Annex 7

REPORT OF THE PACIFIC BLUEFIN TUNA WORKING GROUP WORKSHOP

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

May 28-June 4, 2008
Shimizu, Japan
continued July 17-18, 2008
Takamatsu, Japan

1. Opening and meeting arrangements

The meeting was opened by the Working Group Chair, Mr. Y. Takeuchi. The Director of the Laboratory, Dr. Y. Uozumi welcomed the participants and offered any assistance to make the meeting successful.. The Working Group noted that an informal working group had met during the preceding week of the Working Group to make some preparatory analyses.

Participants introduced themselves. List of the participants is attached as Appendix 2.

2. Adoption of Agenda and appointment of Rapporteurs

Proposed Agenda was adopted which is attached as Appendix 1.

Rapporteurs were nominated for each Agenda Item (whose names appear in Appendix 1). Dr. Miyake served as the general rapporteur.

There were 16 papers submitted at the session (list attached as Appendix 3). Also one information paper and many PowerPoint presentations were made during the session, whose abstracts are included in this report.

3. Review of fisheries indicators

3.1 Catch data

- ISC08/PBF-1/01 Pacific bluefin tuna quarterly catch updates. By K. Oshima.

Quarterly and annual catches in weight (mt) by fishery for Pacific bluefin tuna (PBF) in Japan and Korea were updated up to and including 2007. The input data submitted previously for SS 2 did not include catches by the Japanese longliners operated in the South Pacific, due to a simple oversight. These South Pacific catches have been incorporated into the input data at this time.

Korean PBF catches are exclusively being made by the domestic purse seiners as by-catch of other fish and most of them are exported to the Japanese market as fresh fish. Korean monthly catches for the domestic purse seiners during 2000 – 2007 were updated. These updated data were derived from sales slip data, whereas the data previously presented were based on the Korean export statistics. The updated catch data were considered to be more reliable than the previous data, because they were based on raw data, and hence included in the input data for SS 2 at this time. However, some definite discrepancies appeared in quarterly catches between the updated and previous data. In addition, pattern of quarterly catch of the Korean purse seine fishery was different from that of the Japanese similar fishery and the Korean annual catch has significantly increased in recent years. Consequently, the trends in catch, effort and any changes in the Korean PBF fisheries need to be reported and examined in the future meeting of the Working Group.

The Japanese Annual Report of Catch Statistics on Fisheries and Aquaculture (SD report, previously referred as “SID report”) and logbook data were not yet available for 2007, at the time of the Working Group. Therefore, the catches of some Japanese fisheries, such as longline, troll and set net fisheries (which are estimated generally based on these data sources) are provisional, estimated by database of Research Project on Japanese bluefin tuna (RJB).

Discussion. The Working Group noted that the new Korean catch data were of the official data submission from that country. The Working Group discussed validity of the new data and agreed to use the new series for the assessment at this time. However, it also recommended that the Chair contact the Korean scientists and ask submission of a paper at the ISC PBF WG meeting in July, 2008, to explain the procedure of the updates with a particular emphasis on clarification of the discrepancies observed in 2000 and 2005 between these two data sets, It was agreed that sensitivity runs by Stock Synthesis 2[1] (SS 2) will be carried out at this meeting, using the previous data set.

The Working Group also approved inclusion of Japanese longline catches in the South Pacific which were over sighted in the data set presented at the previous session.

- **Catch update in July, 2008**

At the Working Group session in July, 2008 (Takamatsu, Japan), the additional information became available for Chinese Taipei and Korean Fisheries. The summaries are given below.

- Chinese Taipei

The catch of PBF in 2006 (1,149 t) was the lowest catch in the time series. The 2007 catch of PBF has increased to 1,401 t. This year had higher catches per vessel compared to the previous five years. Catch in 2008 is currently about half of those in 2007. High fuel prices have reduced effort (less searching time and area). The size of PBF caught ranged mainly from 210 cm to 235 cm during 2003-2006 and from 205 cm to 245 cm in 2007. Between 2003 and 2007, over 8000 PBF were measured.

Discussion. The reduction in effort by Chinese-Taipei longliners may influence CPUE estimates. Due to the lack of logbook data for this fishery, the Chinese-Taipei longline nominal CPUE time series currently available came

[1] Methot, R., 2007,User Manual for the Integrated Analysis Program Stock Synthesis 2 (SS2) Model Version 2.00b; Feb 27, 2007 Updated Mar 21, 2007, NOAA Fisheries Service Seattle, WA

from limited market information and hence standardization of CPUE may not be practicable for future years, if there are some changes in fishing pattern.

- Catch data updates of Pacific bluefin tuna in Korea by S. D. Hwang, K. H. Choi, Y. J. Kwon, H. Gwak, J. H. Kim, D. H. An and D. Y. Moon

Catch statistics were revised and updated from the new data sources based on the formal publications and recorded documents. Most Pacific bluefin tuna are caught in Korean waters by domestic purse seiners targeting mackerels. The PBF are mostly small individuals, ranging from 20 to 167 cm in fork length. The 30-80 cm FL size class dominated in 2007. The annual catch of PBF by 29-48 purse seiners and 4 trawlers ranged from 1 to 2,141 t during the 1982-2007 period. PBF fisheries are annually variable as it is not a target species.

Geographical distribution of PBF fishery has recently expanded and catch has increased. Pacific bluefin tuna catch seems to be related to the distribution of target species of the fleet, the degree of association the bluefin tuna with the target species, oceanographic conditions, and the strength of year classes. The recent increasing trend of the Korean PBF catch could be examined through international cooperation.

Korea had submitted catch data before the May meeting and hence the figures given in the Appendix Table 1 are all reflecting these new figures. Catch data coverage is about 90% of the purse seine fleet and the reported catch was not extrapolated, being possibly under-estimated. Port interview of fishermen were used to create geographical distribution of catch and effort. The author suggested to make a comparative studies on the PBF catches by Japanese and Korean purse seiners in the East China Sea and in the Pacific in 2008. The larger fish that are being caught in 2008 could be from a strong year class.

Discussion The Working Group noted that the Japanese catch of PBF landed in the Sakai-Minato indicated that most of the fish caught in 2008 were from 2004 year class.

3.2 Overview of the fishery indicators

Pacific bluefin tuna have been possibly exploited continuously at least since late 19th or early 20th centuries both in the northwestern and eastern Pacific Ocean (Figure 1). According to the study by Muto *et al* (Doc. 04), during the pre-stock assessment period (before 1952), Pacific bluefin tuna catch peaked to the highest of about 47,000 t in 1938, although the data in pre-assessment period should be regarded as less reliable, particularly for the northwestern Pacific. The landings recorded in the eastern Pacific Ocean appear to be reliable even for this period. During the assessment period (starting from 1952), the catch fluctuated within the range from about 9,000 t to 37,000 t. (Appendix Table gives the latest landing data by country, gear and calendar year).

Even though the CPUE series have been standardized (Figure 2), it is very difficult to compare the relative levels among the various series of CPUE that were prepared as input data. The reasons are that gear configurations and fishing grounds changed among the periods which each series covers, mostly due to the change in target species. However the longline CPUE series are believed to well represent the abundance trends of the adult stock. They show some fluctuations with a peak in about 1960 and reached the second peak around late 1970s. Relative levels between two peaks are uncertain. Thereafter it showed more peaks around early 1990s and around 2000, and thereafter a gradual decline.

4. Review of biological studies

4,1 Progress of growth studies by otolith

- ISC08/PBF-1/08. Age and growth of Pacific bluefin tuna, Thunnus orientalis, validated by the sectioned otolith ring counts. By T. Shimose, M. Kai, T. Tanabe, K. S. Chen, C. C. Hsu, F. Muto and Iz. Yamasaki (Shimose et al.)

There were several studies in the past on estimating growth curves for PBF, using modal progression methods, scale ring reading, tag-recapture results and/or vertebral ring counts. According to the previous results, it was generally understood that the fish reach 90cm at age 2, 150cm at age 5 and 200 cm at age 9. But the growth over 200 cm has not been well known. In this study, otolith samples were collected from trolling, longline, purse seine and set net fisheries from all over Japan and Chinese Taipei. Only the otolith samples associated with size data were used. The total of 520 fish over wide range of sizes was sampled. Opaque bands were counted on the section of otolith by only a single reader. Those of less than 2 years old are difficult to read while it is easy for the fish after 10 years.

The time of formation of opaque zones on otolith was studied by examination of edge of otolith for translucent or opaque, by month of sample collected. Percentage of opaque edge was high in May to August, indicating that the opaque zones were being formed during these months. The samples for February through April are missing but it can be concluded that one opaque ring is formed per year.

There were 62 specimens for which age readings were less confident but all the data were included for the analyses. Using these data, von Bertalanffy growth curve (VBG) was obtained. Up to 10 years old, i.e. 210 cm, the growth is relatively rapid and after obtaining that size, the growth slows down. The new curve is compared with the three curves previously proposed. Up to age 10, they all match relatively well, except that the new growth curve exceeds slightly above the previous curves for ages 3 up to 8. Thereafter, the new curve shows a considerably slower growth.

After the study was completed, 197 additional specimens were obtained from Chinese Taipei. Adding the age readings of these new otoliths did not change the results much. Excluding unconfident data or young fish data (1 and 2 years old), another growth curve was obtained and is presented as an appendix.

Age compositions in five data sets from different major fishing grounds showed that older fish tend to inhabit in lower latitude, i.e. in the area Nansei Islands and Chinese Taipei. Sexual difference in growth was also examined, but no significant difference was found. Fork lengths of males tend to be larger than that of females, and the differential growth between sexes may be found in future if more specimens are collected and examined.

Discussion The growth curves currently used seem to be appropriate for young fish (less than age 10). The adequacy of sample sizes for larger fish of over 200 cm was questioned. It was explained by the author that the additional samples obtained from Chinese Taipei are not included in the report. Therefore there will be more samples for those large fish. Later the number of fish sampled including those from Chinese Taipei was presented at the meeting. It was suggested that size frequencies of samples per FL classes would give some idea. Since it is very difficult to obtain samples from large bluefin, the effort by the colleague of Chinese Taipei in colleting these otolith was very much appreciated by the Working Group members.

It was pointed out that maximum length derived from the newly estimated growth curve (L_{inf}.) would be smaller than the value previously reported (December 2007). It might be caused by uncertainty in ageing of older fish due to the small number of larger fish over 15 year old were sampled. However, newly available samples from Chinese Taipei fisheries could improve the result of the estimated age and growth of larger fish. It was requested to add those samples and revise the data table and to prepare the ad-hoc (sample-specific) age-length key of PBF.

The Working Group noted that the author had later provided tables of the results of studies with the Chinese Taipei additional samples. The Working Group agreed that these revised tables be used as it has a larger sample size for large fish older than 15.

4.2 Other biological studies

- Contributions of different spawning seasons and areas to the stock of Pacific bluefin tuna, *Thunnus orientalis*, based on analyses of otolith daily increments and catch-at-length data. By T. Itou (information paper)

Difference in spawning time of PBF is presented. Otolith reading of daily increments from fish collected in the Pacific Ocean and the Sea of Japan revealed some difference in spawning season between the two areas. In general, birth dates were estimated to extend from March to October with a peak in June to August. Spawning seems occurring in the Pacific Ocean side before mid-July and in the Sea of Japan after mid July. Early hatched group in the Pacific grew faster than that in the Sea of Japan, and reached more than 50cm in December. On the other hand, late hatched group in the Sea of Japan grew only to less than 50 cm in December. The latter mode gradually caught up the former, and the two modes almost overlapped in the next May or later. This is because the early group migrated to colder areas early and their growth was considered to have slowed down. The details of seasonal growth in ages 1 and 2 of these two groups need to be further investigated in the future.

- ISC08/PBF-1/09. A review of reproductive biology of Pacific bluefin tuna Thunnus orientaris with description of some problem for further study. By T. Tanabe, K. Yokawa,N. Miyabe, H. Honda and Y. Takeuchi

The reproductive parameters of Pacific bluefin tuna, such as spawning ground and period, sex ratio and fecundity, are briefly reviewed. Two main spawning grounds and periods, one around the Nansei islands in May-June and another in the southwestern Sea of Japan in July-August, are already known. However, there are several unknown biological aspects for this species. In order to better understand these unknown aspects, the following additional research on reproductive biology and relationships of environmental condition to reproductive activity of bluefin tuna were proposed.

1) *Examination for sex ratio of adult PBF;* To collect data of sex ratio by size, area and period will contribute the comparative analyses of age-growth relationship and the estimate of mortality between male and female.

2) *Estimate of fecundity;* To investigate the relationships between body size of adult PBF and the spawning parameters (i.e., batch fecundity, spawning frequency, duration of the spawning period, etc.) are would provide essential information about the reproductive potential of the stock.

3) *Estimate of maturity at size*: To estimate the relationship between mature/immature ratio and size (or age) of PBF is important for the stock assessment. However, to realize that, further improvements in the sampling methodology and technology are necessary.

4) *Early life history in relation to environmental condition;* Investigation on larval and juvenile distribution patterns contribute to provide basic information about the spatio-temporal spawning activity of adult PBF. To collect oceanographic data, i.e., sea surface temperature is important for understanding the spawning procedures of adult fish and the distribution patterns, growth and survival during the period of early life history.

Discussion The relationship between the characteristics of spawning activities of PBF and environmental conditions, especially focused on temperature of the spawning ground was discussed. The larval distribution is associated only with a narrow range of water temperature (around 26 degrees centigrade). The authors provided brief information on the relationship between the daily spawning activities and temperature, with fish in a captivity at the Amami National Center for Stock Enhancement of the Fisheries Research Agency of Japan (with reference to Masuma's document (ICCAT-BFT-SYMP0-34) presented at the "World Symposium for the study into the stock fluctuation of northern bluefin tunas (Thunnus thynnus and *Thunnus orientalis*) including historic periods".)

.It was suggested that the investigations on the influence of oceanographic condition on the spawning and survival of larvae and juveniles in the nursery grounds be considered.

- ISC08/PBF-1/16. Basic results of analysis of sexed size data of large sized Pacific bluefin tuna. By K. Yokawa

Sex ratios by size of fish are studied for fish sampled in Tsugaru Strait (2007) and Okinawa fishing grounds (1999-2007). A total of 4651 fish were examined for sex and size. Total sex ratio is almost 1:1 for all the years for fish collected from Okinawa area. Sex ratio by size indicated a clear trend, i.e. female proportion was higher for tuna of less than 160cm, while it declines for larger fish and get about even with male at about 210-220cm. Thereafter, male dominated in the sample. This declining trend of female ratio from small fish to large fish was consistent between years although there were some variations. It seemed that the FL at which sex ratio was 1:1 increased with a progress of years (190-200cm in 1999 but 220-230 in 2007). The examination of size frequencies of catches show that mode shifted larger through this study period. The fork length at which the sex ratio become 1;1 increased together with the modal shift observed in the total catch. The same trend was also observed in the size data collected from Tsugaru Strait, which is one of the major feeding grounds of bluefin tuna in summer and autumn season. The same trend was also found in the sexed size data whose otolith was used in the aging study by Simose et. al. (ISC08/PBF-1/08).

This study suggested that there are sex specific growth and/or mortality pattern for large sized bluefin tuna. If either or both of these exist, this would have some implications on the stock assessments. For future research, otolith collection should be associated with size and sex data. Sex-size data should also be analyzed with actual locations and time of capture. Such data from the both spawning (Japanese and Chinese Taipei coastal longliners) and feeding grounds should be collected in near future.

Discussion The Working Group discussed as to how to estimate natural mortality, which might be different between sexes. It was noted that natural mortality can be estimated if reliable sex specific growth and catch at size were available. Wider size classes were adopted for large fish, which includes several ages of PBF. Those should be classified into much narrower classes. It was recognized that the study is still of a preliminary nature and no interpretations should be made at this time.

It was suggested that sex specific as well as age specific availability to the longline gear should also be examined as a possible cause of producing such an apparent trend in sex-ratio. If that were the case, these may have some effects in using longline abundance indices. This study is still on-going stage and extensive collection of data would be necessary to obtain information which is useful for the stock assessment.

- ISC08/PBF-1/13. Comparison of von Bertalanffy growth function from otolith sections with observed length frequencies from various fisheries .By M. Ichinokawa

This document (ISC08/PBF/01/13) pointed out three potential problems relating to length frequency data used in the SS 2 stock assessment model to estimate growth for PBF. The first issue is inconsistency between the von Bertalanffy growth equation estimated by Shimose et al. (2008) and length frequency data used in the current stock assessment model. The growth estimated by modal progressions observed in the length frequencies from various fisheries seem to be slower than estimated by the von Bertalanffy growth equation, especially for the winter period and for age 1. In addition, the growth pattern observed in modal progression shows annual variability. These variations would cause misfits of the length frequency data, especially for younger fish, in the stock assessment model which assumes more rapid and no-annual variability in growth. The second issue is confounding among length frequency data from different fisheries in estimating K and L_{inf}. The likelihood profiles on K and L_{inf}. suggested that a growth equation with low K gave better fitted to the length frequency data from Japanese small-pelagic-fish purse seine and set net fisheries, whereas larger K gave better fit to length frequency data from other fisheries. As for the L_{inf}., data from Japanese troll, pole & line and EPO purse seine fitted better with higher L_{inf}., but data for the other fleets showed the opposite pattern. This indicates potential difficulties in estimating the growth curve solely by SS 2 because of contradicting information implied from different fisheries. The third issue is about coefficient of variation of length at age 0 fish. Simple simulation runs suggested that the CV of the length frequencies actually observed from catch data should be larger than instantaneous CV estimated by a von Bertalanffy growth equation with continuous sampling of length data within a quarter and differences of birth date for recruit. Although the length frequency data currently used in the stock assessment can be fully used by the current version of Stock Synthesis 2 and assuming a very simple growth pattern, it is important to note these issues as the potential problems of the current stock assessment model develop address these in future improvements to the model.

Discussion Size samples are possibly biased by gear selectivity and/or partial availability of population for fishery. Also the reliability of the von Bertalanffy Growth (VBG) curve estimated by Shimose et. al. (2008) as to whether it is representative for the total population was discussed. The growth and age of relatively older fish of age 5 or more in the VBG was reliable but growth of fish younger than 2-year-old should be examined with further biological study and the improvement in the model configuration.

- Information PPT presentation. Relation between PBT resources and Climate change in the North Pacific By D. Inagake

PBF recruitment (estimated by VPA in 2006) fluctuates with a period of around 20 years with three peaks in the mid 1950s, 1970s and 1990s. Peaks in 1950s and 1970s correspond with weak Aleutian Low (positive ALPI), warm Sea surface temperature (SST) in the central North Pacific (negative PDO) and warm SST in spawning area. When the regime shift occurred, a rapid change in level of PBF recruitment level is observed without rapid change in spawning stock biomass. Three types of stock-recruitment relationships in PBF were assumed for high, middle and low levels of recruitment. Significant correlations were noted between PBF recruitment and the Pacific Decadal Oscillation (PDO). SST in a spawning area also shows significant positive correlation, that is to say, the period of high temperature in a spawning area corresponded to high recruitments. Climate changes are considered to change larval survival rates in their breeding grounds through changes in food availability, growth rate and the period vulnerable to predation.

Climate conditions in 1930s are characterized by strong Aleutian Low, positive PDO (cold in the central North Pacific) and average or a little colder SST in a spawning area. Although catch of PBF increased in the 1930s, the author guessed that environment in the 1930s was not good for PBF recruitment.

Discussion The Working Group found it to be very interesting and important subject to consider. Particularly in terms of understanding the mechanism of population dynamics particularly for the stock which has been the subject of the fishery for a long time, this type of studies should be further explored. In this respect, suggestion was made that the study results be presented at the coming meeting of the PBF Working Group.

5. Review of fisheries data prepared for stock synthesis 2

- ISC08/PBF-1/02. Data set on Stock Synthesis 2 for Pacific bluefin tuna, Thunnus orientalis. By M. Abe

This paper summarizes the input data to be used in the SS 2 model at this session. At the ISC-PBF/2007 meeting held in April 2007, the Working Group agreed that the Stock Synthesis 2 model to be used for assessing Pacific bluefin tuna, *Thunnus orientalis.* The input data for SS 2 were prepared by the following procedures. Fishery data were re-organized into fishing year that starts from July 1st and ends at the end of June of the following calendar year, for the period of July 1st of 1952 (fishing year 1952) to June 30th of 2006 (fishing year 2005). The fisheries data from eight or more countries were classified into ten fleets. For each fleet, the length bin ranges were set for 16-290cm with a bin size of 2cm for 16-56cm, 4cm bins for 58-116cm and 6cm bins for 122-290cm. Any samples with less than 100 measurements were not accepted. This criterion was agreed after the consideration of the results of the analysis on length frequency database. Maximum and minimum sample size was set at 200 and 100, respectively. Quarterly time step was used and therefore catches were also prepared quarterly for each fleet. Total of 17 series of CPUE was developed to be used for SS 2 model. When CV for a series of indices was larger than 0.2, face value of CV was used. When CV was smaller than 0.2, or not provided, CV was set at 0.2.

Discussion: The Working Group confirmed that the new Japanese longline CPUE series and the updated Korean catch data were used as the input data. It was noted that the length frequency data from Chinese Taipei longline fleet in 2006 were provided recently. It was also noted that small working group reviewed these new data and concluded that the new data series is consistent with those used prior to 2006 and hence it was agreed to include these new data in input data for SS 2.

- ISC08/PBF-1/03. Length frequency of Pacific bluefin tuna caught by Japanese troll and set net fisheries during 1980's and possible effects for stock estimates. By M. Ichinokawa

This document presented length frequency data of Pacific bluefin tuna (PBF) caught by Japanese troll and set net fisheries during 1980’s. The data were recovered and compiled in December, 2007, by NRIFSF. Sample sizes of the length data during 1980’s were smaller than those collected after 1993. However, there seems to be a reasonable consistency in the frequency pattern and average length, between the two data sets; one for 1980’s and another for 1990’s, in troll fisheries. The consistency of the length data from set net was questionable because of the limited sample size in 1980’s and differences in sampling sites between the two periods. The results of the sensitivity analysis indicated that the magnitude of fluctuations in recruitment during 1980s was reduced from 0.82 to 0.41 when the recovered length data for 1980’s are added. This result implies that wide fluctuations in recruitments in the past time without length data of troll fisheries may be artifacts owing to insufficient amount of length data in the period. Further investigations will be needed on the possible effects of the length data on the estimation of magnitude of recruitment fluctuation, as well as representativeness of the current length data.

Discussion It was questioned as to the reason that the additional size data for 1980s had an influence on the recruitment estimated for 1960-70s. It was clarified that these differences in earlier years estimates related to the instability of the model used for the estimation.

