Annex 4

REPORT OF PACIFIC BLUEFIN TUNA WORKING GROUP WORKSHOP

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

10 – 17 December 2008
Ishigaki, Japan

1.0 INTRODUCTION

The ISC Pacific Bluefin Tuna (*Thunnus orientalis*) Working Group (ISC PBFWG) workshop was opened by the Chair Yukio Takeuchi. Naozumi Miyabe, on behalf of the National Research Institute of Far Seas Fisheries (NRIFSF), and Kenzo Yoseda, the Director of the Ishigaki Tropical Station, Seikai National Fisheries Research Institute, both welcomed all the participants to Ishigaki Island, Okinawa Pref., Japan.

Scientists from Chinese Taipei, Japan, Mexico, USA, and Inter-American Tropical Tuna Commission (IATTC) participated the meeting. Invited guests, J. - M. Fromentin (France) and J. Joseph (USA) made special presentations (Appendix 2).

N. Miyabe (WCPFC Scientific Committee (SC) Chairman) and H. Honda (Chairman of SC WG on Biology) also represented the Western and Central Pacific Fisheries Commission (WCPFC) as observers.

2.0 ADOPTION OF AGENDA AND APPOINTMENT OF RAPPORTEURS

A provisional agenda was reviewed and changes made. The new Agenda was adopted and is attached as Appendix 1. The rapporteurs appointed are indicated for each section in parentheses. There were 20 papers and two PowerPoint presentations submitted to this session (see the list in Appendix 3). M. Miyake compiled the rapporteur reports for the workshop report.

3.0 REVIEW OF THE OBJECTIVE AND DESIRED OUTPUT (Y. Takeuchi)

The report of the 2008 annual meeting of the International Scientific Committee (ISC8) clearly identified the objectives of this meeting. It indicates that the results of the May (2008) Stock Assessment Workshop of the PBF WG were generally accepted by the ISC plenary. However, a few issues were identified. The Plenary recommended that some additional and follow-up work to clarify these issues be undertaken before further stock assessments were conducted. The main concern raised by the Plenary was with the high estimated unfished biomass (virgin biomass), which appears to be implausible. This high unfished biomass estimate results in a conclusion that the current F exceeds commonly used potential biological reference points. The PBFWG is tasked with responding to this concern at ISC9 in July 2009.

4.0 OVERVIEW OF THE 2008 STOCK ASSESSMENT (M. Ichinokawa and R. Conser)

4.1 Concerns (parameter estimates with "low plausibility")

The stock assessment conducted in May 2008 was briefly reviewed. Although the results of the stock assessment were generally accepted by the ISC Plenary in July 2008, there were concerns regarding parameter estimates with "low plausibility." These were:

- A very large unfished biomass B_0 (One million t)
- A very high depletion or low current stock ratio to B_0 (about 1~2 %)
- A very low %SPR (1~6%)

4.2 Potential factors driving results

The following factors may have resulted in estimates with low plausibility:

- An unexplained 2005 catch, i.e. the predicted 2005 yield by SS2 (24,822 tons) was smaller than the observed yield (26,902 t) according to ISC8 Appendix 7 of ISC8 plenary report);
- Misspecification of the following parameters in the model:
  - ✓ Natural mortality
  - ✓ Maturity
  - ✓ Fecundity
  - ✓ Age and growth; or
- The stock assessment model itself.

For the study of the long-term stock status, the following questions have to be answered:

- Why do most of the potential target Biological Reference Points (BRPs) indicate that overfishing is occurring?
- How has this situation been occurring from the beginning of the stock assessment period (1952~) without any indication of recruitment overfishing?
- Why does the limit reference point have such low variance?

Those questions will be covered in subsequent sections.

5.0 BIOLOGICAL INFORMATION AND PARAMETERS (T. Tanabe, T. Shimose, A. Aires-da-Silva, and C.-C. Hsu)

5.1 A review of the age, growth, and reproductive biology of Pacific bluefin tuna, Thunnus *orientalis*, with a possible hypothesis for further research activities. By T. Tanabe, T. Shimose, M. Ichinokawa and Y. Takeuchi (ISC08/PBF-2/09)

Age, growth, maturity and spawning capacity of PBF are key biological parameters for the stock assessment. The paper summarizes past studies of growth and reproductive biology of this species and recent progress in biological studies. A possible hypothesis about the PBF population based on the present knowledge is introduced. The biological parameters for stock assessment of PBF which have been advanced throughout recent research activities are presented. However, there are still some uncertainties about estimates for growth and reproduction.

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

Since reliability and accuracy of age determination are most important in estimating mortality of age-10 and older PBF, the growth studies highly depend on the number of aged specimens older than 10 years with validations of annual ring formation. The growth rates estimated by Shimose et al. (2008, ISC08/PBF-1/8) for young PBF were faster than those reported in previous studies. The WG concluded that further research should be carried out to verify the growth estimates for young fish between 1 and 5 years old using adequate techniques (e.g. use of tagging results, combination of studies with daily increment on otolith and annuli on vertebrae). Comparative studies on growth between eastern and western Pacific for the fish of 1-3 years old should be made. However it was also noted that sampling of PBF hard parts for ageing is not an easy task.

With respect to the reproductive studies, the observed differences in length of spawners from the southern area (off Taiwan and Nansei Islands) and the Sea of Japan were pointed out. These differences could not be well explained by the available data. However, it appears that these differences are due to the different sizes of spawners sampled from the two spawning areas rather than due to the differences in selectivity of the gears used in the two areas. The WG concluded that, because the size compositions of adult fish landed at Sakaiminato in the Sea of Japan show yearly changes or annual variations, the length data of spawners from the two areas should be examined more thoroughly for as many years as possible.

Mortality studies have described different sex ratios by PBF sizes. These differences could be explained by different growth rates and/or different natural mortality rates between sexes. Currently there are no data available to support either explanation. It was determined that further research is needed to clarify this point. Estimates of growth in males and females should be compared by sampling otoliths and using size and sex information. In addition, information on hypothetical sub-stocks of PBF, such as the distribution and migration of adult PBF in relation to the two known spawning grounds and the reproductive activities in each area need to be collected.

5.2 Annual report of the mature status of the bluefin tuna landed in the Ishigaki Island (2008). By Y. Aonuma, N. Suzuki, T. Tanabe and H. Ashida (ISC08/PBF-2/13)

Ishigaki Island is located in the most southwestern Japan and coastal longline boats of the island catch adult bluefin tuna during the spawning season. Ovary specimens from 116 females (160-241 cm FL) landed from late April to late June were sampled and analyzed, using histological method. All of the 116 females were mature, including 37 individuals in spawning condition. In order to estimate size (age) composition of spawners and to evaluate maturity status of PBF in the spawning ground/season, the size and gonad sampling will be continued for additional two years.

Discussion

The reproductive parameters including spawning season, size of adult and spawning frequency, were similar to those previously reported by Taiwanese scientists. Because Ishigaki longline fishing occurs on the main PBF spawning ground in the area, it is important to continue collecting catch and biological data from the fishery. In 2009, this research will be continued by the Ishigaki Tropical Station.

6.0 FISHERY INFORMATION AND DATA, INFORMATION ON RELATED SPECIES (K. Oshima, K.Yokawa, and M. Dreyfus)

6.1 Pre-stock assessment period (before 1952)

6.1.1 Review of PBF catch before 1952, Catches and catchabilities. Presented by F. Muto, Y. Takeuchi and K. Yokawa (ISC/08/PBF-02/11)

The authors have searched available literature on Japanese PBF fisheries for the period before 1952 to better understand the exploitation history of the stock. On this subject, the authors presented several papers at the past ISC PBF meetings. Their documents were prepared whenever new data were found. The research has been extensive but information has been sparse and opportunistic. In this paper, all the past results and additional data are compiled by time and place, to show general overview of this research project. The paper presented the results in the following 4 steps:

1. Collection of catch data, which had been reported for all tunas of the genus *Thunnus*, combined but not by species, were made based on the Japanese official statistics, as much as possible. Many data are not consistent throughout the period. Some missing data are estimated from product weight. Gear break-down was not available for most years and catches by gear were estimated.
2. The catch of PBF was estimated based on the combined tuna catches by extrapolation of species composition of 1951
3. Collection of any additional fragmental information of PBF fisheries were made from various sources.
4. The best estimate of PBF catch was made, using all the information as described above.

The estimated PBF catches for pre-WWII time show a trend but this may be unreliable because the absolute catch quantities are very uncertain. Besides, it should be cautioned that the fishing areas and gears have changed substantially between before and after the war.

