Annex 14
(Annex 1 of the December 2012 ISC Meeting)

REPORT OF PACIFIC BLUEFIN TUNA WORKING GROUP WORKSHOP

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

10-16 November 2012
Honolulu, Hawaii, U.S.A.

1 Opening and Introduction

The ISC created the Pacific bluefin tuna Working Group (PBFWG) in 1996 to compile fisheries-related and biological statistics, study the biology, and conduct regular stock assessments of Pacific bluefin tuna. The PBFWG completed the most recent comprehensive stock assessment in 2010 (PBFWG 2010). Based on the results of that assessment, the WCPFC/NC adopted a conservation and management measure (CMM) for Pacific bluefin tuna that entered into effect in 2011 (WCPFC 2010 – CMM2010-04), and the Inter-American Tropical Tuna Commission (IATTC) adopted CMMs for the EPO that came into effect in 2012 (IATTC 2012; Resolution C-12-09).

A new comprehensive stock assessment was scheduled for completion in 2012. To support this directive, the PBFWG held workshops in 2011 and 2012 to prepare data sets, develop biological parameters and investigate modeling approaches.

The first PBFWG Workshop was held in May-June, 2012, but a consensus model was not adopted during the meeting. Therefore, it was decided at the ISC Plenary in July, 2012, that this special Workshop would be organized to finalize the assessment modeling and assessments.

1.1 Welcome and introduction

The welcoming address was given by Dr. Samuel Pooley, Director of the Pacific Islands Fisheries Science Center, NOAA.

1.2 Adoption of agenda and participation

The proposed agenda was adopted and is attached as Attachment 1. The meeting was attended by Chinese Taipei, Japan, the Republic of Korea, Mexico, the United States of America, and the IATTC. The list of participants is attached as Attachment 2.

1.3 Appointment of Rapporteurs

It was agreed that the priority for this session would be to complete the stock assessment and then submit a comprehensive report on the status of the stock, including outlooks and recommendations, to the ISC as soon as possible thereafter. It was also agreed that the comprehensive report should cover all past studies, whereas this meeting report describes only the analyses presented and major discussions held during this session.

1.4 Distribution, numbering and determination of availability of working papers

Nine papers and 1 oral presentation were presented to this session. The list of presented papers is attached as Attachment 3.

2 Review of stock assessment input data

2.1 Biological parameters and data for the stock assessment

Estimate the frequency distribution of steepness for PBFT Shigehide Iwata (ISC/12/PBF-3/1, S. Iwata)

Summary

The value of steepness is an important parameter in stock assessment because steepness affects stock-recruitment dynamics and provides a "benchmark" for fish stock management. In this study, we estimated the frequency distribution of steepness for Pacific bluefin tuna with Monte Carlo simulation procedures similar to those used by Mangel et al. (2010). The estimated frequency distribution of steepness for Pacific bluefin tuna indicates that the stock recruitment relationship is sparse (i.e. high steepness value). The probability mass of the steepness values was concentrated from 0.997 to 0.999. This finding justified the decision by the PBFWG to use 0.999 as the steepness value in the stock assessment, with values of 0.8 and 1.0 selected for sensitivity analyses based on the results in this document and those from Mangel et al. (2012).

Discussion

The PBFWG recognized that this working paper provided the clarification sought by the ISC12 plenary concerning the high steepness value (0.999) used in the current Pacific bluefin tuna stock assessment. Because the results confirmed what had previously discussed by the PBFWG, no further discussions were held.

2.2 Fishery data for input of the stock assessment model

2.2.1 Recent Japanese longline CPUE (S1)

The PBFWG held extensive discussions during the May-June PBFWG workshop regarding interpretation of Japanese longline CPUE in recent years. This matter was not resolved and was left for consideration at this PBFWG meeting. Two working papers (ISC/12/PBFWG-3/5 and ISC/12/PBFWG-3/6) related to this matter were presented at the workshop.

SHIFT OF FISHING EFFORTS FOR PACIFIC BLUEFIN TUNA AND TARGET SHIFT OCCURRED IN JAPANESE COASTAL LONGLINERS IN RECENT YEARS （ISC/12/PBFWG-3/5、K. OSHIMA, A. MIZUNO, M. ICHINOKAWA, Y.TAKEUCHI, H. NAKANO AND Y. UOZUMI）

Summary

The paper reviewed a significant decrease in CPUE in the Japanese coastal longline fishery in recent years in relation to changes in fishing operations. The paper suggested that the apparent CPUE decline may have been exaggerated for two reasons: 1) the main fishing ground for vessels targeting PBF has shifted from the Okinawa-Choshi region to the Ishigaki region since 2006; and 2) the major target species in the Okinawa-Choshi region shifted

concomitantly from Pacific bluefin tuna to yellowfin tuna. This may have caused a gradual decrease in catch ability of PBF for the Japanese coastal longline fishery.

Discussion

It was generally accepted that estimates of Japanese longline CPUE for Pacific bluefin tuna have become increasingly uncertain in recent years, which may be related to a shift in the target species from PBF to yellowfin tuna, along with a decline in PBF stock abundance. This uncertainty may be associated with a change in catch ability, which is difficult to model. The PBFWG agreed to evaluate the uncertainty by examining the yearly coefficients of variation (CVs) of the abundance index.

Two proposals were put forward regarding use of the annual CV value: the first entailed linear increases in the CVs after 2005, as approximated from the variance of the nominal CPUE in four areas; the second entailed making an assumption of a base constant variance, with yearly changes in the variance taken from WP#6 and then scaled to have an average of 0.2. The PBFWG decided to use both scenarios in 20 model runs (see PBF stock assessment report for more details).

Estimation of coefficient of variances in standardized CPUE of Pacific bluefin tuna caught by Japanese coastal longline with a nonparametric method (ISC/12/PBFWG-3/6, M. Ichinokawa and Y. Takeuchi)

Summary

The CPUE of Pacific bluefin tuna caught by Japanese coastal longliners was standardized with the delta-lognormal method for use in the stock assessment (Ichinokawa and Takeuchi 2012, ISCPBFWG/12-1/8). In ISCPBFWG/12-1/8, standard errors of the standardized CPUE were calculated by the method described by Shono (2008), where standard errors are analytically derived from variances of estimated parameters by using Taylor expansion and delta-method. This document provides alternative estimates of standard errors (equivalent to CVs in normal scale) of the standardized CPUE by using non-parametric bootstrap method. CVs estimated from non-parametric method are about 3 times higher than those by the analytical method, and showed increases in the early and late time periods. The discrepancy of the estimated CVs between parametric and non-parametric methods would have been caused by heterogeneous spatiotemporal distribution of fishing efforts and CPUE, which were not fully explained by the standardization models.

Discussion

It was pointed out that an analytic method is commonly used to calculate the variance of a delta type standardized CPUE (Shono, 2008). However, if underestimation of the variance by the analytic method is a common phenomenon, as was observed in this study, caution may be necessary when considering use of the analytic method.

2.2.2 Japanese purse seine in the Sea of Japan (F3) particularly on size composition data

A review of the fishery and size data for the purse seine fleet operating in the Japan Sea (Fleet 3). (ISC/12/PBFWG-3/03, H. Fukuda, M. Kanaiwa, I. Tsuruoka, and Y. Takeuchi.)

Summary

In this document, the fishing operational pattern of the purse seiners in the Sea of Japan per set were reviewed in association with size composition and analyzed to understand the gradual changes in yearly size frequency data for this fishery (Fleet 3). We checked the size and age compositions and detailed information on set (date, position, catch amount, etc.). The review suggested clearly that purse seine fleet in the Sea of Japan (Fleet 3) went through a qualitative change in terms of size of fish captured. The yearly fluctuations in size frequencies before 2006 might have reflected the strength of various year-classes because it was difficult to target the fish of a specific age at that time. After 2007, however, the fishing operational pattern changed with the development of a new fishery in June in the north-eastern part of the Sea of Japan that catches only young (age 3-4) fish.

Discussion

The PBFWG generally accepted as fact that the fishing season for Japanese purse seiners in the Sea of Japan (Fleet 3) has begun earlier in the year (from early June) in the northeastern part Sea of Japan than had previously been the case. Since the mid-2000s (probably from 2007), this change in the start of the fishing season has probably resulted in a change of age (or size) selectivity of this fishery to younger (smaller) adult Pacific bluefin tuna. The Working Group also recognized that mixed (in age and size) Pacific bluefin tuna schools have been exploited by this fishery in the western part of the Sea of Japan from late June onward, as described in this working paper.

2.2.3 EPO purse seine fleet in particular recent size composition data

A critical review of PBF length-composition data from the EPO purse seine fishery with new data collected at Mexican PBF pen rearing operations (ISC/12/PBF-3/2, A. Aires-da-Silva and M. Dreyfus)

Summary

Among of the important pieces of information included in the Pacific bluefin tuna Stock Synthesis assessment model are length-composition data from which selectivities are estimated for different fisheries acting on the Pacific bluefin tuna stock. In this paper, we first critically review the available historic Pacific bluefin tuna length-composition data from the EPO purse seine fishery.

Although the observed length range remained more or less stable over the historic period, the same cannot be stated for the average length of the catch. While the average length of the catch fluctuated around about 75 cm (dominantly 1 year old fish) before the mid-1980s, there is a clear shift towards larger fish beginning around the mid-1980s. Average length of the recent Mexican Pacific bluefin tuna fishery is centerd at about 85 cm (showing increase of 2 year olds). We propose three time blocks of selectivity for the EPO purse seine fishery: 1952-1982 (US PBF target fishery); 1983-2001 (a transition phase which includes the US extinguishing and Mexican Pacific bluefin tuna opportunistic fisheries, as well as a development phase of the Mexican Pacific bluefin tuna target fishery); 2002-present (fully developed Mexican Pacific bluefin tuna target fishery).

Concerns have been raised at previous ISC PBF-WG meetings about the representativeness of available Mexican length-composition data obtained from IATTC at sea observer and port sampling programs. For comparison purposes and validating (or not) the reliability of available IATTC length-composition data for the Mexican fishery, we present Pacific bluefin tuna length-composition data collected from stereoscopic underwater cameras during pen transfer operations which took place in 2010 and 2011. The Pacific bluefin tuna average length estimates from the pen data collected in 2010 and 2011 are 92.2 cm (n=1,476) and 92.6 cm fork length (n=2,829), respectively. The new Pacific bluefin tuna length data collected during pen transfer operation matches very well the IATTC observer data collected during the same trips, as well as the length-composition data used in the stock assessment model.

Discussion

The PBFWG noted that relatively large purse seine nets were developed in 2001 and have been widely used by the Mexican fleet since 2002 to catch large Pacific bluefin tuna. Because these purse seines are set deeper than had previously been typical, the PBFWG requested that Mexican and IATTC scientists provide additional information regarding the operations of this fishery.

The PBFWG did not reach consensus concerning the reliability of size composition data from the commercial purse seine fleet, particularly after the decline of the US purse seine fleet in the early 1980s.

Characteristic of size frequency data of Pacific Bluefin tuna from commercial fishery in the Eastern Pacific Ocean in recent years (ISC/12/PBFWG-3/4, S. Uematsu, K. Oshima, S. Iwata and Y. Takeuchi)

Summary

This paper reviewed size frequency data of Pacific bluefin tuna in EPO, relating to the possible increase in size of fish in the catch, based on the year class strength, trans-Pacific migration and changes of fish size sampled. Results are: Pacific bluefin tuna catch in EPO fishery in recent years consisted mostly fish of ages 1-2. During 1993 to 2004, uncertainties are larger as the transition period. The Paper also indicated that Run2 of SS model (time block was applied for EPO fleet) estimated the Pacific bluefin tuna size larger than observed size.

Discussion

It was generally agreed within the PBFWG that the conclusion drawn in this WP was consistent with WP#2. The PBFWG agreed that the introduction and subsequent adoption of deeper purse seine nets by the EPO commercial fleet may have altered selectivity toward older Pacific bluefin tuna in their catch. However, the PBFWG also considered some of the SS runs conducted in May–June 2012, which generated results with a very high proportion of relatively old Pacific bluefin tuna as estimated by the catch-at-age in recent decades, to have been unrealistic.

2.2.4 Remaining fishery data

Catch characteristics and resources management of Pacific bluefin tuna caught by offshore large purse seine in Korean waters (ISC/12/PBFWG-3/9, S. C. YOON, Z. G. KIM, S. I. LEE, M. K. LEE and D. W. LEE)

Summary

It was introduced that catch characteristics of offshore large purse seiner (OLPS) operates in Korean waters and Pacific bluefin tuna (PBF) caught by OLPS fleets. The number of permitted fleets of offshore large purse seiner in Korea has gradually decreased from 48 in 1994 to 25 in 2011. Total catch of OLPS declined from about 459,000 mt in 1986, when had the highest, to about 192,000 mt in 1991, since then it showed the increasing trend till 1996. But it sharply dropped at 185,000 mt in 1997, and then showed the stable trend with a level of 200,000 mt having fluctuations to recent years. The most dominant species of OLPS was common mackerel, which accounted for 59.2% of total catch, and its main fishing season was likely to be October to December. The PBF catch of OLPS was below 500 mt until early 1990s, and tended to increase with a large fluctuation since 1994. The catch peaked at 2,601 mt in 2003, but decreased to 670 mt in 2011. The main fishing season for PBF by OLPS was likely to be March to April. Korea established the Ministerial Directive on Conservation and Management of PBF, and statistic system for PBF catches to enhance the quality and timeliness of data and data reporting.

Discussion

The PBFWG appreciated the efforts by the Korean scientists to provide the review of their purse seine fishery. It was confirmed that the updated, historical Korean Pacific bluefin tuna catches presented herein had been incorporated into the current stock assessment input data. The PBFWG requested that the Korean scientists provide reviews of the size composition of Pacific bluefin tuna catches taken by their fishery to substantiate the proposed changes in the fleet definitions in order to justify separation of the Korean and Japanese purse seine fleets (currently Fleet 2) in the stock assessment.

3 Model results

3.1 Base case model

Two working papers were presented that described preliminary stock assessment results. Based on these results, the PBFWG developed 20 scenarios for final model runs, using one base case (see stock assessment report).

The preliminary result of stock dynamics for Pacific Bluefin Tuna- The descriptions of stock assessment model – (ISC/12/PBFWG-3/7. S. Iwata, K. Oshima, M. Ichinokawa, A. Mizuno, S. Uematsu,H. Fukuda, M. Kai, K. Fujioka and Y. Takeuchi)

Summary

The paper proposes a setting of stock assessment model for Pacific Bluefin Tuna. The problem in duplicating the natural stock by the model for Pacific Bluefin Tuna relates to the complication of the data set. In this paper, the description of parameters to match the fishery information and the fitting the model in a balanced manner to both the size composition data and CPUE time series is presented.

The setting recommended in the document is tried for stock assessment and the results are presented in this document. In the May-June stock assessment meeting, the fit to the CPUE time series for Japanese long line and size compositions were the main concern. This Paper recommended settings of Stock synthesis model 3 (SS3) which intend that the results fit well not only to the CPUE series but also size composition data and that reasonably explain the actual fishery status.

Discussion

The PBFWG discussed the fit of the presented model run to the input data, especially the size composition data. The discussion gave rise to two distinct viewpoints. The first view held that some size composition data (e.g., F4) were influential and prevented the model from attaining a better fit to the longline CPUEs; it was suggested that down-weighting of the size composition data or use of a two-step model fitting approach (see WP#8 and annex xx) might prove necessary. The other view was that a clear modal progression that was consistently apparent in the Pacific bluefin tuna size composition data from several fleets provides good information on the relative strength of cohorts, and that this information should be used instead of severe down-weighting. The PBFWG did not reach consensus regarding use of a two-step fitting approach rather than some unspecified degree of down-weighting to be applied to the size composition data.

Further discussions are found in the Comprehensive Stock Assessment Report.

Preliminary Population Dynamics Model of Pacific Bluefin Tuna (ISC/12/PBFWG-3/8. S. L. H. Teo, K. Piner)

Summary

This paper presents a dynamic model of Pacific bluefin tuna that follows a modeling approach advocated by Francis (2011). Improvement in the representation of the primary tuning indices was the goal of this work. We considered several potential methods to reduce the conflict between indices of abundance and size composition data. These included statistical down-weighting of composition data, addition of model process in the form of time varying selectivity patterns, or a hybrid approach that modeled composition at a fine temporal scale but fixed the selectivity parameters and did not use the size composition in the model total likelihood. Conflict between indices was handled by creating separate models that represented the trends from the different indices. Two models were put forward that tune to either the Japanese Coastal Longline CPUE (ModS1) or the Taiwanese Longline CPUE (ModS9). Overall, both models showed that spawning biomass has declined in the last decade, but the most recent dynamics were different due to the timing of the decline.

Discussion

The PBFWG noted that this Working Paper proposed several changes in the fleet definitions to reconcile observed conflicts between data sets and to improve model fit. The PBFWG also discussed at length the proposed two-step model fitting approach in relation to the size composition data; this aspect of the discussion considered both theoretical and practical perspectives (see annex 1).

3.1.1 Confirmation of key model setting

3.1.2 Minor model setting

3.1.3 Base case model results

The discussion and outcomes from these three agenda items (3.1.1, 3.1.2, 3.1.3) are reported in detail in the Stock Assessment Report. Therefore, these statements are not repeated here.

