. In those years, in average the values are 0.49 (per month) for quarter 1 is, and 0.16 (per month) for quarter 2 and 3. The reason for the quarterly effects not being observed in all years may be due to annual variance of quarterly factor of natural mortality or other factors (i.e. migration etc.). Finally, authors recommend that future PBF stock assessments should continue to use the current estimate value of natural mortality (1.6) and quarterly effect as a sensitivity test.

<u>**Discussion**</u>

Questions were raised about annual variability of natural mortality (M) and why the analysis was limited to Tosa Bay area. In response, it was clarified that annual variability has not yet evaluated and that it is difficult to conduct in a wider scale due to the lack of effort data. The Chair summarized that it is an important matter but difficult to have a conclusion. It was introduced that at the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) a U-shaped mortality-at-age curve is being used in order not to have too many plus group fish in the assessment of Southern bluefin tuna. The Chair clarified that it is an empirical approach to converge the assessment. It was pointed out that different level of mortality was tested in the sensitivity runs in the previous assessment of PBF and introduced the WG with the result.

The WG was reminded that one of the points raised by the CIE review was the transparency regarding how to derive critical inputs, including natural mortality. In response, the past discussion at PBFWG was clarified; originally the WG used M of 0.14 but it resulted in an unrealistically large virgin biomass (B0). Therefore the WG conducted meta-analysis and compared with other tuna species. The conclusion of the WG was that PBF is probably more productive than most of other bluefin tuna species with fast growth and maturity as well as its longevity and settled with the current natural mortality. It is described in a document presented in the past ISC meeting (Aires-da-Silva et al. 2008). But it was noted that the WG may need to review that. It was mentioned the issue was just simply that the document mentioned was not introduced to the reviewers. The WG viewed that a new study is necessary if it were to change the current value of natural mortality.

4.2.2. Age and Growth

4.2.2.1. Accuracy improvement of age estimation using otolith annual ring

T. Ishihara made an oral presentation. After 2008, age of Pacific bluefin tuna (PBF) is being estimated by number of annuli of otolith thin section. However, annuli formed in young age (<10 years old) are indistinct as is the case of *Thunnus* species. To discuss and compile the current knowledge of the techniques to determine ages of PBF and related species, The Pacific Bluefin Tuna and North Pacific Albacore Tuna Age Determination Workshop was held in November 2013 at Shimizu, and protocols for aging of PBF were standardized. These achievements were summarized as an article "A manual for age determination of Pacific bluefin tuna *Thunnus orientalis*" by T. Shimose and T. Ishihara. This article will be published in Bulletin of Fisheries Research Agency of Japan. In this manual, protocols of otolith sampling, sectioning, counting the annuli and criteria of the first and the second annulus were described. In accordance with this manual, two researchers re-examined the otoliths collected by NRIFSF (N=3,053). As a result, the aging by two researchers matched in 1,106 cases, which showed improvements compared to the previous one. The validation of age estimating based on the manual was also conducted by bomb radiocarbon dating. Otolith core region of 0 to 28 years old fishes were measured for radiocarbon ratio and compared with the radiocarbon ratio of ambient seawater dissolved inorganic carbon when they were spawned. The result suggested that the estimated age were generally reasonable. In order to standardize the aging technique between NRIFSF and National Taiwan University researchers, we conducted cross-reading, and comparison of these aging results.

Discussion

A question was posed regarding the difference of the post bomb radiocarbon estimate results between the elder fish and age-0 fish. The author responded that core sampling from the otolith of elder fish would tend to have contamination of the portion that was formed after 1 year old compared to the age-0 fish. In response to a question regarding the difference of growth curve between the ISC result and the one presented here, it was clarified that the difference would be the result of whether the length is measured annually (this study) or monthly (ISC12 result).

4.2.2.2. Growth equation of Pacific bluefin tuna

H. Fukuda made an oral presentation. In the last stock assessment, the ISC PBFWG needed to make an ad-hoc revision to the growth curve, which was directly estimated age at length of otolith annual rings of PBF, because there is lack of information about the direct reading of Age-0 PBF. For the next stock assessment, we modeled length of PBF as a function of age using both of otolith annual rings and daily rings information considering with the seasonality or age dependency of growth speed. Results indicated that the simple von-Bertalanffy curve could not depict the growth of PBF especially between age 0 and 1. The 2 stanza growth function which considered age dependent growth speed showed better fit to the otolith annual and daily rings data. It would be valuable to put the 2 stanza growth model as a candidate of the growth function in the stock assessment model to calculate right catch at age.