Discussion

The working group discussed the bluefin fishery. It was mentioned that for large bluefin catches recorded for summers from the 1920s-30s at Kushiro, Hokkaido and in 1939-40 in Horoizumi, Hokkaido, PBF liver for vitamin tablets was more valuable than PBF flesh, which was cheap during the latter period (1939-40). Also, if the fish migrated as far north as Sakhalin during that period, their northern limit of distribution might have shifted southwards in recent years (although there has been no tuna fishery known in the Sakhalin area since after the war).If the northern limit has moved southwards, this may suggest environmental differences between the pre- and post-war periods. For example, we may be able to assume pre-war SST is higher than post-war SST. This is similar to the situation in the Atlantic where the northern limit of distribution has shifted southwards.

The WG considered two major points: whether PBF catch levels from the pre- and post-war periods are comparable and (2) whether it is appropriate to use the tuna-species catch composition from 1951 to estimate PBF catch for 1891 through 1945. As for (1), it was noted that PBF catch in the pre-war period consisted of larger fish, while in the post-war period, small PBF dominated the total catch; hence catch from the two periods are not comparable. As for (2),: it was mentioned that if the 1951 species composition is used for the extrapolation, the estimated PBF catches in the pre-war period were almost half those estimated using catch data identified as PBF in official statistics. The species composition fluctuates according to the abundance of various species. It was concluded that the estimation method in this study is insufficient and the absolute quantity of estimated catch is not reliable, although its trends would be reliable. The WG suggested that information on price, products and market structure be collected in future, because such information would help in interpreting and estimating catches.

6.1.2 Presentation: A brief history of bluefin fishing in the EPO. by J. Joseph

During the late 1800s recreational fishing for PBF started in the waters around Catalina Island, California. The first commercial tuna fishing, which targeted albacore for canning, started in Southern California during the early 1900s in response to the reduction of sardine stocks to supply sufficient raw material for canning. Around 1918, small sardine purse-seine vessels began to catch PBF for the canned and fresh fish market. During the first few years of the fishery, catches reached 7 thousand tons, but then declined to less than a thousand tons and stayed low for several years. It is possible that the catch statistics for those first few years were erroneous. By 1930, catches reached 10 thousand tons, but in that year the Mexican government closed its coastal area to all purse-seine vessels. Since nearly all of the catch at that time was being taken by U.S. flag vessels in that water, the PBF catch plummeted and stayed low for 3 years until permission was granted for U.S. purse-seiners to resume fishing in Mexican waters. Catches rose, averaging about 7 thousand tons per year, then declined again during the early 1950s due to market forces. Between 1954 and 1980 catches fluctuate between 4 thousand and 16 thousand tons annually. The greatest majority of this catch was taken by U.S. flag vessels fishing off Mexico. From 1960 through 1980, about 77 seiners, home ported in San Pedro, California, were considered as bluefin targeting vessels. From 1981 until 1996 catches stayed low as the Mexican Government restricted fishing in its EEZ to Mexican flag vessels. For all practical purposes there is no longer a U.S. commercial PBF fishing fleet, but there continues to be an important U.S. recreational fishery for PBF, home ported in San Diego, that takes place mostly in Mexican waters.

Mexico began PBF farming in 1997 and since then catches by Mexican flag vessels have increased significantly and almost all of their catch is destined to the tuna farms. The Mexican purse-seine fleet now accounts for almost all of the PBF catch from the Eastern Pacific Ocean (EPO), the exception being the catch by the U.S. sportfishing fleet. Of the overall catch of PBF from the Pacific Ocean, about 70-75% is taken in the Western Pacific Ocean (WPO), the remainder coming from the EPO. Size data show annual variations in size composition of the catch, with ages 1, 2, and 3 dominating. On occasion, giant PBF exceeding 400 kg have been taken in the EPO, but such events have been rare.

PBF catches are made near coastal waters off Baja California, and offshore near Guadalupe Island, Mexico. The main fishery begins in May-June in the south near Magdalena Bay and moves north as far as off San Diego; it generally ends in September. About 92% of the bluefin catch is taken in Mexican waters, although this may be an underestimate. There is a positive correlation between age-1 in year y and age-2 in year y+1 abundance in the EPO, and an inverse correlation in age-2 abundance between the EPO and the WPO in the same year. Tag recapture data show regular exchange of fish between the EPO and WPO. The minimum time between release of a conventionally tagged bluefin in the EPO and its recapture in the WPO was 674 days, indicating the fish possibly stays in the east for a while, and 215 days for a release in the WPO and return in the EPO. Recent electronic tagging showed a fish moving from the WPO to the EPO in less than two months. Some fish move to southern hemisphere.

Two concessions for PBF farming were given by the Mexican Government in 1997, one in the area of Cedros Island, the other for the Ensenada area. Since those concessions, approximately 10 more were allocated. However, some of these never operated, or the operations were terminated. There are currently about 4-5 farms that are successfully operating in Baja California, Mexico, most of which are in the area of Ensenada.

Discussion

Earlier studies by Bayliff showing a correlation between the abundance of bluefin in the EPO and WPO were discussed. Since these studies were completed nearly 20 years ago, it was suggested that they be updated. Piner's study on the U.S. recreational fishery CPUE (K. Piner, 2008) suggested the possibility that abundance of EPO PBF is correlated with Japanese troll fishery CPUE. It was suggested that this type of work be continued. So far genetic studies have not shown any separations among PBF from different Pacific regions, but such investigations might, among other things shed light on the origin of PBF taken in the southern hemisphere. Some participants suggested that most of the PBF in the EPO are those migrating from the WPO spawning area, but not from the Japan Sea. However, it was pointed out that one tag released in the EPO was recaptured recently in the Japan Sea. More studies are needed to resolve these questions, including tagging, particularly of large fish; however, not many large PBF are available for tagging. It was noted that some tuna that were electronically tagged in the EPO were recovered in Japan, but the data from these tag returns have not yet been made available. It was suggested that a paper on the topic of the early history of the PBF fishery in the EPO should be prepared and published so that this historical information can be available to researchers.

6.1.3 Presentation: What do we learn from the analysis of the historical trap catches of Atlantic bluefin tuna? By J.-M. Fromentin

This presentation aimed at describing an intensive data rescue of the historical trap catches of eastern Atlantic stock of bluefin tuna (BFT – *Thunnus thynnus*) from the North Atlantic and the Mediterranean Sea. After a brief description of the trap system, including its history, main specifications, locations and possible modifications through time, the presentation described the dataset gathered and its validation. The final dataset includes 54 time series of trap catches of > 20 years long (9 time series > 80 years and a few spreading over 4 centuries among which 22 were collected in the Atlantic coast (mostly South coasts of Portugal and Spain) and 32 in the Mediterranean coast (mostly from the Tunisian, Sicilian and Sardinian coasts).

The quantitative analyses of these historical data clearly showed that variations in trap catches displayed conspicuous long-term fluctuations of about 100-120 years, together with cyclic variations of about 20 years. Those variations were significantly synchronous over all the areas (i.e. eastern Atlantic and western Mediterranean coasts). It was therefore considered that these long-term fluctuations are probably not due to changes in catchability or in local environmental conditions, but more likely to variations in the spawning stock levels arriving each year in the Mediterranean Sea.

Further analyses showed that long-term fluctuations in trap catches were not related to large-scale climatic phenomena (such as the North Atlantic Oscillation), but appeared to be negatively and significantly correlated with long-term trends in temperature. The conclusions of this analysis were that long-term fluctuations in trap catches could be result of changes in migration patterns of bluefin tuna in response to the oceanographic conditions. However, another study based on theoretical demographic model indicates that long-term fluctuations in spawning stock biomass may also simply be resulted from stochastic (random year-to-year) fluctuations in recruitments. Both hypotheses are equally likely and hence the current analyses do not allow us to reject either of those.

Finally, the presentation depicted the usefulness of such historical dataset for stock assessment and management purposes. The historical levels of catch in the Western Mediterranean basin and near Atlantic were estimated at about 15,000 tons/year (fluctuating from 7,000 to 25,000 tons/year); about one-third of the current catches. The results of an integrative simulation framework, that was built to evaluate the consequences of variability attributable to changes in carrying capacity or the stock's migration pattern, clearly indicate that the VPA performances were seriously hampered if the long-term variations in catches were due to the changes in migration pattern and/or availability if fish. Reference points based on F (*e.g.*, $F_{0.1}$) were less biased and more precise than those based on yield and/or SSB and were also more robust to uncertainties about the true dynamics than absolute values of F and SSB. However, $F_{0.1}$ cannot indicate past and current levels of exploitation relative to F_{MSY} when there is uncertainty about the stock dynamics.