3.2 Sensitivity analysis

ISC/12/PBFWG-3/7 and ISC/12/PBFWG-3/8 presented under agenda item 4.1 also refer to this section.

3.2.1 Selection of sensitivity scenarios

3.2.2 Sensitivity analysis results

3.3 Future projection scenario and BRPs

3.4 Stock status and conservation advice for Pacific Bluefin tuna

The discussion and outcomes from these four agenda items (3.2.1, 3.2.2, 3.3, 3.4) are reported in detail in the Stock Assessment Report. Therefore, these statements are not repeated here.

4 Work plan and Recommendations

The PBFWG identified five items requiring additional work over and above those identified during the May-June 2012 PBFWG workshop (see the workshop report of the May-June 2012 workshop).

1. Recognizing the potential importance of changes in Japanese coastal longline fisheries in recent years (e.g., a targeting shift from Pacific bluefin tuna to yellowfin tuna), the PBFWG recommended further investigation of the fisheries and improvement of fishery indices to account for such changes.
2. Recognizing that the purse seine fishery operating in the Eastern Pacific Ocean has also undergone historical changes in operations, the PBFWG recommended further detailed review of the fishery in the EPO, especially in the years that followed the introduction to and adoption of deeper purse seine nets by this fishery.

3. Recognizing the importance of size data from the purse seine fishery operating in the Sea of Japan, the PBFWG recommended further investigation of effective sample sizes.
4. Separation of fleets by seasons was suggested for some fisheries in order to improve the fit of the selectivity curves to size data. The PBFWG recommended investigating the effectiveness of such an approach, especially for the purse seine fisheries operating off the Pacific coast of Japan and in the East China Sea.
5. At the second stock assessment in 2012, an iterative method was tried in an effort to estimate and fix the selectivity parameters of the fisheries. The PBFWG recommended that this new method be evaluated for both its theoretical justification and utility when implemented. The PBFWG also recommended investigating any other potentially useful methods for estimating fishery selectivity. This task is expected to be considered at the next PBFWG workshop.

5 Other matters

No other matters were discussed.

6 Clearing of the report

The highest priority for the PBFWG was completion and submittal of the Pacific bluefin tuna Stock Assessment Report in order to permit its adoption by the ISC before the end of 2012. Therefore, the PBFWG decided to rely upon correspondence to finalize and adopt the report after the adjournment of the Workshop.

The report was drafted and circulated later and adopted with some modification.

7 Adjournment.

The meeting was adjourned on November 16. The PBFWG chair appreciated the efforts by all the members to complete the assessment during this session, which resulted in a comprehensive report.

8 Literature cited

ISC. 2012. Report of the Twelfth Meeting of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean, 18-23 July 2012, Sapporo, Hokkaido, Japan.
Available at: http://isc.ac.affrc.go.jp/pdf/ISC12pdf/ISC12_Plenary_Report-FINAL.pdf

Pacific Bluefin Tuna Working Group (PBFWG). 2012. Stock assessment of Pacific bluefin tuna, 10-17 November, 2012, Nagasaki, Japan. Available at:

Mangel, M., Brodziak, J., and DiNardo, G. 2010. Reproductive ecology and scientific inference of steepness: a fundamental metric of population dynamics and strategic fisheries management. Fish and Fisheries 11:89-104.

Attachment 1

Agenda

1. Opening and Introduction (Nov. 10 AM)
1.1. Welcome and introduction (Nov. 10 AM)
1.2. Adoption of agenda (Morning Nov. 10 AM)
1.3. Appointment of rapporteurs (Nov. 10 AM)
1.4. Distribution, numbering and determination of the availability of working papers (10 Nov. AM)
2. Review of stock assessment input data
2.1. Biological parameters and data for the stock assessment (No discussion)
2.2. Fishery data for input of the stock assessment model (Nov. 10 PM – Nov 11PM)
- ✓ Recent Japanese longline CPUE(S1)(WP#5,#6)
- ✓ Japanese purse seine in Sea of Japan (F3) particularly on size composition data(WP#3)
- ✓ EPO purse seine fleet in particular recent size composition data(WP#2,#4)
- ✓ Remaining fishery data(WP#9)

3. Model results
3.1. Base case model (Nov. 10 AM-PM, Nov. 12 AM –Nov 14. AM)(WP#7,#8)
    - ✓ Confirmation of key model setting (Nov. 12 AM)
    - ✓ Minor model setting (Nov. 10 AM-PM)
    - ✓ Base case model results (Nov 13)

3.2. Sensitivity analysis (Nov. 13 PM-Nov. 14AM)(WP#7,#8)
    - ✓ Selection of sensitivity scenarios (Nov. 13PM)
    - ✓ Sensitivity analysis results (Nov 14 AM)

3.3. Future projection scenario and BRPs (Nov 14PM-Nov 15AM, if possible)
3.4. Stock status and conservation advice for Pacific Bluefin tuna (Nov 15 PM)
4. Work plan and Recommendations
5. Other matters
6. Clearing of the report
7. Adjournment
8. Literature cited

Attachment 2

List of participants

Chinese-Taipei
Chien-Chung HSU
Institute of Oceanography National Taiwan University
1, Section 4, Roosevelt Rd., Taipei, Taiwan
hsucc@ntu.edu.tw

Hui-Yui WANG
Institute of Oceanography National Taiwan University
1, Section 4, Roosevelt Rd., Taipei, Taiwan
huiyuwang@ntu.edu.tw

Japan
Hiromu Fukuda
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka, 424-8633
Japan
fukudahiromu@affrc.go.jp

Momoko Ichinokawa
National Research Institute of Fisheries Science
2-12-4 Fukuura, Kanazawa, Yokohama,
236-8648 Japan
ichimomo@fra.affrc.go.jp

Shigehide Iwata
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka, 424-8633
Japan
siwata@affrc.go.jp

Minoru Kanaiwa
Tokyo University of Agriculture
196 Yasaka, Abashiri, Hokkaido, 099-2493
Japan
m3kanaiw@bioindustry.nodai.ac.jp

Toshihide Kitakado
Department of Marine Biosciences Tokyo University of Marine Science & Tech.
5-7, Konan, Minato-ku, Tokyo, 108-8477 Japan
kitakado@kaiyodai.ac.jp

Makoto Miyake
National Research Institute of Far Seas Fisheries
3-3-4 Shimorenjaku, Mitaka-shi, Tokyo,
181-0013 Japan
p.m.miyake@gamma.ocn.ne.jp

Hideki Nakano
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka, 424-8633
Japan
hnakano@affrc.go.jp

Shuya Nakatsuka
Fisheries Agency of Japan
1-2-1 Kasumigaseki, Chiyoda-ku, Tokyo,
100-8907 Japan
shuya_nakatsuka@nm.maff.go.jp

Yumi Okochi
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka, 424-8633
Japan
okochi@affrc.go.jp

Kazuhiro Oshima
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka, 424-8633
Japan
oshimaka@affrc.go.jp

Yukio Takeuchi
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka, 424-8633
Japan
yukiot@fra.affrc.go.jp

Yuji Uozumi

National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka, 424-8633
Japan
uozumi@affrc.go.jp

Mexico

Michel Dreyfus
Centro Regional de Inv Pesquera Km. 97.5,
Carretera Tij-Ensenada Ensenada, Mexico
dreyfus@cicese.mx

Republic of Korea

Mi Kyung Lee
National Fisheries Research and Development Institute
216, Gijanghaean-ro,Gijang-eup,Fijang-gun,
Busan, KOREA, 617-705
mklee@nfrdi.go.kr

Sung ll Lee
National Fisheries Research and Development Institute
216, Gijanghaean-ro, Gijang-eup, Fijang-gun,
Busan, KOREA, 617-705
sllee@nfrdi.go.kr

United States of America

Kevin Piner
NOAA/NMFS/SWFSC
8604 La Jolla Shores Dr. La Jolla, CA, 92037
USA
Kevin.Piner@noaa.gov
Sam Pooley
NOAA/NMFS/PIFSC
2570 Dole Street, Honolulu, HI, 96822 USA
Samuel.Pooley@noaa.gov
Steven Teo
NOAA/NMFS/SWFSC
8604 La Jolla Shores Dr. La Jolla, CA, 92037
USA
Steve.Teo@noaa.gov

Cisco Werner
NOAA/NMFS/SWFSC
3333 N. Torrey Pines Court La Jolla, CA, 92037
USA
Cisco.Werner@noaa.gov

IATTC

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

Mark N. Maunder
Inter-American Tropical Tuna Commission
8604 La Jolla Shores Drive La Jolla, CA,
92037-1508 USA
mmaunder@iattc.org

ISC Chair

Gerard DiNardo
NOAA/NMFS/PIFSC
2570 Dole Street, Honolulu, HI 96822-2396,
USA
Gerard.DiNardo@noaa.gov

Attachment 3

List of Working Papers

No	Title	Author	Contact
ISC/12/PBF WG-3/01	Estimate the frequency distribution of steepness for PBF	Shigehide Iwata	siwata@affrc.go.jp
ISC/12/PBF WG-3/02	A critical review of the PBF length - composition data from the EPO purse seine fishery with new data collected at Mexican PBF pen rearing operations	Alexandre Aires-da -Silva and Michel Dreyfus	alexdasilva@iattc.org
ISC/12/PBF WG-3/03	A review of the fishery and size data for the purse seine fleet operating in the Japan Sea (Fleet 3).	Hiromu Fukuda, Minoru Kanaiwa, Isana Tsuruoka, and Yukio Takeuchi.	fukudahiromu @affrc.go.jp
ISC/12/PBF WG-3/04	The characteristic of recent size frequency data of Pacific Bluefin tuna in the Eastern Pacific Ocean Commercial fishery	Shuhei Uematsu, Shigehide Iwata, Akiko Mizuno, Kazuhiro Oshima, Hiromu Fukuda, Momoko Ichinokawa and Yukio Takeuchi	uematsushu@affrc.go.jp
ISC/12/PBF WG-3/05	Shift of fishing efforts for Pacific bluefin tuna and target shift occurred in Japanese coastal longliners in recent years	Kazuhiro Oshima, Akiko Mizuno, Momoko Ichinokawa, Yukio Takeuchi and Hideki Nakano	oshimaka@affrc.go.jp
ISC/12/PBF WG-3/06	Estimation of coefficient of variances in standardized CPUE of Pacific bluefin tuna caught by Japanese coastal longline with a nonparametric method	Momoko Ichinokawa and Yukio Takeuchi	ichimomo@fra.affrc.go.jp

ISC/12/PBFWG-3/07	The descriptions of stock assessment model for Pacific Bluefin Tuna	Shigehide Iwata, Kazuhiro Oshima, Momoko Ichinokawa, Akiko Mizuno, Shuhei Uematsu, Hiromu Fukuda, Mikihiko Kai, Ko Fujioka and Yukio Takeuchi	siwata@affrc.go.jp
ISC/12/PBFWG-3/08	Preliminary Population Dynamics Model of Pacific Bluefin Tuna	Steven L. H. Teo1, Kevin Piner	Steve.Teo@noaa.gov
ISIIC/12/PBFWG-3/09	Catch characteristics and resources management of Pacific bluefin tuna caught by offshore large purse seine in Korean waters	Sang Chul YOON, Zang Geun KIM, Sung Il LEE, Mi Kyung LEE and Dong Woo LEE	yoonsc@nfrdi.go.kr

Appendix 1

A trial of an iteratively fixing/maximizing procedure over separate likelihood functions in the integrated stock assessment model

Toshihide Kitakado[1*] and Shigehide Iwata[2]

[1]*Tokyo University of Marine Science and Technology, 5-7, Konan 4, Minato, Tokyo, 108-8477, Japan*

[2]*National Research Institute of Far Seas Fisheries, 5-7-1, Orido, Shimizu, Shizuoka, 424-8633, Japan*

**Corresponding author's email address: kitakado@kaiyodai.ac.jp*

The maximum likelihood (ML) method has long been commonly used in fishery science to make inferences about parameters and assess uncertainties in estimates and models. This method has been thoroughly studied theoretically and experimentally, particularly with regard to the asymptotic distribution of ML estimators. There are, however, disadvantages associated with this method when the number of parameters is large (e.g., "The Stein phenomenon", see Stein, 1956; Lehmann, 1983). As a result, several methods such as conditional and marginal likelihood, integrated likelihood and (empirical) Bayesian approaches have been developed (e.g., Cox and Hinkley, 1979; Kalbfleisch and Sprott, 1971) to overcome this difficulty. This concern is relevant in the present context because the Stock Synthesis III assessment model (SSS3) includes many parameters.

The overall likelihood in SS3 is derived from the CPUE series and size compositions, but the method does not always fit the CPUE series or the size composition data satisfactorily. Teo and Piner (2012, ISC/12/PBFWG-3/08) unsatisfactory fits to the size composition data for some fleets, and they proposed an estimation method that entailed fixing the selectivity parameters at values estimated in a preliminary SS3 run, with all parameters estimated simultaneously, as is the default option in SS3.

We acknowledge that the method proposed by Teo and Piner tends to improve the estimation performance by using a partial likelihood treatment. However, from a theoretical point of view, the method might not be appropriate. In this paper, we reexamine their estimation procedure in the framework of a separate likelihood treatment and also suggest a possible extension for better fitting.

Let us suppose that a total likelihood consists of two different sources of data, and that there are two different types of parameter sets as well. Each of the likelihood contributions includes both the parameter sets as in the following formula:

$$L_T(\theta,\varphi) = L_1(\theta,\varphi)L_2(\theta,\varphi)\,.$$

There is a possible situation that each of the two likelihood functions does not have identifiability of the two parameter sets, which means that it is not possible to estimate all the parameters by itself and it is only possible to do estimation when either of two sets of parameters are fixed.

In the SS3 assessment, we can describe Teo and Piner's approach in the framework above. The overall likelihood is decomposed into two parts like the above: 1) the primary part is a likelihood contribution from the CPUE series and size compositions of fleets when fit to their frequencies; 2) the residual part is a likelihood contribution from the size compositions for some fleets in which fitting has been problematic. The parameter set φ includes the selectivity parameters relevant to the fleets for which the residual likelihood is defined, and θ includes the remaining parameters. In their method, at the initial step, the overall likelihood function is maximized simultaneously as

$$(\hat{\theta}_0,\hat{\varphi}_0) = \arg\max_{\theta,\varphi} L_T(\theta,\varphi)$$

and the primary likelihood was then maximized by fixing the selectivity parameters $\hat{\varphi}_0$ as follows:

$$\hat{\theta}_1 = \arg\max_{\theta} L_1(\theta,\hat{\varphi}_0)\,.$$

It might be a possible to improve the fits of the size compositions from some specific fleets by this treatment. However, we wish to express the following concerns about this method:

1) If the estimate $\hat{\theta}_1$ is thought to be more realistic than $\hat{\theta}_0$, then the selectivity parameter φ can be updated by using the residual likelihood according to the formula $\hat{\varphi}_1 = \arg\max L_2(\hat{\theta}_1,\varphi)$. If the newly derived estimate $\hat{\varphi}_1$ is different from the initial one $\hat{\varphi}_0$, the the updated estimate $\hat{\varphi}_1$ may be preferable and should be used for fixing the parameter values.

2) If the newly derived estimate $\hat{\varphi}_1$ is close to $\hat{\varphi}_0$, the estimate $\hat{\theta}_1$ given $\hat{\varphi}_0$ may also be almost close to $\hat{\theta}_0$ and therefore such treatment might not be meaningful. Furthermore, the partial

likelihood given a fixed parameter may be problematic when assessing the estimation uncertainty. If $\hat{\varphi}_0$ is regarded as problematic, the estimate $\hat{\theta}_1$ depending on that estimate $\hat{\varphi}_0$ may be as well.

In this regard, we think that Teo and Piner's method can be modified. Here, we propose an iterative procedure to update parameters continuously by going back-and-forth over the two separate likelihood functions, while maximizing one set of parameters given the other set of parameters and vice-versa (Fig 1). The iterative

$$\hat{\theta}_1 = \arg\max_{\theta} L_1(\theta, \hat{\varphi}_0) \quad \hat{\theta}_2 = \arg\max_{\theta} L_1(\theta, \hat{\varphi}_1) \quad \hat{\theta}_3$$

$$\hat{\varphi}_1 = \arg\max_{\varphi} L_2(\hat{\theta}_1, \varphi) \quad \hat{\varphi}_2 = \arg\max_{\varphi} L_2(\hat{\theta}_2, \varphi) \quad \cdots$$

Figure 1. The iteration process for updating the parameters over two separate likelihood functions

We conducted a small experiment by applying the method to the dataset for the Pacific bluefin tuna fishery. In this exercise, the fleets with the special treatment were F4 and F11. It was shown that the iteration process could reach convergence and provides a seemingly reasonable result; the fits to the CPUE series and size compositions improved more than was the case with simultaneous estimation, which is the default method in SS3.

Step 1	$(\hat{\theta}_0, \hat{\varphi}_0)$	Step 6	$(\hat{\theta}_3, \hat{\varphi}_2)$
Step 2	$(\hat{\theta}_1, \hat{\varphi}_0)$	Step 7	$(\hat{\theta}_3, \hat{\varphi}_3)$
Step 3	$(\hat{\theta}_1, \hat{\varphi}_1)$	Step 8	$(\hat{\theta}_4, \hat{\varphi}_3)$
Step 4	$(\hat{\theta}_2, \hat{\varphi}_1)$	Step 9	$(\hat{\theta}_4, \hat{\varphi}_4)$
Step 5	$(\hat{\theta}_2, \hat{\varphi}_2)$		

We recognize the possibility that the convergence was attained by chance and we deny any possibilities that some sort of oscillations occurs in other scenarios, and therefore it should be noted that full evaluation via theoretical aspects and simulation experiments should be provided. In addition, an associated method for assessing the estimation uncertainty under this procedure should be developed. Therefore these warrant further investigation for the proposed method.