Discussion

It was recognized that a misfit of age-0 fish to growth curve could have a significant impact on model. Since the observed data of age-0 PBF are not fit well to the current growth curve, one possible approach was to split the growth curve. The WG discussed about the modeling approach using random effect for the tagging data, error distribution of the daily and annual ring of otolith data. The authors agreed to continue their study and the WG would consider splitting the growth curve at the next assessment.

4.2.3. Reproduction

4.2.3.1. A review of reproductive biology of Pacific bluefin tuna

Y. Okochi made an oral presentation. Histological analysis of ovaries of Pacific bluefin tuna (*Thunnus orientalis*) has been conducted to provide reproductive parameters around Nansei Islands and the Sea of Japan spawning grounds. Estimated relative batch fecundity and spawning frequency in the Sea of Japan showed higher values than those around Nansei Islands. Further studies are required to explain the differences in reproductive parameters between spawning grounds.

Discussion

The WG noted that the referenced Atlantic bluefin study showed that longline caught bluefin tuna had lower fecundity/spawning frequency than purse seine collected fish. The WG questioned if this was a result of feeding fish not actively spawning or some other issue. It was clarified that this could be behavior or space effects. The WG also noted that the sampled temperature and spawning times in this study using wild caught fish matched those derived from captivity experiments. The WG also discussed the broader aspects of potential biases due to sampling spawning fish or spawning locations and noted that the author has a plan to analyze the sampling-gear effect in the Sea of Japan using not only purse seine samples but also set net samples. It was noted that the maturity ogive used in the assessment is set at a lower proportion maturity at age 3 because of the potential positive bias for maturity schedule. Furthermore it was also noted that the maturity ogive affects calculation of spawners used in generating expected recruitment, but this issue can be minimized in the assessment modeling. However reference point calculation will also be affected. This issue has been explored in previous assessments and may need to be explored in future assessments.

4.2.4. Migration

4.2.4.1. Review and recent developments: the trans-Pacific migration of Pacific bluefin tuna based on tagging studies.

K. Fujioka made an oral presentation. The trans-Pacific migration from WPO to EPO of Pacific bluefin tuna was investigated using archival tags implanted in tagged fish during 1995-2013. The migration to the EPO of age-0 fish occurred in their second year according to the month across the longitude 160 degrees east. We observed different patterns of the timing of the trans-Pacific migration between the two release areas: (i) early and middle timing of the migration in the area off Kochi (Pacific side of Japan), and (ii) middle and late timing of migration in the area off Nagasaki (the East China Sea). The timing of the trans-Pacific migration could be affected by the transport to these nursery areas in their first summer (Pacific side of Japan or the East China Sea).

Discussion

The WG asked about possible hypothesis explaining why PBF make trans-Pacific migration. The authors clarified that it could be for many reasons which include better feeding grounds in the Eastern Pacific. It was further clarified that return migrations to the Western Pacific are related to spawning preparations. However the details about the timing and mechanisms of the return migration to the Western Pacific are unclear. It was also pointed out that the migration information from larger fish (over 2 years old) is not available mainly due to operational reasons. The working group noted that recent publications on bluefin movement including information about movement that available information could be further considered towards the next assessment.

4.3. Model Improvement

4.3.1. Fisheries Definition

4.3.1.1 Fleet definition in the 2012 stock assessment and possible modification

K. Oshima showed a table of two candidates for the revised fleet configuration regarding possible modification of the definition of fisheries to be used in the assessment. First candidate was to split small tuna purse seine to Japanese and Korean and split troll to conventional troll and troll for farming, thus increase the fleet from total of 14 to 16. Another candidate is to combine all Japanese purse seine except for Korean and EPO purse seines, combine troll and pole-and-line, combine all set net and other, thus reducing the fleet to 9.