Discussion

Following the presentation, the WG discussed several points, mostly concerning the implications of long-term fluctuations in the Pacific and Atlantic bluefin tuna population dynamics to stock assessment diagnoses as well as the importance of continuing the data mining of PBF (e.g. the work presented by Muto et al.), possibly by including fisheries information from both the Western and Eastern Pacific Ocean. The WG recommends that mechanism of trans-Pacific migration be studied; Synchronicities of historical series of catches of fisheries catching similar size/age classes of PBF at the both sides of the Pacific be analyzed; and that currently available tagging data be summarized, reviewed and reported.

The WG agreed that applying estimated catches of PBF in the period before 1952 (the starting year of the stock assessment series) to the assessment is still premature since the new information provided in this meeting indicated that before 1952 Japanese PBF fisheries caught larger-sized fish than the current fisheries. More information is necessary to verify the estimated annual catch and fish size for each stratum. Thus, the WG decided to use the information of historic catch only in a qualitative way in the next stock assessment.

The WG also recognized the importance of the socio-economic studies on historical catch to evaluate the reliability of estimated quantities of catches. Because an assessment with a longer period will produce more reliable results, the WG encourages Japan and U.S. (in collaboration with IATTC) to explore further efforts to collect additional information to refine the historic data. The study on the historic trap net catches of BFT, in the Mediterranean and adjacent Atlantic coasts, gave the WG insight on the long-term variation in the bluefin stock level. This study demonstrated that the level of the BFT stock changes dynamically by time, suggesting that this might be the nature of bluefin tunas. The WG noted that if the PBF stock level changes dynamically, the concept of virgin (unfished) biomass may not be appropriate to apply to this species.

The WG discussed the observed differences in catch and CPUE trends of the fisheries catching medium sized PBF between eastern and western sides of the Pacific. They suggest the possible annual variability in the trans-Pacific migration ratios. Considering its possible effects on the result of stock assessment, the WG encouraged to initiate the study on this topic. Analyses of the synchronicities of historical catch series of fish in similar sizes between both sides of the Pacific could be a starting point. This method was presented by J.-M. Fromentin of IFREMER in his work on the historic catch of BFT in the Mediterranean and adjacent Atlantic coasts, The WG also noted that the analysis of existing conventional and archival tag data could contribute to this purpose, but a well designed plan should be established before a tagging study is initiated.

6.2 Stock assessment period (1952 to present)

6.2.1 Review of the current problems and future perspectives on length frequency data for Pacific buluefin tuna. By M. Ichinokawa. (ISC/08/PBF-2/8)

This paper provides brief review of a general method for estimating catch at size (CAS) from stratified fish measurements, and associated problems in estimating CAS for Japanese fisheries. The review covers Japanese fisheries of longline, small purse seine, tuna purse seine, troll, pole and line, set net and others. Since different procedures are applied among fisheries to create input data for stock assessment, procedures should be examined by fisheries. All fisheries with an exception of small purse seine fishery, estimating methods of CAS should be re-examined before the next stock assessment. In order to raise raw length data in an appropriate spatiotemporal stratification, accurate catch data with fine spatiotemporal resolution are required, especially for the coastal fisheries which do not provide with logbook data.

Discussion

The WG generally supported the idea proposed by this study. The WG suggested that a well-designed sampling program may cover even minor fisheries and produce better information than proportional sampling. The information from random samples have additional importance.

6.2.2 Preliminary analysis of the stock abundance indices for Pacific Bluefin Tuna (*Thunnus orientalis*) landed by Japanese Purse Seiners in Sakai-Minato. By M.Kanaiwa. (ISC/08/PBF-02/5)6.2.1

In spite of the recent development of purse seine fishery for PBF in Japan, no abundance indices were developed for this fishery in stock assessment in 2008, due to the difficulty in defining effective fishing effort. In this study, candidates of abundance indices for purse seine fishery are considered. Annual catch per number of landings (ncpue) and average of landings per trip-cruise-days (ocpue) showed better performance than others; coefficient of determinant with estimated stock abundance by SS2 being high for main target age in purse seine fishery. However, even these indices are not reasonably correlated with other abundance indices such as standardize catch per unit effort for Japanese troll fishery, with an appropriate time lag for different age compositions being given. Therefore more detailed information, *i.e.* fishing location, searching time *etc, which are nor not current analyses*., are required for future analysis. Utilization of logbook data may provide with these information

Discussion

The WG discussed definitions for effort of the purse-seine fishery. The WG was informed that in the EPO purse-seine fishery, there are many days with zero catch recorded but logbooks reflect searching time. However, no days with zero catch exist in the tuna purse seine fishery in the Sea of Japan because of targeting for PBF of this fishery. If this fishery catches mainly one-year class fish for several years, the effective CPUE can be used to evaluate annual changes in abundance of year classes. The WG recommends that current collections of data for creating reliable abundance indices be continued and intensified where necessary.

The WG discussed that the abundance indices used in the May 2008 stock assessment will at least be updated by the next assessment and some of them will be improved. Each participant reported its own project to improve the reliability of the abundance index for those fisheries. Japan reported its plan to create new time series of abundance index in its coastal fisheries in Tsugaru Straight and purse seine fishery in Japan Sea.

The WG agreed that an international cooperative study examining the consistency of trends in abundance indices among areas and fishing gears was necessary to evaluate the representativeness and reliability of each abundance index.

In the last assessment (2008), 17 series of indices were examined and only 6 were used. It was noted that the match between model and the series of indices have to be examined. In this respect, it was recognized that the reliable estimates of recruitments for recent years would be very important.

6.2.3 Estimation of catch at size for Pacific bluefin tuna caught by Japanese troll and set net fisheries: current problems and future perspectives. By M. Ichinokawa (ISC/08/PBF-2/7***)***

This paper investigated geographical distribution of number of fish measured and catches of PBF from coastal fisheries of troll and set net, by prefecture collected under the Research Project on Japanese Bluefin Tuna Program. Catches at size are created by raising for each 'prefecture'. Comparison between raw length frequencies and estimated catch at size revealed some problems by unbalanced sampling efforts among prefectures. The unbalanced sampling efforts are due to the inconvenience in accessing local landing ports and to unpredictable landings of PBF at ports by the coastal fisheries. The current unbalanced sampling efforts can lead to waste of information of length measurements in the prefecture with little landing of PBF. In contrast, errors of estimated catch at size become larger in the prefectures where sample size is relatively small while total landings are large. In particular, Nagasaki prefecture has the largest contribution (>60%) to the total catch of PBF by troll fishery, but sample size of length frequencies accounted for only 20% in total sampling (in terms of number of fish). The intensive sampling program for troll fisheries has started in 2007 in Nagasaki Prefecture, in expectation of solving this problem. As for the set net fishery, this problem is common throughout the fishery. At present, no solution is found but every effort should be made to increase size sampling from this fishery before the next assessment.

Discussion

When (RJB) started in 1994, it focused only on collection of catch data but did not address collection of size data. Size data are currently not systematically collected. In recent years, National Research Institute of Far Seas Fisheries (NRIFSF) is trying to conduct intensive size sampling in Nagasaki and Kochi Prefectures. Although the author noted that CAS may affect stock assessments, they have not yet examined how. The author mentioned that another problem is that a stratum of corresponding size data is missing, and data substitution is required.

6.2.4 Preliminary analysis on length data from intensive size sampling of Pacific bluefin tuna caught by Japanese troll fisheries. By K. Oshima (ISC/08/PBF-2/12)

An intensive size sampling program of small PBF caught by Japanese troll fishery was started in the last fishing season (late 2007 – early 2008). The objectives of this program are: 1) to estimate precise length frequency of PBF caught by the troll fishery, which would be applied for stock assessment models as input data; and 2) to evaluate level of recruitment of age-0 fish to this fishery, which may be reflected in change of length distributions. Samplers deployed at major ports in Tsushima Islands and Kochi Prefecture took size samples at regular intervals. Size sampling was stratified by presorted market size categories; CAS being estimated through raising the length frequency by catch in number for each size category. The length distribution did not vary significantly during the fishing season in all size categories. The only exception was that of the largest fish category, where definite temporal variations were noted. The size sampling of PBF in the smallest and largest size categories is important in order to construct precise catch at size and to evaluate the recruitment trends.