The Working Group decided to use the new data set (including the addition of 1980s data) to be used in the input data for the base case assessment.

- ISC08/PBF-1/05. Correction of the standardized CPUE of Pacific bluefin tuna caught by Japanese offshore and distant-water longliners. By K. Yokawa

At the last data preparatory meeting of ISC bluefin tuna Working Group held in Shimizu in December 2007, the abundance index of Pacific bluefin tuna (PBF) caught by Japanese offshore and distant-water longliners, which was expected to represent the abundance trends of adult bluefin tuna, generated many discussions among the meeting participants. Most of these fishing operations were not targeting bluefin tuna. Only in a limited area and season those fleets target on PBF. However, the available catch and effort data for those fisheries do not give a good indicator to identify target species. The procedure to obtain the CPUE, which best represent the true abundance trend was considered. The Working Group tentatively agreed to include the index summarized in the information paper by Yokawa (2007), as a candidate of CPUEs to be used in the assessment

Unfortunately, the author of this information paper found some technical errors in calculating the standardized CPUE. This document explains the errors and provided the revised results.

Previously, Area 1 was not included in developing CPUEs for these fisheries. This time, the data from that area were included. The comparisons of two series showed that the corrections of calculation errors affected very little to the results but the inclusion of Area 1 made some difference in CPUE trends.

Discussion The Working Group concluded that the new corrected data including CPUEs in Area 1 should be used as a possible series of abundance index for SS 2.

- ISC08/PBF-1/04. Annual catches by gears of Pacific bluefin tuna before 1952 in Japan and adjacent areas by gears. By F. Muto、Y. Takeuchi and K. Yokawa

Historical catches of PBF, prior to 1952 in the Japanese waters were updated. It was in high level in late 1930s to early 1940s (max. 47,635 t in 1935). The update involves mostly additions of new data from the provinces which were not covered in the previous studies. Also special data series from Aburatsu and Korea became available.

Catch in 1920s was dominated by drift gillnet in Hokkaido. In 1930s, catch in the Sea of Japan became most significant. Particularly set net catches in three provinces in the Sea of Japan were high, peaked in the mid-1930s. In the late 1930s, Hokkaido became again important, but this time from coastal area. Also the catch on the Pacific side of Kyushu (Aburatsu) made a significant contribution. The size distributions showed three distinct modes, possibly corresponding to ages 8, 9 and 10.

New records of catch series in Korea were found. Most of them were catches by set net.

There are 2 major future tasks that require further attention. One is checking double counting of data in the estimations. The other is further research on sizes of fish caught..

Discussion Coverage of data was asked and the authors responded that almost all the areas where PBF are caught were investigated and that any existing data found there were recovered. Therefore there should not be much uncovered data left. The high catch levels in the 1930s were maintained by large amount of un-synchronized local catches appeared in several areas.

Also the market and type of products in pre-war time was questioned. Some socio-economic studies, such as price investigations (relative to the other important species of fish) and tuna product types would be very interesting.

Also sharp decrease in catch in early 1940s to 1950 was questioned. The catch reduction in the Japanese fisheries during this period may reflect reality of socio-economic situations. However, existence of some unreported catches cannot be declined. Simultaneous sharp drop was also observed in the EPO. This may be due to some socio-economic factors and/or lower abundance of fish. Size distributions in the Japanese longline catch unloaded in Aburatsu port were studied. It was suggested that the peaks in the catch may represent strong year classes. The Working Group agreed that this type of work is very important for the species which have been exploited for such a long time period.

- ISC08/PBF-1/06. Estimation of effective sample size for landing data of Japanese purse seine in Sakai-Minato. By M. Kanaiwa

This purse seine fishing capture almost all the fish in a school and each school is composed of fish of a similar size. One landing generally corresponds to catch of a set (hence, one school). This makes length distribution for each landing narrower than true length distribution of the population. In this paper, studies related to the effective sample size for such purse seine catch is presented, and the historical change in sampling procedures is shown for Sakai-minato (Sakai Port). The results suggested that the effort was optimal in Sakai-minato in 1980s, while recent sampling effort is excessive. However to estimate the optimal sample size for recent years is difficult with currently available data, because that depends on quantities of landing, number of fish sampled (sample size) and/or number of landings (sampling frequencies). The effort to obtain the total quantity of each landing is continuing.

- ISC08/PBF-1/07. Evaluation and recommendation of sampling method for Purse seine by using landing data in Sakai-Minato. By A. Shibano

In the previous study, it was suggested to use the multi-stage bootstrap which contains realistic fishing structure and sampling procedure. Therefore, analyses with such realistic assumptions were conducted. Eight scenarios were considered to propose new sampling procedures to reduce sampling effort, as required. E, f and Ef were provided as the criteria for evaluations, and scenarios were compared from year to year according to these criteria. As a result, sampling a constant number of fish per sample is considered to be advisable. A greater number of samples (or schools) is more effective than a greater number of fish in each sample (or school). Therefore, some reduction can be made in number of sampled fish in each school but not in number of sampled school.

Discussion The previous two papers (Nos. 06 and 07) were discussed together. The actual procedures used in size sampling in Sakai-Minato were discussed. At present, in Sakai-Minato, the samplers try to take as many lengths and weights as possible for each landing (i.e. school). Recently, because the number of total landings has increased, the samplers want to know whether they can reduce the sampling effort per landing or not. It was suggested that under the current situation, to have a limited number of fish be measured per sample (i.e. school) would be better than to reduce sampling frequencies.

The Working Group encouraged to advance this type of investigations in future. The Working Group questioned whether a similar investigation has been conducted in EPO fishery and clarified that the IATTC has very little opportunity of sampling bluefin tuna. However, very extensive studies in sampling design relating to the minimum number of samples and sample sizes required per specific stratum have been conducted in relation to the tropical tunas. .

The Working Group agreed on the importance of investigating the effective sampling strategy not only for this port but for other PBF purse seine fisheries.

6. Review of model setting prepared for Stock Synthesis II

- ISC08/PBF-1/10. Reconsideration to adult natural mortality of Pacific bluefin tuna in the presence of new information of age and growth. By Y. Takeuchi

At the PBF Working Group meeting in December 2007, the natural mortality vectors M were discussed and new age-specific M was agreed upon, whose adult M was determined by averaging of the adult M used for the Atlantic bluefin tuna and that for Southern bluefin tuna stock assessments. The Ms for age 0 and age 1, 2 were determined from tagging studies of Pacific bluefin tuna and Southern bluefin tuna respectively. Empirical estimates of M were updated using the methods of Chen and Watanabe (1989) with different growth parameters and the new age-specific M. Consequently, estimated M for older ages were smaller than the M used in 2006 stock assessment except for when VBGF parameters of Shimose *et al* (2008) were used. The results also showed that relatively high M was estimated when Shimose's growth curve was applied to all the M estimates.

It is important to note very large influence of different M on some key benchmarks, and to have more reliable estimate of spawning potential of the stock. One problem is the difficulty in choosing the best estimate of M. One solution is to develop biological and management benchmarks which are robust to input M.

Discussion The Working Group agreed that this is one of the key issues for stock assessment. It is desirable to reduce the major uncertainties in the assessments owing to the vector M

The extensive discussion was made on the natural mortality vectors used for base case, along with those used for sensitivity analysis, since M is one of the most sensitive parameters affecting stock assessments.

There were opinions that more robust benchmarks for management should be provided and that more effort should be made to reduce the uncertainties in the natural mortality. It was discussed that it may be possible to reduce the uncertainties in M using the biological information such as sex ratio at ages.

There was an opinion that several sensitivity runs must be made with various ranges of M. Another opinion was made to expand the base case to include more scenarios of M to better reflect wide uncertainty stems from M. Consequently the Working Group agreed that for the base case, only the current age specific natural mortality vectors will be used but uncertainty of the stock assessment resulting from various M scenarios must be clearly mentioned in the report.

It was agreed that a clear message should be given to the managers that there is very wide uncertainty in M. and that the plan as to how the scientists would try to treat these uncertainties in the future study be explained.

- ISC08/PBF-1/12. Sensitivity analysis of stock assessment for Pacific bluefin tuna using Stock Synthesis 2. By M. Kai

Sensitivity analyses were made based on the base-case parameterization by Takeuchi *et al* (2008) using SS 2 to examine the influences of uncertainties regarding the parameters. Time series of SSB and recruitment were mainly used for evaluation of the results. In sensitivity analyses, the focus was on the natural mortality rate, the weight length relationship, steepness, sigma R, CV of length at age 0 and 3, parameter k, mean length at age 0 and 3, and those were set different from the base-case. Then several scenarios on size selectivity patterns, survey lambda and initial equilibrium catches for combinations of fleets were tested with sensitivity runs. Additional test runs were made by various M.

The results showed that yearly changes in SSB and recruitment are more sensitive to the natural mortality rate, steepness, parameter k and mean length at age 3. Different scenarios for size selectivity pattern and initial equilibrium catches produced some but very little difference. Different scenarios for combinations of survey lambda by fleets did give some difference.

Time series of SSB and R, are more sensitive to natural mortality rate. Virgin SSB estimated was very high and SPR was very low. Those unrealistic values could be changed by the choice of the M (i.e. using higher M).

Further sensitivity analyses were done for various M values, particularly high adult M gave a high impact on stock biomass estimates.

Discussion Discussion on M used in this study was postponed until a later time when the rationale for the estimate used will be revisited. One concern was the change in mean length at age 3 fish owing to biological changes which would make a difference in the level of the SSB time series.

7. stock assessment analysis work

7.1 Base case

- ISC08/PBF-1/17. Stock assessment of Pacific bluefin tuna –Specification of modeling and base case results-. Y. Takeuchi, M. Ichinokawa, M. Kai, K. Oshima, M. Abe, K. Yokawa, R. Conser,, K. Piner, A. Aires-da-Silva , H. H. Lee and M. Dreyfus.

The results of base case model run were reported. According to the base case results, total biomass (Figure 3) at 1952 was about 55,00 t. Then it reached the highest around 1960 due to an increase in spawners. Thereafter it declined to the level of about 20,000 t and increased again to a second peak around 1980, due to several strong year classes (1978-1980).Total biomass stayed within the similar range thereafter. Spawning stock biomass (Figure 4) started from the level of slightly below 40,000 T. Then it increased to the highest of 60,000 t due to the two strong year classes during the 1950s. After those strong year classes had passed through, spawning biomass stayed in the range between about 10,000 to 30,000 t. During 1980s spawning biomass remained at the historically lowest level (7,803 t in 1983). From the late 1980s, spawning stock biomass recovered to about 30,000 t by mid-1990s, and then declined to the level of 20,000 t. The time series of recruitment appeared to have large variations (Figure 5).

Figure 6 shows annual estimated fishing mortality for age 0, ages 1-3 and ages 4 and older fish are given. A five-year moving average of Fs was used to characterize trends in F over the assessment time period. The trend line indicates that F on recruits (age 0) has been increasing (with fluctuation) since 1990. Moving average F on recruits in the most recent years (2000-2005) is approximately 0.8 yr^{-1} level higher than that estimated earlier in the assessment period. For juveniles (ages 1-3), a similar increasing trend is apparent in the moving average F since 1990; and the recent-F is similar to that on recruit fish (~0.8 yr^{-1}). The level of juvenile F has generally been higher than that for other age groups, while recruit F has only reached similar magnitude in recent years. The moving average F on adults (ages 4+) has remained at a relatively lower level for most of the assessment time period (0.2-0.4 yr^{-1})

Several management benchmarks were presented. YPR and %SPR plots were shown in Figure 7. Ratio of F_{max} against current F (defined as the average of quarterly F of 2002-2004) is about 0.21. Ratio of $F_{0.1}$ against current F was 0.14. Ratio of F_{med} against current F was about 1.01. Ratios of F40%, F30% and F20% against $F_{current}$ are 0.15, 0.21 and 0.30 respectively. Reduction of the fishing mortality may improve the yield per recruit and spawners per recruit. For example, 20% reduction of the fishing mortality results in about 16% increases of the yield per recruitment and about 100% increase of the %SPR. More drastic reduction of the fishing mortality might improve yield per recruitment and %SPR. But exact amount of the improvement of YPR as well as %SPR is highly uncertain since corresponding equilibrium biomass with more reduction of fishing mortality is likely beyond the range of historically observed stock size. Current results suggest that over 50 years, %SPR remains at most about 6 % (Figure 8). From the scatter plots of spawner-recruit relationship (Figure 9), it is very difficult to find any functional relationship between spawning biomass and recruitments, while high degree of yearly recruitment variation may obscure stock recruitment relationship. While spawner-recruit plot suggests no apparent recruitment overfishing, %SPR have remained quite low level for more than 50 years. This might be an indication of potential problem of current definition of spawning biomass of Pacific bluefin tuna or a potential model miss-specification. These two potential problems of current base case modeling should be investigated in the future.

7.2 Diagnostic

- ISC08/PBF-1/17. Stock assessment of Pacific bluefin tuna –Specification of modeling and base case results-. Y. Takeuchi, M. Ichinokawa, M. Kai, K. Oshima, M. Abe, K. Yokawa, R. Conser,, K. Piner, A. Aires-da-Silva , H. H. Lee and M. Dreyfus

Some diagnostics of the base case results were presented. Fishing mortality by age has stable pattern except for the ages 0 and 2 of the most recent year (2005). The reliability of the estimated F in the most recent year was later investigated in the ISC/08/PBF-2/01? during the Working Group meeting in July 2008, since this has a lot of implications to the future prospects of the stock. CVs (Coefficients of variations) of the estimated parameters were also presented. In particular, very large CV observed in the recruitment deviation parameter in starting year of the stock assessment may be an indication of confounding of the other parameters such as offset parameter to scale the initial population size. The correlation matrix of recruitment related parameters ($logR_0$ and recruitment deviations indicated that the recruitment deviations of adjacent years are highly negatively correlated. This should be due to the high uncertainty in recruitment estimates. Correlation matrix of the other estimated parameters were also examined. There are several parameters which have high correlations. In the future less correlated parameterizations should be investigated to improve the model stability.

One of the important uncertainties is unexplainable yield in 2005 by the base case stock assessment results. The model predicted yield in 2005 (24,821 t) was about 8% (about 2,000 t) less than observed yield in 2005 (26,902 t). Ideally, in principle, stock assessment model should be able to explain historically observed catch with more precision. This has an indication that the short term projection results stated in the later paragraphs as well as the most recent biomass estimated by the model might be slightly optimistic.

- ISC08/PBF-2/01. Uncertainty of the estimates in the terminal year of 2005 estimated by SS2 for Pacific bluefin tuna. M. Ichinokawa

This Working Paper was submitted and discussed later at the Working Group meeting in July, 2008 (Takamatsu, Japan). It suggests that too high fishing mortality and un-explained catch in 2005 estimated by the base case of the current stock assessment model were caused by two possible artifacts of (1) under-estimation of number of fish in the population in 2005 and (2) over-estimation of number of fish in the catch in 2005. The possible under-estimation of population size in 2005 is resulted from under-estimation of the number of younger age fish near the terminal year. This can be evidenced by retrospective analysis (Figure 14). The possible over-estimation of catch (in number of fish) in 2005 would have been occurred mainly in the catch by EPO purse seine fisheries. This is caused from miss-fitting of the current model to the observed length frequencies in the fisheries. Considering those possible artifacts in the terminal year of 2005, it is recommended that estimated stock status for 2005 shouldn't be referred in the discussion of current stock status and/or the future management strategy. Collection of information on age and length compositions of the catch by EPO purse seine, immediate monitoring on the strength of recruitments and improvement of model structure are also recommended for the future improvement of stock assessment.

Discussion The working group agreed with the conclusions of this analysis that starting the projections in 2006 has some pessimistic bias associated with underestimation of the recruitment in 2005 (resulting in unrealistically higher F on age 0 fish). This effect was most notable on short-term projections. It was noted that starting projections in 2005 has an optimistic bias associated with failure of removal of reported total catch of 2005. No general consensus could be reached on which issue was the most influential. It was noted that the underestimation of recruitment in the terminal year was noted in a short-term retrospective and may be the result of model misspecification, such as selectivity patterns changing. A more flexible assessment model structure may be needed in future assessments to correct this issue. It was concluded that both projections (starting in 2005 and 2006) should go forward discussing the problems associated with both analyses. With regard to the EPO size data, the Working Group was informed that the Fisheries Institute of Mexico (INAPESCA) developed a Management Plan that is being reviewed in other areas of the government before its implementation. This management plan includes the obligation for size data being provided by the farmers, since basically all bluefin tuna is going to holding pens and sampling on board or port is extremely low.

7.3 Likelihood profiles on R_0 (Figs in Appendix 5)

An issue that received substantial discussion by the Working Group was the depletion to a extremely low level of the population (<5%) with respect to virgin biomass (B_0) at the starting year of the model (1952). It was decided that the unreasonably high estimate of B_0 makes comparisons with the more recent period problematic. Therefore, B_0 should not be taken to derive management quantities (e.g., SBR, spawning biomass ratios as used by the IATTC).

It was also discussed that this unrealistic result could be data-driven or due to model misspecification. These two possibilities were investigated. Likelihood profiles on virgin recruitment (R_0) were constructed to evaluate the contribution to the total likelihood of each CPUE and size composition data, and check for conflicting trends. Sensitivity analysis to different model assumptions we conducted to investigate model misspecification.

The total likelihood profile shows that the bluefin data is very informative about log R_0 (MLE=9.25) given the model structure. Relative to other CPUE series, there seems to be stronger signal about R_0 from JP-CLL, TW-LL, JP-troll, and JP-DWLL. There is conflicting information between these indices and the US-PS index from the EPO. With respect to the size frequency data, the size data from the JP-LL provides the stronger signal on R_0.

7.4 Sensitivity analyses

The WG covered very large aspects of the sensitivity of the base case runthe summary of the results of those sensitivity runs as well as the associated commonly used biological reference points are shown in Appendix 8 Table.

7.4.1 Sensitivity to M

Kevin Piner presented an analysis of the sensitivity of the base assessment model and resulting per-recruit reference calculations to changes in Natural Mortality (M). Seven alternative M vectors were used in the SS2 model (in addition to that of the base case). Each of the seven M vectors increased or decreased the magnitude of M for the juvenile and adult ages relative to the base case. The results of this analysis were intended to evaluate the importance of both juvenile and adult M on the assessment results.

Assessment results were most sensitive to the magnitude of the M assumed for adults (age 4+) and relatively less sensitive to the magnitude of the juvenile M (age 0-3). Increasing M resulted in a smaller initial spawning stock size and a less exploited and depleted stock in 1952-2005. Decreasing M results in a larger initial spawning stock and more heavily exploited and depleted stock in 1952-2005. In 6 scenarios of M out of 7, current fishing mortality exceeded F_{max}. On the contrary 6 out of 7 scenarios of M, the current F is less than F_{med}. Rest of F reference points other than F_{max} and F_{med}, current F exceeded reference F for all M scenarios. Across all M vectors the range of current SPR was 0.01-0.15, with higher M scenarios reflecting the higher SPR levels.

Michel Dreyfus presented results of a discrete dynamic population model (different from SS2), that estimated B_0 for all the M vectors（Appendix 4）. B_0 was estimated in those cases for two levels of recruitment. It was shown that the results are similar to SS2 estimates. M was considered the main parameter affecting B_0 estimates that range over a high spectrum of values and needs to be evaluated further in the future. B_0 was also considered as an unrealistic value, since those models don't take into account interactions in the ecosystem as well as its carrying capacity.

Discussion The Working Group discussed the reliability and importance of the stock assessment estimate of initial spawning biomass (B_0). Estimates of B_0 are influence by both data and model assumptions, but the assumed natural mortality vector appeared to have a significant impact on results. It was noted that the IATTC uses depletion ratio which depends on B_0 as one statistic to characterize stock status, but that other fisheries organizations often do not use B_0 because of its uncertainty. The primary criticism of estimates of B_0 is the lack of knowledge about potential density dependent compensatory mechanisms or the potential for productivity regimes. It was acknowledged that despite differences of opinion expressed by the working group on the appropriateness of the estimate of B_0, an alternative statistic to characterize stock status should be considered. It was suggested that a robust statistic may come from examining per-recruit type analyses across different model assumptions because the per-recruit analyses is not dependent upon estimates of initial recruitment.

7.4.2 Sensitivity to Growth and Maturity

R. Conser presented the sensitivity of the base case results to the growth and maturity assumptions and related model settings was examined by conducting five sensitivity runs (Sensitivity Runs 1, 2, 3, 4, and 15).

Growth Sensitivity to the assumed mean length at age was examined by varying the base case von Bertalanffy k parameter (0.195). Sensitivities were conducted at k=0.15 (Run 1) and k=0.25 (Run 2). Run 1 SS2 results show no important differences from the base case. Run 2 (k=0.25), however, showed that biomass scaling is quite sensitive to larger values of k. Exploitation rates as well as total biomass and SSB trends were also affected – implying a more significant decline for some parts of the assessment time series (1952-2005). However, it should be noted that while the base case (k=0.195) was established using recent age and growth research results (WP No. 8), the sensitivity k's (0.15 and 0.25) were arbitrarily set to create "low" and "high" k values.

Discussion While this analysis demonstrated the importance of the k parameter (and perhaps the need for future age-growth research to verify the k=0.195 estimate), the PBF Working Group recommended the continued use of k=0.195 for the base case.

Variance in Age-at-Length Sensitivity Runs 3 and 4 examined the variability in length-at-age – a user-specified input for the SS2 model. Given the large catch of young PBF (ages 0-3) coupled with the not well-understood length variability at these ages (especially age 0), there was concern that SS2 results may be sensitive to the values set for the base case (age_{min}=0 with CV=0.25 and age_{max}=3 with CV=0.8). Sensitivity Run 3 explored the affect of assuming better precision in the length at age 0 (CV=0.15); and Sensitivity Run 4 employed a younger age_{max} (age 1.5), as suggested by simulation analysis presented at this meeting (WP 13). Although some differences in age composition fits and selectivity estimates were noted, the key results from both of these sensitivity runs (biomass, SSB, recruitment and exploitation rates) were virtually the same as the base case results.

Maturity Sensitivity Run 15 considered the affect of a delayed maturity schedule;

AGE	% MATURE (Base Case)	% MATURE (Run 15)
0	0	0
1	0	0
2	0	0
3	20	0
4	50	20
5	100	50
6+	100	100

Evidence from the limited maturity research on PBT suggests that it is unlikely that a significant number of PBF are attaining maturing prior to age 3 – hence the use of one-sided sensitivity analysis for maturity. Although some differences in age composition fits and selectivity estimates were noted, the key results from both of these sensitivity runs (biomass, SSB, recruitment and exploitation rates) were virtually the same as the base case results.