Discussion
The WG discussed plausible scenarios to define fleets in the next stock assessment. The WG noted the general benefit to have fewer fleet by combining size compositions for fisheries without abundance indices. However, it was also noted that the data once aggregated would be difficult to be separated later, so the aggregation process needs to be cautious. It was also recognized that managers may have legitimate reason to separate fleet for management purposes. An alternative was presented to combine catch data in a separable manner but treat them as one fleet under one selectivity so as to enable to separate the data when necessary. Also, since the past information is less important, time-varying selectivity may only be necessary for recent period. The WG agreed to further investigate the possibility of fleet aggregation towards the next assessment.

4.3.2. Model Settings
4.3.2.1. Future work to improve the PBF assessment modeling
H.H. Lee made an oral presentation. Large pelagic fish life history often includes predictable migrations that are thought to improve population fitness. Although our subjective understanding of movement may be adequate to understand general biology, incorporation of this understanding into a spatially explicit integrated stock assessment model is considerably more difficult. PBF are an example of a population of large pelagic fish that have a well-understood migration pattern consisting of movement of a proportion of juvenile fish from the natal areas of the Western Pacific to feeding grounds in the productive Eastern Pacific, and then returning prior to spawning. Due to a lack of data, the current stock assessment of PBF does not explicitly model this process, but instead assumes an instantaneously mixed population and incorporates regional selection patterns and catchability coefficients to account for spatial effects. We propose to conduct simulation analyses to evaluate alternative methods of incorporating spatial effects into the current stock assessment model with the existing data available. The impact of the method of dealing with movement on derived quantities of interest and diagnostics of model performance will be used to offer guidance on future stock assessments.

Discussion
It was recognized that the proposed exercise is to evaluate the different modeling approaches. Hurtado-Ferro et al. (2014) emphasized the importance of getting the spatial structure right using simulation approach. The WG pointed out the importance of simulation evaluation and experimental design in the simulation. The WG recognized that the potential benefit of the simulation approach to provide guidance on future stock assessment and encouraged the authors to conduct their research and to present the results to the future meetings.

4.3.2.2. Impact of setting of catch limits on stock assessment results of Pacific bluefin tuna presented by K. Oshima (ISC/15/PBFWG-1/09)
WCPFC CMM 2014-04 and IATTC Resolution C-14-06 came into effect in 2015 and placed catch limits on the overall growth stages of PBF in the North Pacific Ocean. These measures a significant reduction of catch of PBF less than 30 kg. This study aimed to examine whether setting of the catch limits would have an effect on stock assessment results such as estimates of recruitment and spawning stock biomass by conducting sensitivity and retrospective analyses based on past data by introducing hypothetical catch limit. It was found that that the catch limits set for fisheries targeting PBF younger than six years old would have resulted in underestimate of recruitment and, in addition, annual accumulation of catch information under catch restriction of young fish caused a further bias of recruitment estimates. It was concluded that measures to avoid the underestimation of recruitment, such as raising lambdas of abundance indices, should be taken into account in the future stock assessment.

Discussion
It was pointed out that, since impact of the reduction of catch on other input data is not fully considered, the result could be inaccurate. However, it was recognized that when the catch of

juvenile rapidly increases due to introduction of new fishery, stock assessment model in general tends to estimate larger recruitment in order to explain the catch and the opposite, underestimation of recruitment under catch limitation condition, could be possible. The WG noted that the best approach for this kind of issues would be simulation work (see Agenda 4.3.2.1), and this possibility should be taken into account at the next assessment.

4.4. Model Structure Improvements
Based on the discussions above, the WG discussed potential improvements for the next assessment. The summary of possible improvements is attached as Appendix 4. It was pointed out that the continuity of assessment is important and possible modifications may be best addressed through sensitivity analysis. It was also noted that it would be probably impossible to test all the proposed modifications and prioritization might be necessary. The WG agreed to further consider the list towards the next assessment.