Discussion

The WG discussed the objectives of collecting size data. Collection of size data has two objectives: to create CAS indices and to study biological parameters. This document analyzed the quality of size sampling. The next step would be to obtain accurate catch data (in number of fish) by presorted size categories. The WG also recognized that more sampling was needed for the Tsushima area. The minimum size of samples required for Nagasaki and how to achieve this was discussed. One idea was developing a co-management program where scientists and fishers cooperate with each other in measuring fish size.

The troll fishery catches mostly age-0 fish; hence its catch may represent the strength of recruitment. As a series of catch records covers many years, the age-0 CPUE would provide some index for the level of recruitment. However size-frequency data for this fishery are not available for before 1980.

The WG discussed sampling from the EPO but determined that it would not be useful due to farming activities, though onboard observer sampling still occurs. IATTC collects size data from some of the farms and that Instituto Nacional de Pesca (INAPESCA) will have data on size compositions from all farms in the near future. Some efforts are also being made to sample from recreational fisheries. It was pointed out that the EPO fishery targets only a very limited age range of bluefin tuna.

6.2.5 Catch and distribution of Pacific bluefin tuna, *Thunnus orientalis*, around the Tsugaru Strait. By Masayuki Abe. (ISC/08/PBF-02/17)

This paper reviewed information collected currently from PBF fishery in Tsugaru Strait and discussed future sampling plans. The large sized PBF are landed by coastal small longline and troll fisheries in Hokkaido and Aomori during July through December. These large sized PBF in Tsugaru Strait should have migrated to the north for feeding after spawning.

Size ranges and mode of fish landed by troll and longline in the Tsugaru Strait in July through December of 2004, 2005 and 2006 were as follows: Miumaya troll range 50-250cm and mode 100-150cm; Fukaura troll range 50-170cm and mode 50-100cm; Ooma troll range 100-250cm and mode 150-250cm; and Ooma longline range 100-250c and mode 150-250cm. For each landing port, monthly variations in size compositions were small. While significant differences were found in length compositions of troll and longline catches among landing ports.

In the Tsugaru Strait, there was a tendency that PBF landed in the ports of eastern side of the Tsugaru Strait were larger in size. It is important to collect fishing information and detailed catch data around the Tsugaru Strait. At the same time, information on bait and oceanographic environment would explain formation of fishing ground of large-sized PBF in feeding season.

Discussion

The WG discussed whether the fish in the eastern side (Pacific side) in the Tsugaru Strait are larger than those in the western side (Japan Sea side). Based on the currently available data, the size of the fish caught by longline do indicate that fish are larger on the eastern side but size of fish caught by set net do not. Therefore it is too early to draw any conclusion.

To investigate the sex ratio of large fish, size sampling by sex is being conducted in the two areas where large PBF are caught, i.e. the Tsugaru Strait and Nansei Islands. The WG recommends that member countries and relevant organizations collect sex and size data from large PBF in the fisheries, in particular: the Japanese coastal-longline, Japan Sea purse-seine, Tsugaru Straight coastal, and Taiwan longline fisheries.

6.2.6 Assessing the precision of length-frequency estimates with consideration of finite population sampling by using landing data in Sakai-Minato Port. By A. Shibano. (ISC/08/PBF-2/6)

Effective sample size, m_{eff}, in finite population sampling was estimated. In comparison of the indicator, *E*, of precision in samples from single landing against total landings per year, m_{eff} had a big difference in absolute values, i.e. m_{eff} is much smaller than *E*. However, both indicators showed relatively similar trend. This means both

m_{eff} and *E* can be considered when the annual trend is in question. *E* was significantly based on the assumption that coefficient of variance in total sample per year is equal to that in true population. On the other hand, m_{eff} takes some nature of purse seine operation into consideration, while E does not. Therefore using m_{eff} is probably more desirable. Furthermore, it is advisable that when effective sample size in absolute number is required for other purse seine data, and it should be calculated by the methods of m_{eff} and relative number, *f*, of effective sample size rather than actual total sample size.

Discussion

The WG discussed what the appropriate effective sample size of fish length from this fishery should be. Because the original research target of this study to propose a reasonable reduction in sampling effort was completed this year, the WG reviewed the future plan for this project. As shown in scenario 2 - 1 in the presentation, a constant number of PBF is measured from each landing. A proposal was made to adopt a new sampling plan to collect size data by sex. For example, sex can also be recorded if only 100 individuals are measured per landing. In this case, the effect of reducing the sample size should be investigated. Reducing sample size may also allow otoliths to be collected. CPUE by year class could be calculated, and a growth analysis may be possible from modal progressions. The growth of PBF in the Sea of Japan can be examined if the results of a growth analysis from modal-progression are compared with those of otolith ageing.

6.2.7 General discussion for 6.0

The WG recognized that the fishery-related information used in the May (2008) stock assessment was the best available data and that it would be difficult to improve it in the short term. The WG also realized that its PBF data are generally of good quality compared with data that other organizations use for other areas and stocks.

As for the Japanese longline indices, the coastal index has to be updated and re-examined. Development of single time series from the offshore and distant-water longline indices is under consideration. The WG recognized the advantage of having a continuous time series of indices. However, development of a single time series is difficult because target species of the offshore and distant-water longline fisheries have changed historically.

For the EPO, collection of the catch and effort data for the U.S. recreational fishery will continue in the future. It was pointed out that IATTC's current method for getting data from the U.S. recreational fishery is opportunistic. If the EPO fishery targets a certain strong cohort for several years, the index from this fishery cannot be applied to the stock assessment models. In this case, breaking down the index into each cohort is necessary and is possible but CPUE standardization becomes complicated. As a first step, the age composition of EPO catches must be collected and examined.

It was pointed out that the Korean catch appears to have increased substantially from 2007 to 2008 and the information on this catch is very important to improve the stock assessment. The WG recommended that Korea obtain catch and size data from the Korean fishery and that Korea continue participating in the WG and the plenary sessions.

7.0 STOCK ASSESSMENT MODEL (K. Piner, H.H. Lee,and Y. Takeuchi)

7.1 General issues

7.1.1 Estimation of population size for Pacific bluefin tuna using Bayesian production models. Presented by H.-H. Lee. (ISC/08/PBF-2/03)

There is an increased reliance on highly complex models to assess the stock status of exploited fish populations. When assessment results from these complex models are inconsistent with accumulated knowledge of the fishery and biological characteristics, diagnosing if a highly parameterized model is mis-specified can be challenging. Less complex model can therefore provide an alternative approach to test model performance by constraining model assumptions and limiting the data used to only those of the most reliable. Although they have fundamentally different structures, comparisons of the results can be made by applying to the same data set. In this paper, stock size for PBF was estimated using production model with a Bayesian approach. The attempt is to capture the scale of fishery by applying the data set used in the last stock synthesis II (SS2) assessment and compare results from two model platforms. The simulation results showed that the shape of the posterior distributions became sharper than that of the uniform and vague inverse gamma prior distributions. It implies that the prior loses its influence on the shape of the posterior and that data used are informative. As the results, estimated medians of biomass showed similar trend with biomass estimated from the SS2. However, the estimated carrying capacity (around 160,000-290,000 t) was one magnitude smaller than the virgin biomass (around 1,500,000 tons) estimated by SS2. Stock status was reviewed by a two-parameter plot referred to the relative rate of removal of fish from the population and the relative stock size to their associated reference points. The stock maintained itself in the region where stock was not overfished and overfishing by the fisheries during the late 1950's to the early 1960's. Since the stock biomass declined below the median of biomass at the level that yields the maximum production B_{MSY} in 1965, the stock has been overfished in terms of biomass ratio.

Discussion

The WG noted that the fit to the indices was very precise and that the median of the distribution of some estimated parameters were near the bounds of their priors. The WG recommended that a new run be made with a widened range of the priors (especially on the shape parameter) to determine if it affects estimates of carrying capacity. It was agreed that this new analysis would then be included in the revised working document as the primary model run. A second run was also requested that used estimated biomass series from the 2008 assessment as the abundance indices fixing catchability to 1 and the catch. The WG decided that result of that run will be included as the appendix C.