REFERENCES

Cox, D.R. and Hinkley, D.V. (1980) Theoretical Statistics. Chapman & Hall/CRC.

Kalbfleisch, D.A. and Sprott, J.D. (1970) Application of likelihood methods to models involving large numbers of parameters, JRSS B, 32: 175—208.

Lehmann, E.L. (1983) Theory of Point Estimation. Wiley.

Stein, C.M. (1956) Inadmissibility of the usual estimator for the mean of a multivariate normal distribution. Proc. 3rd Berkeley Symp. Math. Statist. Probab., Vol. 1: 197–206.

Teo, S.L.H. and Piner, K. (2012) Preliminary population dynamics model of Pacific bluefin tuna. ISC/12/PBFWG-3/08.

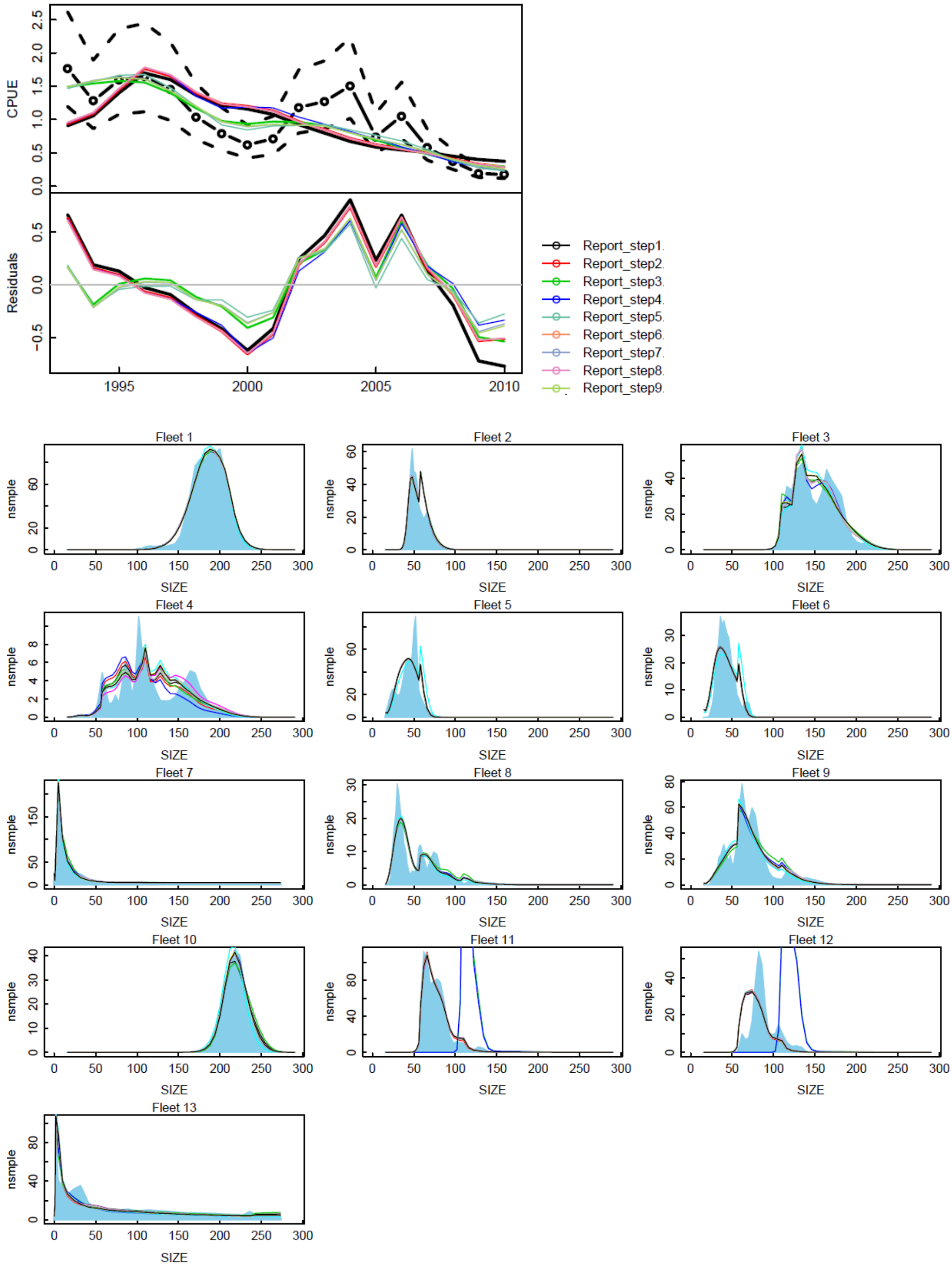


Figure 2. Processes of updates in fit to the JPN_LL CPUE and size compositions.

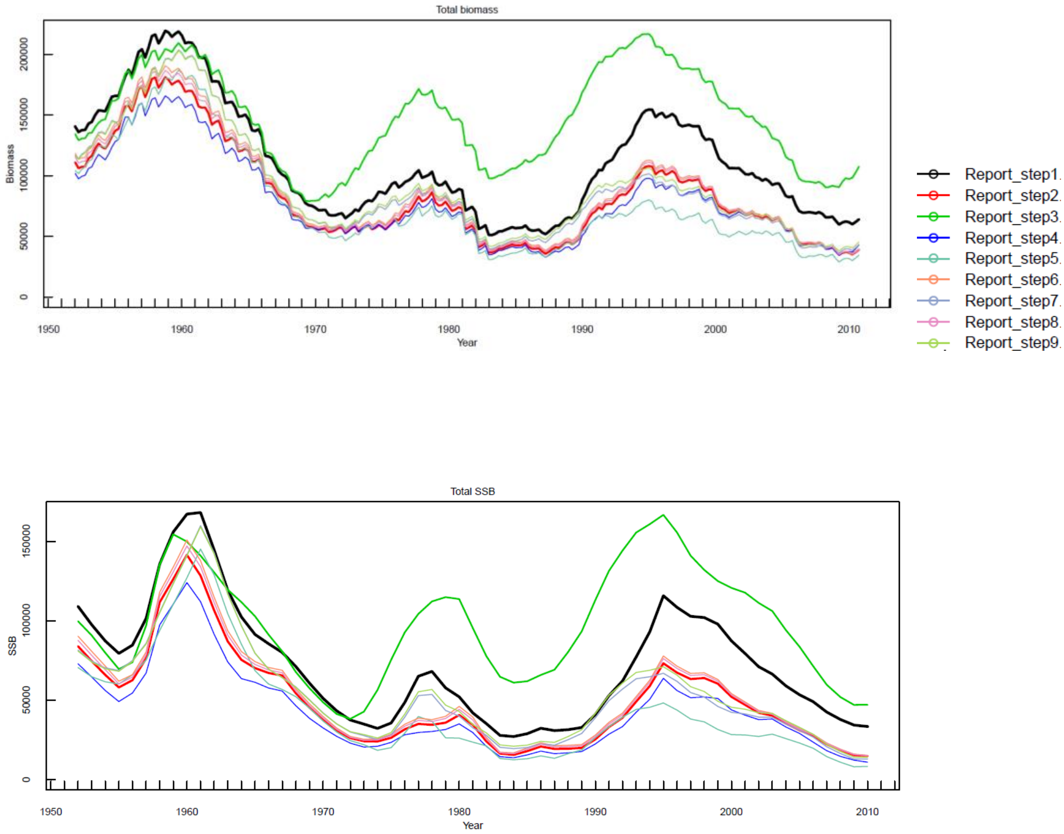


Figure 3. Processes of updates of trends in the total biomass and SSB.

Appendix 2

REPORT OF PACIFIC BLUEFIN TUNA WORKING GROUP WORKING GROUP MEETING

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

14-15 July 2013
Busan, Korea

1.0 OPENING AND INTRODUCTION

1. Welcome

The Chair of the Pacific Bluefin Tuna Working Group (PBFWG), Y. Takeuchi (Japan) opened the meeting at 9:30 on 14 July 2013 and thanked participants for their attendance. He highlighted the main objectives of the meeting as a review and update of statistics; progress with tasks assigned by the ISC Plenary in December 2012; developing a response to the recent Pacific Bluefin Tuna (PBF) stock assessment peer review; and planning for the work of the PBFWG over the coming year.

The Chair expressed the appreciation of the PBFWG to its Korean hosts for a spectacular seafood banquet held on the first evening of the meeting.

2. Adoption of Agenda

The Chair introduced the agenda for the meeting and the PBFWG adopted it (Attachment A). A list of participants is provided as Attachment B, and list of working papers can be found in Attachment C.

3. Appointment of Rapporteurs

S. Clarke was appointed as the lead rapporteur for the meeting and support rapporteurs were assigned by the Chair as follows: Item 2-Review and Update of Fishery Statistics (M. Dreyfus, Y. Ishida); Item 3.1-Review of results of additional future projections assuming low recruitment (S. Teo, K. Oshima); Item 3.2-Reference points (M. Ichinokawa, H. Park); Item 3.3-Fishery impact analysis (Y. Hiraoka); Item 3.4-Kobe plots (S. Teo, Y. Ishida); Item 4.1-Discussion of the CIE review (S. Shoffler); 4.4-Recommendations for the ISC 13 Plenary (K. Piner, H. Fukuda).

2.0 REVIEW AND UPDATE OF PBF FISHERY STATISTICS

The Chair asked for each delegation to briefly present any updates to their fishery statistics. A catch table reflected the latest updated statistics is attached as PBFWG December 2012 WG Report, Appendix H.

2.1 PBF Fishery Statistics of Mexico

Mexico conducts a target fishery for PBF in the Eastern Pacific Ocean (EPO). Updated catch statistics for 2011 show a catch of 2,700 t for the purse seine fleet and 1 t for other fleets (mainly pole and line, but also including longline). For 2012, preliminary data show catches of 6,667 t for the purse seine fleet, and 1 t for other fleets.

Discussion

In response to a question about management regulations in the EPO for 2012-2013, it was explained that there is a biannual quota of 10,000 t for commercial fisheries, and the remaining quota for 2013 is 3,292 t. The amount of catch recorded thus far for 2013 is approaching the limit of the remaining quota but has not exceeded it.

2.2 PBF Fishery Statistics of Chinese Taipei

PBF is mainly caught by the offshore and coastal small-scale tuna longline fleet fishing off Chinese Taipei. The main fishing season is from April to June. The catch of this fleet in 2012 was 210 t which is a historically low value compared to recent years (e.g. the catch in 2011 was 292 t and the catch through June 2013 is 280 t).

Discussion

A question was raised regarding incidental catches of PBF by set net gear. In response it was explained there are about 19 set net vessels targeting pelagic species with some incidentally taking PBF off Eastern Taiwan. Their catch, which is generally less than 10 t per year, is included in the “other” fleet catch statistics for Chinese Taipei. Individual weights of these fish are available; sizes are not measured but are generally > 150 cm.

2.3 PBF Fishery Statistics of Korea

Korea reported that its catch of PBF in 2012 by offshore large purse seiners was 1,421 t and by coastal trollers was 1.1 t. In 2012, the number of offshore large purse seiners was 24, and the number of coastal trollers was 34. Catches occur in the waters around Jeju Island throughout the year but catches are highest in May and < 10 t from August to November. The peak periods of monthly catches differ from year to year. Size composition data showed that for 2012 the average length was 53.5 cm FL, an increase of 7 cm compared to 2011. On 6 June 2013, a pop-up archival tag (MK-10) was attached to a 78 cm FL Pacific bluefin tuna.

Discussion

In response to a query regarding why catches by Korean set net fisheries are not shown in the catch statistics, it was clarified that these statistics are currently compiled but not included in the statistical data reported by Korea to the ISC.

Japan noted that it has been able to compile some data on Korean set net fisheries from import declarations submitted to Japanese customs authorities by Korean exporters. Korea asked that these data be discussed by the Statistics Working Group and stated that it is continuing its efforts to improve data collection and reporting across gear types to produce more complete catch table statistics for next year. Korea also indicated they will continue their tagging program for PBF.

Clarification was requested regarding whether all Korean purse seine vessels catch PBF or whether the number of vessels cited simply reflects the number of purse seines registered. It was clarified that the number of offshore large purse seiners cited refers to the number registered, but that all of these catch PBF as bycatch.

2.4 PBF Fishery Statistics of the United States

The United States (US) currently does not have any commercial fishery that is directed at PBF but a purse seine fishery and other miscellaneous fisheries opportunistically catch and land this species. In addition, a recreational sport fishery based in the US and operating in both US and Mexican waters, targets a suite of highly migratory species, including PBF. In 2012, the US purse seine and other miscellaneous fisheries landed 0 and 43 t, respectively. The US sport fishery caught 617 t in 2012. The 2011 and 2012 catches are still currently considered provisional.

Discussion

In response to a question regarding why the recreational catch is increasing, it was explained that that sport fishing effort is known to track the trends in the US economy and there is no evidence suggesting increased targeting of PBF by recreational fishers. The discussion also considered whether there might be sufficient information in a sport fishing index of abundance to inform future modeling, and the PBFWG agreed that use of such data in the future might be worthwhile.

2.5 PBF Fishery Statistics of Japan

K. Oshima (Japan) informed the group that Japan’s total catch of PBF in 2012 was 6,283 t, which is the second lowest annual catch on record. Apparent decreases of catch in 2012 were observed in the fisheries of tuna purse seine and small purse seine, longline and troll fisheries. Of particular note, an unusually small troll catch in 2012 was highlighted.

K. Oshima also made a presentation on how annual catches of age 0 PBF for farming from 1998 to 2012 were derived from catch statistics for the troll fishery (PBFWG December 2012 WG Report, Appendix A). The analysis used three types of data sources with different coverage rates to estimate the total number of fish released into sea pens. The following two assumptions were made in order to estimate the catch in weight for farming:

i. The number of fish which died or were excluded before release into sea pens is equal to the number of PBF released into sea pens; and

ii. Individual weight is assumed to be 0.25 kg and is used as conversion factor to estimate catch in weight.

The years of 1998 to 2003 are regarded as a developing period for the fishery. Hence, it was assumed that the catch in number for farming increased linearly from 1998 to 2004.

Discussion

In response to a question it was explained that RJB (Research project on Japanese Bluefin tuna) is a data source comprised of sales slips compiled from the main landing ports for PBF in Japan since 2004. The JFA (Japan Fishery Agency) data derives from a survey of PBF catch in Japan’s coastal areas but does not represent complete coverage and did not begin until 2008. Data from fish farmers has 100% coverage but only began in 2011. This study focused on the troll fishery because this new source of data can supplement other data from the purse seine fishery. Special methods are required to assess age 0 PBF catches by the troll fishery for fish farms because in general live fish are not measured, only counted, and so are not always included in troll fishery catch statistics. Fish which die before reaching the farms are usually discarded but this is accounted for by the assumptions in the estimation methodology.

In response to another question regarding differences in annual catch values between purse seine and troll fisheries, it was explained that the troll fishery catches age 0 fish and that small purse seiners catch age 1 fish. There appears to be a correlation between catch in the troll/purse seine fisheries and recruitment, or recruitment with a one-year lag, respectively.

The PBFWG also discussed whether using linear interpolation between the small catch value at the start of the fishery (1998) and 2004 was the best approach to filling this historical data gap. Since catch depends on recruitment, it was suggested to define a ratio between the catch for farming and the total catch in years where both are known and then using this ratio to fill the data gap for the missing years. The PBFWG agreed that this approach has merit and should be applied as a sensitivity test.

Y. Hiraoka (Japan) presented an update of the standardized catch per unit effort (CPUE) series for Japanese coastline longliners using data through 2012 and the same method as Ichinokawa and Takeuchi (2012) used for this fishery through 2011 (PBFWG December 2012 WG Report, Appendix B). Both nominal and standardized CPUEs decreased in 2012, but these should be considered provisional values because the data are still incomplete. The target and fishing ground shift which is mentioned by Oshima et al. (2012) could not be considered carefully in this study. Thus, the standardization method should be improved.

K. Oshima (Japan) presented an update of the CPUE series for the Japanese troll fishery targeting age 0 PBF (PBFWG December 2012 WG Report, Appendix C). This CPUE series is used as a recruitment abundance index for age 0 PBF in the stock assessment and was updated using data through 2011. The data source and the methods applied for standardizing CPUE were identical to those in Ichinokawa et al. (2012). Residuals distributed centrally around zero, but their distributions showed a slight leftward skew. Standardized CPUE decreased in 2012 such that it was slightly below the historical average.

Discussion

The group discussed the potential reasons behind an apparent shift in recruitment levels before and after 1993 and whether this may be due to environmental or fishery factors. It was noted that there is some evidence for this shift in several different data sources. The group agreed that while it would be interesting to look into these questions in more detail in the future, at this point it is sufficient to note that the 2012 CPUE value for the longline fishery has declined relative to 2011, and that the 2011 CPUE value for the troll fishery is also slightly less than 2010 but within the range of variability for recent years.