4.5. Stock Status Determinations
4.5.1. Reference Points and Harvest Control Rules
The Chair noted that the discussion on reference points of PBF is a difficult issue and there is only an interim recovery target. He further noted the current simple harvest control rules (HCR) adopted by WCPFC. The ISC Chair introduced the outcome of the ISC Management Strategy Evaluation (MSE) Workshop held in Yokohama previous week. He noted that the purpose of the Workshop was to help scientists, managers, and stakeholders better understand MSE and how to implement it. It was also noted that how to implement it in ISC is up to each WG. What became clear through the Workshop was it is a long process and need involvement of managers.

The Chair further noted that, due to the lack of formal reference points, the WG employs two different reference points to draw Kobe plot; one with MSY concept and the other with median spawning stock biomass (SSB), which requires fewer assumptions. He considered that it would probably impossible to get consensus on the reference points by the next assessment. The WG considered if there are additional reference point candidates to be used in the next assessment in addition to the current list. It was pointed out that IATTC is considering limit reference point at a level of SSB which is expected to produce 50% of recruitment at B0. It was noted that a conservative stock-recruitment relationship is assumed in the IATTC method. One participant noted that a possible reference point for PBF based on maintaining healthy recruitment was presented in the MSE Workshop, which received no negative response, and that is based on a similar concept with IATTC's approach. In response, it was clarified that IATTC's approach is for interim limit reference point. It was pointed out that drastically different approach such as management based on catch or catch rate could be evaluated through MSE process. It was also pointed out that reference points could be used either to present the current stock status or to establish HCR, but the PBF assessment is probably still at the first stage.

5. Others
5.1. Discussion on the impact of possible low recruitment in 2014
5.1.1. Updates of recruitment and harvesting scenario for the future projection of Pacific bluefin tuna presented by H. Fukuda (ISC/15/PBFWG-1/10)
A future projection document was presented that took into account latest preliminary information about very low recruitment in 2014. Given the possibility of very weak recruitment in 2014, the authors conducted a minimally changed projection which used the lowest estimated recruitment in the past (1958) as the recruitment of 2014 followed by the low recruitment scenario as conducted in last assessment. The result showed that the stock is still able to achieve the interim management objective adopted by the WCPFC (to recover to B_{med} by 2024 with more than 60% probability) with 72 % probability where it was 89% in ISC 2014 scenario6 if the current measures are strictly implemented. The risk for SSB to decline below the historically lowest level observed at least one time within 10 years was about 34%, where it was about 24% in ISC2014

scenario 6.

Discussion

The WG noted that the recruitment information for 2014 is preliminary and uncertain. However, even if it is low, the presented result indicates it does not have a significant negative impact on stock recovery. The WG agreed that it is not necessary to change the past conservation advice. This matter will be appropriately addressed at the next full stock assessment scheduled in early next year, where it has more information including the recruitment estimate for 2014. However, the WG reemphasized the importance to continue and intensify recruitment monitoring as well as strict compliance of current fishing regulations for PBF in case the recruitment in 2014 is in fact very low.

5.2 Schedule of Meetings

The WG tentatively agreed to hold the next data preparatory WG in late 2015 (October or November) in Taiwan and the next assessment meeting in early 2016 (February or early March) in the US and will discuss the specific date further.

6. Reporting

The WG reviewed, discussed and amended the draft Working Group report.

7. Adoption of Report

The report was adopted by consensus.

8. Adjournment

The meeting was adjourned on 24 April 2015**.**

9. References

Aires-da-Silva, A., Maunder, M., Deriso, R., Piner, K., and Lee, H. H. 2008. An Evaluation of the Natural Mortality Schedule Assumed in the PBF 2008 Stock Assessment and Proposed Changes. ISC/08/PBF-2/04. Available at: http://isc.ac.affrc.go.jp/pdf/PBF/ISC08_PBF_2/ISC_08_PBFWG2_04.pdf

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Appendix 1. Meeting Agenda

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

PACIFIC BLUEFIN TUNA WORKING GROUP
WORKING GROUP MEETING

April 20-24, 2015

National Research Institute of Far Seas Fisheries, Shimizu, Shizuoka, Japan

1. Opening and Introduction
    - 1.1. Welcome and Introduction
    - 1.2. Adoption of Agenda
    - 1.3. Appointment of Rapporteurs
2. Summary and Review of the 2014 Stock Assessment
    - 2.1. Assessment
    - 2.2. CIE Review
3. Recent information on PBFT fisheries
    - 3.1. Latest preliminary 2014 recruitment estimate
4. Status and Work Plan for 2016 Stock Assessment