7**.1.2** The Estimate of Unfished Bluefin Spawning Stock Biomass: the result of density-dependent processes? Presented by K. Piner. (ISC/08/PBF-2/01)

PBF stock status was assessed at the WG meeting in May 2008. Status was uncertain due to mixed signals from the results of the stock assessment. A common reference point, Spawning Biomass Ratio (current spawning biomass/unfished spawning biomass), was not used because the assessment estimate of unfished spawning biomass was much larger than expected. Thus the Spawning Biomass Ratio was skewed too low to be considered plausible (<5% over the whole historical period). The WG concluded that such an unrealistic result was due to density-dependent effects of slowed growth and delayed maturation at larger stock biomasses. In this paper, growth and maturation as well as juvenile mortality were altered to reflect compensatory processes to determine if changes to these life-history traits could produce more reasonable estimates of an unfished condition. Slowing growth and delaying maturation by more than 3 years coupled with an increased period of juvenile mortality did not fully explain the large unfished biomass estimates. Other structural causes of a high initial population size need to be investigated.

Discussion

The WG was informed that the method of adjusting the growth, maturity and mortality schedules was not intended to be a realistic representation of density-dependence processes but used to bound the magnitude of changes needed to explain the assessment results. Although density-dependent affects cannot be ruled out, it is unlikely that density dependence can fully explain the large estimate of unfished biomass. It was also noted that the spatial segregation of age classes and migratory nature of PBF are mechanisms that reduce competition and intra-specific predation and thus PBF may not show large density-dependent effects.

7.1.3 Simulation of the Estimation of M as a Model mis-specification diagnostic. Presented by K. Piner. (ISC/08/PBF-2/02)

A new method of assessing potential model mis-specification using simulation methods is demonstrated using the 2008 ISC PBF stock assessment. Estimation of M from parametric bootstraps and random recruitment deviations is compared with the estimation of M from the original data set. The current assessment adjusts for some degree of model mis-specification by estimating M outside the bounds of the bootstrapped simulation. This indicates some level of model mis-specification that likely corresponds to mis-fitting of the size composition data.

Discussion

The WG questioned the use of the estimation of M as a method of diagnosing model mis-specification because of the correlation of the parameter M with most other model parameters. It was also noted that adding additional error through the use of a vector of random recruitment deviations introduced some level of bias to the estimation of M. It was suggested that the effects of this bias should be investigated. It was also suggested that the variability of the estimate of M from the original base model data file should be compared to the M in the bootstrapped distribution.

7.1.4 An Evaluation of the Natural Mortality Schedule Assumed in the PBF 2008 Stock Assessment and Proposed Changes. Presented by A. Aires-da-Silva. (ISC/08/PBF-2/04)

The stock status of PBF was evaluated by the PBF WG at its meeting in May 2008. The stock status remains uncertain and the WG is investigating the possibility that there may be a model mis-specification. This paper focuses on natural mortality. It reviews the scientific process leading to the PBF natural mortality (M) schedule assumed for the 2008 PBF assessment. It also provides a critical evaluation of the assumptions and proposes an alternative natural mortality schedule for PBF.

In the absence of direct estimates of M for PBF beyond age-0 (1+ years), the WG adopted a vector based on assumptions made for southern bluefin tuna (*Thunnus maccoyii* SBF). This choice should be re-visited and revised considering the differences that exist between the life-history of PBF and SBF. The adoption for PBF of the SBF estimate of M=0.12 yr^{-1} for the 4+ year old adult fish seems the most problematic. The latter is based on the long life-span of SBF (maximum age of 42) which does not seem to be the case for PBF (maximum observed age of 21 years). In addition, while the mean age at maturity for SBF varies from age 8-12 years, PBF begins to mature at age 3 and are fully mature at age 5. It seems reasonable to assume that such an early investment on reproduction would result in higher natural mortality levels for mature PBF. An alternative M estimate for the adult fish (3+ year) could be taken as the median value (M=0.27) obtained across a large suite of life-history based methods. Estimates of natural mortality for ages 1 and 2 also need to be revised.

Discussion

It was pointed out that the maximum observed age of PBF should not be taken as an estimate of longevity because of the limited sample size of aged PBF ($n \approx 200$ for PBF in the age 10+ range) – especially in comparison to SBF. Differences in the exploitation history of PBF and SBF also may have clouded the interpretation of "maximum age" determined from samples taken from recent-year fisheries. However, it was noted that more recently otoliths from PBF have been sampled from some of the largest PBF available in an attempt to gather information from the oldest individuals to produce a more representative growth curve. Consequently, this sampling strategy may have sampled even more than enough of the oldest individuals for determining growth for the population.

While PBF differ from SBF in age-at-maturity and growth rate, there are similarities between PBF and eastern Atlantic bluefin tuna (BFT-E) in population vital rates. However, comparisons of PBF made with the BFT-E should be regarded with caution because they are not independent of estimates made for SBF. No direct estimates of adult M (e.g. from tagging experiments) are available for either PBF or BFT-E. For both stocks, the qualitative level of adult M was established by WG consensus after considering knowledge of the biology, comparison with other bluefin species/stocks, fisheries data, and modeling considerations. For BFT-E, the ICCAT WG used the lower bound of the SBF estimates (M=0.10) to quantify BFT-E adult M, while the ISC WG used the mean of the SBF estimates (M=0.12) to quantify PBF adult M.

7.1.5 General discussion for 7.1

The WG hypothesized that natural mortality of ages 1-3 was likely related to size more than age of fish. It was noted that the mortality schedule used in the 2008 stock assessment was mostly based upon a comparison to SBF and BFT mortality-at-size. Because understanding of PBF length-at-age has improved, a new series of PBF mortality-at-age (based upon new growth rate) and subsequent survivorship curves were requested. Those were presented at the meeting. The survivorship schedule was further refined by projections of survivorship of spawners in number and in weight. The new survivorship schedule was compared to schedules for other bluefin tuna stocks. Results of the new spawner survivorship analysis and the comparison to other bluefin tuna stocks are attached as Appendix A. It was noted that the results of cumulative number and weight of spawners by ages of PBF are higher than similar calculations for other bluefin tuna stocks, except for the western Atlantic bluefin tuna (BFT-W) stock. However, due to uncertainties about the length-age relationship for the BFT-W stock, a comparison with this stock may not be appropriate.

The WG recommends the following:

1. A re-examination of all assumptions of M;
2. A new sensitivity analysis of the population dynamics using the current assessment model structure and the new mortality schedule derived during this session (Appendix B) be completed for presentation to the plenary along with original assessment results;
3. The effect of the new run be assessed by the next WG, even if the main conclusion of the May2008 assessment does not change.

7.2 Stock Synthesis software

7.2.1 Evaluating the utility of stock synthesis version 3 for Pacific bluefin tuna stock assessment. Presented by Y. Takeuchi. (ISC/08/PBF-2/16)

The ISC stock assessment of PBF in May 2008 used Stock Synthesis 2 version 2q. Since then, the Stock Synthesis 2 software has been modified with significant changes and issued as version 3 (SS3). A study was initiated to: firstly, review briefly the new features introduced in the SSv3; and secondly, compare the results from the base case run of the May 2008 (SS2) assessment with identical base case run using SS3. The results indicated that SS2 is unable to accurately estimate F when F is high. Consequently it was determined that the problem of unexplained catch with the May 2008 assessment is due to flaws in the software used.. This study also discussed additional considerations for accurately accounting for the additional parameters with SS3.

Discussion

The additional flexibility of SS3 (e.g., seasonal M interpolation, weight frequency likelihood component) is useful for conducting future stock assessments with a software, but differences between SS2 and SS3 should be investigated. The WG noted that by the time the next PBF assessment will be executed, SS3 will have been more fully tested by researchers (*e.g.*, U.S., IATTC and others). It was also noted that the SS2 may not be fully supported by the developer after SSv3 becomes widely available; hence, the PBF WG needs to plan on transitioning to the new SS3 platform for conducting the next PBF stock assessment.

7.3 Conclusions

From the results of the working papers, analyses performed by the participants and the discussions, the WG concluded as follows**:**

1) The model mis-specification appears to be the source of implausible results;
2) The estimate of unfished biomass (B_0) from the 2008 assessment appears to be implausible.
3) The estimate of unfished biomass of the 2008 assessment is unlikely to be the result of density-dependent changes in growth and maturation.
4) Although we cannot be certain of the specific model mis-specification, it is likely that M of adults is higher than that used in the 2008 assessment.
5) A re-examination of all assumptions about M should be initiated.
6) A sensitivity model run given in the 2008 stock assessment report that used the 2006 M schedule (reflecting higher adult M=0.25) may be more plausible than the current assessment. In addition, a new sensitivity run that reflects both higher adult M (age 3+ = 0.25) and a revision to juvenile M (age 0 = 1.6, age 1 = 0.386, age 2 = 0.25) should be accomplished for the next PBF WG meeting (Apendix B).
7) Unexplained catch in the 2008 assessment was a source of uncertainty. This was due to the assessment software and not a structural issue of the stock assessment. It was recommended that the effect of the corrected run should be assessed at the next WG meeting, while the main conclusion of the May 2008 assessment may not change.
8) The WG should work toward moving the assessment to SS3.