Discussion The Working Group noted that recent efforts to improve our understanding of bluefin growth had improved the current assessment. Ongoing research age and growth research should improve our understanding of potential growth and reduce uncertainty in future assessments.

7.4.3 Sensitivity to stock recruitment relationship

A. Aires-da-Silva presented sensitivity results to stock-recruitment relationship. The base case stock assessment model assumes a Beverton-Holt (1957) stock recruitment (S-R) relationship in which the steepness (h) parameter was fixed at 1.0. A value of 0.6 was assumed for the standard deviation of log-recruitment (sigma-r). Three sensitivity analyses were made to evaluate the impact on the assessment results from different assumptions about the nature of the S-R relationship: 1) steepness h fixed at 0.8; 2) a higher standard deviation of the recruitment deviates (sigma-r fixed at 1.0); 3) a CAGEAN-like S-R relationship (unconstrained recruitments estimates). In general, the base case results were robust to the different assumptions made about the S-R relationship. The exception is the sensitivity in which the steepness (h) parameter was fixed at 0.8. However, a pronounced increase of the biomasses since the early 1990s seems unrealistic. Likelihood comparisons across sensitivities showed that the base case model produced the best model fit.

Discussion The Working Group noted that the biomass trend from h=0.8 was similar to earlier models that did not fit the longline CPUE. This was the basis for increasing the emphasis on the longline CPUE in the base case model to prevent this unrealistic result.

7.4.4 Sensitivity to weighting on length frequency and CPUE series:

H. H. Lee presented sensitivity analyses that sequentially removing each likelihood component. Eliminating the length composition from fleet 1 (Japanese longline fishery), fleet 3 (Japanese tuna purse seine fishery), 4 (Japanese troll fishery) and fleet 8 (EPO purse seine fishery) improved the fit to fleet 2 (Japanese small purse seine fishery). However, model results (spawning biomass, recruitment and exploitation estimates) were not sensitive to elimination of those length composition data as trends were the same with slight differences in scaling. Sequentially eliminating individual CPUE likelihood components from fleet 11 (Japanese costal longline fishery), 14 (Japanese offshore longline fishery in 1952-1974) and 15 (Japanese offshore longline fishery in 1975-1992) and both fleet 14 and 15 degraded the fit of fleet 23 (Taiwanese longline fishery). Model results were more sensitive to the contribution of longline CPUE than other model components.

Discussion The Working Group noted that these results indicated some level of conflict between likelihood components. This could be the result of data bias or model misspecification. It was also noted that longline CPUE was more influential on model results. Although further work should be done to determine the cause of data conflict, it did not appear to constitute a significant problem as model results were robust to this issue.

7.4.5 Sensitivity runs for secondary CPUEs and equilibrium catches

K. Oshima presented nine sensitivity runs that were carried out with respect to the inclusion of secondary CPUE series. In general, there was no difference in assessment model results between the base case and the sensitivity runs. However, only in the case of replacement of CPUE of Fleet14 and Fleet 15 with Feet 12 and Fleet 13, the total biomass and SSB were larger than those in base case between the late of 1950s and the early 1980s. Because CPUE series for Fleet 14 did not include CPUEs during 1967 – 1974, SS 2 might fail to explain the population dynamics during this period. Overall, the SS 2 results for PBF stock assessment were robust to the substitutions of secondary CPUE. In addition, six sensitivity runs were performed for various equilibrium catches, making equilibrium catches half or double that of the base case. Model results were not sensitive to the changes in equilibrium catch.

Discussion The Working Group agreed that these results confirmed those presented by H. H. Lee as indicating the importance of the longline CPUE and general model robustness.

7.4.6 Sensitivity runs for effective sample size, Korean catch and estimating recruitment deviation.

M. Abe presented a summary of sensitivity runs from changes in effective sample size, Korean catch and the period of estimating recruitment deviations. Total biomass, SSB, recruitment, total exploitation rate, SPR and Y/R of each scenario were compared with those of base case. Model results were robust to the changes.

Discussion The Working Group noted that both the estimated recruitment period and the estimate of equilibrium recruitment offset helped in reducing conflicts between data sources at the start of the model.

7.4.7 Discussion on the overall Sensitivity section

The Working Group discussed the current assessment model's sensitivity to many of the model assumptions and data. The assessment model results were sensitive to growth estimates and heavily influenced by assumptions of the magnitude of M. It was noted that assessment results were largely insensitive to most other assumptions and data changes. The Working Group acknowledged that this insensitivity could be an indication of model miss-specification. However, the Working Group concluded that the base case model is the best available science to determine stock status at present. Calculations of current F relative to F_{max} were robust across all sensitivity model runs. Calculations of current SPR were also relatively consistent across all sensitivity models. Although no biological reference points are accepted by the ISC bluefin Working Group, it may be that these kinds of per-recruit benchmarks could be used to characterize stock status using the results of the current assessment model.

7.5 Future projection.

- ISC08/PBF/01/15: Future projections from the current stock status of Pacific bluefin tuna estimated from stock assessment model of Stock Synthesis II. M. Ichinokawa, Y. Takeuchi, R. Conser, K. Piner, M. Dreyfus, A. Aires-da-Silva

M. Ichinokawa presented the results of ISC08/PBF/01/15. The working paper summarizes the results of future projections based on the current stock assessment results. Projections were started from numbers of fish at age in the 1st quarter in 2006 except for the recruitment in 2006, and continued for 20 years. Biological parameters used in the future projections were inherited from those estimated or used in the stock assessment phase. Twenty time stochastic projections were conducted from respective 210 time bootstrap results. Arithmetic average F's by quarter of the 3 anterior years (2002-2004) was used for current F. Future harvest scenarios were determined by current F multiplied by 0.6, 0.8, 1.0 and 1.2. Future recruitments were re-sampled from recruitments estimated during the whole stock assessment period with fishery data from 1952 to 2005 (Figure 10). The probabilities that the focused future statistics such as SSB fall below some percentiles of historically observed value were also shown.

Within the current fishing mortality matrix, F at the age of 3 or less and that for age 8 or older were relatively high, exceeding 0.2 per quarter (Table 1). SSB in 2006 (21,320 t, point estimates) were close to the median of the historically observed SSB. The current F scenario reduced the SSB by 30% by 2010, and then increased to the same SSB level of 2006 by 2026 (Figure 11). Various harvest scenarios ranging from 0.6 to 1.2 of F multipliers showed clear differences in future SSB and total catch trajectories. Particularly in the lowest F scenario of 0.6, the SSB rapidly increased from 2010, and then its median exceeded historical highest SSB by 2014. It is noteworthy that the rapid increase of future SSB in 0.6 scenario is very uncertain because the projection should have inherited the high uncertainty of very high depletion level estimated in the stock assessment phase, which is very sensitive to the biological parameters such as M.

Appendix B of doc 15 shows results of additional future projections and some modified figs and tables in response to the discussion at the Working Group. In the additional scenario, future projections started from 2005 without adjusting total catch in 2005 (Figure 12). The recruitment in 2005 was re-sampled without using the one estimated in stock assessment. The estimated recruitment in 2005 (5,004 x 1000 inds) within the model was about a half of the simple average of the historical recruitments (10,537 x 1000 inds). Therefore, the replacement of recruitment in 2005 with re-sampled ones caused more optimistic future projections than that in the base case (Figure 13). However, the median of the total catch in 2005 was 21,049 t (18,403-24,979, 80% conf.), which did not explain the total catch (24,822 t) predicted by the SS2[2] in 2005. Therefore, those results suggest that the total catch observed in 2005 can not be explained by the current F even if the recruitment in 2005 had been at the average level of the historical recruitments. The results of future projections from the stock assessment results with previous M were also shown. The confidence interval of historical SSB in previous M scenario seems to be wider than that in the base case. The future SSB in the previous M scenario was declined from 2006 to 2011 by 35%. This percentage of the decline was higher than that indicated in the base case (30%), while the probability-related-reference points in this scenario were more optimistic.

Discussion: It was noted that the reference points based on the stochastic projections are applied for the first time to PBF. The reason of the choice of the reference point is due to the fact that the WG cannot predict the consequence of the declined spawning stock biomass below the historically observed level, and also because there is no clear stock recruitment relationship within the historically observed range of the spawning biomass. Hence such reference point which results in the spawning stock size above at least minimum observed range of the spawning stock would be preferable. Further description of the method may be required to convey the results more efficiently to the managers.

Considering the high uncertainty of the F's of young fish in 2005, it was proposed that 2005 be the first year of the projections, where recruitment in 2005 were replaced with re-sampling without adjusting observed catch in 2005 (appendix B of Doc 14). As for the additional future projection results, a difference of approximately 6,000 t between the 2005 estimated catch (~21,000 t) and the actual observed catch (~27,000 t) was emphasized. This indicates that the model can not explain the 2005 observed catch based upon the estimates of current F and average levels of recruitment. This result also pointed out that the short-term prospect of the stock is dependent upon the most recent recruitment levels which are very uncertain and difficult to estimate. Because it was recognized that a reliable statement about the 2005 year-class strength can not be made, this parameter should be monitored closely in the future. In addition, it was proposed that further projection work should be conducted hypothesizing different recruitment levels in 2005 with adjusting observed catch in 2005.

Simultaneously, it was also pointed out that the results should be reliable for the later years of the projection period (e.g., after 2010) Current fishing mortality level will likely keep the stock about the most recent level regardless of either the level of the 2005 year class or effects of unexplained catch in 2005. In other words, if fishing mortality remains approximately close to the current level, the future spawning stock biomass will stay at the current level with about 50% of the probability, regardless the strength of the 2005 year class or different M assumption (Table 2). If fishing mortality is reduced by 20% from the current

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[2] As explained in 7.2 the predicted yield by SS2 in 2005 (24,822 t) was smaller than the observed yield in 2005(26,902 t)

level, spawning biomass will double from the current level.

There were also discussions about the effect of the unreasonably high estimate of the virgin biomass (B_0) on the projection results. It was agreed that the projection results obtained for the low 0.6 F-multiplier (Fmult) are too optimistic, and that the population under such low fishing mortality levels will rebuild towards B_0 under the current stock assessment model assumptions. It was commented that while the projection results for low levels of F are mainly driven by the population dynamics (mainly assumptions of future recruitment), results of the projection for higher levels of F are mainly determined by the fishing mortality levels. It was further pointed out that the "B_0 effect" should not be a problem for the higher F-multiplier cases (0.8, 1.0 and 1.2). Except for the 0.6 F-multiplier, the projected biomasses for all F-multipliers fall within a 20% range of the historical estimates. This provided a rationale for eliminating the low 0.6 F-multiplier.

The possibility of using some form of recruitment auto-correlation in the projection analysis was discussed. The value of the SS2 correlation matrix is limited for this purpose. It was agreed that this issue should be considered in future work. Question was raised on sensitivity of the projection from the stock assessment results using previous M in appendix B. In particular, it was asked why the equilibrium catch is similar in 2006 among different harvest scenarios, which is different from that observed in base case. That is explained by the lower fishing mortality estimated in the case of previous M, which can cause only minor change of future dynamics of SSB and total catch by relatively minor changes of fishing efforts such as multipliers of 0.8 and 1.2.

The working group noted that projection work in the future may need to consider the number of bootstraps needed to precisely estimate confidence intervals. The working group agreed that the new analysis better describes the uncertainty than previous projections.

7.6 Recommendations:

- Additional technical information and justification on the choice of reference points, and the stochastic approach;
- Consider recruitment auto-correlation for projections in future stock assessments;
- Improve treatment of future projection scenarios for future stock assessments.
- Projections analysis with improved growth estimates should be conducted in the future.
- Careful monitoring of the 2005 year class
- Further developments and improvements of R code for projections. In particular, it would be important for the most recent years since the PBF fishery catches a large proportion of 0 and 1-year old fish.
- Make decision table based on the future projections under some hypothesis

of recruitment in 2005 to characterize the effect on future stock status from alternative hypothesis about the 2005 recruitment level

7.7 Overview of the uncertainties related to the stock assessment results

The Working Group identified the most important uncertainties associated with this assessment:

1. The assumed natural mortality rate.
2. Recruitment strength (and F on recruits) in the terminal year (2005).
3. Short term projection results due to (ii), above, and the inability of both assessment/projection scenarios to adequately reflect the actual catch in 2005.

While recognizing the importance of these uncertainties, the Working Group noted that a large number of sensitivity runs were conducted for this stock assessment (more than 100). The key assessment results were robust to nearly all sensitivity trials – the notable exception being the assumed natural mortality rate. The Working Group suggested that results from the assessment period and the projections using F-multipliers in the range 0.8-1.2 provide a good characterization of stock status; and until such time that the stock assessment can be revisited, provide the best information on the status of the PBF stock.

7.8 Stock status relative to target and limit (F-based) reference points

In conducting the PBF stock assessment, the WG followed a rigorous process in developing the base case coupled with extensive sensitivity analysis (Section 7.4). While some important aspects of the base case results were found to be sensitive to the assumed M (Section 7.4.1), the following conclusions were robust to the assumed M and all of the other factors considered in the sensitivity analysis:

1. The ratio[3] ($F_{current}/F_{BRP}$) ≥ 1 for all of commonly used biological reference points (BRP) that the WG considered, in principle, as potential target reference points for PBF, namely $F_{40\%}$, $F_{30\%}$, $F_{20\%}$, $F_{0.1}$, F_{MAX} (Table xx).
2. Conversely, the ratio ($F_{current}/F_{BRP}$) ≤ 1 for all the commonly used BRPs that the WG considered, in principle, as potential recruitment overfishing threshold reference points, namely F_{MED} and $F_{SSB\text{-}Min}$,which can be considered Fs above which, the likelihood of recruitment failure is high.
3. Recruitment has fluctuated without trend over the assessment period; and does not appear to have been adversely affected by the relatively high rate of exploitation.
4. Deviance[4] from the base case among the sensitivity runs is smaller for

[3] All ratios referenced in this section have been rounded to one-decimal precision.

[4] As used here, the deviance for a sensitivity run is the difference (in percent) between the sensitivity run

the limit reference point ratios than for the target reference point ratios.

For PBF fisheries management purposes, these robust conclusions imply that:

a. If F remains at the current level and environmental conditions continue to be favorable, then recruitment should be sufficient to maintain current yield well into the future.
b. A reduction in F should lead to greater Y/R and SPR and after some lag, greater sustained yield.
c. Increases in F and/or unfavorable changes in the environmental conditions, should be cause for concern.

8. Conclusion on the stock status

The PBF stock assessment has undergone a major revision over the past two years, and represents a substantial advancement in understanding of the PBF population dynamics and the fisheries that exploit the stock. While there remain significant uncertainties in the assessment results (described fully in the Section 7), the following key factors regarding stock status emerge:

1. Recruitment has fluctuated without trend over the assessment period (1952-2004); and does not appear to have been adversely affected by the relatively high rate of exploitation. Recent recruitment (2005-present) is highly uncertain – making short-term forecasting difficult. In particular, the 2005 year class strength may have been underestimated in this assessment.

2. Spawning stock biomass (SSB) in 2005 is near the median level over the assessment period. If the future fishing mortality rate (F) continues at the current F level, the short-term outlook (2009-2010) indicates SSB will either (i) decline until 2010 or (ii) remain at approximately the 2005 level. In the longer term, SSB is expected to be at a level comparable to the SSB in 2005.

3. No relationship between SSB and recruitment is apparent over the range of “observed” SSB from the assessment. The assessment structure tacitly assumes that at least over the SSB levels “observed,” recruitment is more environmentally-driven than SSB-driven.

4. Current F (2002-2004) is greater than commonly used biological reference points (BRP) that may serve, in principle, as potential target reference points. This includes F_{MAX} – a BRP that given the assessment structure and assumptions is theoretically equivalent to F_{MSY}. But the magnitude by which the $F_{current}$ exceeds the target BRPs is variable.

5. Conversely, current F is less than commonly used BRPs that may serve, in principle, as potential recruitment overfishing threshold BRPs, e.g. F_{MED} and

ratio and the base case ratio.

$F_{SSB\text{-}Min}$ (probability based reference point) i.e. Fs above which, the likelihood of recruitment failure is high.

6. Fs on recruits (age 0) and on juveniles (ages 1-3) have been generally increasing for more than a decade (1990-2005). The catch (in weight) is dominated by recruits and juveniles (ages 0-3).

7. Total catch has fluctuated widely in the range of 9,000-40,000 t during the assessment time period (Figure 1). Recent catch is near the average for the assessment period (~22, 000 t). Over the entire catch history, annual catch has never attained the equilibrium catch at F_{MAX} (45,000t).

Evaluation of the status of the stock is not straightforward, and may depend in large part on management objectives and specification of an acceptable level of risk. The latter is particularly important if the consequences of future increases in F and/or a less favorable environment are to be evaluated quantitatively. However, the following conservation advice can be drawn from the current stock assessment results:

I. If F remains at the current level and environmental conditions continue to be favorable, then recruitment should be sufficient to maintain current yield well into the future.
II. A reduction in F should lead to greater Y/R and SPR and after some lag, greater sustained yield.
III. Increases in F and/or unfavorable changes in the environmental conditions should be cause for concern.
IV. It may be advisable to ensure that further increases in F do not occur.

Finally, given the large number of uncertainties in the stock assessment, it is recommended that the WG review the assessment results prior to the ISC Plenary meeting in July 2009.

9. Recommendations, review of schedule and assignments

9.1 Fisheries indicators and data

9.1.1 Short-term recommendations

Catch and effort trends and any specific changes in Korean PBF fishery should be reported. (Doc 01). The Chair contacts the Korean scientists asking submission of a document of reviews on the Korean catch data updates with a particular emphasis on the discrepancies observed in 2000 and 2005 between these two data sets, at the ISC PBF Working Group meeting in July, 2008. (Doc 01)

Examination of the reliability of the estimated catch for pre-1952 period, particularly by excavating new data and eliminating double counting of the same catch from different sources.(Doc 04) be made

Investigation of influences of socio-economic policies on the fluctuations in catch (e.g. during 1940s), both for the western and eastern Pacific. (Doc. 04) be carried out.

Investigation on sources of conflicting trends among CPUE series should be made.

Investigation of discrepancies in size frequency data by year, fisheries and those estimated by different growth curves should be made.

Careful monitoring of the 2005 year class be carried out.

9.1.2. Medium-term recommendations

Further study on sampling design (effective sample size and frequencies) relating to collect length/weight data from Sakai-Minato (Sakai Port) and eventually from other fisheries should be made.

Collection of data on fish sizes and fishing areas/seasons for the catches estimated in pre-1952 period (Doc. 04) should be continued.

Study on the effective sample size of bluefin tuna in EPO purse seine fishery (Doc 10) should be carried out.

Quantitative review of the Japanese coastal fisheries length frequency data should be made in relation to the amount of catch by area and season
Improvement of estimates of recruitment trends should be explored.

9.1.3. Long-term recommendations

Effort of excavating more historical data on bluefin tuna should be continued.

Socio economic study of PBF market including its value and product type in pre-war time (before the development of the cold chain) should be commenced; as such studies may change the motivation of fishers for catching bluefin tuna. (Doc 04)

9.2 Biological studies

9. 2.1. Short-term recommendations

Seasonal growth and variability of growth by birth month in ages 1 and 2 be further investigated (Information paper) and an appropriate growth curve for the young fish must be established with a high priority

Existing tag-recovery information (including conventional and electronic memory type) should be gathered to make better estimates on natural mortality at age, spatial structure of the stock and growth curve. IATTC has already certain amount of conventional tag data. Besides, the collaboration of other groups on this issue should be sought.

9.2.2. Medium-term recommendations

Otolith with sex/size data be collected and examined, especially for large sized fish to investigate sex specific growth for its implications on estimates of natural mortality and possible effects on CPUE indices of longline fishery. (Docs 08 and 16)

Shimose's VBG should be validated for large fish (over 230cm) with increased sample size.(Doc 08)

9.2.3. Long-term recommendations

Investigation on reproductive biology including 1) Examination for sex ratio of adult PBF, 2) Estimate of the spawning parameters to investigate the relationship between body size of adult PBF and fecundity, and 3) Estimation of maturity at size

Early life history in relation to environmental condition should be promoted. Investigation on larval and juvenile distribution patterns would contribute to provide basic information on the spatiotemporal spawning activity of adult PBF. To collect oceanographic data, i.e., sea surface temperature is important to understand the spawning strategy of adult fish and the distribution patterns, growth and survival during the period of early life history.

It is desirable to reduce the major uncertainties regarding to M.vectors (Doc 10)

9.3 Assessments and projections

The major objective is to reduce the uncertainties associated with input data and assessments. Those are all related to the recommendations on fishery related issues or biological studies listed above. Besides, it is recommended that research carried out on the followings:

- Additional technical information and justification on the choice of reference points, and the stochastic approach;
- Improvement in treatment of future projection scenarios for future stock assessments.
- Projections analysis with an alternative growth estimates should be conducted in the future.

- Further developments and improvements of R code for projections In particular, it would be important for the most recent years since the PBF fishery catches a large proportion of 0 and 1-year old fish.
- Make decision table based on the future projections under some hypothesis of recruitment in 2005 to characterize the effect on future stock status from alternative hypothesis about the 2005 recruitment level
- Improve modeling of the initial population structure
- Improve modeling of the catch e.g. introduce explicit likelihood component allowing error in catch
- Improve future projection components of SS 2 to fit the way of tuna stock assessment.
- Introduce more flexible growth curve parameterization, in particular, growth of young fish.

9.4 Next Working Group meeting

The Working Group recognized the extensive efforts made by the Working Group to deal with the uncertainties and limitations found in assessment within the time constraints of the meeting. However, these shortcomings justify that the assessment be re-visited in the near future, and further work be conducted to deal with the limitations at hand. It was recommended that the Working Group will review the problems identified in the current stock assessment at the November-December, 2008 meeting (time and place may be modified later), before the ISC Plenary meeting in July 2009 and the IATTC Stock Assessment Review Meeting in May 2009.

10. Other matter

Study on environment

It was pointed out that long-term change in oceanographic condition was important to understand the relationship of environmental condition and the stock level by the extent of recruitment success of PBF. Introducing the recent progress on the oceanographic study related to recruitment magnitude of PBF will be informative to understand in the coming ISC8 plenary session at Takamatsu. The details will be finalized by the correspondence.

11. Adoption of reports and closure of the meeting.

The draft report was adopted with the understanding that at the WG meeting in July 17-18, 2008, the Item 8 and corresponding part in Item 7 will be revisited and finalized. In mean time, the communications among the participants in the effort to draft for and finalize Item 8 is encouraged. Editorial work to complete the other sections is left to the Chair and the Rapporteurs.