3.0 REVIEW OF WORK TASKED FROM ISC PLENARY IN DECEMBER 2012

3.1 Review of results of additional future projections assuming low recruitment

The ISC Chair introduced this work by explaining that the ISC Plenary in December 2012 requested the PBFWG “conduct additional projection scenarios with recruitment levels consistent with the lower values estimated in the 1980s”. The PBFWG Chair then introduced work undertaken on the requested additional future projections with two scenarios of low recruitment levels (PBFWG December 2012 WG Report, Appendix D). In order to meet the ISC Plenary’s request, two types of future recruitment scenarios were considered: i) future recruitment levels will continue at the level of 1980-1989 i.e. average recruitment was 10 million fish per year, ii) future recruitment for the first 10 years will be at the level of 1980-1989, but will subsequently recover to an average levels calculated from values from 1952-2009.

Discussion

There was some discussion of the usefulness of conducting projections for 30 years since it was considered that managers would be most interested in the immediate future. In this sense there may not be any meaningful difference between the two recruitment scenarios since they assume the same recruitment in the first ten years. Nevertheless, as the group agreed that the duration of low recruitment periods are difficult to predict, the two alternative scenarios provide some useful insight into the implications for varying duration of the low recruitment period.

It was noted that under conditions of low recruitment, either with or without catch limits (capping), the risk that spawning stock biomass (SSB) will fall below historically low SSB levels will increase if F approximates 2007-2009 levels and will remain small in the long term if F approximates 2002-2004 levels. Low recruitment could result from either environmental conditions or because the stock size falls to such a low level that the number of spawners available is not sufficient to maintain recruitment levels.

The PBFWG discussed that the F levels at 2002-2004 and 2007-2009 in combination with catch limits assumed in the projections may or may not reflect the current implementation of either the WCPFC or IATTC management measures. For future work, the PBFWG agreed that more information from the WCPFC NC and IATTC through the ISC Chair on actual implementation of the management measures would help ISC to improve model projections.

3.2 Discussion of Reference Points

The ISC Plenary in December 2012 requested that the PBFWG "pending approval from the WCPFC-NC, conduct reference point research similar to that being conducted for North Pacific albacore and swordfish." Regarding this matter, H. Fukuda (Japan) presented a paper which addressed this request in terms of the following two specific questions posed by the ISC Plenary (PBFWG December 2012 WG Report, Appendix E):

i. Is the stock-recruitment relationship known, and in particular a reliable estimate of the steepness parameter (h) for the stock?

ii. Are the key biological (natural mortality, maturity) and fishery (selectivity) variables reasonably well estimated?

The paper described some of the key biological (stock recruitment and steepness, maturity and fecundity, natural mortality, growth) and fishery (selectivity) variables and whether or not these variables are reasonably well-estimated. The background to how the PBFWG decided to set these variables in the stock assessment model, and uncertainty in the parameters relating to steepness, fecundity, and selectivity, were also discussed. The author added an explanation about the necessity to revise a part of steepness parameter. This was necessary because although using growth parameters to estimate steepness is entirely consistent with the approach in the stock assessment model, the length-weight relationship is not same in the estimation of steepness and stock assessment model.

Discussion

It was remarked that although there are detailed studies on the fecundities of the PBF as described in the paper, the current PBF stock assessment has used a rather simple hypothesis to assume proportionality between fecundity at age and weight at age, as a "rule of thumb" in fish stock assessment applied when information on fecundity is lacking. After discussion the PBFWG agreed that this paper should be submitted to the ISC Plenary in response to the request.

S. Uematsu (Japan) prepared a paper which addresses part of this question, i.e. future projection under suites of biological reference points and examination of the effects under different recruitment regimes (Working Paper ISC/13/PBFWG-1/01). Future F-levels were combined with catch limits for purse seine fleets as four different scenarios. The results were as expected and consistent across two base selectivities (averages of 2002-2004 vs. 2007-2009), i.e. a restrictive future F corresponding to a lower F-based reference point reduced the risk of future SSB falling below a certain threshold SSB level except in the case of Floss, in which the catch limits of one of purse seine fleets had different effects across two base selectivities.

Discussion

During discussion it was clarified that if any one of the simulations in any one of the years within the five-year period falls below the threshold, then that simulation is considered to count as a "failure". This is consistent with the methodology applied in the stock assessment. However, it was questioned how "failures" were counted when the threshold is considered as a target rather than a limit, i.e. when values may fluctuate around the threshold.

It was also noted that while the first two probability columns are measuring "failures" (i.e. how often a minimum level is breached), the third and fourth probability columns appear to be measuring "successes" (i.e. how often a minimum level is not breached). This makes it more difficult to interpret the table.

Other comments were raised regarding the selection of reference points and whether they are i) appropriate for PBF; and ii) sufficiently aligned with the parameter estimates produced by the PBF stock assessment models.

The Chair agreed to liaise with the author of the paper to address these issues, if possible. Given that there was no consensus on whether to accept this paper, it was agreed to refer to it as a working paper associated with this meeting and to place it on the ISC website. The PBFWG also agreed that further work on candidate reference points will need to be postponed until clear, and PBF-specific direction is received from the Plenary regarding which reference points should be considered.

3.3 Fishery impact analysis

H. Fukuda (Japan) presented a fishery impact analysis designed to document the effects of various groups of fishing fleets on the stock (PBFWG December 2012 WG Report, Appendix F). The groups modeled included western Pacific longliners, western Pacific purse seiners, eastern Pacific fisheries (purse seine and recreational fisheries), and other Japanese coastal fleets (pole and line, troll, set net, etc.). Fishery impact plots were developed using Stock Synthesis 3.23b and parameters estimated by the representative run of the 2012 stock assessment. Despite a technical problem associated with the initial equilibrium age structure, the results illustrated the effect of the four fishery groups on the SSB. Historically, the western Pacific coastal fishery has had the greatest impact on the stock, but since about 1999 the western Pacific purse seine fleet's impact has increased to the point where it is currently greater than any other group. The impact of the eastern Pacific fishery was large before the mid 1980s, but decreased after the 1990s. The western Pacific longline fleet has had a limited effect on the stock throughout the analysis period.

Discussion

A query was raised regarding whether these results are similar to those from a fishery impact assessment conducted by IATTC. It was noted that the results are similar in the period analyzed by both models, but explained that in the ISC model results prior to 1970 were truncated because they were deemed unreliable.

Another issue discussed was whether an analysis of grouped fleets, rather than individual fleets, can fully address management concerns. It was noted that the results should be considered as indicative and thus not appropriate as the basis for fine-scale management decisions. The increasing impact of the purse seine fleet was attributed to i) its growth in the western and central Pacific and ii) to a relative increase in its proportion of the total catch as other fleets, such as the purse seine fleet in the eastern Pacific, decreased.

3.4 Kobe plots

K. Oshima (Japan) presented two versions of a Kobe plot prepared in response to requests from the ISC Plenary in December 2012. One version uses reference points of SSB20% and SPR20% and indicates that PBF have been overfished and overfishing has occurred during almost the entire assessment period. The other version is based on reference points of SSBmed and Fmed and shows that stock status has moved through all quadrants of the plot during the assessment period.

Discussion

The PBFWG noted that because no reference points for PBF have yet been agreed, these versions of the Kobe plot chose arbitrary reference points; other reference points can and will be considered. The PBFWG also discussed whether the Kobe plots should be modified to include projections of stock status, e.g. a point representing the projected stock status for 2012 or a projection of ten years, and whether such projections would best be plotted separately or as an overlay. These presentational issues, as well as issues of which projections should be used for plotting, could not be resolved. Therefore, it was agreed to present the two Kobe plot versions as they are for further discussion by the ISC Plenary (PBFWG December 2012 WG Report, Appendix G).

4.0 WORK PLAN

4.1 Discussion of the CIE Review

The PBFWG Chair explained that the Center for Independent Experts (CIE) peer review report of the PBF stock assessment was received recently. The PBFWG was invited to consider the peer review report to i) prepare a response to the peer review for the ISC Plenary’s consideration; and ii) incorporate useful suggestions into the PBFWG’s planning for future work.

The US scientists explained that since the CIE review was contracted through the National Oceanic and Atmospheric Administration (NOAA) it is likely that NOAA will wish to provide a response to the review alongside the release of the review to the public. The exact mechanism and timing of this is unknown but it is likely to be posted on one of NOAA’s websites by the beginning of October. PBFWG members from the US will clarify the schedule and process for a NOAA response to the peer review following ISC13. Also they will consider any feedback from the PBFWG when preparing the NOAA response. Once a US response is released the PBFWG can consider that response when developing its own response.

PBFWG members suggested that a table of peer review comments prepared by Japan could be used as a starting point for the PBFWG to prioritize comments for action and to identify those comments that have arisen from misunderstandings. It was agreed that Y. Ishida (Japan) would lead the compilation of responses and prioritization electronically before the next intercessional PBFWG Workshop (WS) so that the ISC response can be finalized at that workshop. At that time, the PBFWG work plan will also be finalized.

4.2 Schedule for the next workshop

The Chair of the PBFWG reminded the group that one of the key tasks for the next meeting would be to complete the response to the CIE peer review and to finalize the PBFWG's Work Plan. In addition, the PBFWG was invited to consider three options for the next round of analysis on the status of the stock: an evaluation of fishery indicators; a update of the existing stock assessment with additional one or two years of data; or a new full stock assessment. The Chair noted that the next PBF stock assessment was scheduled for completion by ISC15. It was also noted that the next workshop of the PBFWG may also consider a new suite of projections based on any new information regarding PBF management measures that may become available through communications with relevant RFMOs (WCPFC (NC) and IATTC) or based on new requests from the ISC Plenary.

It was agreed that an update of the existing stock assessment would be the best option as it would allow the PBFWG and managers to closely track the stock status by modeling the most recent data and paying close attention to recruitment trends. Further clarification was sought on what changes to the existing stock assessment model could be accommodated in the update, e.g. could changes be made to steepness or natural mortality parameters in response to the peer review. It was generally agreed that the previous base case (the representative run) should be maintained and re-run with the updated data, and any changes to the model should be handled as sensitivity runs. By the same token, all data processing routines such as standardization or estimation methodologies should remain unchanged and simply be updated with the new data. Changes to historical data, e.g. if errors are discovered, should also be handled as sensitivity runs.

The PBFWG Chair asked members whether it would be possible to for them to provide all relevant data through the first half of 2013, corresponding to the end of the 2012 fishing year, by early December 2013. This would include abundance indices for the Japanese and Chinese Taipei longline fisheries and the Japanese troll fishery; quarterly catch time series; and size composition data. All members confirmed that they would do their best to compile and provide these data within the suggested timeframe. It was acknowledged that sufficient time would need to be allowed for the modeling in order to ensure that the models converge.

It was agreed that the most useful timing for the update stock assessment would be in the first quarter of 2014. The Chair asked for nominations for a venue for the next meeting and the possibility of holding the meeting electronically was raised for consideration. It was noted that the scheduling and resourcing issues associated with the ISC WG meetings would be discussed by the ISC Plenary and the calendar would be finalized at ISC13.

4.3 Schedule for the Ageing workshop

The PBFWG noted that the PBF ageing workshop is now scheduled for 13-15 November 2013. Up to three experts can be invited to attend and at this time only Dr Jessica Farley of CSIRO is confirmed. Other potential candidates were discussed and it was noted that further planning would be conducted at a meeting to be held in the margins of the ISC Plenary.

4.4 Recommendations for ISC13 Plenary – Stock Status and Conservation Advice

The PBFWG reviewed the previous stock status and conservation advice text and discussed the need to update this text based on the finding of this meeting. The following text was agreed:

Stock Status

Based on the reference point ratios, overfishing is occurring (see F-based ratios in Table 1 in the intercessional plenary report in Dec 2012(ISC 2012)) and the stock is heavily overfished (see depletion ratios in Table 1 in ISC 2012). Model estimates of 2010 SSB are at or near their lowest level and SSB are at or near their lowest level and SSB has been declining for over a decade; however, the 2012 stock assessment which used data through the first half of 2011 did not find evidence of reduced recruitment.

Newly available fishery data were presented. Concerns about stock status were reinforced by reported catches in 2012 that were lower than those reported in previous years across a number of fisheries in the Western and Central Pacific Ocean catching juvenile and adult PBF. CPUE in the troll fishery in 2011 was within the range of variability for recent years, but the unusually small amount of catch in the troll fishery in 2012 may be a sign of very low recruitment which might signal reoccurrence of low recruitment similar to that observed in the1980s. Japanese longline CPUE continued to decrease in 2012 and indicates no sign of stock recovery. This information suggests that the potential risk of decline of the spawning stock may be higher than previously thought. It was noted that under conditions of low recruitment, the risk of SSB falling below the historically lowest SSB level will increase under F2007-2009 conditions while the risk under F2002-2004 conditions will remain small in the long term despite some short term risk.

Conservation Advice

The current (2010) PBF biomass level is near historically low levels and experiencing high exploitation rates above all biological reference points (BRPs) commonly used by fisheries managers. Based on projection results, extending the status quo (2007-2009) fishing levels is unlikely to improve stock status. Continued monitoring of abundance indices is recommended to track SSB.

Recent WCPFC (entered into force in 2011) and IATTC (entered into force in 2012) conservation and management measures combined with additional Japanese voluntary domestic regulations aimed at reducing mortality, if properly implemented and enforced, are expected to contribute to improvements in PBF stock status under historical average recruitment conditions. However, preliminary data indicating an unusually low catch of age 0 PBF in 2012, which may imply low recruitment, and if confirmed, is expected to adversely affect projected stock rebuilding. Strengthening the monitoring of recruitment is highly recommended to comprehend the trend of recruitment in a timely manner. Further reduction of fishing mortality is expected to reduce the risk of SSB falling below its historically lowest level.

Based on those findings, it should be noted that implementation of catch limits is particularly effective in increasing future SSB when strong recruitment occurs. It is also important to note that if recruitment is less favorable, a reduction of F could be more effective than catch limits to reduce the risk of the stock declining.

The ISC requires advice from the WCPFC regarding which reference point managers prefer so that it can provide the most useful scientific advice. Until which time a decision is rendered, the ISC will continue to provide a suite of potential biological reference points for managers to consider. PBF is currently (2010) near historically low biomass levels and experiencing high exploitation levels above BRPs. Extending the status quo (2007 – 2009) fishing levels is unlikely to improve the stock condition.

5.0 ELECTION OF THE WG CHAIR

The ISC Chair thanked Y. Takeuchi (Japan) for his two terms of service as the Chair of the PBFWG and noted that due to a two-term limit for ISC WG Chairs, election of a new Chair was necessary. Japan nominated Z. Suzuki (Japan) and he was elected unanimously by the PBFWG.

6.0 OTHER MATTERS

No other matters were discussed.

7.0 CLEARING OF THE REPORT

The report was cleared by the PBFWG in July 18.

8.0 ADJOURNMENT

The meeting was adjourned at 5:00 on the afternoon of July 15.