8.0 ONGOING STUDIES ON RECRUITMENT MONITORING (N. Miyabe, and K. Satoh)

8.1 Fishery independent surveys

8.1.1 Optimum oceanic environment for spawning ground of Pacific bluefin tuna presented by M. Masujima (ISC/2008/PBF-2/19)

Oceanic environments in the spawning grounds of PBF were studied statistically with generalized linear model (GLM), and numerically with Ocean General Circulation model (FRA-JCOPE) and particle tracking method. Compiled data set of the PBF larvae sampled between 1956-1989 showed that the distribution area of the PBF larvae is between the Kuroshio current and the Subtropical Countercurrent, around the Ryukyu Islands. After standardizing the effect by the difference of net, towing depth, day/night and single/double tow using GLM, the maximum probability of presence of PBF larvae is at the sea-surface temperature of 26ºC, from May to July. The real spawned positions for the sampled PBF larvae were traced back from sampling points during the research cruise of R/V Shunyo-maru in 2004. It was concluded that the spawning grounds are about 200 km away from the PBF larvae sampling points because the particles trapped within meso-scale eddies on the scale of about 200 km. It can be said that the meso-scale eddies have a role to restrict the diffusing area of the PBF larvae from the spawning ground to the open ocean. The importance of oceanic parameters of sea-surface temperature, salinity, chlorophyll and velocity for the spawning ground were evaluated by application of the GLM. It was found that all parameters listed above are significant; the optimal values for the PBF spawning grounds being 25.4ºC of sea-surface temperature, 1.02e-05S-1 of velocity, 34.98 psu (ppm?) of salinity and 0.41 mg/m^3 of chlorophyll.

Discussion

Characteristics of spawning grounds were compared between two hot spots, areas near Taiwan and near Ryukyu Islands. Spawning seasons are somewhat different in these two areas but water temperature is similar. The WG was informed that the birth date was back-calculated from the standard length of sampled larvae. The author noted that there are other tuna species including yellowfin and skipjack on the same grounds but species identification is not difficult to do by pigmentation pattern. It was pointed out that the current oceanographic model (FRA-JCOPE) does not handle data south of 18ºN, consequently areas south of 18ºN were not included in this study. In response to this, it was hypothesized that the sea surface temperature in the area south of 18ºN may be too high to spawn. The larval distribution of was the widest in June. The spawning area is in the counter-clockwise eddy related to upwelling and such eddies propagate to the west and are always present in this area. The WG posited that it would be interesting to know if the upwelling information was included in the GLM. The WG was informed that temperature is the most important factor on spawning activities, followed by amounts of chlorophyll, nutrient and plankton. Conducting similar analysis on spawning grounds in the Japan Sea was suggested. However, the oceanographic model for the Japan Sea is not incorporated in the FRA-JCOPE system. In the absence of such a system, it was recommended that a relatively gross look at gyres and chlorophyll may detect some information on this point. It was suggested that PBF spawning in captivity was induced by the sudden increase in water temperature, but this was not proved by experiment. It was noted that in the Mediterranean Sea the environmental variability in the spawning ground is quite large, so that the variance of observed environmental variables could be large.

8.1.2 Effect of physical impact on Pacific bluefin tuna larvae on the basis of rearing experiments presented by Y. Kato. (ISC/2008/PBF-2/15)

Analyses of historical fisheries data suggest that the spawning area of PBF is very limited. Therefore, physical environment could have a critical effect on survival of bluefin tuna larvae. Rearing experiment with just fertilized PBF eggs and hatched out larvae was carried out with different temperatures; 26ºC was found to be optimum water temperature for hatching, growth and survival. On the other hand, an optimum turbulence intensity estimated in this study was a turbulence induced by 7.5~12.5m/s wind speed. It means that the strong wind mixing is necessary for the appropriate survival.

Discussion

The WG was informed that the RNA/DNA ratio of the larvae was estimated and that turbulence is related to the contact rate of larvae to bait. Lasker (1978)[1] was the first to illustrate the importance of turbulence to larvae. It is important on the meso-scale to have a structure like an eddy. The necessity of taking depth measurements for turbulence was suggested. It was noted that such analyses were conducted about 10 years ago to see the effects of typhoons, and inverse relationship between larval survival and depth were found. That means stronger turbulence will lead to less recruitment. It was suggested that such an analysis may be interesting to conduct in the Sea of Japan.

8.1.3 Preliminary results of horizontal and vertical distribution of patches of Pacific bluefin tuna, *Thunnus orientalis*, in the northwestern Pacific Ocean. Presented by K. Satoh. (ISC/2008/PBF-2/18)

Nine high density larval populations (patches) were identified, of which seven patches were tracked with reference buoys over a duration ranging from 28 to 171 hours in the western Pacific Ocean between 2004 and 2008. In fine and meso-scale observations (about 15 - 30 km range), patches consisted of a number of cohorts (identified from analysis of otolith daily rings), which had different distributions within a patch. Larvae from a cohort were advected together loosely for a several days to a week, although the larval horizontal distribution shrinks and/or decoupled even from early larval days. The larval distributions were strongly correlated with distributions of sea surface temperature, salinity and density of copepods and copepod nauplii in the observed area. The larvae only distributed in the mixed layer; clear diurnal vertical movement not being observed. Patches were entrained in meso-scale eddies (about 100 -500 km diameter), which propagated westward. Some of the meso-scale eddies are known to coalesce with the Kuroshio. The spawning area and the fishing ground for newly recruited fish are linked by the Kuroshio. The larvae characterized by not-fully-developed swimming ability likely succeed in the feeding migrations, only if they could utilize the combination of westward propagating eddies and the Kuroshio.

Discussion

The author indicated that it would be difficult to estimate the PBF recruitment based on this type of survey. However, it may be possible to show when mortality becomes stable during the larval stage. The WG noted that this study, the first for bluefin tuna is worthwhile to be continued over the next several years to consider year-to-year fluctuations in the environment. It was further noted that the number of larvae increased during the series of sampling. This increase was due to the fact that the larval distribution within a patch is affected by distribution of environmental conditions; and that the location of the sampling within a patch differs by tracking day.

The WG discussed whether a larval index may be useful in estimating spawner biomass by back calculation. There was an opinion that larval index may be used to indicate abundance of recruitment but not of spawning biomass. Some representatives indicated that to make meaningful PBF recruitment estimates would require sampling with good precision because M is high. After spawning, recruitment starts in July (in the Pacific) until December (in the Sea of Japan).

8.1.4 Annual changes of abundance and mitochondrial variability (genetic variability) in the Pacific bluefin tuna larvae around the Ryukyu Archipelago, presented by N. Suzuki et al. (ISC/2008/PBF-2/14)

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[1] Lasker R. 1978. The relationship between oceanographic conditions and larval anchovy food in the California Current: identification of factors contributing to recruitment failure. Rapp. P.-V. Reun. Cons. Int. Explor. Mer., 173: 212-230.

In order to accumulate biological knowledge concerning reproduction and larval distribution of wild PBF, research cruises were carried out during June to July in 2007 and 2008. Sampling stations were designed so that the analyses could be focused on; (i) edge of a middle-scale gyre, and (ii) sub-currents of the Kuroshio Current. Collected larvae were roughly sorted on board, preserved in 99.5% ethanol immediately and then transferred to the laboratory. After morphological observations, species identification and genetic variability evaluation were made based on the mitochondrial DNA analyses. In 2007, a total of 348 PBF larvae were identified from ten sampling stations and five patches were found. Of the 348 larvae, 224 individuals (64.4%, 4.4-7.4 mm in TL) were from a single patch. Three of the five patches were found on northeastern region of Miyako Island and appeared to be along the edge of gyre; the remaining two in nearside of the warm-water of Kuroshio Current. In the largest patch, 180 individuals showed unique mtDNA haplotype and a total of 192 haplotypes were identified. The haplotype diversity of the patch (h=0.993) was comparable to those of the Y-O-Y (Young-of-the-year) juvenile schools reported previously (h=0.995-0.999). The large mitochondrial variability indicates reproductive contributions were by a large number of spawning females. In 2008, only twelve PBF larvae were found from six sampling stations and no patch was apparent. Regional pattern of the larval occurrence was almost consistent with that in 2007 in spite of the different occurrence of the surface currents. Total of 120 larvae of yellowfin tuna were identified by DNA analysis, which was much less than in 2007. The annual change of larval species composition around the Ryukyu Archipelago may imply changes of the relative level of spawning activity between tuna species. Much more data are needed to elucidate the potential fluctuations of larval biomass of tuna species and further researches are essential to monitor larval abundance and genetic variability.