During July 17-18, 2008 the Working Group was convened to finalize drafting of items 7 and 8. Drafting was completed and the reported adopted by participants.

A brief report of this drafting meeting and a list of participants are contained in Appendix 9. Logistics for the next meeting of the WG were also reviewed and approved (section 9.4). On July 18, the completed report of the PBFWG was approved and the meeting adjourned.

Table 1. Current F (average of 2002-2004) by ages and quarters, which is applied to the future projections and calculation of biological reference points.

Ages	0	1	2	3	4	5	6	7	8	9	10
Through the year	0.65	0.92	0.54	0.33	0.24	0.23	0.26	0.32	0.38	0.44	0.48
Qt 1	0.02	0.36	0.35	0.23	0.15	0.11	0.1	0.1	0.1	0.1	0.11
Qt 2	0.18	0.26	0.06	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03
Qt 3	0.1	0.05	0.01	0	0	0	0	0	0	0	0
Qt 4	0.35	0.25	0.12	0.07	0.07	0.09	0.13	0.19	0.25	0.3	0.35

Ages	11	12	13	14	15	16	17	18	19	20+
Through the year	0.51	0.53	0.54	0.56	0.56	0.57	0.57	0.58	0.58	0.58
Qt 1	0.1	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Qt 2	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Qt 3	0	0	0	0	0	0	0	0	0	0
Qt 4	0.37	0.39	0.41	0.42	0.43	0.43	0.44	0.44	0.44	0.44

Table 2. Probability (%) that future SSB or total catch fall below the historical percentiles of SSB or total catch, respectively. The definition of future statistics were described in the document #15. F multiplier means a scalar multiplied by matrix of current F.

F multi	(a) Base case: Percentiles of historical SSB 0 (min)	0.05	0.1	0.25	0.5	(b) Start year=2005: Percentiles of historical SSB 0 (min)	0.05	0.1	0.25	0.5
Pr[median(SSB_{future})<percentile($SSB_{observed}$)|F]										
1.20					98.8					97.3
1.10					91.3					80.9
1.00					60.1					37.2
0.95					34.5					15.8
0.90					14.1					4.4
0.85					3.9					0.7
0.80					0.7					0.1
Pr[any(SSB_{future})<percentile($SSB_{observed}$)|F]										
1.20	40.9	56.7	68.9	92.9	99.9	30.0	45.2	57.4	88.6	99.8
1.10	12.6	22.9	33.4	77.0	99.1	5.1	10.7	17.1	56.3	97.7
1.00	2.6	5.7	10.6	49.1	96.3	0.4	0.9	2.0	15.5	84.3
0.95	1.3	2.8	5.1	34.5	93.8	0.1	0.2	0.4	5.1	70.1
0.90	0.7	1.3	2.6	22.5	91.0	0.0	0.0	0.1	1.8	58.7
0.85	0.3	0.7	1.6	12.6	86.1	0.0	0.0	0.0	0.6	49.5
0.80	0.0	0.2	0.6	7.3	78.8	0.0	0.0	0.0	0.3	45.6
Pr[SSB_{2016}<percentile($SSB_{observed}$)|F]										
1.20	6.8	12.7	19.3	55.5	96.6	5.5	10.7	16.9	52.2	95.9
1.10	0.8	1.7	3.2	19.8	79.5	0.6	1.4	2.8	16.0	75.4
1.00	0.0	0.1	0.3	2.9	37.9	0.0	0.1	0.1	2.0	31.9
0.95	0.0	0.0	0.0	0.6	18.2	0.0	0.0	0.0	0.4	13.6
0.90	0.0	0.0	0.0	0.2	6.5	0.0	0.0	0.0	0.1	4.1
0.85	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.8
0.80	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0

F multi	(c) M=previous M: Percentiles of historical SSB 0 (min)	0.05	0.1	0.25	0.5	(d) M=Lower M: Percentiles of historical SSB 0 (min)	0.05	0.1	0.25	0.5
Pr[median(SSB_{future})<percentile($SSB_{observed}$)|F]										
1.20					86.6					99.8
1.10					74.9					93.1
1.00					55.2					64.6
0.95					43.4					40.0
0.90					31.9					17.8
0.85					20.9					5.4
0.80					12.8					0.9
Pr[any(SSB_{future})<percentile($SSB_{observed}$)|F]										
1.20	2.5	3.8	7.1	40.2	97.4	58.3	71.8	80.8	96.4	100.0
1.10	0.5	0.8	2.2	21.3	93.7	23.7	36.7	47.9	83.0	99.9
1.00	0.0	0.1	0.5	9.6	87.3	5.3	11.1	18.4	57.0	97.5
0.95	0.0	0.1	0.2	5.8	83.1	1.7	5.3	9.6	42.0	94.3
0.90	0.0	0.0	0.1	3.6	79.1	0.4	2.3	4.7	29.1	90.2
0.85	0.0	0.0	0.0	2.6	75.1	0.0	0.4	2.0	19.1	84.7
0.80	0.0	0.0	0.0	1.8	71.6	0.0	0.1	0.6	11.2	78.0
Pr[SSB_{2016}<percentile($SSB_{observed}$)|F]										
1.20	0.3	0.5	1.1	13.2	84.0	15.2	23.9	32.4	67.5	97.9
1.10	0.0	0.1	0.2	4.7	68.7	2.3	4.6	7.5	30.1	82.5
1.00	0.0	0.0	0.0	1.3	48.6	0.1	0.3	0.6	6.2	43.6
0.95	0.0	0.0	0.0	0.6	37.0	0.0	0.1	0.1	2.0	22.0
0.90	0.0	0.0	0.0	0.2	26.9	0.0	0.0	0.0	0.6	8.6
0.85	0.0	0.0	0.0	0.1	17.0	0.0	0.0	0.0	0.1	2.7
0.80	0.0	0.0	0.0	0.0	9.9	0.0	0.0	0.0	0.0	0.5

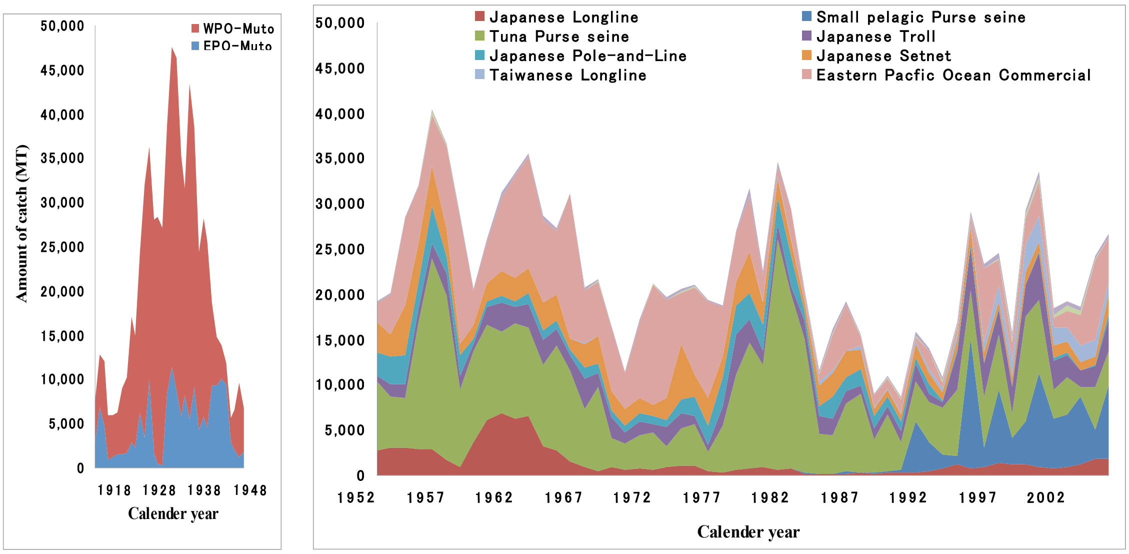


Figure 1 Pacific bluefin tuna landings of pre-assessment period by area (left panel) and assessment period by fishing fleet defined in the base-case model (right pane)

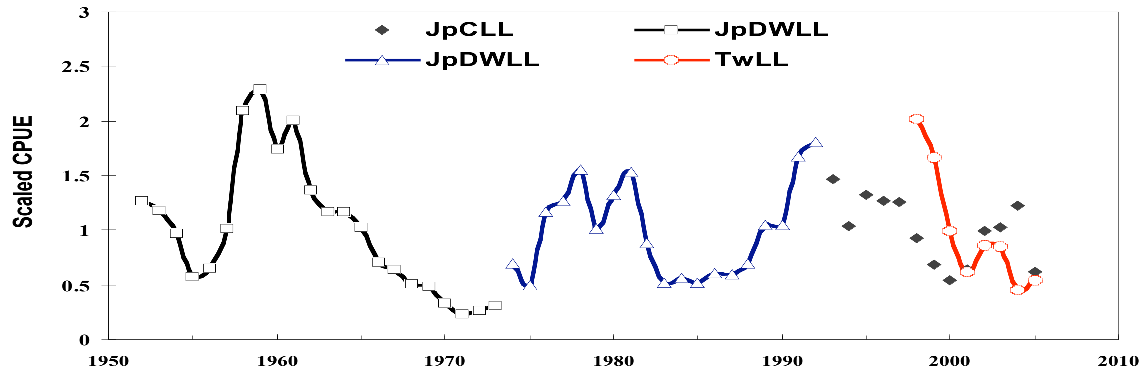


Figure 2 Standardized longline CPUE used in the base-case model.

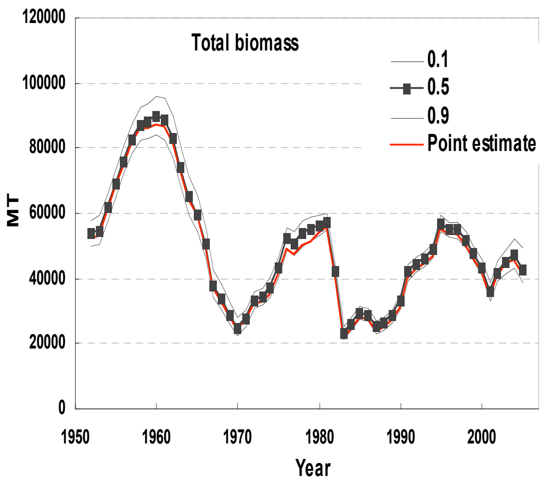


Figure 3 Total biomass trend with 80% confidence intervals

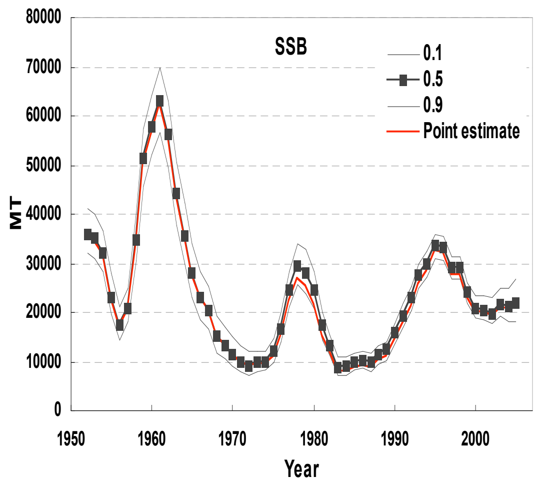


Figure 4 Spawning biomass trend with 80% confidence intervals

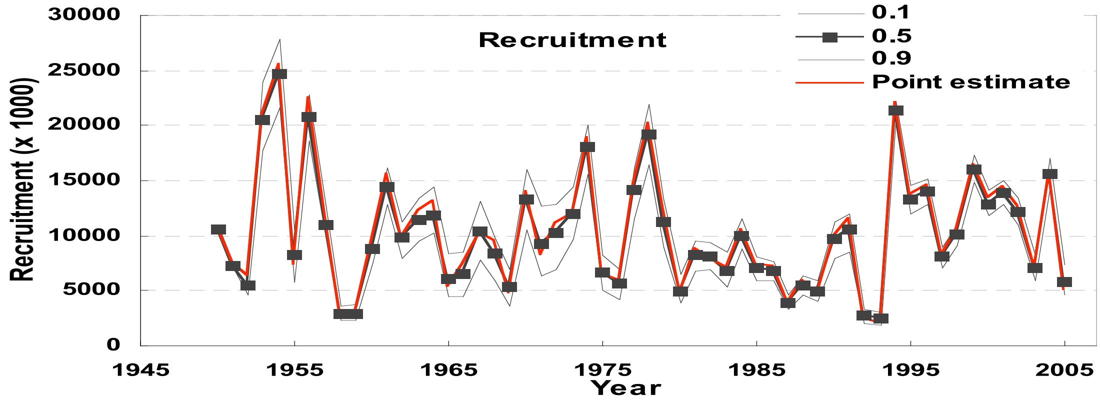


Figure 5. Historical trend of recruitment with 80% confidence intervals

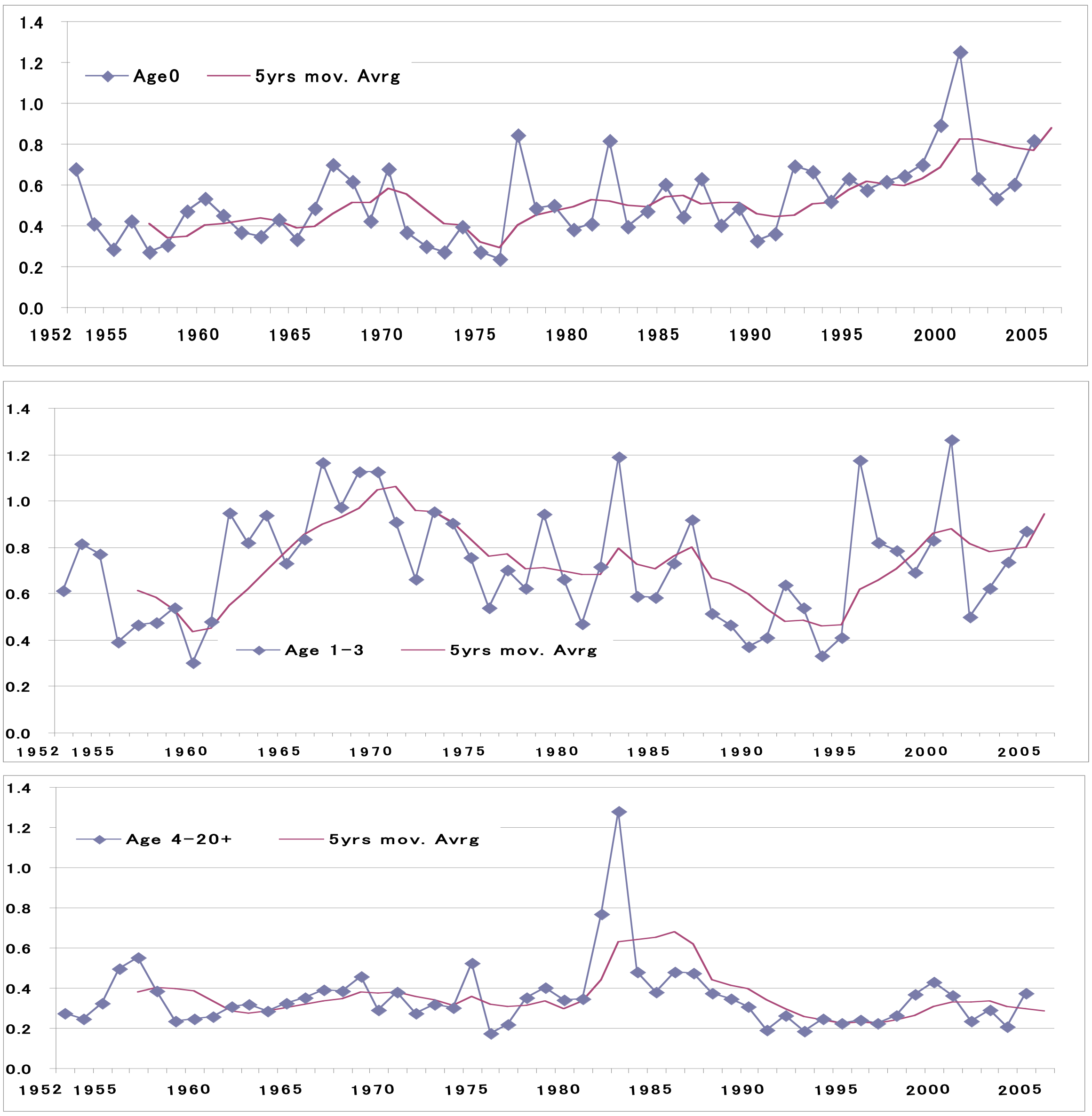


Figure 6 Trends of annual fishing mortality and 5 year moving averages of age 0, ages 1-3, and ages 4 and older. F of ages 1-3 was calculated as the ratio of sum of predicted catch divided by sum of mid year numbers at age of age 1-3. Moving average include 2005 mortality estimates.

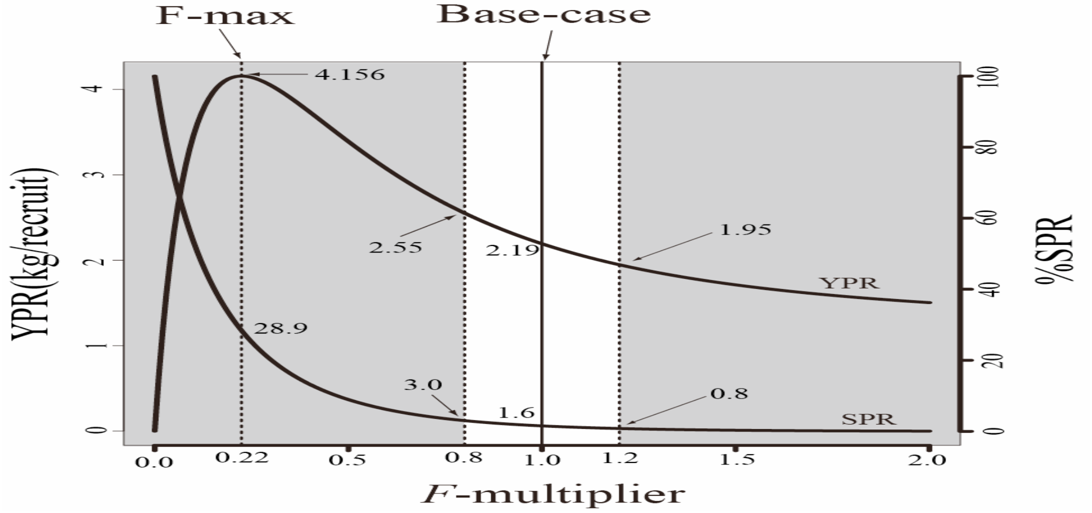
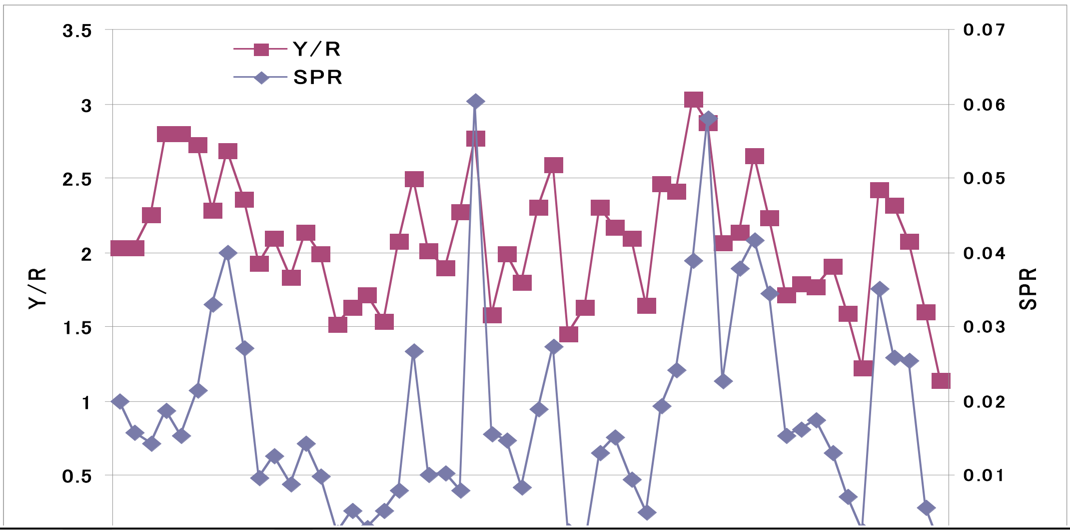


Figure 7. Yield per Recruitment and %SPR plot of the base case run. The area smaller than 0.8 and larger than 1.2 of F-multipliers is shaded. Note that the expected YPR and %SPR within the shaded area are highly uncertain since corresponding equilibrium biomass in the area is beyond the range of historically observed stock size.



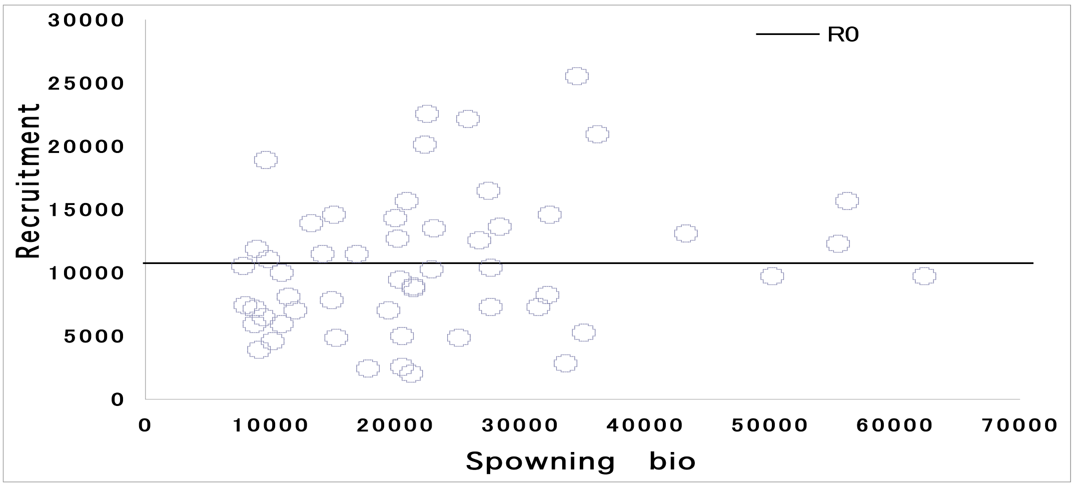


Figure 9. Spawner-recruitment relationship based on Base case estimates.