9.0 REFERENCES CITED

Ichinokawa, M. and Takeuchi, Y. 2012. Estimation of coefficient of variances in standardized CPUE of Pacific bluefin tuna caught by Japanese coastal longline with a nonparametric method. Working paper submitted to the ISC Pacific Bluefin Tuna Working Group Meeting, 10-17 November 2012, Honolulu, Hawaii, USA. ISC/12/PBFWG-3/06. Available at: http://isc.ac.affrc.go.jp/pdf/PBF/ISC12_PBF_3/ISC12_PBFWG-3_06_ichinokawaRev.pdf

Oshima, K., Mizuno, A., Ichinokawa, M., Takeuchi, Y., and Nakano, H. 2012b. Shift of fishing efforts for Pacific bluefin tuna and target shift occurred in Japanese coastal longliners in recent years. Working paper submitted to the ISC Pacific Bluefin Tuna Working Group Meeting, 10-17 November 2012, Honolulu, Hawaii, USA. ISC/12/PBFWG-3/05. Available at: http://isc.ac.affrc.go.jp/pdf/PBF/ISC12_PBF_3/ISC12_PBFWG-3_05_Oshima.pdf

Ichinokawa, M., Oshima, K., and Takeuchi, Y. 2012. Abundance indices of young Pacific bluefin tuna, derived from catch-and-effort data of troll fisheries in various regions of Japan. Working paper submitted to the ISC Pacific Bluefin Tuna Working Group Meeting, 31 January-7 February 2012, La Jolla, California, USA. ISC/12/PBFWG-1/11: 35p. Available at: http://isc.ac.affrc.go.jp/pdf/PBF/ISC12_PBF_1/ISC12-1PBFWG11_ichinokawa.pdf

ISC. 2012. Report of the 2012 Intercessional meeting of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean, available at: http://isc.ac.affrc.go.jp/pdf/2012Intercession/FINAL%20-%20Dec%202012%20ISC%20Intercessional%20Plenary%20Meeting%20Report.pdf

Attachment A. Meeting Agenda

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

PACIFIC BLUEFIN TUNA WORKING GROUP MEETING

Iris Rm, 4th Floor
Novotel Ambassador Hotel
Busan, Korea
14-15 July 2013

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

2. Review and Update of Fishery Statistics

3. Review of work tasked from ISC plenary in Dec. 2012
   - 3.1 Review of results of additional future projection assuming low recruitment
   - 3.2 Discussion on the reference points
   - 3.3 Fishery impact analysis
   - 3.4 Kobe plots

4. Work Plan
   - 4.1 Discussion on the CIE review
   - 4.2 Schedule for the next workshop
   - 4.3 Schedule for aging workshop
   - 4.4 Recommendations for ISC 13 plenary -Stock status and conservation advice

5. Election of the WG chair

6. Other matters

7. Clearing of the report

8. Adjournment

Attachment B. List of Meeting Participants

Chinese Taipei
Wei-Jen Wang
Overseas Fisheries Development Council of the Republic of China
19, Lane 113, Roosevelt Road, Sec. 4
Taipei, 106 Taiwan
weijen@ofdc.org.tw

Ren-Fen Wu
Overseas Fisheries Development Council of the Republic of China
19, Lane 113, Roosevelt Road, Sec. 4
Taipei, 106 Taiwan
fan@ofdc.org.tw

Japan
Yujiro Akatsuka
Fisheries Agency of Japan
1-2-1 Kasumigaseki, Chiyoda-ku
Tokyo, 100-8907 Japan
yuujiro_akatsuka@nm.maff.go.jp

Hiromu Fukuda
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu
Shizuoka, 424-8633 Japan
fukudahiromu@affrc.go.jp

Momoko Ichinokawa
National Research Institute of Fisheries Science
2-12-4 Fukuura, Kanazawa
Yokohama, 236-8648 Japan
ichimomo@fra.affrc.go.jp

Yukimasa Ishida
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu
Shizuoka, 424-8633 Japan
ishiday@affrc.go.jp

Shigehide Iwata
Tokyo University of Marine Science and Technology
4-5-6 Konan, Minato-ku
Tokyo, 108-8477 Japan
siwata0@kaiyodai.ac.jp

Takashi Koya
Fisheries Agency of Japan
1-2-1 Kasumigaseki, Chiyoda-ku
Tokyo, 100-8907 Japan
takashi_koya@nm.maff.go.jp

Hideki Nakano
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu
Shizuoka, 424-8633 Japan
hnakano@affrc.go.jp

Yumi Okochi
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu
Shizuoka, 424-8633 Japan
okochi@affrc.go.jp

Kazuhiro Oshima
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu
Shizuoka, 424-8633 Japan
oshimaka@affrc.go.jp

Keisuke Satoh
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu
Shizuoka, 424-8633 Japan
kstu21@fra.affrc.go.jp

Yuko Hiraoka
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu
Shizuoka, 424-8633 Japan
yhira415@affrc.go.jp

Ziro Suzuki
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu
Shizuoka, 424-8633 Japan
zsuzuki@affrc.go.jp

Yukio Takeuchi
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu
Shizuoka, 424-8633 Japan
yukiot@fra.affrc.go.jp

Yuji Uozumi
National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu
Shizuoka, 424-8633 Japan
uozumi@affrc.go.jp

Izumi Yamasaki
National Research Inst. of Far Seas Fisheries
5-7-1 Orido, Shimizu
Shizuoka, 424-8633 Japan
izyam@affrc.go.jp

Republic of Korea

Zang Geun Kim
National Fisheries Research and Development Institute
216 Haean-ro, Gijang-up, Gijang-gun
Busan, 619-705 Korea
zgkim@korea.kr

Jeong Yeon Kyu
National Fisheries Research and Development Institute
216 Haean-ro, Gijang-up, Gijang-gun
Busan, 619-705 Korea
yunggooda@gmail.com

Hee Won Park
National Fisheries Research and Development Institute
216 Gijang-Haeanro, Gijang-eup, Gijang-gun
Busan, 619-705, Korea
heewon81@gmail.com

Sang Chul Yoon
National Fisheries Research and Development Institute
216 Gijanghaean-ro, Gijang-up, Gijang-gun
Busan, 619-705 Korea
scyoon@korea.kr

Mexico

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

Luis Fleischer
Instituto Nacional de la Pesca, Mexico
Km 1. Carretera a Pichnilingue
La Paz, B.C.S. CP. 23000, Mexico
lfleischer21@hotmail.com

United States of America

Kevin Piner
NOAA/NMFS/SWFSC
8604 La Jolla Shores Dr.
La Jolla, CA, 92037 USA
Kevin.Piner@noaa.gov

Sarah Shoffler
NMFS/SWFSC
8604 La Jolla Shores Drive
La Jolla, California 92037 USA
Sarah.Shoffler@noaa.gov

Steven Teo
NOAA/NMFS/SWFSC
8604 La Jolla Shores Dr. La Jolla, CA, 92037 USA
Steve.Teo@noaa.gov

WCPFC
Tony Beeching
Federated States of Micronesia
P.O. Box 2356 Kolonia
Pohnpei 96941
tony.beeching@wcpfc.int

Rapporteur
Shelley Clarke
Sasama Consulting
1675 Sasama-kami
Shizuoka, 428-0211, Japan
scc@sasama.info

ISC Chair
Gerard DiNardo
NOAA/NMFS/PIFSC
2570 Dole Street, Honolulu, HI 96822-2396, USA
Gerard.DiNardo@noaa.gov

Attachment C. List of Working Papers

ISC/13/PBFWG-1/01	Shuhei Uematsu (Japan)	uematsushu@affrc.go.jp
	Future projection under suites of biological reference points and examination of effect under different recruitment regime	

Appendix A

Estimation of age 0 PBF catch for farming by the Japanese troll fishery

Age 0 PBF at 2- or 3-months-old are caught for farming by the troll fishery in the coastal waters off western Japan. This fishery is carried out from July to September and from October to December for fish hatched in May-June in the Nansei Islands, and July-August in the Sea of Japan, respectively. This fishery was started around 1998 on a small scale in limited regions, developed in a gradual manner until 2004, and started full-scale operations thereafter. Annual catches for the troll fishery targeting age 0 PBF have been officially reported since 1952 but have not always included the annual catch amount for farming. In the latest catch table, the annual catches for farming from 2008 to 2012 were incorporated into the total catches for the troll fishery. This paper outlines an estimation method for annual age 0 PBF catch for farming. In this paper, final results are referred to as 'catch for farming' which includes age 0 PBF caught by the troll fishery for farming whether dead or alive.

Table A-1 shows the number of fish released into sea pens used for estimation of catch for farming and estimated catch in number and weight for farming. There are the following three kinds of data sources available for each year:

1) RJB[1]: catch data obtained at the main fishery cooperatives, available since 1998.

2) JFA[2]: monthly catch data from all fishery cooperatives, available since 2008.

3) Reports from fish farmers: the number of age 0 PBF caught by the troll fishery and released for sea pens submitted by all fish farmers of PBF, available since 2011.

All PBF fish farmers have been mandated to report their operational data to the Japan Fishery Agency since 2011. Therefore, the third data source is able to cover the total number of fish released into sea pens. On the other hand, the first and second data sources do not cover the total number of fish and, in addition, coverage of the first dataset is relatively low. In order to estimate catch in number and weight for farming, we assumed the following:

1) The number of PBF which died or were excluded before release into the sea pens is equal to the number of PBF released into the sea pens.

2) Individual weight is 0.25 kg and this is used to convert catch in number to catch in weight.

The catches in number of age 0 PBF for farming in 2011 and 2012 were estimated by simply doubling the number of fish released into the sea pens as obtained from the reports of the PBF fish farmers.

The annual catches in number for farming were calculated for 2008 to 2010 by multiplying the number of fish from JFA by 1.629, which is ratio of the number of fish from JFA to the number as reported by PBF fish farmers in 2011.

[1] Research Project on Japanese Bluefin Tuna
[2] Survey on Catch of Bluefin Tuna in Japan's Coastal Areas implemented by the Japan Fishery Agency

For the period from 2004 to 2007, only RJB data are available. First, we calculated the mean ratio of the total reported troll catch to the number of fish reported from the RJB data from 2008 to 2011, which was 3.839. Subsequently, each annual value from the RJB data source from 2004 to 2007 was multiplied by this ratio, resulting in an estimate of the total age 0 troll catch for each year from 2004-2007.

As mentioned above, the years of 1998 to 2003 are regarded as a developing period in the fishery. Hence, we assumed that the catch in number for farming increased linearly from 1998 to 2004 and estimated the total catch of age 0 PBF for the years of 1998 to 2003 using the following procedure:

1) The catch in number for farming in 1998 was determined by doubling the number from the RJB, resulting in 47,000 individuals.

2) A straight line was fitted to the catch in numbers for farming in 1998 and 2004, which were 47,000 and 1.051 million individuals, respectively (Fig. A-1).

3) The annual catches in number from 1999 to 2003 were estimated by interpolation of a straight line to these years.

The available data sources used for estimation of the catch for farming were limited before 2008 and, especially, the data source in the developing period of 1998-2003 had low coverage relative to the total number of fish released into the sea pens. Hence, there is relatively greater uncertainty in the estimated catches for farming before 2008. These estimates will be revised if additional data sources become available in the future. In addition, valid information on the number of fish which died and are excluded before release into sea pens is not available at present. Therefore, this information should be collected in cooperation with fish farmers and local research bodies.

Table A-1 The number of fish released into sea pens by data source used for estimation of the catch of age 0 PBF for farming, estimated catch in number (in 1000 individuals) and weight (t) for farming, and combined catch in weight of the troll fishery for farming and non-farming. Gray cells indicate the developing period of the troll fishery for farming.

Year	Number of fish released into sea pens (1000 inds)			C/B in 2011 (D)	Total number of fish released into sea pens for 2008-2011 (1000 inds) BxD (E)	E/A	Total number of fish released into sea pens for 2004-2007 (1000 inds) AxF	Catch in number for farming (1000 inds)	Individual weight (kg/ind.)	Catch in weight for fariming (t)	Conventional catch for non-farming (t)	Combined catch in weight (t)
	RJB (A)	JFA (B)	Reports from fish farmers (C)									
1998	23							47	0.25	12	2865	2876
1999	5							214	0.25	54	3387	3440
2000	31							382	0.25	95	5121	5217
2001	71							549	0.25	137	3329	3466
2002	15							716	0.25	179	2427	2607
2003	52							884	0.25	221	1839	2060
2004	137						526	1051	0.25	263	2182	2445
2005	118						454	908	0.25	227	3406	3633
2006	165						633	1265	0.25	316	1544	1860
2007	228						876	1753	0.25	438	2385	2823
2008	198	373			607	3.072		1214	0.25	304	2074	2377
2009	40	157			256	6.418		512	0.25	128	1875	2003
2010	200	346			563	2.823		1127	0.25	282	1301	1583
2011	133	248	404	1.629 (D)	404	3.045		808	0.25	202	1618	1820
2012			173					346	0.25	86	484	570
Mean						3.839 (F)		785		196		
SD						1.723		457		114		

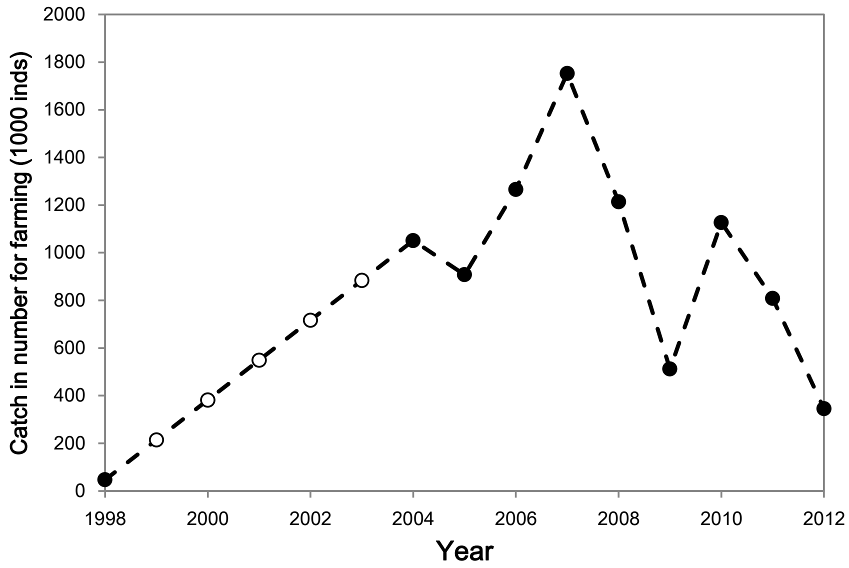


Fig. A-1 Annual catch in number of age 0 PBF caught by the troll fishery for farming.

Appendix B

Standardized CPUE of North Pacific Bluefin tuna caught by Japanese coastal longliners: updates through 2012

Standardized CPUEs were estimated through 2012 (calendar year) using the same method as Ichinokawa and Takeuchi (2012). Updating of data for this study increased the number of operations by 2991 in 2012 and 1030 in 2011 as compared to the previous study. Due to the insufficiency of the data analyzed thus far for 2012, the results for 2012 should be considered as provisional values.

The GLMs for standardizing CPUE applied exactly the same explanatory variables as the previous study for both steps of the delta-lognormal model. The results showed that both nominal and standardized CPUEs decreased in 2012 relative to 2011. However, the following issues are noted with regard to this standardization methodology:

1) The target and fishing ground shift described by Oshima et al. (2012) was not fully taken account of.

2) The area definition in this study could not adequately partition the data into the assumed potential fishing grounds of PBF. The fishing area in this study was defined as 1 x 1 degree blocks where at least one PBF per year has been caught for more than 9 years. In recent years, low catches have been observed around the Nansei Islands, whereas a high amount of landings were observed off Honshu Island. These trends were not usually observed in the past and the standardization method in this study should be improved if it is confirmed that these trends have continued.

References

Ichinokawa, M. and Takeuchi, Y. 2012. Standardized CPUE of North Pacific Bluefin tuna caught by Japanese coastal longliners: updates until 2011. ISC/12-1/PBFWG/8. 1-15

Oshima, K., Mizuno, A., Ichinokawa, M. Takeuchi, M., Nakano, H. and Uozumi, Y. 2012. Shift of fishing efforts for Pacific bluefin tuna and target shift occurred in Japanese coastal longliners in recent years. ICS/12/PBFWG-3/05. 1-18

Table B-1 Data set used for standardized CPUE. Note that the fishing year is defined to start from July and end in June.

Calendar year	Fishing year	N of operations	N of hooks (x1000 hooks)	N of PBF catch	Nominal CPUE
1994	1993	3182	5063	2771	0.547
1995	1994	2672	4333	1555	0.359
1996	1995	2924	4763	2400	0.504
1997	1996	3062	5025	2352	0.468
1998	1997	3510	5769	2775	0.481
1999	1998	5578	9086	3769	0.415
2000	1999	4937	8195	2230	0.272
2001	2000	5497	9377	1837	0.196
2002	2001	5113	8600	2008	0.233
2003	2002	4362	7347	2475	0.337
2004	2003	5254	9048	3365	0.372
2005	2004	4871	8364	3674	0.439
2006	2005	4743	7901	1893	0.240
2007	2006	4609	7803	3103	0.398
2008	2007	4550	8004	1459	0.182
2009	2008	4712	8182	1218	0.149
2010	2009	4925	8357	747	0.089
2011	2010	4434	7819	563	0.072
2012	2011	2951	5448	271	0.050

Table B-2 Results of model selection with BIC.

(1) Binomial model (1st step)

	Added explanatory veriables	BIC	
(1)	year	48649.16	
(2)	+year*day10	44852.58	
(3)	+area*shiptype	44363.93	
(4)	+day10*area	44209.77	
(5)	+year*area	43710.62	
(6)	+gear*shiptype	43704.09	
(7)	+area*gear	43703.76	Final model

(2) Lognormal model (2nd step)

	Added explanatory veriables	BIC	
(1)	Intercept	-30378.95	
(2)	+day10*gear	-32092.37	
(3)	+year	-32942.25	
(4)	+area*shiptype	-33367.58	Final model

Table B-3 Results of type III analysis of the explanatory variables. The table shows the hypothesis tests for each of the variables in the model individually.

(1) Binomial model (1st step)

Effects	Num DF	Den DF	Chi squared value	F value	Pr>Chi	Pr>F
year*day10	144	16562	1187.47	8.25	<.0001	<.0001
area*shiptype	2	16562	7.53	3.77	0.0232	0.0232
day10*area	8	16562	168.6	21.07	<.0001	<.0001
year*area	18	16562	183.72	10.21	<.0001	<.0001
gear*shiptype	2	16562	20.77	10.39	<.0001	<.0001
area*gear	1	16562	6.33	6.33	0.0119	0.0119
				Variance parameter of shipname with SD in paraenthes		0.393 (0.04)
					Extra-dispersion scale	1.22

(2) Lognormal model (2nd step)

Effects	Num DF	Type III SS	Mean Square	F value	Pr>F
Model	40	922.7	23.1	90.80	<.0001
Error	24584	6245.7	0.3		
Corrected Total	24624	7168.4			
				R squaread value	0.129

Effects	Num DF	Type III SS	Mean Square	F value	Pr>F
year	18	298.85	16.60	65.35	<.0001
day10*gear	17	346.91	20.41	80.32	<.0001
area*shiptype	5	121.87	24.37	95.94	<.0001

Table B-4 Nominal and standardized CPUE of Japanese coastal longliners April to July.