Discussion

A question was raised about the genetic characterization. In response, it was noted that there is no problem in genetic technique. The movement of larvae is strongly related to the meso-scale feature as shown by Bakun 1996[2].

8.1.5 Estimating potential habitat of young Pacific bluefin tuna in the North Pacific presented by K. Segawa and H. Yamada. (ISC/2008/PBF-2/20)

Potential habitat of immature PBF in the North Pacific was estimated based on locations of fish obtained from archival tag data, the sea surface temperature (SST) and the sea surface chlorophyll pigment concentration (SSC) derived by satellite. Combining tag and satellite data, the index of distribution density was estimated to represent potential habitat for PBF. Based on this index, the potential habitat suitability is not high in the in EPO except for the North American coastal waters off USA and Baja California due to low SSC.

Discussion

The WG was informed that in August and September there is a high probability of habitat suitability off northern California. The question of whether PBF catches are made in that area was raised. It was also suggested that the matching the possible habitat of PBF with the distribution of catch of young PBF might confirm estimated habitat suitability. Similarly, comparing annual variability of corridor and/or transition zones may be of interest.

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[2] Bakun, A. 1996. Patterns in the Ocean: Ocean Processes and Marine Population Dynamics. University of California Sea Grant, San Diego, California, USA, in cooperation with Centro de Investigaciones Biologicas de Noroeste, La Paz, Baja California Sur, Mexico. 323pp.

8.2 General discussion

The WG discussed the three research projects (8.1.2, 8.1.3, 8.1.4) being conducted to improve recruitment strength estimates. If abundance estimates of larvae or juveniles are feasible, then it may be possible to identify when a critical point occurs. It was agreed that more biology and environmental data are required to draw any conclusions. It would be difficult to conduct both quantitative and qualitative studies, therefore the WG advised narrowing scope of research to complete either qualitative or quantitative analysis. It was reminded that completion of recruitment to the fishery will take place 6 months after spawning; there would be some choices of which time the year-class strength is measured. Fisheries data and scientific data, including fine-scale information from the local fishery, should be combined. On the other hand, indexing young PBF is also important. Grid survey using pelagic trawl gear in the Sea of Japan would be interesting at about three months after the spawning season.

In summary, the papers presented at this meeting emphasized the importance of gyres in which spawning takes place. Oceanographic features such as gyres and turbulence appear to be critical to a good environment for PBF larvae. Given the current difficulty in sampling young juveniles, developing fishing gear that effectively samples juveniles is critical. Factors affecting the survival of juvenile PBF should be also investigated.

Finally, the WG discussed the need to review past work with the intention of implementing improved research projects. At this review process, objectives and priorities for each project could be set. It was further suggested that a workshop similar to the CLIOTOP symposium would benefit these research projects. Japan stated their willingness to host such a symposium.

9.0 RESPONSE TO ISSUES RAISED BY ISC PLENARY (H. Honda, and Y. Takeuchi)

The WG considered several factors of the 2008 stock assessment which may have led to a very high unfished biomass estimate (see discussions in Agenda Item 7.0). Considerations include several elements of biological parameters, model mis-specifications and alternative model considerations. As to alternative model consideration, biomass dynamics model results suggested the carrying capacity might be about 200,000t which is roughly one fifth of the unfished biomass estimated by the base case stock assessment.

From the examination of biological information of this species, the WG determined that the uncertainties in age and growth of young fish, maturity at age, possibility of sex differential growth, the effects of lack of information on the relationship between two spawning grounds and different spawning seasons between spawning grounds may have influenced the estimates of unfished biomass. However due to a limited understanding of PBF biology, the WG can only evaluate the partial effects of these factors by simple calculation in relation to the effects of density dependence. During the workshop in May 2008, the effects of density dependence on the unfished biomass estimate were discussed. The WG concluded that, although density-dependent effects could not be ruled out, it was unlikely that density dependence can fully explain the large unfished biomass estimated. In addition, the spatial segregation of age classes observed on spawning grounds and the migratory nature of PBF may reduce competition and intra-specific predation, thus bluefin may not show large density-dependent effects. It is difficult to identify specific model mis-specification; only the modification of M from the 2008 stock assessment can resolve the high estimated unfished biomass in the 2008 stock assessment. For this reason the WG recommends re-examining the derivation assumptions for M and fully evaluating the effects of uncertainties in M on the stock assessment.

If the plenary wishes to improve the stock assessment further, the WG recommends promoting comprehensive studies on the biology of the species, in particular reproductive biology; and further refining the age and growth estimates of the fish. This new information may enable the WG to resolve the issues with uncertainty in M. Despite the uncertainties described above, the WG concluded that adult M is likely higher than that used in the May 2008 stock assessment.

10.0 RECOMMENDATIONS, REVIEW OF SCHEDULE AND ASSIGNMENTS (K. Yokawa)

The following is a summary of recommendations by Agenda Topic (Sections):

For Section 5.0

1) The estimated growth at ages 1 to 5 years old be confirmed by using adequate techniques (e.g. use of tagging results, combination of studies with daily increment on otolith and annuli on vertebrae).
2) Estimates of growth in males and females should be compared by sampling otoliths and using size and sex information.
3) To determine if there are differences in growth in the EPO and the WPO size data and/or otoliths of fish 1- to 3-years old should be collected. Maturity and size data in the two main spawning grounds (Taiwan-Nansei Islands and Sea of Japan) should be collected.
4) Information on hypothetical sub-stocks of PBF, such as the distribution and migration of adult PBF in relation to the two known spawning grounds and the reproductive activities in each area need to be collected.

For Section 6.0

1) Size data

Member counties and relevant organizations should continue research and update current data collections and sampling programs, and intensify/improve them where necessary. Collecting the adequate data to estimate catch at size and evaluate effective sample size is also essential.

2) Sex and size data

Member countries and relevant organizations should collect sexed size data of large PBFs from the fisheries; for example, from Japanese coastal longline, purse seine in Japan Sea, coastal fisheries conducted in Tsugaru Straight, and Taiwanese longline. Member countries and relevant organizations should also collect sex and size data from large PBF in the fisheries, in particular: the Japanese coastal-longline, Japan Sea purse-seine, Tsugaru Straight coastal, and Taiwan longline fisheries.

3) Abundance index

The current collection of data for creating reliable abundance indices be continued and intensified where necessary should be continued.

4) Estimation of historical catch data

a. The surveys of Japanese historic catch be continued.
b. Historic catch data in EPO be reviewed and summarized.
c. In both Japanese and EPO fisheries, related socio-economic studies be conducted

5) Study related to trans-Pacific migration

a. The mechanism of trans-Pacific migration be studied;
b. Synchronicities of historical series of catches of fisheries catching similar size/age classes of PBF at the both side of the Pacific be analyzed;

c. Currently available tagging data be summarized, reviewed and reported;
d. A well-designed tagging program for further tagging be developed.

For Section 7.0
1. A re-examination of all assumptions of M;
2. A new sensitivity analysis of the population dynamics using the current assessment model structure and the new mortality schedule derived during this session (Appendix XXX B) be completed for presentation to the plenary along with original assessment results;
3. The WG moves toward SS3
4. The effect of the new run be assessed by the next WG, even if the main conclusion of the May 2008 assessment does not change.

For Section 8.1
1. Past works, with the intention of implementing improved research should be reviewed;
2. Objectives and priorities for each project should be set;
3. A workshop similar to the CLIOTOP symposium be conducted.

For Section 11.0
The WG recommends that the ISC change its policy to: all working papers submitted to WG sessions should be made accessible to the public if the authors authorize such access and that the documents clearly state that the material is preliminary and not to be cited without author’s permission.

Priority recommendations/Assignments
Among the various recommendations, the WG considered the following to have first priority and plans to complete them by July 2009:

- A new sensitivity analysis of the population dynamics using the current assessment model structure and the new mortality schedule derived during this session (Appendix A) should be completed for presentation to the plenary along with the original assessment results.
- The effect of the corrected run should be assessed by the next WG, even if the main conclusion of May 2008 assessment does not change.

Meeting schedule
It was agreed that the WG will meet for two days prior to the plenary session of ISC in 2009. During that session, the future meeting schedule should be determined.