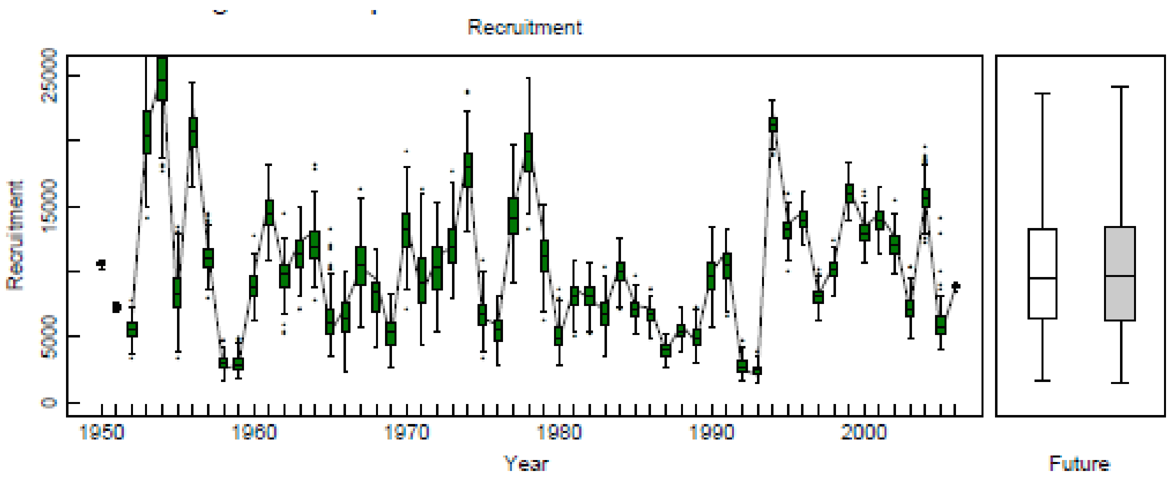


Figure 10. Historical recruitments estimated in the stock assessment model (left panel) and re-sampled recruitments used in the future projections.

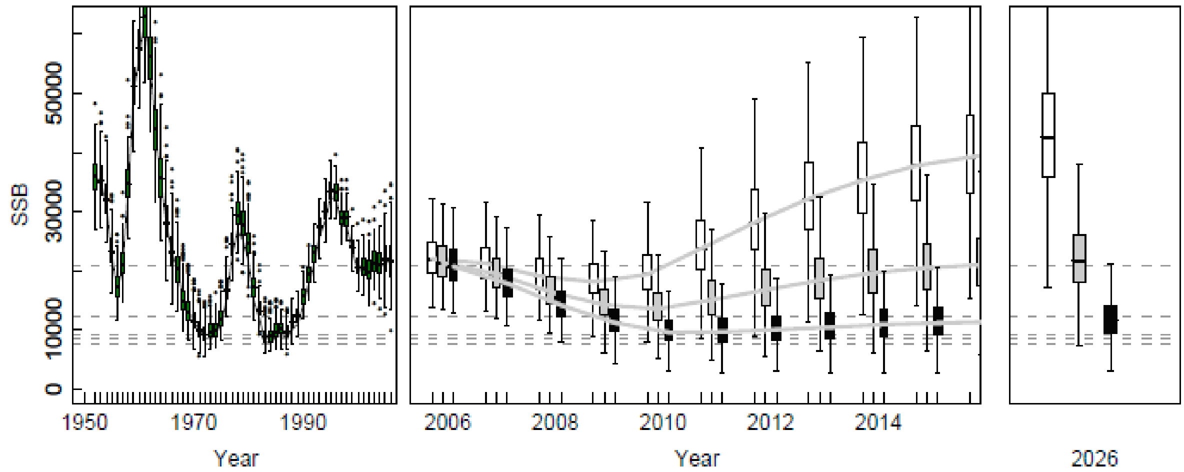


Figure 11. Estimated historical (the left panel) and future (middle and right panels) SSB. The future SSB was results of future projections starting from 2006 (base case). White, gray and black present future harvest scenarios of current F multiplied by 0.8, 1 and 1.2, respectively.

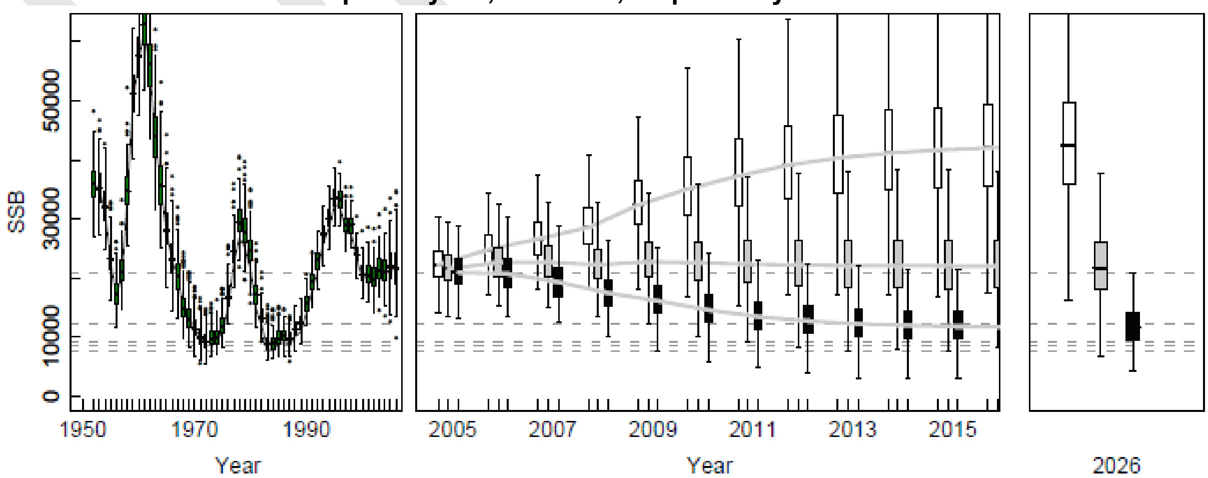


Figure 12. Estimated historical (the left panel) and future (middle and right panels) SSB. The future SSB was results of future projections starting from 2005 without using recruitment estimated in the stock assessment model or adjusting observed catch. White, gray and black present future harvest

scenarios of current F multiplied by 0.8, 1 and 1.2, respectively.

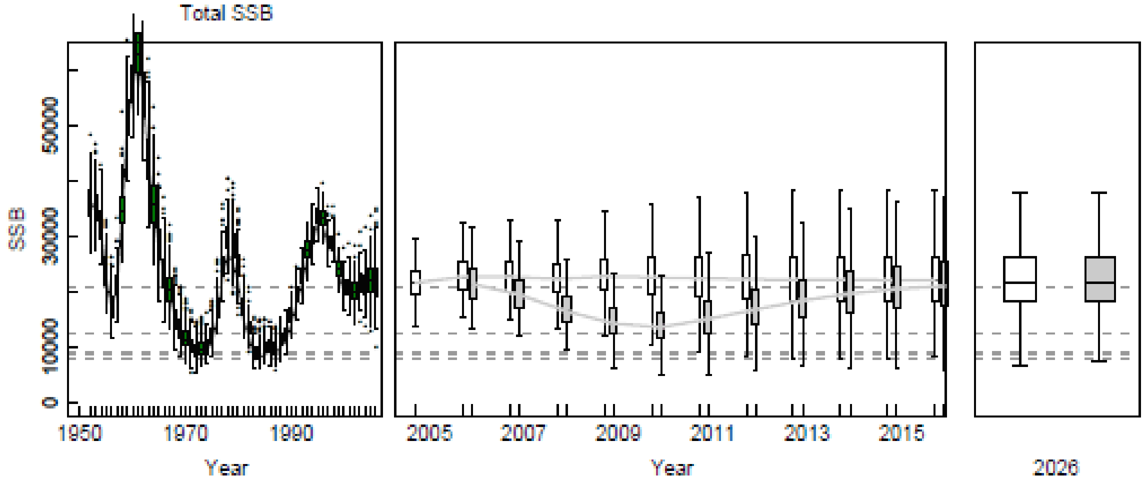


Figure 13. Comparison of the two future projection results and estimated historical (the left panel) and future (middle and right panels) SSB. The future SSB was results of future projections starting from 2005 without using recruitment estimated in the stock assessment model or adjusting observed catch. White, gray and black present future harvest scenarios of current F multiplied by 0.8, 1 and 1.2, respectively.

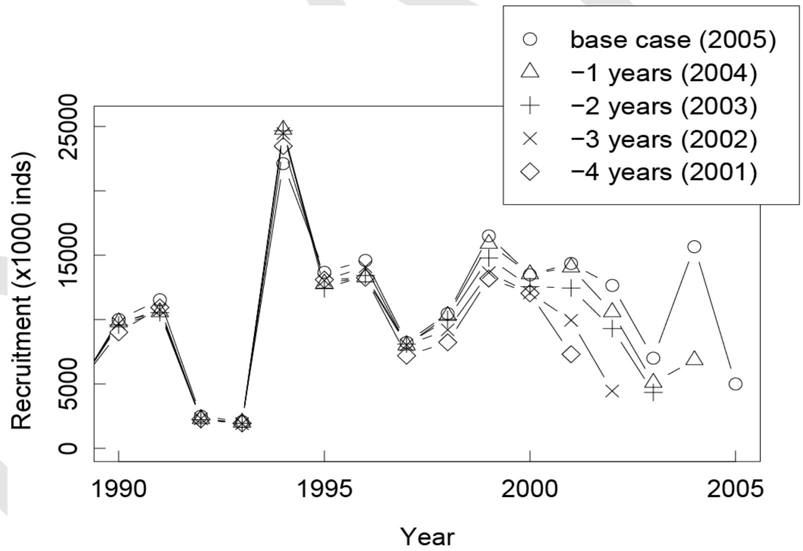


Figure 14. Retrospective patterns of the estimated recruitments after 1990.

Appendix Table 1. Nominal landing of Pacific bluefin tuna in metric tons, by country and by gear for eastern and western Pacific

	Western Pacific States								
	Japan								
	Purse Seine		Dist. & Off. Longline*		Coastal Longline**	Troll****	Pole and Line	Set Net	Others†
	Tuna PS	Small PS	NP**	SP**					
1952	7,680		2,694	9		667	2,198	2,145	1,700
1953	5,570		3,040	8		1,472	3,052	2,335	160
1954	5,366		3,088	28		1,656	3,044	5,579	266
1955	14,016		2,951	17		1,507	2,841	3,256	1,151
1956	20,979		2,672	238		1,763	4,060	4,170	385
1957	18,147		1,685	48		2,392	1,795	2,822	414
1958	8,586		818	25		1,497	2,337	1,187	215
1959	9,996		3,136	565		736	586	1,575	167
1960	10,541		5,910	193		1,885	600	2,032	369
1961	9,124		6,364	427		3,193	662	2,710	599
1962	10,657		5,769	413		1,683	747	2,545	293
1963	9,786		6,077	449		2,542	1,256	2,797	294
1964	8,973		3,140	114		2,784	1,037	1,475	1,884
1965	11,496		2,569	194		1,963	831	2,121	1,106
1966	10,082		1,370	174		1,614	613	1,261	129
1967	6,462		878	44		3,273	1,210	2,603	302
1968	9,268		500	7		1,568	983	3,058	217
1969	3,236		313	20	565	2,219	721	2,187	195
1970	2,907		181	11	426	1,198	723	1,779	224
1971	3,721		280	51	417	1,492	938	1,555	317
1972	4,212		107	27	405	842	944	1,107	197
1973	2,266		110	63	728	2,108	526	2,351	636
1974	4,106		108	43	3,183	1,656	1,192	6,019	754
1975	4,491		215	41	846	1,031	1,401	2,433	808
1976	2,148		87	83	233	830	1,082	2,996	1,237
1977	5,110		155	23	183	2,166	2,256	2,257	1,052
1978	10,427		444	7	204	4,517	1,154	2,546	2,276
1979	13,881		220	35	509	2,655	1,250	4,558	2,429
1980	11,327		140	40	671	1,531	1,392	2,521	1,953
1981	25,422		313	29	277	1,777	754	2,129	2,653
1982	19,234		206	20	512	864	1,777	1,667	1,709
1983	14,774		87	8	130	2,028	356	972	1,117
1984	4,433		57	22	85	1,874	587	2,234	868
1985	4,154		38	9	67	1,850	1,817	2,562	1,175
1986	7,412		30	14	72	1,467	1,086	2,914	719
1987	8,653		30	33	181	880	1,565	2,198	445
1988	3,583	22	51	30	106	1,124	907	843	498
1989	6,077	113	37	32	172	903	754	748	283
1990	2,834	155	42	27	267	1,250	536	716	455
1991	4,336	5,472	48	20	170	2,069	286	1,485	650
1992	4,255	2,907	85	16	428	915	166	1,208	1,081
1993	5,156	1,444	145	10	667	546	129	848	365
1994	7,345	786	238	20	968	4,111	162	1,158	398
1995	5,334	13,575	107	10	571	4,778	270	1,859	586
1996	5,540	2,104	123	9	778	3,640	94	1,149	570
1997	6,137	7,015	142	12	1,158	2,740	34	803	811
1998	2,715	2,676	169	10	1,086	2,865	85	874	700
1999	11,619	4,554	127	17	1,030	3,387	35	1,097	709
2000	8,193	8,293	121	7	832	5,121	102	1,125	689
2001	3,139	4,481	63	6	728	3,329	180	1,366	782
2002	4,171	5,102	47	5	794	2,427	99	1,100	631
2003	945	5,399	85	12	1,152	1,839	44	839	446
2004	4,792	2,577	231	9	1,616	2,182	132	896	514
2005	3,871	7,389	117	14	1,818	3,406	549	2,182	548
2006	3,889	3,272	77	16	1,058	1,544	108	1,421	777
2007‡	2,943	2,749	372‡‡	–	684‡‡‡	2,385	236	1,395	1,209

Appendix Table 1. Continued….

	Western Pacvific States						Western Pacivic Subtotal	Eastern Pacific States					Eastern Pacivic Subtotal	NZ	Other	Grand Total
	Korea††		Chinese Taipei*****					United States*****			Mexico*****					
	Purse Seine†††	Trawl	Longline	Purse Seine	Distant Driftne	Others		Purse Seine	Others	Sport	Purse Seine	Others				
1952							17,094	2,076		2			2,078			19,172
1953							15,636	4,433		48			4,481			20,117
1954							19,027	9,537		11			9,548			28,575
1955							25,739	6,173		93			6,266			32,005
1956							34,268	5,727		388			6,115			40,383
1957							27,302	9,215		73			9,288			36,590
1958							14,666	13,934		10			13,944			28,610
1959							16,760	3,506	56	13	171	32	3,779			20,539
1960							21,531	4,547	0	1			4,548			26,079
1961							23,078	7,989	16	23	130		8,158			31,236
1962							22,107	10,769	0	25	294		11,088			33,195
1963							23,201	11,832	28	7	412		12,280			35,481
1964							19,406	9,047	39	7	131		9,224			28,631
1965			54				20,334	6,523	77	1	289		6,890			27,224
1966							15,243	15,450	12	20	435		15,918			31,161
1967			53				14,825	5,517	0	32	371		5,920			20,745
1968			33				15,634	5,773	8	12	195		5,989			21,623
1969			23				9,479	6,657	9	15	260		6,940			16,419
1970							7,448	3,873	0	19	92		3,983			11,432
1971			1				8,773	7,804	0	8	555		8,367			17,140
1972			14				7,854	11,656	45	15	1,646		13,362			21,216
1973			33				8,821	9,639	21	54	1,084		10,798			19,619
1974			47			15	17,124	5,243	30	58	344		5,675			22,799
1975			61			5	11,332	7,353	84	34	2,145		9,616			20,948
1976			17			2	8,716	8,652	25	21	1,968		10,666			19,381
1977			131			2	13,335	3,259	13	19	2,186		5,477			18,811
1978			66			2	21,645	4,663	6	5	545		5,218			26,863
1979			58				25,595	5,889	6	11	213		6,119			31,715
1980			114			5	19,693	2,327	24	7	582		2,940			22,634
1981			179				33,532	867	14	9	218		1,109			34,641
1982	31		207		2		26,228	2,639	2	11	506		3,159			29,387
1983	13		175	9	2		19,670	629	11	33	214		887			20,557
1984	4		477	5		8	10,655	673	29	49	166		917			11,573
1985	1		210	80	11		11,975	3,320	28	89	676		4,113			16,089
1986	344		70	16	13		14,157	4,851	57	12	189		5,109			19,266
1987	89		365	21	14		14,474	861	20	34	119		1,033			15,507
1988	32		108	197	37	25	7,562	923	50	6	447	1	1,427			8,989
1989	71		205	259	51	3	9,707	1,046	21	112	57		1,236			10,943
1990	132		189	149	299	16	7,067	1,380	92	65	50		1,587			8,653
1991	265		342		107	12	15,262	410	6	92	9		517	2		15,781
1992	288		464	73	3	5	11,896	1,928	61	110	0		2,099	0		13,995
1993	40		471	1		3	9,825	580	103	298			981	6		10,811
1994	50		559				15,795	906	59	89	63	2	1,118	2		16,916
1995	821		335			2	28,248	657	49	258	11		975	2		29,225
1996	102		956				15,066	4,639	70	40	3,700		8,449	4		23,519
1997	1,054		1,814				21,720	2,240	133	156	367		2,897	14		24,632
1998	188		1,910				13,277	1,771	281	413	1	0	2,466	20		15,763
1999	256		3,089				25,919	184	184	441	2,369	35	3,213	21		29,153
2000	1,976	0	2,780			2	29,239	693	61	342	3,019	99	4,214	21		33,474
2001	968	10	1,839			4	16,896	292	48	356	863		1,559	50		18,505
2002	767	1	1,523			4	16,672	50	12	654	1,708	2	2,427	55	10	19,164
2003	2,141	0	1,863			21	14,786	22	18	394	3,211	43	3,689	41	19	18,534
2004	636	0	1,714			3	15,301	0	11	49	8,880	14	8,954	67	10	24,333
2005	594		1,368				21,857	201	6	79	4,542		4,828	20	7	26,713
2006	949		1,148				14,259	0	1	96	9,816		9,913	21	3	24,196
2007‡	946		–	–	–	–	12,918	–	–	–	–	–	–	–	–	12,918

Footnotes for Appendix Table 1.

*Catch of the distant-water and offshore longline consist of those yielded by vessels larger than 0 GRT.
**NP and SP indicate North and South Pacific, respectively.
***Catch of the coastal longline consist of those yielded by vessels smaller than 20 GRT.
****The troll catch for farming estimating 10 - 20 mt since 2000 is excluded.
*****Updated catches for these countries ware not provided to this meeting.

† Others fisheries include drift net, handline, trawl, other longline and unclassified fisheries.

† † Catch statistics of Korea was derived from Japanese Import statistics for 1982-1999.

† † † Annual catches of the Korean purse seine from 2000 to 2006 were modified due to chage of data source.

‡ Annual catches in 2007 of Japanese longline, troll and set net were tentative estimates.

‡ ‡ Because of unavailability of logbook data, annual catch of the distant-water and offshore longline fishery could not estimate for NP and SP Annual catch of the dist. & off. longline might be contaminated by the catch of small vessel (< 20 GRT) categorized into the offshore longliners.

‡ ‡ ‡ Annual catch of a part of coastal longline might be incorpolated into that of the dist. & off. longline.

The table contains figures used for the assessments in May, 2008. Thereafter, the following updates were made on the annual nominal catches.

Chinese Taipei as shown below.

Changes are bolded

Year	Longline	Others
2005	1368	**2**
2006	**1149**	**1**
2007	**1401**	**10**

Appendix 1. Meeting Agenda

1 Opening and meeting arrangements (Rapporteur: Miyake)

2, Adoption of agenda and appointment of Rapporteurs (Rapporteur: Miyake)

3. Review of fisheries indicators[5] (Rapporteurs: Oshima and Abe)
   - 3.1 Catch data
   - 3.2 Overview of the fishery indicator

4. Review of biological studies (Rapporteurs: Tanabe, Shimose and Yokawa)
   - 4.1 Progress of growth studies by otolith
   - 4.2 Other studies

5. Review of fisheries data prepared for Stock Synthesis 2 (Rapporteurs: Abe and Oshima)

6. Review of model setting prepared for Stock Synthesis 2 (Rapporteur: Kai)

7 Stock Assessment analysis work (Rapporteurs: Ichinokawa, Piner, Aires-da-Silva, Lee and Dreyfus)
   - 7.1 Base case
   - 7.2 Diagnostics
   - 7.3 Likelihood profiles on R_0
   - 7.4 Sensitivity analysis
   - 7.5 Future projection
   - 7.6 Recommendations

8. Conclusion on the stock status (Rapporteurs: Takeuchi and Conser)

9. Recommendations, Review of schedule and assignments (Rapporteur: Yokawa
   - 9.1 Fisheries indicators and data
   - 9.2 Biological studies
   - 9.3 Assessments and projections
   - 9.4 Next Working Group meeting

10. Other matters (Rapporteur: Miyake)

11. Adoption of reports and closure (Rapporteur: Miyake)

Appendix 2. List of Participants

- Japan

Yuji Uozumi
Director, National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka,
424-8633 Japan
81-54-336-6001, 81-54-335-9642 (fax)
uozumi@affrc.go.jp

Naozumi Miyabe
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka,
424-8633 Japan
81-54-336-6032, 81-54-335-9642 (fax)
miyabe@affrc.go.jp

Hitoshi Honda
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka,
424-8633 Japan
81-54-336-6042, 81-54-335-9642 (fax)
hhonda@affrc.go.jp

Kazuhiro Oshima
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka,
424-8633 Japan
81-54-336-6034, 81-54-335-9642 (fax)
oshimaka@affrc.go.jp

Kotaro Yokawa
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka,
424-8633 Japan
81-54-336-6035, 81-54-335-9642 (fax)
yokawa@affrc.go.jp

Makoto Miyake
Contractee of NRIFSF
3-3-4, Shimorenjaku, Mitaka-shi Tokyo,
181-0013 Japan
+81 422 46 3917
p.m.miyake@gamma.ocn.ne.jp

Mikihiko Kai
Japan NUS Co., ltd
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka,
424-8633 Japan
81-54-336-6035, 81-54-335-9642 (fax)
kaim@affrc.go.jp

Minoru Kanaiwa
Tokyo University of Agriculture
196 Yasaka, Abashiri, Hokkaido,
099-2493 Japan
81-152-48-3906, 81-152-48-2940 (fax)
m3ikanaiw@bioindustry.nodai.ac.jp

Momoko Ichinokawa
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka,
424-8633 Japan
81-54-336-6039, 81-54-335-9642 (fax)
ichimomo@fra.affrc.go.jp

Ayumi Shibano
Tokyo University of Agriculture
196 Yasaka, Abashiri, Hokkaido,
099-2493 Japan
81-152-48-3906, 81-152-48-2940 (fax)
18040056@bioindustry.nodai.ac.jp

Tamaki Shimose
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka,
424-8633 Japan
81-54-336-6045, 81-54-335-9642 (fax)
shimose@affrc.go.jp

Toshiyuki Tanabe
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka,
424-8633 Japan
81-54-336-6045, 81-54-335-9642 (fax)
katsuwo@affrc.go.jp

Yukio Takeuchi
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka,
424-8633 Japan
81-54-336-6039, 81-54-335-9642 (fax)
yukiot@fra.affrc.go.jp

Masayuki Abe
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka,
424-8633 Japan
81-54-336-6039, 81-54-335-9642 (fax)
abemasa@affrc.go.jp

Izumi Yamasaki
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka,
424-8633 Japan
81-54-336-6035, 81-54-335-9642 (fax)
izyam@affrc.go.jp

Tomoyuki Itou
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka,
424-8633 Japan
81-54-336-6033, 81-54-335-9642 (fax)
itou@affrc.go.jp

Fumihito Muto
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka,
424-8633 Japan
81-54-336-6035, 81-54-335-9642 (fax)
mtf@affrc.go.jp

Denzo Inagake
National Research Institute of Fisheries Science, Fisheries Research Agency,
2-12-4 Fukuura, Kanazawa, Yokohama, Kanagawa, 236-8648, Japan.
ina@affrc.go.jp

Yuuji Yoshihara
Fisheries Agency of Japan
Resources and Environment Research Division
1-2-1 Kasumigaseki, Chiyoda, Tokyo, 100-8907 Japan
Yuuji_yoshihara@nm.maff.go.jp

- Mexico

Michel Dreyfus
Instituto Nacional de la Pesca
CRIP-Ensenada, B.C. Mexico
dreyfus@cicese.mx

- United States

Kevin Piner
NOAA/NMFS Southwest Fisheries Science Center
8604 La Jolla Shores Drive La Jolla, CA 92037 U.S.A.
858-546-5613, 858-546-7003 (fax)
Kevin.Piner@noaa.gov

Gary Sakagawa
NOAA/NMFS Southwest Fisheries Science Center
8604 La Jolla Shores Drive La Jolla, CA 92037 U.S.A.
858-546-7177
Gary.Sakagawa@noaa.gov

Ray Conser
NOAA/NMFS Southwest Fisheries Science Center
8604 La Jolla Shores Drive La Jolla, CA 92037 U.S.A.
858-546-7081
ray.conser@noaa.gov

Hui-Hua Lee
NOAA/NMFS Southwest Fisheries Science Center
8604 La Jolla Shores Drive La Jolla, CA 92037 U.S.A.
858-546-7081
huihua.lee@gmail.com

- IATTC

Alexandre Aires-da-Silva
Inter-American Tropical Tuna
Commission (IATTC),
8604 La Jolla CA 92037-1508,
USA.
alexdasilva@iattc.org

Appendix 3. List of working papers.