4.1 Fishery Data Improvement
- 4.1.1. Catch Data
- 4.1.2. CPUE Data
- 4.1.3. Length Composition Data

4.2. Biological Parameters Improvement
- 4.2.1. Natural Mortality
- 4.2.2. Age and Growth
- 4.2.3. Reproduction
- 4.2.4. Migration

4.3. Model Improvement
- 4.3.1. Fisheries Definition
- 4.3.2. Model Settings

4.4. Model Structure Improvements

4.5. Stock Status Determinations
- 4.5.1. Reference Points and Harvest Control Rules

5. Others
    - 5.1. Discussion on the impact of possible low recruitment in 2014
    - 5.2 Schedule of Meetings
6. Reporting
7. Adoption of Report
8. Adjournment

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Appendix 3. List of Working Papers and Presentations

Working Papers

No.	**Title**	**Authors**	**Contact**
ISC/15/PBFWG-1/01	A sensitivity analysis of the 2014 stock assessment for Pacific bluefin tuna	Kumegai, Y., Tei, Y., Uyama, H., Tsuruoka, I., Shimose, T., Ishihara, T., Okochi, Y., and Fukuda, H.	yukikumegai @affrc.go.jp
ISC/15/PBFWG-1/02	Status and Response to the CIE Review of the 2012 Pacific Bluefin Tuna Stock Assessment	Pacific Bluefin Tuna Working Group	
ISC/15/PBFWG-1/03	Revision of estimates of catch in weight from the US recreational fishery from 1993 to 2014	Teo, L. H. S., Suter, M. J., Childers, J., and Aires-da-Silva, A.	steve.teo@noaa.gov
ISC/15/PBFWG-1/04	Standardized CPUE for Pacific bluefin tuna caught by Japanese coastal longliners, by zero-inflated negative binomial model using cruise aggregated data	Hiraoka, Y., Tei, Y., Kanaiwa, M., and Oshima, K.	yhira415@fra.affrc.go.jp
ISC/15/PBFWG-1/05	Estimation of annual stock indices for Pacific bluefin tuna using catch data at Sakai-minato Port	Kanaiwa, M., Yamamoto, A., Ishihara, Y., Tsuruoka, I., Oshima, K., Fukuda, H., and Takeuchi, Y.	m3kanaiw@bioindustry.nodai.ac.jp
ISC/15/PBFWG-1/06	Re-estimation of length frequency for Pacific bluefin tuna caught by Japanese coastal longliners for 1994-2013	Hiraoka, Y., Kumegai, Y., and Oshima, K.	yhira415@fra.affrc.go.jp
ISC/15/PBFWG-1/07	Updated length frequency for Pacific Bluefin Tuna caught by Japanese set net with modified method	Hiraoka, Y., Uyama, H., Kanaiwa, M., Fukuda, H., and Oshima, K.	yhira415@fra.affrc.go.jp

ISC/15/PBFWG-1/08	The seasonality of natural mortality for age-0 fish of the Pacific bluefin tuna using 1996-2012 mark-recapture data in Tosa Bay	Iwata, S., Kitakado, T., Fujioka, K., Fukuda, H., and Takeuchi, Y.	siwata0@kaiyodai.ac.jp
ISC/15/PBFWG-1/09	Impact of setting of catch limits on stock assessment results of Pacific bluefin tuna	Oshima, K., and Fukuda, H.,	oshimaka@affrc.go.jp
ISC/15/PBFWG-1/10	Updates of recruitment and harvesting scenario for the future projection of Pacific bluefin tuna	Fukuda, H., Tsuruoka, I., and Oshima K.	fukudahiromu@affrc.go.jp