11.0 OTHER MATTERS (M. Miyake, and Y. Takeuchi)

It was noted that there have been some outside comments on the availability of working documents presented at the WG to the public or scientists working with other institutes and RFMOs.

The ISC Chairperson explained that the ISC’s current policy for working documents submitted and used by the ISC WGs is: In the interest of protecting the rights of authors of working documents to publish their documents in peer-reviewed journals, the ISC does not make working documents available to the public. Instead, the ISC provides a list of documents for each workshop and the email addresses of the authors of the documents. In this way, any person wishing to receive the working document could contact the authors for copies. He added that the policy can be changed if a new policy is recommended by one of the WGs and if the plenary approves it.

The WG discussed in depth of pros and cons of having working documents to be open to the public. One of the problems would be that ISC has no Secretariat and it might be difficult to keep them under control. It was commented that the construction of a home page has been progressing by the efforts of NRIFSF.

Another possibility is that the WG decides which papers would be on the web-site. However, WGs may have difficulty in selecting specific papers. There is a general consensus that all the working papers which authors have authorized should be available; so that the procedures are clear and the working group process is transparent. At the same time, all papers should clearly indicate that they are temporary working documents and should not be cited without authors' permission.

Another suggestion was made that a template for reporting various elements of each working paper can be developed and using such a template, the papers can be reduced to executive summaries in the WG report, if all working documents are in the public domain.

12.0 ADOPTION OF REPORTS AND CLOSURE (M. Miyake, and Y. Takeuchi)

The draft report was presented and adopted after modifications and with the understanding that substantial editorial corrections may be introduced later.

It was agreed that this report is not finalized and officially available to the public until the adoption by the ISC Plenary, but that it does not prevent the observers from the WCPFC to report on the results at its session.

Appreciation was expressed by all the participants to the host, Ishigaki Tropical Station, Seikai National Fisheries Research Institute, for their efficiently organizing the meeting and for their hospitality.

The meeting was adjourned.

Appendix 1.

Agenda and Rapporteurs (in parenthesis)

1 Opening and meeting arrangements (Miyake, Takeuchi)
2 Adoption of agenda and appointment of Rapporteurs (Miyake, Takecuhi)
3 Review of objective and desired output (Takeuchi)
4 Overview of the 2008 stock assessment (Ichinokawa, Conser)
 4.1 Concerns (parameter estimates with "low plausibility")
 4.2 Potential factors driving results
5 Review of input and information
 5.1 Biological information and parameters (Tanabe, Shimose, Alex,Hsu)
  5.1.1 Age and growth
  5.1.2 Reproductive parameters
  5.1.3 Natural mortality
  5.1.4 General discussion for 5.1
 5.2 Fishery information and data, information on related species (Oshima, Yokawa, Michel)
  5.2.1 Pre-stock assessment period
  5.2.2 Stock assessment period
  5.2.3 General discussion for 5.2
 5.3 Stock assessment model (Piner, Lee, Takeuchi)
  5.3.1. General issue
  5.3.2. Stock Synthesis
  5.3.2. Alternative approach
  5.3.4. General discussion for 5.3
  5.3.5. Conclusions for 5.3
6 On going studies on recruitment monitoring (Miyabe, Satoh)
 6.1 Fishery independent Survey
 6.2 Fishery information
 6.3 General discussion for 6
7 Drafting of response to issues raised by ISC plenary (Honda, Takeuchi)
8 Recommendations, Review of schedule and assignments (Yokawa)
9 Other matters (Miyake, Takeuchi)
10 Adoption of reports and closure (Miyake, Takeuchi)

Appendix 2

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Appendix 3

List of Documents

ISC/08/PBF-2/01	The Estimate of Unfished Bluefin Spawning Stock Biomass: the result of Density-dependent processes? (K. Piner [Kevin.Piner@noaa.gov], and H. H. Lee
ISC/08/PBF-2/02	Simulation of the Estimation of M as a Model mis-specification diagnostic (K. Piner [Kevin.Piner@noaa.gov], H.H. Lee, M. Maunder and A. Aires-da-Silva)
ISC/08/PBF-2/03	Estimation of population size for Pacific bluefin tuna using Bayesian production models (H.H. Lee [Huihua.lee@noaa.gov], K. Piner, C. C. Hsu and R. Conser)
ISC/08/PBF-2/04	An Evaluation of the Natural Mortality Schedule Assumed in the PBF 2008 Stock Assessment and Proposed Changes (A. Silva [alexdasilva@iattc.org], M. Maunder1, R. Deriso, K. Piner and H.H. Lee)
ISC/08/PBF-2/05	Preliminary analysis of the stock abundance indices for Pacific Bulefin Tuna (*Thunnus orientalis*) landed by Japanese Purse Seiners in Sakai-Minato (M. Kanaiwa [m3ikanaiw@bioindustry.nodai.ac.jp], A. Shibano, T. Shimura, R.Uji and Y. Takeuchi)
ISC/08/PBF-2/06	Assessing the precision of length-frequency estimates with consideration of finite population sampling by using landing data in Sakai-Minato Port (A. Shibano [18040056@bioindustry.nodai.ac.jp], M. Kanaiwa , R. Uji, T. Shimura, K. Yokawa and Y.Takeuchi)
ISC/08/PBF-2/07	Estimation of catch at size for Pacific bluefin tuna caught by Japanese troll and set net fisheries: current problems and future perspectives (M. Ichinokawa [ichimomo@fra.affrc.go.jp])
ISC/08/PBF-2/08	Review of the current problems and future perspectives on length frequency data for Pacific bluefin tuna (M. Ichinokawa [ichimomo@fra.affrc.go.jp] and Y. Takeuchi)
ISC/08/PBF-2/09	A review of the age, growth, and reproductive biology of Pacific bluefin tuna, Thunnus orientalis, with a possible hypothesis for further research activities (T. Tanabe [katsuwo@affrc.go.jp], T.Shimose, M. Ichinokawa and Y. Takeuchi)
ISC/08/PBF-2/10	Basic information to review the PBF catch before 1952: Descriptions of statistical information sources and development of fishing areas. (F.Muto [mtf@affrc.go.jp] , Y.Takeuchi and K.Yokawa)

ISC/08/PBF-2/11	Review of PBF catch before 1952 II: Catches and catchabilities. (F.Muto [mtf@affrc.go.jp])
ISC/08/PBF-2/12	Preliminary analysis on length data from intensive size sampling of Pacific bluefin tuna caught by Japanese troll fisheries. (K. Oshima [oshimaka@affrc.go.jp], M. Ichinokawa, K. Yokawa and Y. Takeuchi)
ISC/08/PBF-2/13	Annual report of the maturity status of the bluefin tuna landed in the Ishigaki Island (2008) (Y. Aonuma [aonuma@fra.affrc.go.jp], N. Suzuki, T. Tanabe,H.Ashida)
ISC/08/PBF-2/14	Annual change of abundance and mitochondrial variability in the Pacific bluefin tuna larvae around the Ryukyu archipelago (N. Suzuki [suzunobu@affrc.go.jp], H. Ashida, T. Tanabe and Y. Aonuma)
ISC/08/PBF-2/15	Effect of physical impact on Pacific bluefin tuna larvae on the basis of rearing experiments. (Y. Katoh [kyoshiki@affrc.go.jp])
ISC/08/PBF-2/16	Evaluating the utility of Stock Synthesis Version 3 for Pacific bluefin tuna stock assessment. (Y. Takeuchi [yukiot@fra.affrc.go.jp])
ISC/08/PBF-2/17	Catch and distribution of Pacific bluefin tuna, *Thunnus orientalis*, around the Tsugaru Strait. (M. Abe [abemasa@affrc.go.jp] and I. Yamazaki)
ISC/08/PBF-2/18	Preliminary results of horizontal and vertical distributions of patches of Pacific bluefin tuna Thunnus orientalis in the northwestern Pacific Ocean (K. Satoh [kstu21@fra.affrc.go.jp])
ISC/08/PBF-2/19	Optimum Oceanic Environment for Spawning Ground of Pacific Bluefin Tuna . Masujima [masujima@affrc.go.jp])
ISC/08/PBF-2/20	Estimating potential habitat of young Pacific bluefin tuna in the North Pacific (K. Segawa [kyo@affrc.go.jp] and H. Yamada)

Power point presentations

Presentation 1	A brief history of bluefin fishing in the EPO; James Joseph
Presentation 2	What do we learn from the analysis of the historical trap catches of Atlantic bluefin tuna? Jean-Marc Fromentin