ISC08/PBF-1/01.Pacific bluefin tuna quarterly catch updates.
K. Oshima (oshimaka@affrc.go.jp), M. Abe, M. Kai, I. Yamasaki, Y. Takeuchi, K. Yokawa and S. D. Hwang

ISC08/PBF-1/02.Data set on Stock Synthesis 2 for Pacific bluefin tuna, *Thunnus orientalis.*
M. Abe (abemasa@affrc.go.jp), K. Oshima, M. Kai, M. Ichinokawa, H. Yamada, Y. Takeuchi and K.Yokawa

ISC08/PBF-1/03. Length frequency of Pacific bluefin tuna caught by Japanese troll and set net fisheries during 1980's and possible effects for stock.estimates.
M.Ichinokawa (ichimomo@fra.affrc.go.jp)

ISC08/PBF-1/04.Annual catches by gears of Pacific bluefin tuna before 1952 in Japan and adjacent areas by gears.
F. Muto (mtf@affrc.go.jp), Y. Takeuchi and K. Yokawa

ISC08/PBF-1/05.Correction of the standardized CPUE of Pacific bluefin tuna caught by Japanese offshore and distant-water longliners
K. Yokawa (yokawa@affrc.go.jp)

ISC08/PBF-1/06. Estimation of effective sample size for landing data of Japanese purse seine in Sakai-Minato. M. Kanaiwa (m3kanaiw@bioindustry.nodai.ac.jp), A. Shibano, T. Shimura, R. Uji and Y. Takeuchi

ISC08/PBF-1/07.Evaluation and recommendation of sampling method for Purse seine by using landing data in Sakai-Minato.
A. Shibano (18040056@cp.bioindustry.nodai.ac.jp), M. Kanaiwa, T. Shimura, R. Uji and Y. Takeuchi

ISC08/PBF-1/08.Age and growth of Pacific bluefin tuna, *Thunnus orientalis*, validated by the sectioned otolith ring counts.
T. Shimose(shimose@affrc.go.jp), M. Kai, T. Tanabe, K. S. Chen, C. C. Hsu, F. Muto and I. Yamasaki

ISC08/PBF-1/09.A review of reproductive biology of Pacific bluefin tuna *Thunnus orientaris* with description of some problem for further study.
T. Tanabe(katsuwo@affrc.go.jp), K. Yokawa, N. Miyabe, H. Honda and Y. Takeuchi.

ISC08/PBF-1/10.Reconsideration to adult natural mortality of Pacific bluefin tuna in the presence of new information of age and growth.
Y. Takeuchi (yukiot@fra.affrc.go.jp)

ISC08/PBF-1/11.Preliminary stock assessment of Pacific bluefin tuna.
Y. Takeuchi (yukiot@fra.affrc.go.jp), M. Ichinokawa, O. Kazuhiro, M. Kai, M. Abe and K. Yokawa

ISC08/PBF-1/12.Sensitivity analysis of stock assessment for Pacific bluefin tuna using Stock Synthesis 2.
M. Kai (kaim@affrc.go.jp)

ISC08/PBF-1/13.Comparison of von Bertalanffy growth function from otolith sections with

observed length frequencies from various fisheries.
M. Ichinokawa (ichimomo@fra.affrc.go.jp)

ISC08/PBF-1/14.Withdrawn

ISC08/PBF-1/15. Future projections from the current stock status estimated by Stock Synthesis II for Pacific bluefin tuna.
M. Ichinokawa (ichimomo@fra.affrc.go.jp), Y. Takeuchi, R. Conser, K. Piner, M. Dreyfus,

ISC08/PBF-1/16.Basic results of analysis of sexed size data of large sized Pacific bluefin tuna.
K. Yokawa (yokawa@affrc.go.jp)

ISC08/PBF-1/17.Stock assessment of Pacific bluefin tuna –Specification of modeling and base case results-.
Y. Takeuchi (yukiot@fra.affrc.go.jp), M. Ichinokawa, M. Kai, K. Oshima, M. Abe, K. Yokawa, R. Conser,, K. Piner, A. Air's-Da-Silva , H. H. Lee and M. Dreyfus.

ISC08/PBF-2/01 Uncertainty of the estimates in the terminal year of 2005 estimated by SS2 for Pacific bluefin tuna.
M. Ichinokawa (ichimomo@fra.affrc.go.jp)

Information paper:
Contributions of different spawning seasons and areas to the stock of Pacific bluefin tuna, *Thunnus orientalis*, based on analyses of otolith daily increments and catch-at-length data.
T. Itou (itou@.affrc.go.jp)

Appendix 4. Sensitivity analyses of a discrete dynamic population model by Michel Dreyfus

Estimated B_0 parameters with a discrete population dynamic model using Working Group schedules for natural mortality (7) and levels of recruitment (2).

	R = 7 million	**R = 10 million**
B_0 Base Case	880000 t	1255000 t
Adult M_{02}	437000 t	624000 t
Adult M_{08}	1474000 t	2095000 t
Low Y M	1587000 t	2257000 t
M_{2006}	192200 t	274000 t
High Sp M	153000 t	219000 t
Lowest M	2369000 t	3371000 t

Appendix 5. Sensitivity analyses – stock recruitment relationship by A. Aires-da-Silva

The base case stock assessment model assumes a Beverton-Holt (1957) stock recruitment (S-R) relationship in which the steepness (*h*) parameter was fixed at 1.0. A value of 0.6 was assumed for the standard deviation of log-recruitment (sigma-r). Three sensitivity analyses were made to evaluate the impact on the assessment results from different assumptions about the nature of the S-R relationship: 1) steepness *h* fixed at 0.8; 2) a higher standard deviation of the recruitment deviates (sigma-r fixed at 1.0); 3) a CAGEAN-like unconstrained recruitments estimates.

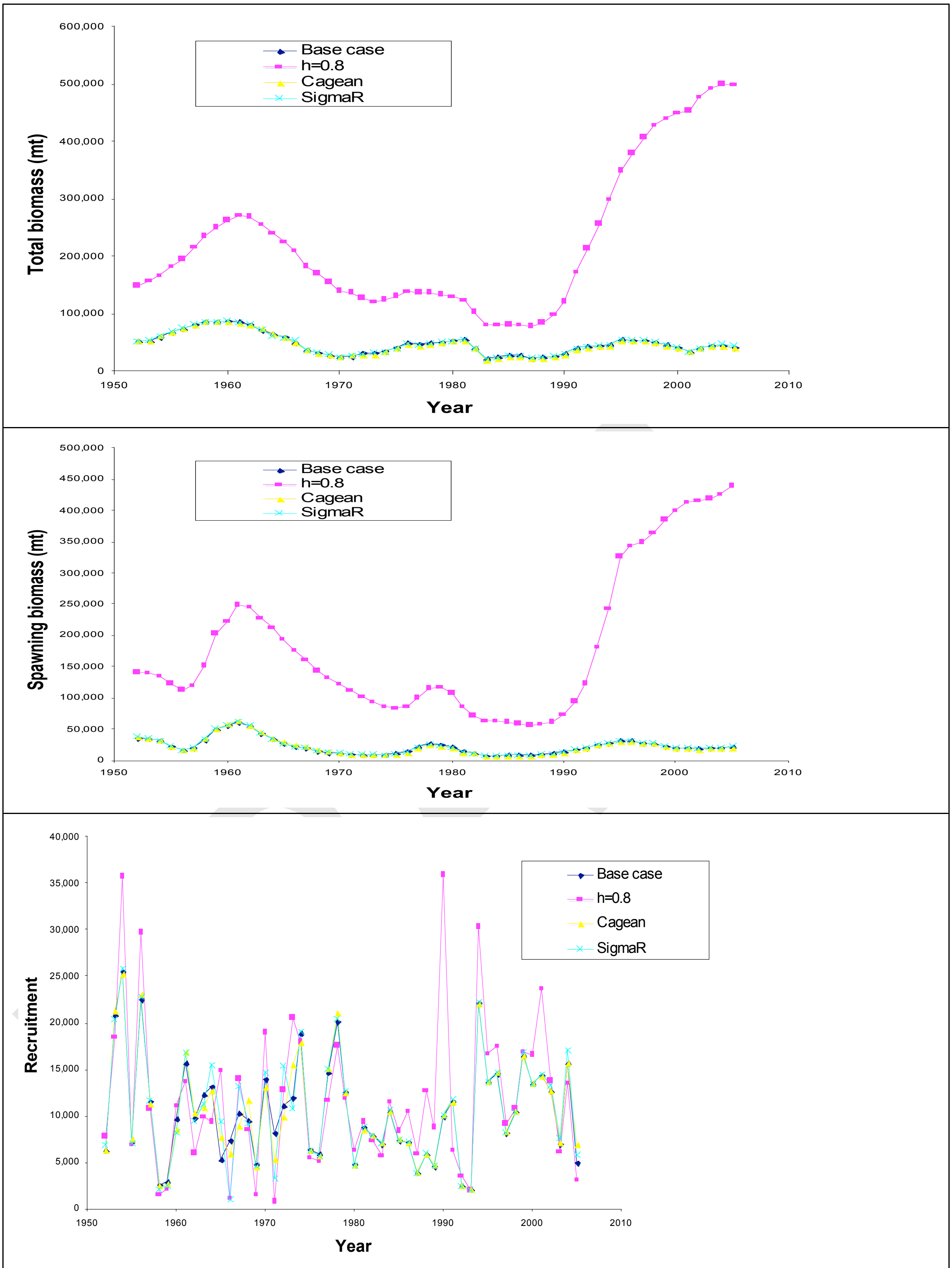
Appendix 5 presents the time series of estimated biomasses, recruitments, proportions of spawners-per-recruit (SPR), total fishing mortalities (F) and yield-per-recruit (Y/R) estimates for the base case model and different sensitivity runs. In general, the base case results were robust to the different assumptions made about the stock-recruitment relationship. The exception is the sensitivity in which the steepness (*h*) parameter was fixed at 0.8. However, a pronounced increase of the biomasses since the early 1990s seems unrealistic. The likelihood components and selected derived quantities obtained for the different sensitivities are shown in Appendix table 5.1. The base case model produced the best model fit when compared to the different S-R sensitivity runs.

Reference

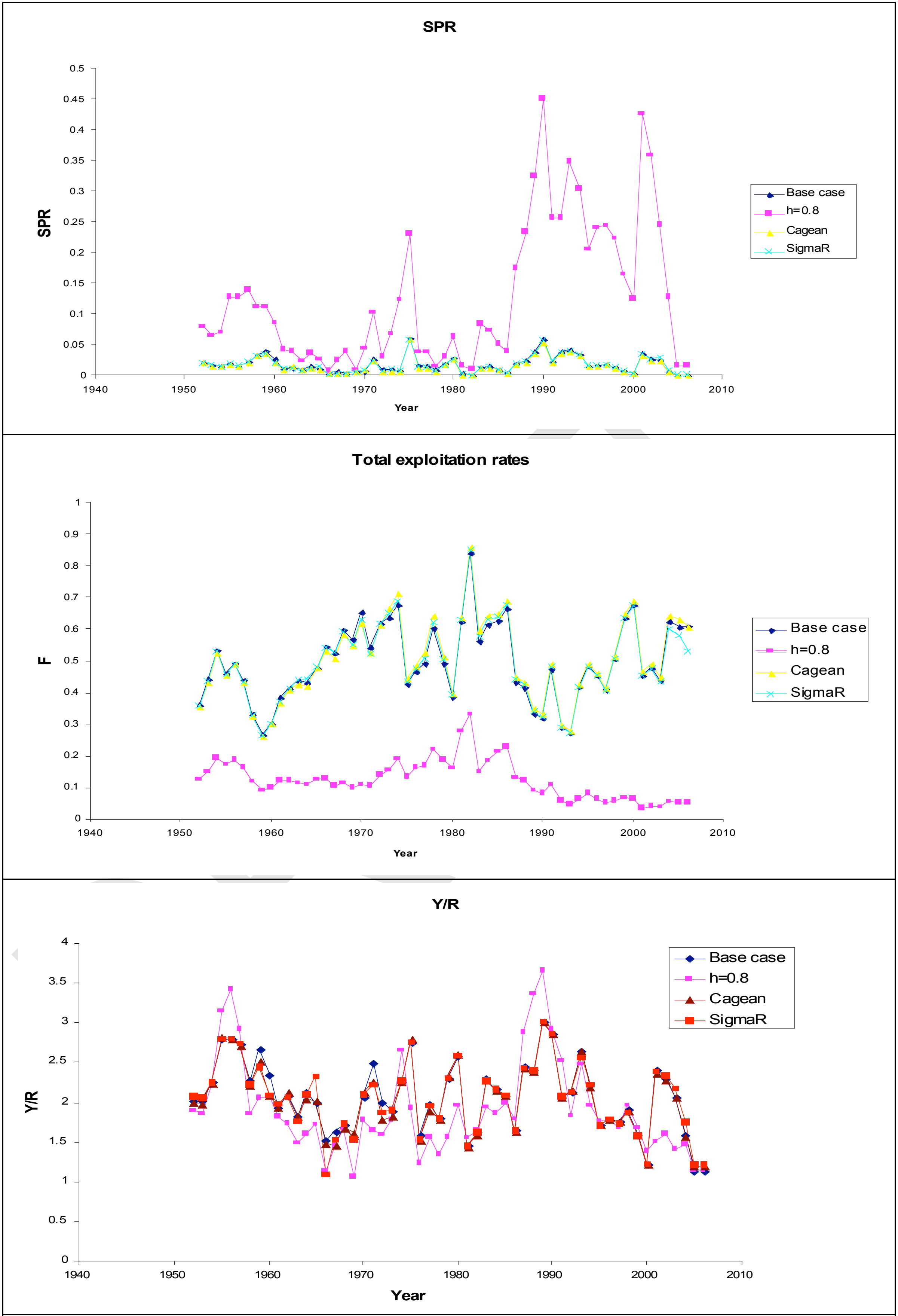
Beverton, R. J. H. and Holt, S.J. 1957, On the dynamics of exploited fish populations. U.K. Minist. Agric. Fish. Ser. 2,19, 533p

Appendix Table 5.1. Likelihoods and selected derived quantities for the base case and S-R sensitivity runs.

	Base case	h = 0.8	Cagean	sigmaR_1
LIKELIHOOD	4345.75	4802.33	4346.75	4372.07
indices	-195.761	-44.6147	-195.696	-187.633
length_comps	4510.21	4657.25	4505.68	4514.62
Equil_catch	0.10206	0.951812	0.0299319	0.0462037
catch	17.6132	29.9194	30.8764	14.7561
Recruitment	14.6146	159.842	6.87341	30.2834
Forecast_Recruitment	-1.02165	-1.02165	-1.02165	0
DERIVED QUANTITIES				
SSB_{zero}	1,377,640	2,825,390	1,157,680	1,830,260
SSB_{start}	36,262	141,218	37,008	38,514
SSB_{end}	21,451	440,155	20,552	22,685
SBR_{start}	0.03	0.05	0.03	0.02
SBR_{end}	0.02	0.16	0.02	0.01



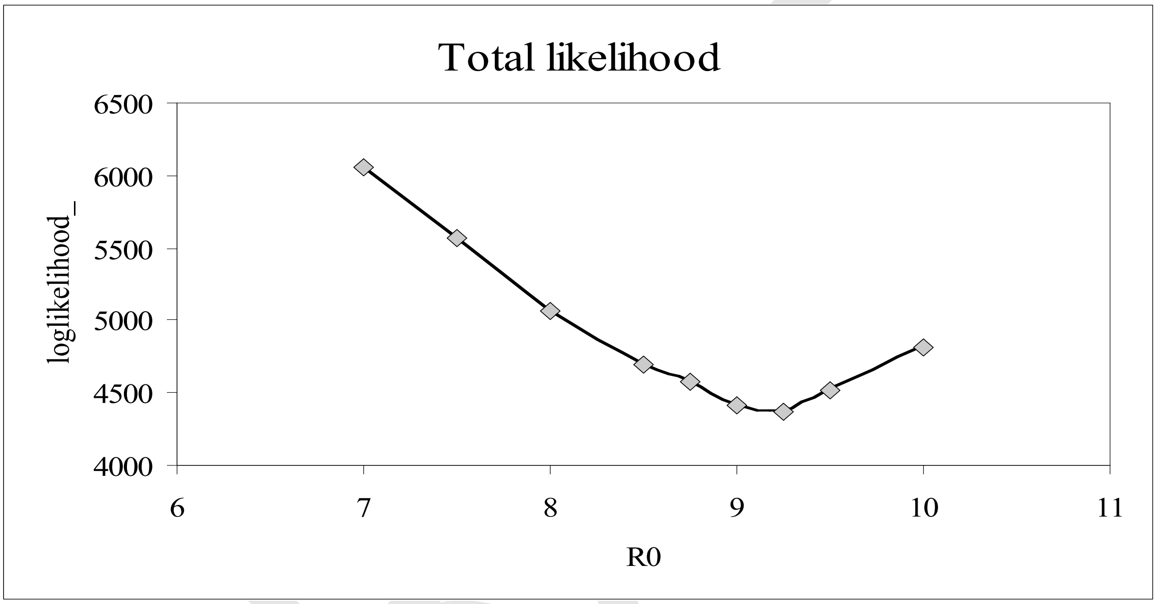
Appendix Figure. 5.1. Time series of estimated biomasses and recruitments for the base case and sensitivity runs to the S-R assumptions.



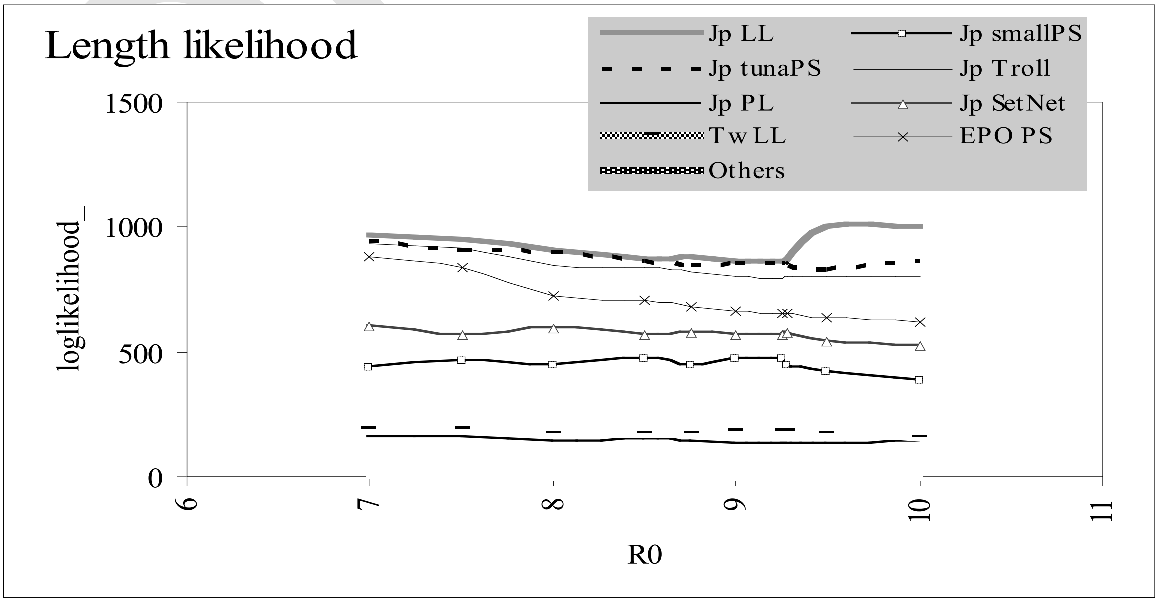
Appendix Figure 5.2. Time series of estimated proportions of spawners-per-recruit, total fishing mortality and yield-per-recruit for the base case and sensitivity runs to the S-R assumptions.