Calendar year	Fishing year	Nominal	Nominal (normalized)	Standardized	Standardized (normalized)	CV
1994	1993	0.547	1.792	0.307	1.856	0.082
1995	1994	0.359	1.175	0.224	1.353	0.061
1996	1995	0.504	1.650	0.277	1.679	0.077
1997	1996	0.468	1.532	0.288	1.740	0.051
1998	1997	0.481	1.575	0.252	1.527	0.056
1999	1998	0.415	1.358	0.180	1.090	0.043
2000	1999	0.272	0.891	0.138	0.835	0.050
2001	2000	0.196	0.641	0.107	0.649	0.047
2002	2001	0.233	0.764	0.122	0.741	0.058
2003	2002	0.337	1.103	0.204	1.233	0.042
2004	2003	0.372	1.218	0.219	1.324	0.035
2005	2004	0.439	1.438	0.260	1.572	0.034
2006	2005	0.240	0.784	0.130	0.784	0.043
2007	2006	0.398	1.302	0.181	1.097	0.039
2008	2007	0.182	0.597	0.099	0.602	0.045
2009	2008	0.149	0.487	0.063	0.381	0.053
2010	2009	0.089	0.293	0.033	0.199	0.076
2011	2010	0.072	0.236	0.033	0.199	0.075
2012	2011	0.050	0.163	0.023	0.139	0.099

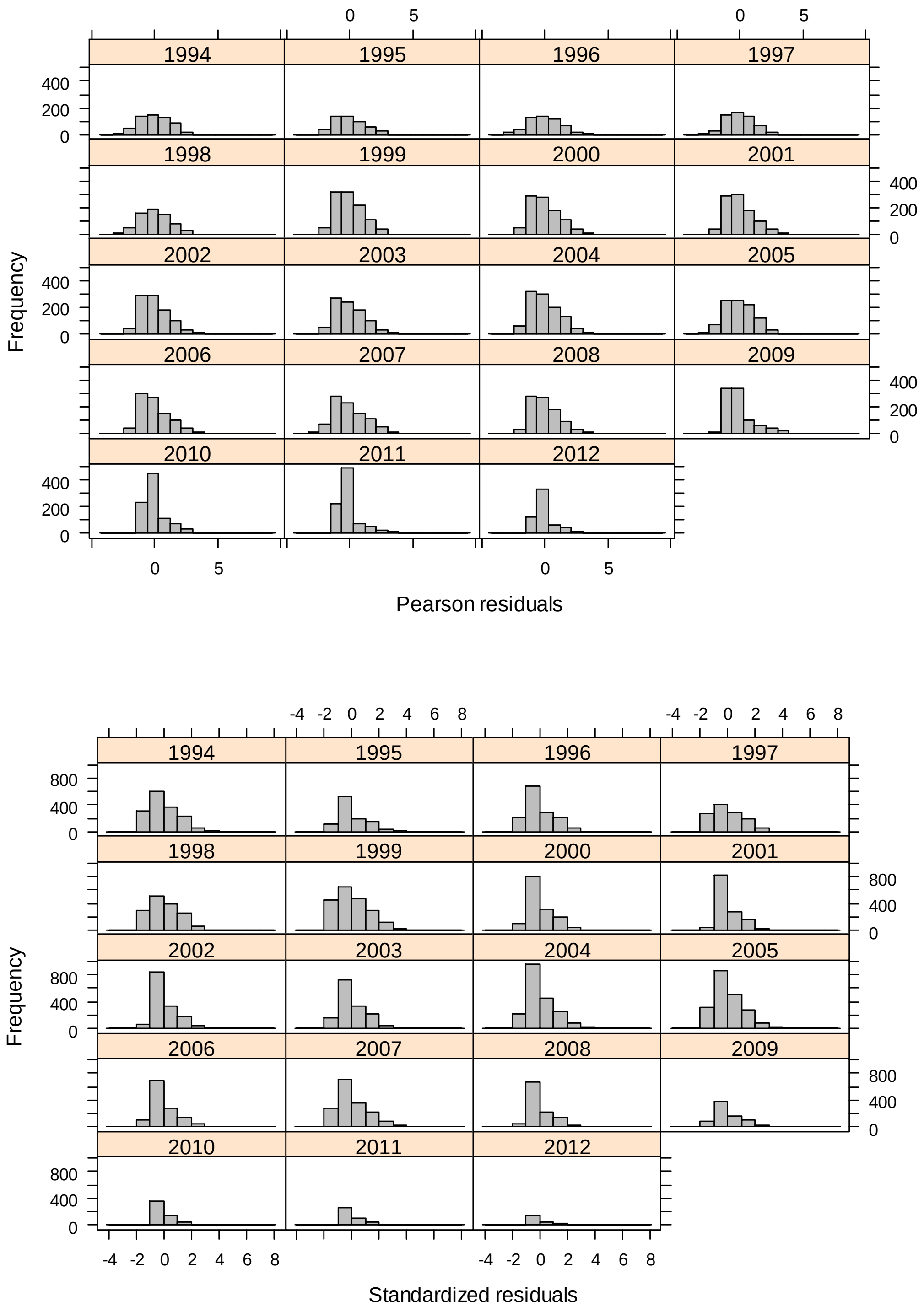


Fig. B-1 Residual distributions by year. Upper panels: Pearson residuals in the binomial model of the first step. Lower panels: standardized residuals in the lognormal model of the second step.

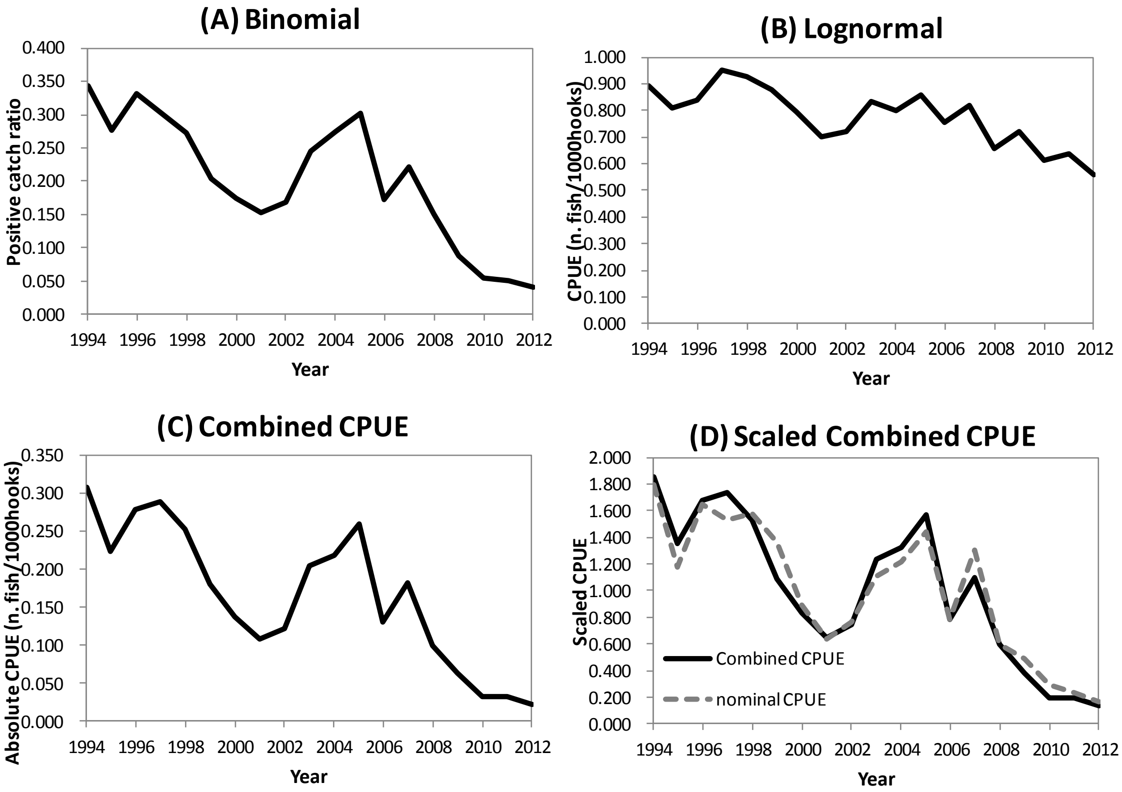


Fig. B-2 Annual trends in (a) standardized positive catch ratio, (b) CPUE of positive catch , (c) absolute combined CPUE and (d) scaled combined CPUE. Grey broken line indicates scaled nominal CPUE.

Appendix C

Updated Japanese troll CPUE targeting age 0 PBF through 2011

The Japanese troll fishery targeting age 0 PBF operates in the coastal areas of Western Japan. Ichinokawa et al. (2012) estimated standardized catch per unit effort (CPUE) time series for Nagasaki, Kochi and Wakayama Prefectures through 2010 but only the CPUE for Nagasaki Prefecture was used for the latest stock assessment. In this paper, we update the CPUE for Nagasaki Prefecture through 2011 by following the methods of CPUE standardization used by Ichinokawa et al. (2012).

The data sources of catch and effort were identical to those used in Ichinokawa et al. (2012) (Fig. C-1). The following four effects used for standardization were as follows:

1) Fishing year (fy); 1980-2011 (starting in July and ending in June);

2) Fishing month (fm) aligned with fishing year;

3) Port (five ports located in regions ranging from the Goto Islands to the Tsushima Islands).

Generalized linear models (GLM) with lognormal error distributions were applied because there were no zero catch data. The predicted variable was log(CPUE) and the explanatory variables were the four effects listed above and all possible first-order interactions. The GLM was carried out using the GLM procedure of SAS 9.3. The best model was determined based on BIC. The standardized CPUE was calculated from the least squares mean of the 'fy' effect.

The final model was a combination of 'fy' and 'fm*port' (Table C-1). Residuals were distributed centrally around zero, although those distributions showed slight left-skewed shapes (Figs C-2 and C-3). Standardized CPUEs, CVs and 95% confidence limits are listed in Table C-2. The range of CVs was between 0.05 and 0.10, only slightly different from that in Ichinokawa et al. (2012). Figure C-4 shows a time series of nominal CPUE and standardized CPUE estimated in this study and the standardized CPUE provided by the previous study. The standardized CPUE from 2010 to 2011 decreased, although nominal CPUE increased in the same period. The annual trends in CPUE in this study did not differ from those estimated by Ichinokawa et al. (2012).

Reference

Ichinokawa, M., Oshima, K. and Takeuchi Y. 2012. Abundance indices of young Pacific bluefin tuna, derived from catch-and-effort data of troll fisheries in various regions of Japan. ISC/12-1/PBFWG/11.

Table C-1 Type 3 analysis of the explanatory variables in the final model for CPUE standardization.

Efffects	df	Type III SS	Mean squire	F value	Pr > F
fy	31	1128.6	36.4	38.8	<.0001
fm*port	21	1043.3	49.7	53.0	<.0001

Table C-2 Nominal CPUE, standardized CPUE and coefficient of variation (CV), comparing with estimation by Ichinokawa et al (2012). All CPUEs are normalized by each average.

Fishing year	Nominal CPUE	Standardized CPUE				Ichinokawa et al. (2012)	
		Estimation	CV	Lower 5%	Upper 5%	Estimation	CV
1980	0.57	0.65	0.07	0.57	0.74	0.64	0.06
1981	0.87	1.13	0.07	0.99	1.28	1.11	0.06
1982	0.55	0.57	0.08	0.49	0.67	0.57	0.07
1983	0.86	0.87	0.06	0.78	0.98	0.87	0.05
1984	0.72	0.88	0.05	0.79	0.97	0.87	0.05
1985	0.80	0.82	0.06	0.74	0.91	0.81	0.05
1986	0.69	0.94	0.05	0.85	1.03	0.93	0.04
1987	0.58	0.67	0.06	0.59	0.75	0.67	0.06
1988	0.69	0.76	0.06	0.68	0.85	0.76	0.05
1989	0.50	0.61	0.06	0.55	0.69	0.61	0.05
1990	1.14	1.21	0.06	1.08	1.35	1.20	0.05
1991	1.08	1.30	0.06	1.15	1.48	1.29	0.06
1992	0.47	0.56	0.06	0.50	0.63	0.55	0.06
1993	0.40	0.47	0.06	0.42	0.52	0.46	0.05
1994	1.73	1.94	0.05	1.76	2.15	1.93	0.05
1995	0.92	1.06	0.07	0.93	1.21	1.05	0.06
1996	1.16	1.58	0.05	1.43	1.74	1.56	0.05
1997	0.92	0.88	0.07	0.78	1.01	0.89	0.06
1998	0.94	0.80	0.06	0.72	0.90	0.81	0.05
1999	1.44	1.48	0.06	1.31	1.67	1.47	0.06
2000	1.52	1.14	0.06	1.00	1.29	1.14	0.06
2001	1.26	1.15	0.06	1.01	1.30	1.15	0.06
2002	0.71	0.72	0.06	0.64	0.82	0.73	0.06
2003	0.78	0.64	0.08	0.55	0.74	0.64	0.07
2004	1.46	1.27	0.05	1.14	1.42	1.27	0.05
2005	1.63	1.34	0.07	1.17	1.53	1.35	0.06
2006	1.03	0.70	0.10	0.57	0.85	0.71	0.09
2007	1.55	1.36	0.07	1.19	1.56	1.38	0.06
2008	1.63	1.42	0.06	1.25	1.60	1.41	0.06
2009	0.98	1.09	0.07	0.95	1.26	1.09	0.07
2010	1.06	1.07	0.06	0.96	1.20	1.07	0.05
2011	1.37	0.93	0.07	0.81	1.06		

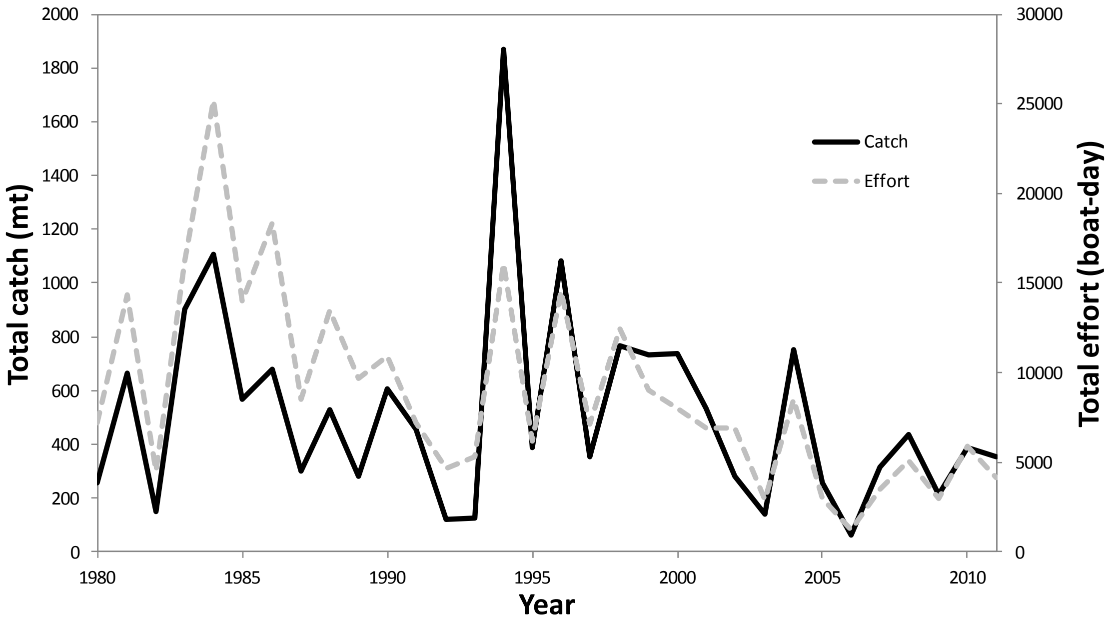


Fig. C-1 Year trends of total catch in weight and total effort by year from five ports used for CPUE standardization.

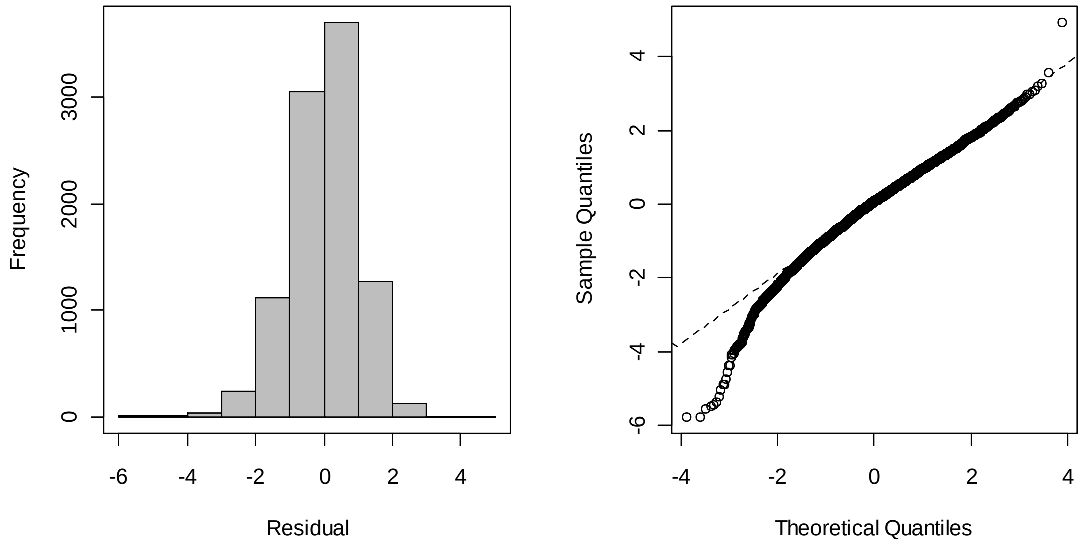


Fig. C-2 Standardized residuals (left panel) and their Q-Q plot (right panel).