Presentations

Agenda No	Title	Presenters	Contact
2.1.1.	Review of the 2014 Pacific bluefin tuna stock assessment	Fukuda, H.	fukudahiromu@affrc.go.jp
3.1.	Latest preliminary 2014 recruitment estimate	Oshima, K.	oshimaka@affrc.go.jp
4.1.1.1.	Quarterly catch, length frequencies and CPUE from troll fishery for farming	Oshima, K., Tsuruoka, I., and Suzuki, N.	oshimaka@affrc.go.jp
4.1.2.2.	Data preparation for PBF CPUE analyses for Taiwanese longline fishery	Chang, S.K.	skchang@faculty.nsysu.edu.tw
4.1.3.1.	Body size of Pacific bluefin tuna caught by Japanese purse seine off the Pacific coast of Japan	Ishida, Y., Suzuki, N., Oshima, K., Hiraoka, Y., Fukuda, H., Takeuchi, Y., and Shimada, H.	ishiday@affrc.go.jp
4.2.2.1.	Accuracy improvement of age estimation using otolith annual ring	Ishihara, T., Shimose, T., and Yamasaki, I.	ishiha@affrc.go.jp
4.2.2.2.	Growth equation of Pacific bluefin tuna	Fukuda, H. and Yamasaki, I.	fukudahiromu@affrc.go.jp
4.2.3.1.	A review of reproductive biology of Pacific bluefin tuna	Okochi, Y. and Shimose, T.	okochi@affrc.go.jp
4.2.4.1.	Review and recent developments: the trans-Pacific migration of Pacific bluefin tuna based on tagging studies.	Fujioka, K.	fuji88@affrc.go.jp
4.3.2.1.	Future work to improve the PBF assessment modeling	Lee, H.H., Piner, K.R., and Maunder, M.N.	huihua.lee@noaa.gov

*For detail information about these presentations, contact to the author

Appendix 4. Model Setting in the 2012 Stock Assessment and Available Options

	Full stock assess. in 2012	Available options
SS version	SS-V3.23b	(latest version available if needed)
Year definition	July to June	
	Fishing year	
Time step	Quarter	Quarter
Stock(spawning population)	Single spawning population	
Area	Single for assessment	two area (following simulation study)
Number of age class	21(0-20) -default; 21- lumped	
Ngender	sex-combined	
Fishery definition	14 Fleets	Simple model (ex; troll, set net)
		16 (at least) model
Natural mortality	Age specifc M	Alternative scenario
	M0=1.6	
	M1=0.386	Sensitivity analysis
	M2+=0.25	Mortality examined by Iwata
		Rebecca's one
Maturity	Age specific Maturity	need some sensitivity analysis
	Age3=0.2	slow maturity
	Age4=0.5	batch fecundity
	Age 5+=1.0	
Growth curve	Shimose et al. 2009 for single sex model	2-stanza growth
	adjust L1=21.5 for optimal fit	
	Shimose et al. (2012)	
	CV(L1); estimate	
	CV(L2);0.05	
#of growth patterns	1	
#of morphs, sub-morphs	1	

Functional form of CV growth	CV=F(L)	
	Full stock assess. in 2012	
Amin	0	related to 2 stanza growth
Amax	3	
L-W	Kai et al. 2007,sensitivity:seasonal L-W(Mikihiko will calculate by the end of March)	
Length bin definition	2 cm for young, 4 cm for middle, 6 cm for old	
Weight bin definition		
Popo length bin	2cm for all	
Catch unit	Weight/numbers	
	EPO-sport (numbers)	TLL (numbers)
		troll4pen(numbers)
Catch error	0.1	
F-method	3 (solve catch eq) - catch exact	
upperF	10	
CPUE likelihood	lognormal	
CPUE (JLL) selectivity	dome shape	
CPUE (TWLL) selectivity	flattop	
CPUE lambda	1	5 for troll CPUE
CPUEcv	Lowest CV is set as 0.2	JLL CV 0.2 constant (depend on the standerdization)
effN for LenComps		No of trip well measured, No of days well measured, bootstrapping method
SRR	B-H w/ h=0.999	
R0	estimated	

sigmaR	0.6	1.0 w/ steepness sensitivity
1st year of main Rdev	1953	
R0 offset	estimated	
SR auto correlation	no	
Initial F	Estimate Finit without fitting to EqC	
	LL, troll with eqC	
Diagnostics of the model	Jitters, Jackknife resampling, retrospective analysis, Likelihood profile relative to R0,	