Appendix 6. Likelihood Profile

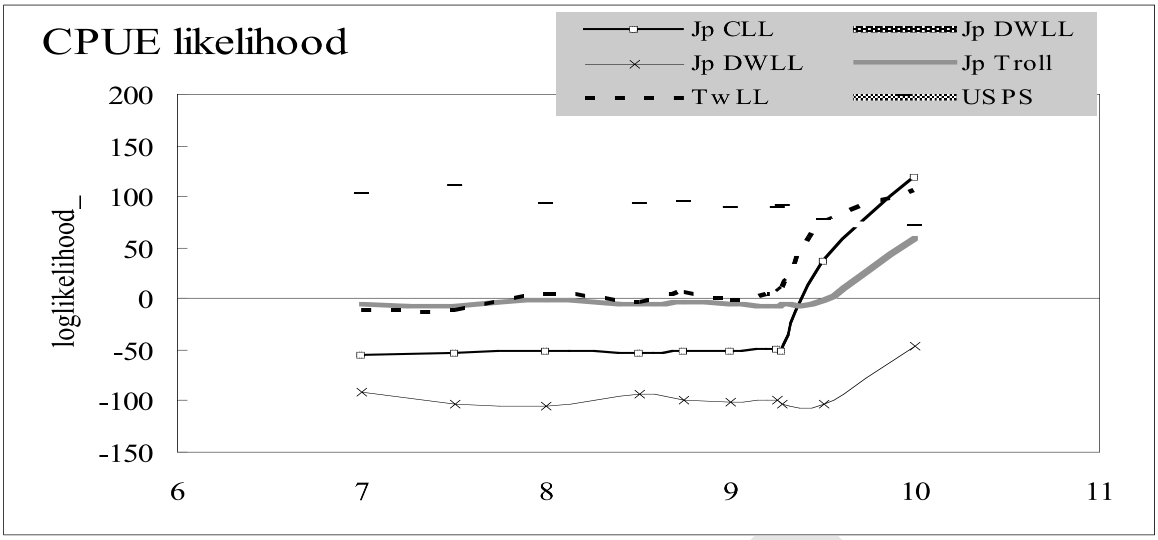
Likelihood profiles on virgin recruitment (R_0) were constructed (Range 7-10) to evaluate the contribution to the total likelihood of size composition data and each CPUE, and check for conflicting trends. The total likelihood profile (Figure 6.1) indicated that the scaling parameter log R_0 (MLE=9.25) appears well defined given the model structure. The size frequency profile (Figure 6.2) indicates that generally small fish fisheries fit better at higher R_0 but that the JPN-LL size component provided an upper bound to R_0. The CPUE indices profile (Figure 6.3) indicated that the JPN-CLL and JPN-Troll and TW-LL provide an upper bound to R_0. There is conflicting information between these indices and the US-PS index from the EPO which fits better at higher values of R_0.



Appendix Figure 6.1. Total likelihood profile on R0.



Appendix Figure 6.2 Total likelihood profiles on R0 by size composition data.



Appendix Figure 6.3. Total likelihood profiles on R0 by size CPUE data.

Appendix 7 Sensitivity of Assessment Model to Changes in Natural Mortality Rate (M)

Sensitivity of the assessment model results and resulting biological reference calculations to changes in Natural Mortality (M) was evaluated by fitting the base case model with alternative M vectors. Seven alternative M vectors (Table 7.1) were used in addition to that of the base case. The model was configured with the same parameterization as the base model except for the changes to M. Each of the seven M vectors increased or decreased the magnitude of M for either juvenile or adults as well both groups together. We note that the base model was tuned (CPUE SE, size composition Effective N as well as Sigma-R) using the original vector of M. Each alternative vector of M scenario was not re-tuned, and thus these sensitivity analyses do not represent the best models for that alternative M vector.

The estimated time series of spawning biomass (Figure Appendix 7-1) was most sensitive to the magnitude of the M assumed for adults (age 4+) while recruitment trends (Figure Appendix 7-2) were sensitive to the magnitude of the juvenile M (age 0-3) and to a lesser extent adult M. In general, increasing M resulted in a smaller initial spawning stock size and a less exploited and depleted stock in 1952-2005. Decreasing M resulted in a larger initial spawning stock and more heavily exploited and depleted stock in 1952-2005.

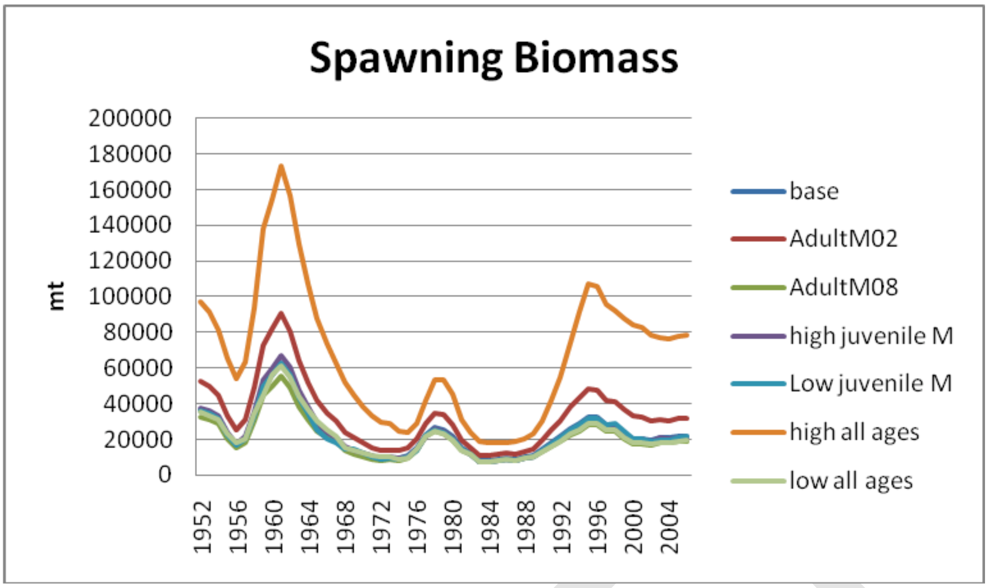
While the ratio of $F_{current}$ to F_{BRP} could be sensitive to the M vector depending upon the BRP, some general conclusion could be drawn across all sensitivity runs. Specifically, $F_{current}$ was generally greater than F_{BRP} (Table 7.2) for all of the commonly used biological reference points (BRP) that the WG considered as potential target reference points ($F_{40\%}$, $F_{30\%}$, $F_{20\%}$, $F_{0.1}$, F_{MAX}). Conversely, $F_{current}$ was generally below F_{BRP} (Table 7.2) for all the commonly used BRPs that the WG considered as potential recruitment overfishing threshold reference points (F_{MED}).

Appendix Table 7.1. Base case and alternative M vectors used in the sensitivity analyses.

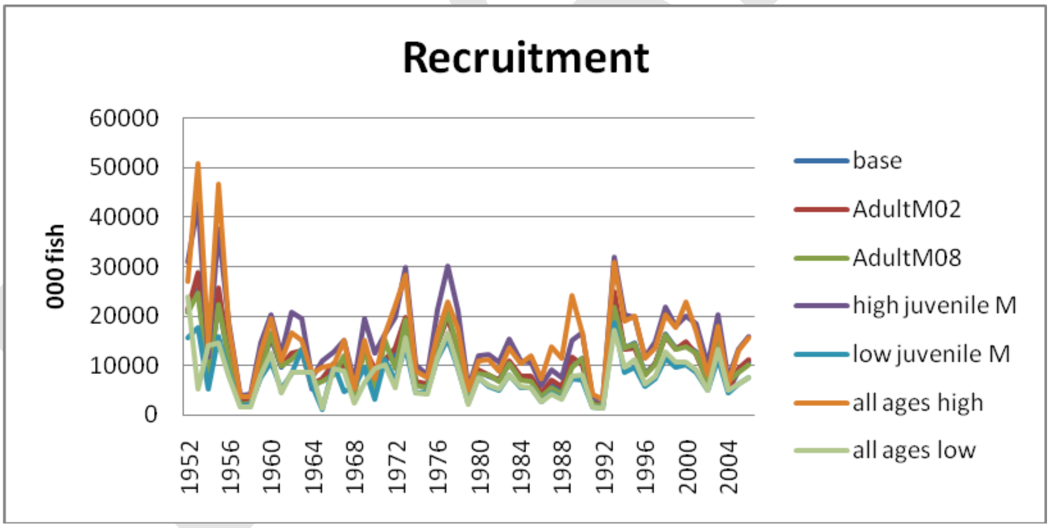
age	base	AdultM=02	AdultM=08	High_youngM	LowYoungM	High age1+	High M Spawn	Low M
0	1.6	1.6	1.6	1.9	1.3	1.6	1.68	1.3
1	0.46	0.46	0.46	0.66	0.4	0.8	0.84	0.4
2	0.27	0.27	0.27	0.5	0.12	0.4	0.42	0.2
3	0.2	0.2	0.2	0.2	0.12	0.25	0.4	0.15
4+	0.12	0.2	0.08	0.12	0.12	0.25	0.3	0.08

Appendix Table 7.2. Yield-per-Recruit F multiplier ($F_{MAX}/F_{current}$), $F_{0.1}/F_{current}$, $F_{40\%}/F_{current}$, $F_{30\%}/F_{current}$, $F_{20\%}/F_{current}$, $F_{MED}/F_{current}$ and SPR levels (expressed as proportion) calculated for each vector of M. $F_{current}$ was calculated as an average of 2002 to 2004. An F-multiplier <1 indicates $F_{current} > F_{BRP}$ and F-multiplier>1 that $F_{current} < F_{BRP}$.

	base	high adult M	Low adult M	High juvenile M	Low juvenile M	High age1+ M	High spawning M	Low all ages M
Fmax/Fcurrent	0.21	0.40	0.15	0.25	0.21	1.01	0.83	0.15
F0.1/Fcurrent	0.14	0.28	0.10	0.15	0.14	0.65	0.51	0.10
F40%/Fcurrent	0.15	0.26	0.11	0.16	0.15	0.48	0.40	0.11
F30%/Fcurrent	0.21	0.35	0.15	0.22	0.21	0.63	0.53	0.15
F20%/Fcurrent	0.30	0.49	0.22	0.32	0.30	0.85	0.72	0.22
Fmed/Fcurrent	1.03	1.17	0.98	1.08	1.18	1.45	1.17	1.09
SPRcurrent	0.02	0.05	0.01	0.02	0.01	0.15	0.11	0.01



Appendix Figure 7.1. Spawning biomass time series estimated from base and alternative M scenarios. Note that in all figures the plot from the vector of High Spawning M (Table 7.1) is not plotted as the results are nearly identical to vector of High age 1+ and thus in the figures the plot of both is referred to as high all ages.



Appendix Figure 7.2. Recruitment time series estimated from base and alternative M scenarios. Note that in all figures the plot from the vector of High Spawning M (Table 7.1) is not plotted as the results are nearly identical to vector of High age 1+ and thus in the figures the plot of both is referred to as high all ages.

Appendix 8 Comprehensive summary table of sensitivity runs considered by the WG.

Appendix Table 8.1. Summary of results of each sensitivity model. A column is for each sensitivity run and rows are key models results. Column headings indicate the change from the base case model.

Components and derived	Base case	Natural Mortality						
		high adult M	Low adult M	High juvenile M	Low juvenile M	High age1+ M	High spawning M	Low all ages M
Likelihood components								
Negative log-likelihood	4345,750	4303,400	4395,560	4338,830	4409,710	4220,760	4247,030	4469,070
indices	-195,761	-205,096	-187,326	-191,296	-183,593	-200,085	-200,460	-174,012
length_comps	4510,210	4494,040	4525,890	4509,250	4550,670	4401,720	4438,650	4544,690
Equil_catch	0,102	0,012	0,353	0,041	0,117	0,003	0,003	0,517
catch	17,613	9,021	31,756	13,868	22,005	13,131	4,151	61,437
Recruitment	14,615	6,446	25,904	7,989	21,537	7,012	5,707	37,459
Forecast_Recruitment	-1,022	-1,022	-1,022	-1,022	-1,022	-1,022	-1,022	-1,022
Estimated SSB								
SSB at 1952	36262,2	52725,6	32324,0	37685,8	36313,6	97391,6	66781,4	35293,4
SSB at 2005	21450,7	31543,3	18352,0	20859,1	21144,3	78144,7	45592,5	18809,2
Minimum SSB	7803,1	10827,3	7222,6	7633,7	7391,0	18427,6	12563,3	7268,7
Maximum SSB	62291,3	90719,0	55188,3	66796,8	62647,1	173486,0	116445,0	61384,0
CV of SSB	56,3	56,8	55,5	58,9	57,0	57,9	58,2	57,6
B0	1378407	706273	2232165	1356275	1776526	416275	373281	2680333
Estimated recruitments (REC)								
REC at 1952	20896,9	21175,1	20845,4	30765,0	15586,7	27122,7	27880,6	23985,8
REC at 2005	8973,4	9438,7	8621,5	13173,1	6411,8	13023,8	13890,8	6406,3
Minimum REC	2080,4	2169,7	2024,0	3126,5	1227,0	3273,7	3384,3	1469,1
Maximum REC	25559,8	28752,8	24734,6	42783,8	18682,1	50865,9	54828,4	23985,8
CV of REC	51,5	52,0	53,1	53,7	53,6	60,0	59,2	56,5
R0	10743	11300	10322	15771	7676	15592	16630	7670
SD_REC_dev	0,583	0,562	0,608	0,578	0,625	0,585	0,583	0,655
Exploitation rates (EX)								
EX at 1952	0,361	0,261	0,405	0,339	0,368	0,152	0,204	0,394
EX at 2005	0,608	0,459	0,698	0,624	0,623	0,215	0,329	0,688
Mimimum EX	0,266	0,189	0,300	0,249	0,277	0,094	0,132	0,293
Maximum EX	0,840	0,743	0,870	0,822	0,871	0,573	0,641	0,887
CV of EX	24,508	28,804	23,137	25,579	24,406	40,906	33,593	23,897
Depletion level								
SPR1952	0,020	0,049	0,011	0,029	0,015	0,135	0,110	0,003
SSBcurrent/SSB1952	0,592	0,598	0,568	0,554	0,582	0,802	0,683	0,533
SSB1952/virginSSB	0,026	0,075	0,015	0,039	0,020	0,234	0,179	0,013
BRPs								
Fmax/Fcurrent	0,210	0,40	0,15	0,25	0,21	1,01	0,83	0,15
F0,1/Fcurrent	0,143	0,277	0,098	0,151	0,141	0,648	0,515	0,099
F20%/Fcurrent	0,302	0,486	0,220	0,316	0,298	0,848	0,722	0,220
F30%/Fcurrent	0,212	0,355	0,151	0,223	0,210	0,629	0,529	0,152
F40%/Fcurrent	0,154	0,265	0,107	0,161	0,153	0,476	0,397	0,109
Fmed/Fcurrent	1,027	1,165	0,982	1,084	1,185	1,447	1,173	1,087
SSB at the BRPs								
SSB at Fmax	408825	184375	657072	395910	537887	62262	60216	806348
SSB at F0,1	583768	271938	949403	570257	757701	120623	115569	1146546
SSB at F20%	275673	141230	446154	271256	355297	83254	74674	535716
SSB at F30%	413524	211909	669661	406523	532961	124888	111982	804117
SSB at F40%	551381	282511	892577	542516	710633	166584	149302	1071948
SSB at Fmed	19400	20420	18637	19092	13866	28179	30041	13858
Yield at the BRPs								
Yield at Fmax	45340	28341	60683	45711	56607	19921	20943	69449
Yield at F0,1	43072	27104	57322	43378	53877	18904	19772	65808
Yield at F20%	43596	27958	58270	44128	54094	19767	20847	66277
Yield at F30%	45338	28206	60676	45701	56605	18767	19905	69449
Yield at F40%	43797	26811	58435	44025	54874	17121	18240	67158
Yield at Fmed	20200	19412	20264	20915	19270	19327	20373	18206
Expected Equilibrium yield at Fmax by gear								
FL1 Japanese LL	8130	4101	11378	8477	10777	1285	1794	13174
FL2 Small pelagic fish P	2199	3512	1725	2592	3170	5360	4703	1982
FL3 Tuna PS	11582	7232	14827	11939	14795	2871	3780	17991
FL4 Japanese troll	715	1175	542	730	756	2230	1854	562
FL5 Japanese P&L	102	176	74	103	100	343	285	72
FL6 Japanese Set net	977	1168	857	941	1013	1209	1208	943
FL7 Taiwanese LL	16140	5477	26359	15723	20160	1259	1900	29625
FL8 EPO PS	3664	4395	2971	3563	3854	4785	4712	2805
FL9 EPO sport	246	285	199	256	283	254	279	207
FL10 Other	1586	819	1752	1385	1701	325	427	2090
Expected Equilibrium yield at F0,1 by gear								
FL1 Japanese LL	7914	4272	10801	8270	10474	1626	2203	12526
FL2 Small pelagic fish PS	1607	2787	1202	1902	2406	4162	3449	1420
FL3 Tuna PS	10826	7216	13577	11162	13846	3447	4288	16582
FL4 Japanese troll	515	892	374	521	556	1647	1301	399
FL5 Japanese P&L	71	130	49	71	70	253	200	49
FL6 Japanese Set net	752	977	629	717	786	1099	1023	709
FL7 Taiwanese LL	16907	6123	26814	16558	20972	1727	2621	30000
FL8 EPO PS	2790	3653	2128	2688	2958	4322	3968	2045
FL9 EPO sport	188	238	142	194	217	232	237	151
FL10 Other	1503	817	1605	1296	1592	388	483	1926

Appendix Table 8.1 Continued…….

Components and derived	Growth and Maturity					Stock Recruitment		
	k-015	k-025	CV-015	_maxage-1!	15-maturity	h=0,8 un-converge(	cagean	sigmaR=1
Likelihood components								
Negative log-likelihood	4556,030	4355,750	4893,560	4467,230	4368,730	4802,330	4346,750	4372,070
indices	-150,734	-147,313	-191,666	-196,000	-186,933	-44,615	-195,696	-187,633
length_comps	4664,050	4461,900	5046,380	4638,880	4509,970	4657,250	4505,680	4514,620
Equil_catch	0,102	0,079	0,128	0,111	0,103	0,952	0,030	0,046
catch	37,043	20,286	22,363	9,406	31,411	29,919	30,876	14,756
Recruitment	6,586	21,816	17,378	15,850	15,191	159,842	6,873	30,283
Forecast_Recruitment	-1,022	-1,022	-1,022	-1,022	-1,022	-1,022	-1,022	0,000
Estimated SSB								
SSB at 1952	17542,6	89505,4	36839,7	36096,8	20433,1	141218,0	37007,6	38513,6
SSB at 2005	12569,0	72058,1	21626,8	20241,0	15619,8	440155,0	20552,3	22684,6
Minimum SSB	4642,2	20972,3	7577,0	7369,3	5220,1	56740,5	7038,3	7415,7
Maximum SSB	34211,1	135190,0	63678,5	62071,0	52794,8	454091,0	63827,8	63242,0
CV of SSB	49,7	48,9	56,8	57,1	61,5	66,1	58,9	57,0
B0	1955810	929951	1422686	1384125	1311352	2826947	1158321	1831277
Estimated recruitments (REC)								
REC at 1952	17144,9	35479,2	22077,5	21032,1	20954,5	18440,1	21205,6	20365,1
REC at 2005	9193,8	8416,5	9261,6	9011,5	8970,0	13747,3	9027,8	8656,8
Minimum REC	2695,0	1634,6	2163,0	2210,6	2084,8	780,2	2106,2	967,9
Maximum REC	24333,2	35479,2	24978,9	23962,9	25609,8	35898,6	25227,7	25848,9
CV of REC	48,1	57,9	50,5	50,7	51,3	67,3	51,8	54,2
R0	11007	10076	11088	10789	10739	22033	9028	14273
SD_REC_dev	0,512	0,630	0,562	0,572	0,575	0,884	0,578	0,686
Exploitation rates (EX)								
EX at 1952	0,486	0,174	0,357	0,360	0,359	0,126	0,354	0,359
EX at 2005	0,840	0,251	0,619	0,656	0,624	0,054	0,633	0,582
Mimimum EX	0,388	0,116	0,264	0,268	0,260	0,034	0,264	0,264
Maximum EX	0,894	0,584	0,839	0,846	0,836	0,330	0,863	0,851
CV of EX	21,128	34,605	24,181	24,303	24,768	49,653	24,940	24,372
Depletion level								
SPR1952	0,012	0,037	0,023	0,023	0,016	0,079	0,020	0,021
SSBcurrent/SSB1952	0,716	0,805	0,587	0,869	0,764	3,117	0,555	0,589
SSB1952/virginSSB	0,009	0,096	0,026	0,026	0,016	0,050	0,032	0,021
BRPs								
Fmax/Fcurrent	0,13	0,51	0,21	0,20	0,21	1,05	0,21	0,23
F0,1/Fcurrent	0,079	0,358	0,143	0,135	0,143	0,745	0,138	0,150
F20%/Fcurrent	0,188	0,609	0,305	0,281	0,281	1,078	0,305	0,328
F30%/Fcurrent	0,129	0,445	0,211	0,199	0,199	0,797	0,211	0,223
F40%/Fcurrent	0,088	0,328	0,152	0,146	0,146	0,609	0,152	0,164
Fmed/Fcurrent	0,850	1,504	0,991	0,950	0,920	2,822	0,981	1,060
SSB at the BRPs								
SSB at Fmax	580095	230443	422275	410751	371493	583608	345068	542909
SSB at F0,1	843652	343251	602009	586916	537848	924502	492674	776338
SSB at F20%	390366	178290	279861	283457	268953	563492	221966	352025
SSB at F30%	573213	272741	428953	419756	400261	855999	341320	551885
SSB at F40%	783738	372234	573511	551936	527380	1132288	457782	725038
SSB at Fmed	21939	20096	22027	21432	21368	43620	17874	28411
Yield at the BRPs								
Yield at Fmax	74379	22330	46511	45906	44893	33348	38418	61014
Yield at F0,1	69935	21406	44204	43595	42666	32016	36477	57929
Yield at F20%	71163	22077	44574	44313	43775	33342	36601	58238
Yield at F30%	74375	22187	46507	45899	44818	32469	38417	61009
Yield at F40%	71627	20919	44843	44382	42920	30191	37250	59080
Yield at Fmed	25387	15390	20884	20703	21878	25763	17415	27744
Expected Equilibrium yield at Fmax by gear								
FL1 Japanese LL	12902	2706	8407	8187	8143	2327	6945	11186
FL2 Small pelagic fish PS	2029	3410	2323	2208	2187	9028	1797	2854
FL3 Tuna PS	14778	5408	11987	11559	11728	5177	9929	15951
FL4 Japanese troll	502	1269	723	714	712	3941	584	917
FL5 Japanese P&L	67	190	102	99	102	631	84	130
FL6 Japanese Set net	786	1080	1015	1012	994	1946	817	1254
FL7 Taiwanese LL	29347	3344	16508	16665	15892	2573	14030	21818
FL8 EPO PS	2588	4058	3803	3885	3537	6756	2912	4736
FL9 EPO sport	178	257	251	251	233	383	192	341
FL10 Other	11202	607	1392	1327	1367	586	1129	1828
Expected Equilibrium yield at F0,1 by gear								
FL1 Japanese LL	11995	2878	8192	7966	7932	2606	6737	10865
FL2 Small pelagic fish PS	1376	2756	1708	1608	1603	7675	1309	2076
FL3 Tuna PS	13149	5572	11228	10798	10985	5753	9253	14875
FL4 Japanese troll	335	988	523	513	514	3236	419	658
FL5 Japanese P&L	43	145	72	69	71	507	58	91
FL6 Japanese Set net	550	940	785	779	769	1845	627	960
FL7 Taiwanese LL	28921	3771	17290	17463	16642	2927	14680	22856
FL8 EPO PS	1769	3508	2910	2967	2690	6448	2198	3586
FL9 EPO sport	122	223	193	192	177	367	145	258
FL10 Other	11676	625	1304	1239	1282	651	1051	1704