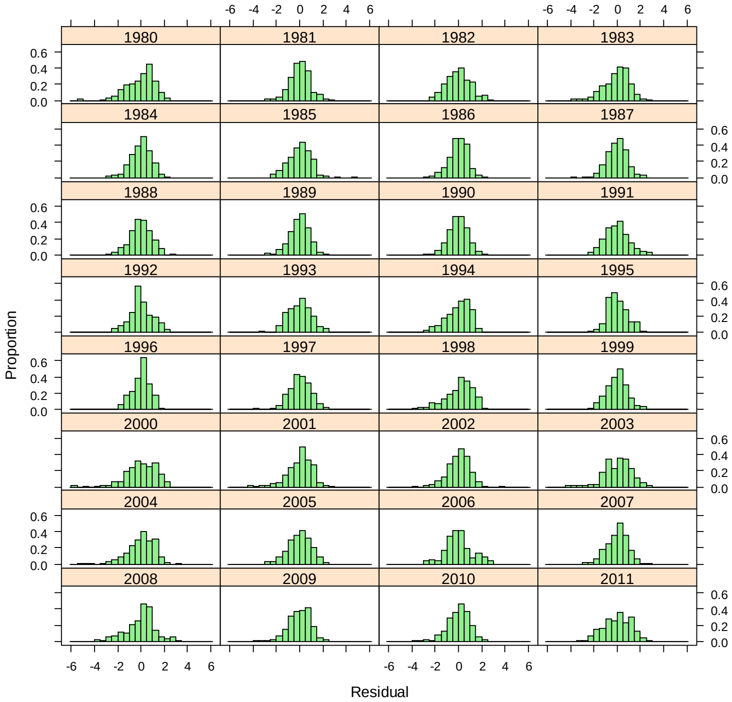


Fig. C-3 Standardized residuals by year.

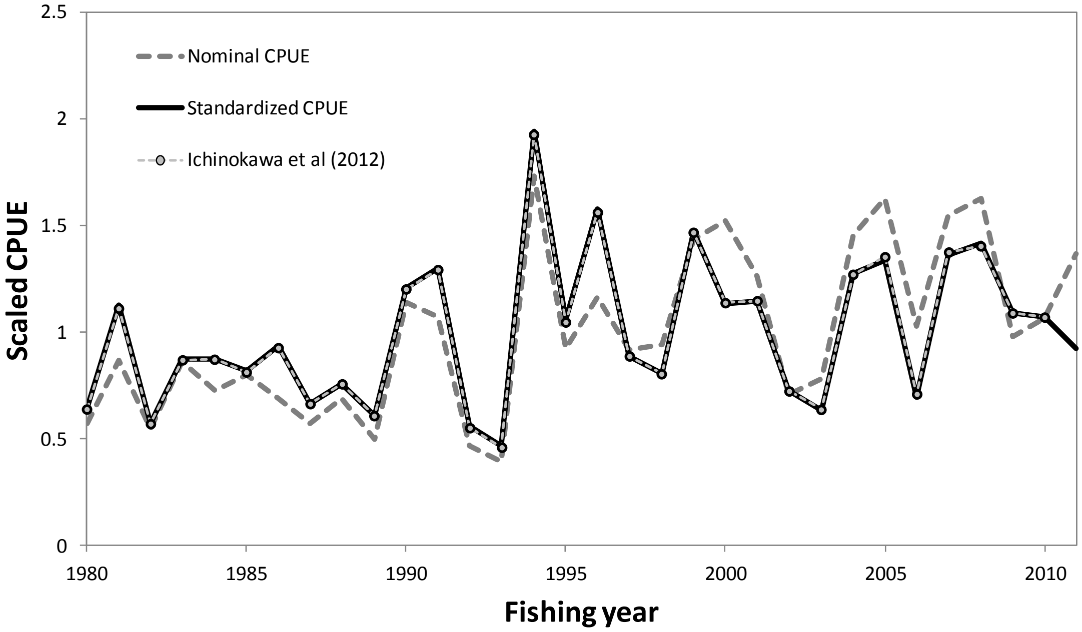


Fig. C-4 Comparison of time series of CPUE. Gray and black lines indicate nominal and standardized CPUE from 1980 to 2011 fishing years. Solid circles show the standardized CPUE as estimated by Ichinokawa et al. (2012).

Appendix D

Additional future projections with two low recruitment levels

The ISC plenary in December 2012 requested the PBFWG to "conduct additional projection scenarios with recruitment levels consistent with the lower values estimated in the 1980s". This appendix reports the results of the requested additional future projections with two low recruitment levels.

In order to meet the Plenary's request, two types of future recruitment scenarios were constructed: A) future recruitment will continue at the level observed in 1980-1989 when the average annual recruitment was 10 million fish; and B) future recruitment for the first 10 years will be at the level observed in 1980-1989, but will gradually recover to the average level observed over 1952-2009. The choice of the historical low recruitment period as 1980-1989 is somewhat arbitrary but average recruitment in that period was 10 million fish, 30% lower than the average of 1952-2009 (14 million fish). The rationale for Scenario B is that based on past observations the duration of the low recruitment period is roughly only 10 years but it might be expected that future low recruitment periods would continue longer than this or fluctuate around the ten year mark to some extent. The main concept represented in Scenario B is that low recruitment will not continue for a very long period such as 20 or 30 years.

Tables D-1-A and D-1-B summarize the results of projection scenarios with recruitment levels consistent with the lower levels observed in the 1980s (Scenario A) and mixed levels (Scenario B, first decade's recruitment is at the lower level, and the later 20 years are at the historical average level), respectively in the same format as Table 5-6 in the Stock Assessment Report (ISC Pacific Bluefin Working Group, 2012).

The probability that future SSB may fall to a level below the historical minimum SSB changes according to which scenario of future recruitment levels is modeled. In either scenario presented here, if fishing mortality (F) is assumed to be at 2007-2009 levels the probability exceeds 50% after 2016 regardless of whether or not a catch limit is placed on purse seine fisheries. In contrast, the probability is zero when F is assumed to be at 2002-2004 levels without catch limits.

These results suggest that if recruitment is at the lower level, a reduction of F is more effective than a purse seine catch limit in reducing the risk of the stock declining as pointed out in the Stock Assessment Report. In other words, if future F is held is at the average level of F in 2002-2004 as the ISC has repeatedly suggested, the risk of SSB falling below historical minimum levels can be minimized.

References

Pacific Bluefin Tuna Working Group. 2012. STOCK ASSESSMENT OF PACIFIC BLUEFIN TUNA IN 2012. ISC12.

ISC Plenary Session. 2012. REPORT OF THE 2012 INTERCESSIONAL MEETING OF THE INTERNATIONAL SCIENTIFIC COMMITTEE FOR TUNA AND TUNA-LIKE SPECIES IN THE NORTH PACIFIC OCEAN. ISC12.

Table D-1 Results of additional future projections with two low recruitment levels (Scenario A: future recruitment will continue at the level of 1980-1989, Scenario B: future recruitment in the first 10 years will be at the level observed in 1980-1989, but afterward will gradually recover to the average level). Numbers in parentheses indicate harvest scenarios in the text. Harvest scenarios 1 and 2 used F levels of 2007-2009 and F levels of 2001-2004 as future fishing mortality values. Harvest scenarios 3 and 4 imposed additional catch limits on several commercial purse seine fisheries (Fleets 2, 3, 4, and 12) in addition to the conditions of harvest scenarios 1 and 2.

A) Low recruitment level

		(1)	(2)	(3)	(4)
F scenario		F0709	F0204	F0709	F0204
Scenarios for capping	F2	-	-	5,500	5,500
	F3	-	-	2,000	2,000
	F4	-	-	500	500
	F12	-	-	5,000	5,000
point estimation	terminal year (2010) SSB	22,613			
	histrical median SSB	46,122			
	histrical minimum (SSB min)	18,433			
Future Median SSB	2015	20,733	27,354	22,004	29,903
	2020	16,116	27,846	17,199	32,972
	2025	14,955	27,695	15,878	33,564
	2030	14,721	27,754	15,566	33,742
Prob(SSB_y<SSBmin|y1<=y<y2)	y1 - y2				
	2011-2015	34	17	28	17
	2016-2020	70	1	63	0
	2021-2025	83	0	76	0
	2026-2030	86	0	79	0
Total catch 5 years average	2011-2015	22,041	19,594	21,408	18,245
	2016-2020	19,608	19,075	19,723	17,830
	2021-2025	19,317	19,111	19,394	18,059
	2026-2030	19,230	19,122	19,254	18,102

B) Mixed recruitment level (first decade is the lower level, next 20 years are the historical average level)

		(1)	(2)	(3)	(4)
F scenario		F0709	F0204	F0709	F0204
Scenarios for capping	F2	-	-	5,500	5,500
	F3	-	-	2,000	2,000
	F4	-	-	500	500
	F12	-	-	5,000	5,000
point estimation	terminal year (2010) SSB	22,613			
	histrical median SSB	46,122			
	histrical minimum (SSB min)	18,433			
Future Median SSB	2015	20,715	27,302	21,989	29,796
	2020	16,083	27,804	17,219	32,708
	2025	15,917	29,319	18,524	37,156
	2030	20,016	37,577	36,911	64,905
Prob(SSB_y<SSBmin|y1<=y<y2)	y1 - y2				
	2011-2015	34	17	28	17
	2016-2020	71	0	62	0
	2021-2025	81	0	73	0
	2026-2030	64	0	38	0
Total catch 5 years average	2011-2015	22,059	19,586	21,404	18,154
	2016-2020	19,629	19,133	19,772	17,772
	2021-2025	25,042	24,458	23,125	20,909
	2026-2030	27,736	27,197	25,831	23,389

Appendix E

The description about some of the key biological and fishery variables

For the purpose of determining potential limit reference points, the ISC Chairman directed PBFWG to develop the description about some of the key biological (Stock recruitment and steepness, maturity and fecundity, natural mortality, growth) and fishery (selectivity) variables whether those variables were reasonably well estimated or not.

1. Stock-Recruitment and Steepness

- Beverton and Holt stock recruitment relationship with fixed steepness (h) of 0.999 was assumed in 2012 stock assessment, because preliminary runs estimated the parameter to be approximately equal to 1, and a sensitivity run to fix the parameter as 0.8 did not converge.

- Some studies estimated h outside of the stock assessment model. Mangel et al. (2010) estimated the parameter using early life-history parameters near from those of PBF. In addition, Iwata et al. (2012; 2012b) followed the analysis with growth parameters exactly same as those used in the actual stock assessment of PBF. Those studies found that mean h was estimated approximately as 0.999. The WG noted in the 2012 stock assessment report that the estimates were highly uncertain due to the lack of information on early life history stages and other parameters such as 'weight-length-key'. Estimating the steepness parameter is an ongoing area of research;

2. Maturity and Fecundity

- A recent histological study (Tanaka 2006) showed that 80% of the fish of about 30 kg (corresponding to age-3) caught in the Sea of Japan from July to August were mature. Almost all the fish caught off the Ryukyu Islands and east of Taiwan were above 60 kg (over 150 cm fork length [FL], corresponding to age 5+) and mature. However, there is not enough information about the maturity of age 3-5 PBF except in the Sea of Japan. In the current stock assessment model, the age-specific proportion of mature fish were fixed as 0.2 at age-3, 0.5 at age-4 and 1.0 at age-5+. Further researches are necessary about the migration pattern and maturity of PBF especially between age 3 to 5 to understand the actual age-specific proportion of mature fish and its distribution in each spawning area.

- Current stock assessment is based on the constant fecundity depending on the weight of the matured fish, as a standard practice of fish stock assessment, when available information is not enough.

- Chen et al. (2006) showed the correlation between the batch fecundity and the fork length. On the other hand, a recent study showed a possibility of the regionally independent relationships between the gonad weight and the body weight around Japan (Pers. Comm.).

- There is a need to develop the comparative information about a potential for reproduction in each age/size class.

3. Natural mortality

- Age-specific estimates of M were fixed in the SS model as 1.6 year-1 for age 0, 0.386 year-1 for age 1, and 0.25 year-1 for age 2+. Because of the absence of direct estimates of M for PBF beyond age-0, the WG discussed the setting of natural mortality based on the natural mortalities of the other tuna species in the 2008 stock assessment and 2012 data preparation. Then the WG reached a consensus about the natural mortality for PBF that the current value of M vector is appropriate. The natural mortality estimate for age-0 fish was based on results obtained from a conventional tagging study (Takeuchi and Takahashi 2006; Iwata et al. 2012a). For age 1-2 fish, natural mortality was based on length-adjusted M estimates from southern bluefin tuna (Thunnus maccoyii) conventional tagging studies (Polacheck et al. 1997, PBFWG 2008). Natural mortality of older fish (age 3+) was estimated as 0.25 per year using the Pauly's equation. WG also confirmed that the possible M scenario of age 3+ fish from many different methods, including Pauly, Hoenig and others, ranged about 0.17 to 0.41 (PBFWG 2011).
- The WG recommended a seasonal natural mortality for Age-0 in the future assessment, because M likely changes with size based on tagging studies, and age-0 PBF are growing very rapidly.
- A recent published paper (Whitlock et al., 2012) showed lower natural mortality (0.15 year-1) for age 2+ PBF. However, the WG noted several issue on the data bias for EPO and the bias for young fish (very few older fish on which to base an estimates of M5+) in the 2012 data preparatory report.

4. Growth

- Current stock assessment is based on the growth curve proposed by Shimose et al. (2009). However, this growth curve underestimates the size of age 0 fish from the commercial catch taken during summer. Therefore, the WG adjusted the expected length at age of fish at age 0.125 to a higher value (21.54 cm FL from 15.47 cm FL).
- The PBFWG recommended continuing research to further improve the growth curve before the next stock assessment.

5. Selectivity

- Given data available for estimating the selectivity of each fleet, WG notes on quality of input size composition data for each fleet in 2012 stock assessment report.
- Eight fleets on 14 fleets were judged to be better than good, and most of the selectivity parameters were relatively well estimated.
- The rest of the fleets were judged to be fair. Some of those for which no reliable size data were available were mirrored to one of the above mentioned eight fleets based on similarities in operating characteristics. The selectivity of a fleet which contains the miscellaneous fisheries (Fleet 14; others), was fixed with parameters estimated by a

preliminary run with lambda=0.1. Due to the fixed parameters, the composition data were not fit in the final model. The selectivity of two purse seine fleets (Fleet 4 and Fleet 12), which contained no reliable size data depend on the time period, was estimated based on the size composition data of reliable time period.

- Thus, several issues about the ways to estimate the selectivity of each fleet were still on the discussion table (i.e., seasonal selectivity, time-varying selectivity, relative weighting of the data), the selectivity should be improved further.

References

Chen, K.S., Crone, P., Hsu, C.C. 2006. Reproductive biology of female Pacific bluefin tuna *Thunnus orientalis* from south-western North Pacific Ocean. Fisheries Science 72: 985-994.

Iwata, S., Fujioka, K., Fukuda, H., and Takeuchi, Y. 2012a. Reconsideration of natural mortality of age-0 Pacific bluefin tuna and its variability relative to fish size. Working paper submitted to the ISC Pacific Bluefin Tuna Working Group Meeting, 31 January-7 February 2012, La Jolla, California, USA. ISC/12/PBFWG-1/13.

Iwata, S., Fukuda, H., Abe, O., and Takeuchi, Y. 2012b. Estimation of steepness of PBFT -By using biological feature. Working paper submitted to the ISC Pacific Bluefin Tuna Working Group Meeting, 31 January-7 February 2012, La Jolla, California, USA. ISC/12/PBFWG-1/15.

Iwata, S. 2012. Estimate the frequency distribution of steepness for PBF. Working paper submitted to the ISC Pacific Bluefin Tuna Working Group Meeting, 10-17 November 2012, Honolulu, Hawaii, USA. ISC/12/PBFWG-3/01.

Mangel, M., Brodziak, J., and DiNardo, G. 2010. Reproductive ecology and scientific inference of steepness: a fundamental metric of population dynamics and strategic fisheries management. Fish and Fisheries. 11: 89-104.

Pacific Bluefin Tuna Working Group (PBFWG). 2008. Report of the Pacific Bluefin Tuna Working Group Workshop, 10-17 December 2008, Ishigaki, Japan. Annex 4. Report of the Eighth Meeting of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean, Plenary Session. 10-11 July 2009, Kaoshiung, Taiwan. Available at: http://isc.ac.affrc.go.jp/pdf/ISC9pdf/Annex_4_ISC9_PBFWG_Dec08.pdf

Pacific Bluefin Tuna Working Group (PBFWG). 2011. Report of the Pacific Bluefin Tuna Working Group Workshop, 6-13 January 2011 Shizuoka, Japan. Annex 5. Report of the Eleventh Meeting of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean, Plenary Session. 20-25 July 2011 San Francisco, USA. Available at: http://isc.ac.affrc.go.jp/pdf/ISC11pdf/Annex_5_ISC11_PBFWG-1_FINAL.pdf

Pacific Bluefin Tuna Working Group (PBFWG). 2012. Report of the Pacific Bluefin Tuna Working Group Workshop, 31 January-7 February 2012 La Jolla, USA. Annex 6. Report of the Twelfth Meeting of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean, Plenary Session. 18-23 July 2012, Sapporo, Japan. Available at: http://isc.ac.affrc.go.jp/pdf/ISC12pdf/Annex%208%20-%20Report%20of%20the%20PBFWG%20Workshop%20(May-June%202012)%20Formatted.pdf

Pacific Bluefin Tuna Working Group (PBFWG). 2012. STOCK ASSESSMENT OF PACIFIC BLUEFIN TUNA IN 2012.
Available at:

http://isc.ac.affrc.go.jp/pdf/Stock_assessment/Stock%20Assessment%20of%20Pacific%20Bluefin%20Assmt%20Report%20-%20May15.pdf

Polacheck, T., Hearn, W.S., Miller, C., Whitelaw, W. and Stanley, C. 1997. Updated estimates of mortality rates for juvenile SBT from multi-year tagging of cohorts. CCSBTSC/9707/26.