Appendix Tabel 8.1 . Continued

Components and derived	Secondary CPUE and Equlibrium Catches							
	Add 25 to_base	Add 26 to_base	Add 27 to_base	All lambda_1	replace14,15 with12,13	replace14,15 with16,17	replace14,15 with18,19	replace20 with21
Likelihood components								
Negative log-likelihood	4620,250	4454,100	4406,460	4479,690	4509,710	4414,000	4344,550	4420,040
indices	76,990	-116,648	-176,300	87,581	51,211	-151,521	-198,778	-158,030
length_comps	4501,810	4519,210	4524,500	4362,440	4435,570	4506,450	4512,520	4502,190
Equil_catch	0,098	0,087	0,094	0,109	0,094	0,105	0,110	0,095
catch	25,800	37,461	43,418	17,145	9,876	46,682	18,537	59,535
Recruitment	16,570	15,014	15,774	13,439	13,976	13,307	13,181	17,277
Forecast_Recruitment	-1,022	-1,022	-1,022	-1,022	-1,022	-1,022	-1,022	-1,022
Estimated SSB								
SSB at 1952	36767,7	37557,3	39835,5	34772,7	43014,1	31733,4	33265,5	39468,0
SSB at 2005	20275,7	21489,0	21465,5	30539,3	18754,3	22129,3	22840,5	21536,7
Minimum SSB	7687,2	7771,2	7249,9	8756,5	6483,7	7774,8	7890,6	7327,2
Maximum SSB	63460,3	66718,2	67885,7	56680,2	75966,1	60478,1	60631,7	69060,9
CV of SSB	56,7	58,2	60,4	49,2	54,2	53,4	55,6	60,6
B0	1364884	1351951	1354247	1406596	1349628	1382680	1393612	1365936
Estimated recruitments (REC)								
REC at 1952	21031,0	21160,8	24821,0	18254,0	17588,9	15726,6	17426,6	24468,4
REC at 2005	8885,3	8801,1	8816,1	9156,9	8786,0	9001,2	9072,4	8892,2
Minimum REC	2160,6	2045,3	2050,1	2283,3	2079,4	2092,2	2146,2	1908,9
Maximum REC	25456,0	25674,5	24821,0	24874,5	26878,3	26035,8	24461,1	24468,4
CV of REC	52,6	53,5	54,1	50,6	52,1	53,2	51,5	53,7
R0	10638	10537	10555	10963	10519	10776	10862	10646
SD_REC_dev	0,598	0,593	0,598	0,568	0,582	0,599	0,583	0,613
Exploitation rates (EX)								
EX at 1952	0,358	0,354	0,346	0,362	0,317	0,365	0,360	0,348
EX at 2005	0,638	0,610	0,622	0,476	0,675	0,612	0,587	0,610
Mimimum EX	0,265	0,258	0,256	0,290	0,236	0,278	0,278	0,253
Maximum EX	0,839	0,845	0,859	0,745	0,766	0,807	0,801	0,857
CV of EX	24,657	24,883	25,578	20,574	29,930	23,182	23,255	25,530
Depletion level								
SPR1952	0,020	0,020	0,011	0,022	0,028	0,026	0,025	0,011
SSBcurrent/SSB1952	0,551	0,572	0,539	0,878	0,436	0,697	0,687	0,546
SSB1952/virginSSB	0,027	0,028	0,029	0,025	0,032	0,023	0,024	0,029
BRPs								
Fmax/Fcurrent	0,21	0,23	0,22	0,25	0,20	0,21	0,22	0,22
F0,1/Fcurrent	0,137	0,151	0,146	0,170	0,132	0,142	0,148	0,145
F20%/Fcurrent	0,293	0,328	0,305	0,352	0,281	0,305	0,328	0,305
F30%/Fcurrent	0,211	0,223	0,211	0,258	0,199	0,211	0,223	0,211
F40%/Fcurrent	0,152	0,164	0,152	0,188	0,141	0,152	0,164	0,152
Fmed/Fcurrent	0,974	1,045	1,011	1,157	0,969	0,989	1,052	1,008
SSB at the BRPs								
SSB at Fmax	406389	396260	397803	422198	399660	412753	414239	405939
SSB at F0,1	580598	568663	570497	597926	575942	587760	592088	578777
SSB at F20%	272209	256883	272976	287772	276306	271817	265192	274408
SSB at F30%	398241	404963	415831	413923	406550	416637	416679	418312
SSB at F40%	535039	533473	553644	554743	550142	557020	548181	557243
SSB at Fmed	21140	20829	20959	21748	20915	21428	21571	21146
Yield at the BRPs								
Yield at Fmax	45485	44769	44667	44189	46824	44993	46456	44591
Yield at F0,1	43178	42520	42425	42054	44345	42756	44102	42374
Yield at F20%	43665	42787	43118	42555	45220	43061	44221	42891
Yield at F30%	45479	44763	44639	44184	46820	44991	46455	44578
Yield at F40%	44183	43305	42818	42936	44982	43438	45076	42864
Yield at Fmed	20603	20894	20907	20176	21446	20501	21032	20380
Expected Equilibrium yield at Fmax by gear								
FL1 Japanese LL	8265	8311	8114	7872	8327	8047	8755	8091
FL2 Small pelagic fish P	2107	2606	2607	2381	2478	2212	2198	2153
FL3 Tuna PS	11642	11858	11670	11334	11536	11460	11955	11828
FL4 Japanese troll	682	761	731	788	701	704	701	673
FL5 Japanese P&L	97	108	103	109	100	100	99	95
FL6 Japanese Set net	967	947	951	960	927	1006	966	966
FL7 Taiwanese LL	16690	15294	15577	15636	17804	16288	16408	15814
FL8 EPO PS	3460	3287	3360	3539	3424	3625	3730	3388
FL9 EPO sport	228	225	219	231	233	235	264	221
FL10 Other	1348	1374	1334	1339	1294	1316	1380	1362
Expected Equilibrium yield at F0,1 by gear								
FL1 Japanese LL	8017	8110	7910	7709	8024	7846	8548	7866
FL2 Small pelagic fish PS	1532	1928	1930	1766	1794	1621	1599	1578
FL3 Tuna PS	10838	11115	10940	10650	10653	10716	11138	11069
FL4 Japanese troll	489	547	525	575	494	508	502	486
FL5 Japanese P&L	68	75	72	78	68	70	69	66
FL6 Japanese Set net	741	726	730	751	697	779	740	746
FL7 Taiwanese LL	17457	16080	16369	16361	18707	17045	17188	16554
FL8 EPO PS	2610	2479	2533	2726	2542	2760	2831	2566
FL9 EPO sport	172	170	166	179	173	179	201	168
FL10 Other	1255	1288	1250	1260	1193	1230	1286	1274

Appendix Tabel 8.1 . Continued

Components and derived	Secondary CPUE and Equlibrium Catches						EffN, Korean Catch and Devs			
	replace20 with22	All_EqC double	All_EqC half	PS_EqC double	PS_EqC half	TR_EqC double	Efe_sample ALL1	Korean catch	Rdev 4-41	Rdev 4-51
Likelihood components										
Negative log-likelihood	4407,140	4377,330	4519,120	4349,850	4399,880	4367,060	2111,070	4377,900	4366,280	4424,440
indices	-173,580	-186,597	-172,093	-183,890	-198,395	-189,899	-267,134	-188,262	-187,723	-162,053
length_comps	4532,820	4543,850	4540,570	4503,370	4525,090	4533,410	2361,160	4517,640	4512,420	4545,300
Equil_catch	0,080	0,196	1,020	0,045	0,540	0,203	0,089	0,088	0,084	0,177
catch	32,922	4,676	34,343	25,458	22,732	18,083	5,662	32,507	28,260	27,045
Recruitment	15,915	16,227	116,296	5,890	50,934	6,285	12,308	16,948	14,267	14,996
Forecast_Recruitment	-1,022	-1,022	-1,022	-1,022	-1,022	-1,022	-1,022	-1,022	-1,022	-1,022
Estimated SSB										
SSB at 1952	37362,9	34420,7	34966,6	37209,7	39120,0	35663,7	31367,2	35959,3	36278,6	27137,2
SSB at 2005	20685,2	21004,6	22103,4	22893,4	20463,0	20237,3	22897,8	20599,4	23192,7	22822,4
Minimum SSB	7649,3	7292,1	7911,3	7120,6	7072,5	7357,0	7462,5	7867,5	7046,2	7676,8
Maximum SSB	63816,9	61125,6	69155,2	66983,3	64156,0	62991,1	55060,0	63681,5	62172,1	67753,9
CV of SSB	57,1	56,5	58,5	59,6	59,0	57,9	54,8	57,1	57,5	58,4
B0	1342648	1314318	1408649	1343765	1353285	1342199	1343713	1351335	1322004	1379370
Estimated recruitments (REC)										
REC at 1952	21155,9	21188,7	20400,3	21431,7	20276,5	20822,2	23486,4	20888,2	20810,0	19232,7
REC at 2005	8740,6	8556,2	9170,3	8747,9	8809,8	8737,7	8747,5	8797,2	8606,2	8979,7
Minimum REC	2249,3	2138,8	1967,9	2129,3	2004,4	2080,4	2246,2	1881,4	2070,1	2080,4
Maximum REC	25594,4	25134,7	26468,5	25276,2	25897,3	25318,1	24949,5	25596,1	25663,5	28143,7
CV of REC	54,4	51,0	56,1	51,2	54,1	53,5	51,4	52,5	53,2	53,3
R0	10464	10244	10979	10473	10547	10461	10473	10532	10304	10751
SD_REC_dev	0,612	0,564	0,637	0,566	0,608	0,605	0,580	0,616	0,616	0,589
Exploitation rates (EX)										
EX at 1952	0,354	0,354	0,345	0,341	0,358	0,360	0,393	0,363	0,359	0,332
EX at 2005	0,641	0,621	0,589	0,575	0,637	0,645	0,610	0,634	0,559	0,577
Mimimum EX	0,263	0,269	0,252	0,257	0,262	0,265	0,243	0,264	0,266	0,254
Maximum EX	0,848	0,852	0,842	0,860	0,861	0,854	0,846	0,842	0,860	0,845
CV of EX	24,895	24,327	25,164	25,190	25,003	24,586	25,809	24,553	24,524	25,025
Depletion level										
SPR1952	0,020	0,020	0,022	0,020	0,021	0,021	0,015	0,019	0,020	0,009
SSBcurrent/SSB1952	0,554	0,610	0,632	0,615	0,523	0,567	0,730	0,573	0,639	0,841
SSB1952/virginSSB	0,028	0,026	0,025	0,028	0,029	0,027	0,023	0,027	0,027	0,020
BRPs										
Fmax/Fcurrent	0,22	0,22	0,24	0,23	0,22	0,22	0,23	0,21	0,23	0,23
F0,1/Fcurrent	0,146	0,148	0,157	0,152	0,144	0,143	0,151	0,142	0,153	0,151
F20%/Fcurrent	0,305	0,305	0,328	0,328	0,305	0,305	0,305	0,305	0,328	0,328
F30%/Fcurrent	0,211	0,223	0,234	0,223	0,211	0,211	0,223	0,211	0,234	0,223
F40%/Fcurrent	0,152	0,158	0,164	0,164	0,152	0,152	0,164	0,152	0,164	0,164
Fmed/Fcurrent	1,003	1,045	1,069	1,072	1,006	1,001	1,025	0,999	1,082	1,069
SSB at the BRPs										
SSB at Fmax	393208	384263	410677	398706	396839	393444	389580	400532	391679	408770
SSB at F0,1	564339	553904	589942	569902	570368	565692	560889	572717	560111	584497
SSB at F20%	268183	271478	277495	261869	268943	264746	277197	265515	260389	268209
SSB at F30%	409602	388127	412184	409100	410405	404670	398265	406101	385299	419321
SSB at F40%	546285	526666	569072	536304	547364	540360	526371	542557	530970	549934
SSB at Fmed	20741	20354	21692	20803	20917	20718	20851	20878	20434	21363
Yield at the BRPs										
Yield at Fmax	44299	44659	46368	44742	45216	44897	44422	44845	44114	45918
Yield at F0,1	42079	42359	44053	42481	42921	42615	42199	42583	41884	43599
Yield at F20%	42729	43320	44667	42807	43559	43199	43168	42989	42303	43929
Yield at F30%	44276	44657	46367	44733	45200	44886	44415	44842	44110	45909
Yield at F40%	42498	43003	44532	43243	43458	43204	42965	43269	42553	44382
Yield at Fmed	20773	20838	21901	20312	21155	21019	21141	20465	19959	20893
Expected Equilibrium yield at Fmax by gear										
FL1 Japanese LL	8116	8279	8607	8197	8242	8205	7824	8140	8153	8463
FL2 Small pelagic fish P	2603	2488	2738	2079	2577	2546	2962	1982	2049	2144
FL3 Tuna PS	11558	11619	12539	11887	11686	11601	10949	11643	11530	12141
FL4 Japanese troll	734	706	736	660	759	763	830	716	670	683
FL5 Japanese P&L	103	100	103	94	109	110	120	101	95	97
FL6 Japanese Set net	953	897	1009	917	957	944	970	995	889	982
FL7 Taiwanese LL	15218	15570	15424	15939	15847	15730	15662	16089	15649	16265
FL8 EPO PS	3463	3445	3499	3375	3462	3450	3591	3585	3492	3485
FL9 EPO sport	228	248	245	243	235	235	240	243	259	251
FL10 Other	1324	1306	1467	1352	1342	1312	1274	1352	1328	1409
Expected Equilibrium yield at F0,1 by gear										
FL1 Japanese LL	7930	8064	8415	7953	8032	7999	7653	7912	7923	8224
FL2 Small pelagic fish PS	1927	1819	2029	1513	1896	1871	2216	1444	1491	1560
FL3 Tuna PS	10846	10840	11784	11087	10930	10849	10302	10866	10751	11327
FL4 Japanese troll	528	502	529	474	543	545	597	514	481	490
FL5 Japanese P&L	71	69	72	65	76	77	83	70	66	68
FL6 Japanese Set net	732	680	777	703	732	721	745	764	680	754
FL7 Taiwanese LL	16007	16392	16239	16694	16670	16548	16485	16856	16402	17038
FL8 EPO PS	2622	2590	2641	2549	2610	2602	2735	2711	2654	2633
FL9 EPO sport	173	187	185	184	178	178	183	184	197	190
FL10 Other	1242	1216	1380	1260	1255	1226	1200	1262	1238	1315

APPENDIX 9

Report of the ISC Pacific Bluefin Tuna Stock Assessment Working Group
(July 17-18, 2008、 Takamatsu, Japan)

1.0 Introduction

A brief, one and a half-day meeting, 17-18 July 2008, of the International Scientific Committee – Pacific Bluefin Tuna Working Group (ISC-PBFWG) was held in conjunction with the 8th Meeting of the ISC Plenary, Takamatsu, Kagawa Prefecture, Japan, as a continuation of the May-June meeting in order to draft agenda items 7 and 8 of the 2008 stock assessment.

Participants from Chinese Taipei, Japan, Korea, Mexico and the United States attended in the meeting. Y. Takeuchi chaired the meeting and P. Miyake served as rapporteur, continuing his role from the May-June meeting..

2.0 Meeting procedures

The PBFWG held two intercessional sessions since the 7th Meeting of the ISC Plenary, Busan, Korea (July, 2007); one in Shimizu, in December, 2007 and another in Shimizu in May-June, 2008. The December meeting was devoted to data preparation and for framing the SS2 model to be used in the stock assessment. The May-June meeting was devoted to the stock assessment analysis and interpretation of the results.

The PBF Working Group reconvened during 17-18 July 2008 and completed outstanding items for the 2008 stock assessment report. Because additional and supplemental analytical work was performed since the May-June meeting, results of the work were reviewed and informative information incorporated into the May-June report. In addition, new information on Chinese Taipei and Korean fisheries were received and were included in the findings of the Report.

After discussion and consideration of the complete content of the report, the report was finalized and approved by the WG.

3.0 Future meeting schedule

The Working Group Chair suggested that the next WG meeting be held in 10-17 December 2008, possibly on Ishigaki Island, Okinawa Prefecture, Japan. The objective of the WG meeting will be to review and evaluate facets that were revealed by the 2008 assessment..

The WG was informed that the ISC Chair suggested 2011 as the date for the next full PBF stock assessment The WG felt that the final decision on this matter should wait until after the December 2008 meeting, but that the next full stock assessment be completed no later than 2011.

4.0 Adjournment

The meeting of the Working Group was adjourned on July 18, 2008.

5.0 List of Participants

Chinese-Taipei

Shui-Kai Chang
National Sun Yat-sen University
No. 70, Lainhai Rd.
Gushan District, Kaohsiung City
804, Taipei, Taiwan
Phone:
skchang@faculty.nsysu.edu.tw

Kuo-Nan Chung
No. 1, Fishing Harbour North 1st Road
Chien Chen district
Kaohsiung Taipei, Taiwan
Phone:
kuonan@ms1.fa.gov.tw

Shyh-Jiun Wang
Overseas Fisheries Development Council
Republic of China
19, Ln 113, Sec 4, Roosevelt Road
Taipei, Taiwan
886-2-2738-1522 ext. 116, 886-2-2738-4329 (fax)
shyhjiun@ofdc.org.tw

Japan

Naozumi Miyabe
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka, Japan, 424-8633
+81-54-336-6022, +81-54-335-9642 (fax)
miyabe@fra.affrc.go.jp

Hitoshi Honda
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka, Japan, 424-8633
+81-54-336-6034, +81-54-335-9642 (fax)
hkiyofuj@affrc.go.jp

Momoko Ichinokawa
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka, Japan, 424-8633
+81-54-336-6039, +81-54-335-9642 (fax)
ichimomo@fra.affrc.go.jp

Hideo Kiyofuji
National Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka, Japan, 424-8633
+81-54-336-6037, +81-54-335-9642 (fax)
hhonda@affrc.go.jp

Makoto Miyake
Scientific Advisor, NRIFSF
3-3-4 Shimorenjaku, Mitaka-shi
Tokyo, Japan 181-0013
+81 422-46-3917
p.m.miyake@gamma.ocn.ne.jp

Kazuhiro Oshima
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka, Japan, 424-8633
+81-54-336-6034,+81-54-335-9642 (fax)
oshimaka@affrc.go.jp

Toshiyuki Tanabe
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka, Japan, 424-8633
+81-54-336-6045,+81-54-336-9642(fax)
katsuwo@fra.affrc.go.jp

*Yukio Takeuchi (Chair)
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka, Japan, 424-8633
+81-54-336-6039, +81-54-335-9642 (fax)
yukiot@fra.affrc.go.jp

Koji Uosaki
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka, Japan, 424-8633
+81-54-336-6044, +81-54-335-9642 (fax)
uosaki@affrc.go.jp

Kotaro Yokawa
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka, Japan, 424-8633
+81-54-336-6035, +81-54-335-9642 (fax)
yokawa@fra.affrc.go.jp

Korea

Sun-Do Hwang
National Fisheries Research and Development Institute
408-1 Sirang-ri, Gijang-eup, Gijang-gun
Busan, 619-705, Korea
+82-51-720-2334, +82-51-720-2337 (fax)
sdhwang@nfrdi.re.kr

Mexico

Michel Dreyfus-Leon
Instituto Nacional de la Pesca (INAPESCA)
Centro Regional de Investigaciones Pesqueras de Ensenada (CRIP-Ensenada)
KM 975 Carretera Tijuana-Ensenada
Ensenada, Baja California, Mexico
dreyfus@cicese.mx

United States

Jon Brodziak
NOAA/NMFS PIFSC
2570 Dole Street
Honolulu, HI 96822-2396
808-983-2964, 808-983-2902 (fax)
Jon.Brodziak@noaa.gov

Ray Conser
NOAA/NMFS SWFSC
8604 La Jolla Shores Dr.
La Jolla, CA 92037 USA
1-858-546-5688, 858-546-7003 (fax)
rconser@ucsd.edu

Paul Crone
NOAA/NMFS SWFSC
8604 La Jolla Shores Dr.
La Jolla, CA 92037 USA
Phone:
Paul.Crone@noaa.gov

John Childers
NOAA/NMFS SWFSC
8604 La Jolla Shores Dr.
La Jolla, CA 92037 USA
Phone:
John.Childers@noaa.gov

Gerard DiNardo
NOAA/NMFS PIFSC
2570 Dole Street
Honolulu, HI 96822-2396 USA
1-808-983-5397, 1-808-983-2902 (fax)
Gerard.Dinardo@noaa.gov

Kevin Piner
NOAA/NMFS SWFSC
8604 La Jolla Shores Dr.
La Jolla, CA 92037 USA
1-858-546-5613, 858-546-7003 (fax)
Kevin.Piner@noaa.gov

Gary Sakagawa
NOAA/NMFS SWFSC
8604 La Jolla Shores Dr.
La Jolla, CA 92037 USA
1-858-546-7177
Gary.Sakagawa@noaa.gov

Sarah Shoffler
NOAA/NMFS SWFSC
8604 La Jolla Shores Dr.
La Jolla, CA 92037 USA
1-858-546-5678,858 546 5655
Sarah.shoffler@noaa.gov