Shimose, T., Tanabe, T., Chen, K.-S., and Hsu, C.-C. 2009. Age determination and growth of Pacific bluefin tuna, Thunnus orientalis, off Japan and Taiwan. Fish. Res. 100: 134-139.

Takeuchi, Y. and Takahashi, M. 2006. Estimation of natural morality of age-0 Pacific bluefin tuna from conventional tagging data. Working paper submitted to the ISC Pacific Bluefin Tuna Working Group Meeting, 31 January-7 February 2006, Shimizu, Japan. ISC/06/PBFWG/07.

Tanaka, S. 2006. Maturation of bluefin tuna in the Sea of Japan. Working paper submitted to the ISC Pacific Bluefin Tuna Working Group Meeting, 16-20 January 2006, Shimizu, Shizuoka, Japan. ISC/06/PBFWG/09.

Appendix F

Fishery Impact Plots: Evaluating Fishery Impacts on the Current Stock Status

The ISC Plenary requested the PBFWG to conduct a fishery impact analysis to determine the extent to which certain gear types are contributing to PBF overfishing and overfished status. To respond to this request, fishery impact plots were developed using the representative run from the current stock assessment. The effects of the different fisheries on spawning stock biomass (SSB) were evaluated by simulating the population dynamics while removing each fishery.

In this analysis, we defined the longline fisheries (those from Japan and Chinese Taipei: Fleets 1 and 11) as a single group; the Western Pacific Ocean (WPO) purse seine fisheries as a second group (Japan and Korea purse seines operating in the East China Sea, Japan purse seines operating in the Sea of Japan, and Japan purse seines operating in the Pacific: Fleets 2, 3, and 4); the Eastern Pacific Ocean (EPO) fisheries (EPO purse seine and sport fishing fleets: Fleets 12 and 13) as a third group; and other fisheries as a fourth group. The fourth group corresponds to Japanese troll, pole and line, set net, and miscellaneous fisheries (Fleets 5, 6, 7, 8, 9, 10 and 14), which are all Japan coastal fisheries mainly catching small-sized PBF. In addition to evaluating the impacts of these fishery groups, non-fishery impacts were also evaluated.

The following procedures were conducted for this analysis:

(1) Set the S-R steepness parameter to 1.0 to fix the recruitment without any re-estimation of other parameters with this steepness value.

(2) Set the catch for all fisheries and the initial F parameters to zero. Simulate the dynamics from the parameters of the representative run to estimate the dynamic unexploited stock size (dynamic virgin SSB).

(3) Set the catch for the fishery group and the initial F parameters for that fishery group to zero. Simulate the dynamics from the parameters of the representative run to estimate the unexploited stock size in the absence of that fishery group.

(4) Repeat Step 3 for each fishery group. (The sum of the fishery impacts for the fishery groups will not equal the impact for all fisheries combined that was estimated in Step 2). Assign the impact from all fisheries combined to each fishery group by using the ratios of the impacts estimated in Step 3.

Historically, the Japan coastal fishery group has had the greatest impact on the stock of PBF, but since about 1999 the WPO purse seine fleet has increased its impact, and the effect of this fleet is currently greater than any of the other fishery groups. The impact of the EPO fishery was large before the mid-1980s, but decreased after the 1990s. The WPO longline fleet has had a limited effect on the stock throughout the analysis period.

The impact of a fishery on a stock depends on both the number and size of the fish caught by each fleet. In particular, catching juvenile fish has had a large impact on the spawning stock biomass compared with catching the same weight of mature fish.

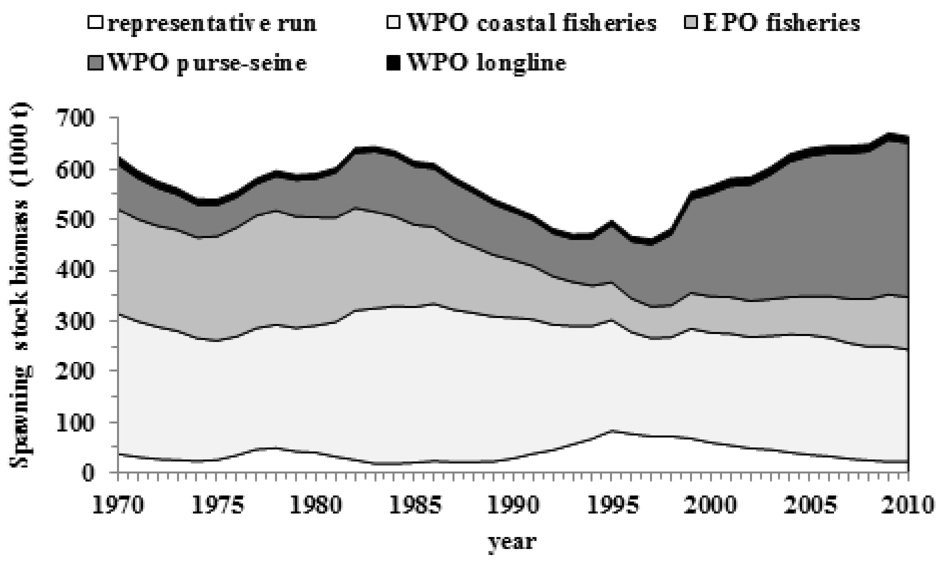


Fig. F-1 Trajectory of the spawning stock biomass of a simulated population of PBF that was unexploited (topmost line) and that predicted by the representative run (white area). The shaded areas between the two lines show the proportions of the fishery impact of each group.

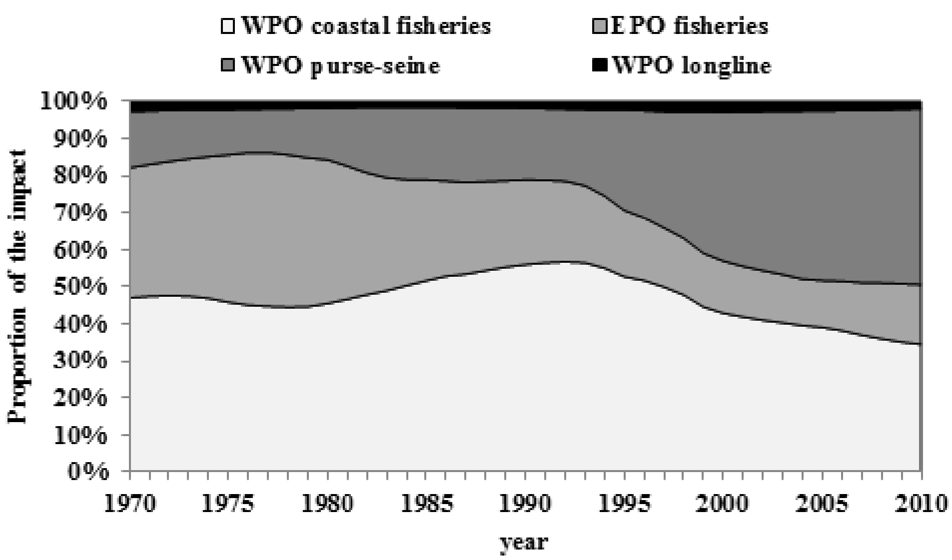


Fig. F-2 The proportion of the impact on the spawning stock biomass in each group.

Appendix G

Inspection of Kobe plots

The ISC plenary held in December 2012 made the following assignment concerning Kobe plot(s):

- ✓ Develop and recommend Kobe plot(s) based on results from the current Pacific bluefin tuna stock assessment model.
- ✓ Provide plausible explanations for PBF being in an overfished condition throughout the entire assessment period.

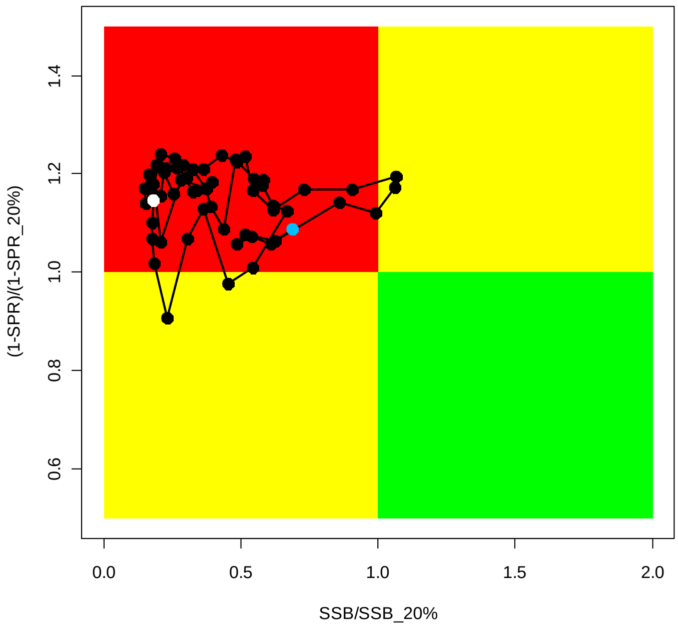
This appendix provides examples of candidate Kobe plot based on the current stock assessment.

At the present stage, the following issues are noted relative to specifying a Kobe plot for PBF:

- ✓ There is no consensus among the members of the ISC PBFWG on appropriate criteria such as reference points to be used for Kobe plot(s).
- ✓ The ISC and WCPFC have not specified reference points for PBF.

Therefore, for illustrative purposes, two examples of Kobe plots are shown in Fig. F-1. The first plot is based on SSB20% and SPR20%, and shows that PBF have been overfished and overfishing has occurred almost throughout the entire assessment period and the PBF stock has remarkably decreased from its initial biomass in the early 1950s. On the other hand, in the second plot, which is based on SSBmed and Fmed, there are points in all quadrants throughout the assessment period. These two plots represent different views of long term stock status and management objectives. However, in both plots the points for recent years are located in the overfished and overfishing quadrant (red zone).

As noted earlier in this text, the PBFWG is not in a position to present any single Kobe plot unless reference points for PBF are determined.



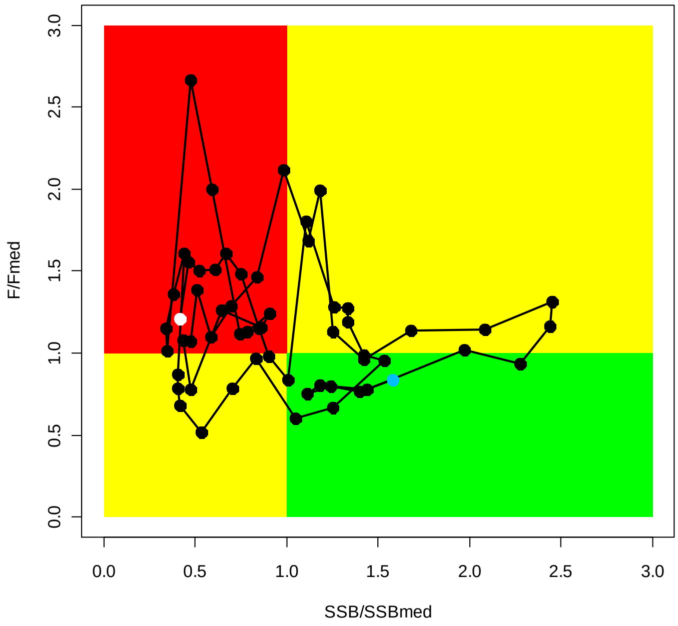


Fig. G-1 Two examples of Kobe plots derived from the representative run of the current stock assessment model for PBF. Upper and lower panels are based on (SSB20%, SPR20%) and (SSBmed, Fmed), respectively. Points for the starting and terminal years are colored in light blue and white, respectively.

Appendix H Catch table of Pacific Bluefin tuna

Year	Japan[1]								
	Purse Seine		Dist. & Off. Longline		Coastal Longline	Troll[2]	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	1,069	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	2,876	85	874	700
1999	11,619	4,554	127	17	1,030	3,440	35	1,097	709
2000	8,193	8,293	121	7	832	5,217	102	1,125	689
2001	3,139	4,481	63	6	728	3,466	180	1,366	782
2002	3,922	4,981	47	5	794	2,607	99	1,100	631
2003	956	4,812	85	12	1,152	2,060	44	839	446
2004	4,934	3,323	231	9	1,616	2,445	132	896	514
2005	4,034	8,783	107	14	1,818	3,633	549	2,182	548
2006	3,644	5,236	63	11	1,058	1,860	108	1,421	777
2007	2,965	3,875	83	8	2,004	2,823	236	1,503	1,209
2008	3,029	7,192	19	8	1,476	2,377	64	2,358	1,192
2009	2,127	5,950	8	7	1,304	2,003	50	2,236	913
2010	1,122	2,620	5	6	903	1,583	83	1,047	918
2011	2,227	6,113	9	11	933	1,820	63	1,957	654
2012	1,043	1,419	-[3]	-[3]	594	570	113	1,765	779

1 Part of Japanese catch is estimated by the WG from best available source for the stock assessment use.
2 Japanese troll catch since 1998 includes catch for farming.
3 The catch for Japanese coastal longline in 2011 includes that for the distant water and offshore lonliners.

Catches in shaded cells are provisional.

Appendix H Continued

Year	Korea[4]			Taiwan				United States[5]			Mexico		Out of ISC members		Grand total
	Purse Seine	Troll	Trawl	Longline	Purse Seine	Distant Driftnet	Others	Purse Seine	Others	Sport	Purse Seine	Others	NZ[6]	Others[7]	
1952								2,076		2					19,172
1953								4,433		48					20,117
1954								9,537		11					28,575
1955								6,173		93					32,005
1956								5,727		388					40,383
1957								9,215		73					36,590
1958								13,934		10					28,610
1959								3,506	56	13	171	32			20,539
1960								4,547	0	1					26,079
1961								7,989	16	23	130				31,236
1962								10,769	0	25	294				33,195
1963								11,832	28	7	412				35,481
1964								9,047	39	7	131				28,631
1965				54				6,523	77	1	289				27,224
1966								15,450	12	20	435				31,161
1967				53				5,517	0	32	371				20,745
1968				33				5,773	8	12	195				21,623
1969				23				6,657	9	15	260				16,419
1970								3,873	0	19	92				11,432
1971				1				7,804	0	8	555				17,140
1972				14				11,656	45	15	1,646				21,216
1973				33				9,639	21	54	1,084				19,619
1974				47			15	5,243	30	58	344				20,685
1975				61			5	7,353	84	34	2,145				20,948
1976				17			2	8,652	25	21	1,968				19,381
1977				131			2	3,259	13	19	2,186				18,811
1978				66			2	4,663	6	5	545				26,863
1979				58				5,889	6	11	213				31,715
1980				114			5	2,327	24	7	582				22,634
1981				179				867	14	9	218				34,641
1982	31			207		2		2,639	2	11	506				29,387
1983	13			175	9	2		629	11	33	214				20,557
1984	4			477	5		8	673	29	49	166				11,573
1985	1			210	80	11		3,320	28	89	676				16,089
1986	344			70	16	13		4,851	57	12	189				19,266
1987	89			365	21	14		861	20	34	119				15,507
1988	32			108	197	37	25	923	50	6	447	1			8,989
1989	71			205	259	51	3	1,046	21	112	57				10,943
1990	132			189	149	299	16	1,380	92	65	50				8,653
1991	265			342		107	12	410	6	92	9		2		15,781
1992	288			464	73	3	5	1,928	61	110	0		0		13,995
1993	40			471	1		3	580	103	298			6		10,811
1994	50			559				906	59	89	63	2	2		16,916
1995	821			335			2	657	49	258	11		2		29,225
1996	102			956				4,639	70	40	3,700		4		23,519
1997	1,054			1,814				2,240	133	156	367		14		24,632
1998	188			1,910				1,771	281	413	1	0	20		15,775
1999	256			3,089				184	184	441	2,369	35	21		29,207
2000	2,401		0	2,780			2	693	61	342	3,019	99	21		33,995
2001	1,176		10	1,839			4	292	48	356	863		50		18,850
2002	932		1	1,523			4	50	12	654	1,708	2	55	10	19,139
2003	2,601		0	1,863			21	22	18	394	3,211	43	41	19	18,640
2004	773		0	1,714			3		11	49	8,880	14	67	10	25,620
2005	1,318			1,368			2	201	7	79	4,542		20	7	29,213
2006	1,012			1,149			1		2	96	9,927		21	3	26,389
2007	1,281			1,401			10	42	2	14	4,147		21[8]	3[8]	21,627
2008	1,866			979			2		1	93	4,392	15	21[8]	3[8]	25,087
2009	936			877			11	410	5	176	3,019		21[8]	3[8]	20,056
2010	1,196			373			36		1	122	7,746		21[8]	3[8]	17,785
2011	670	0		292			24		120	499	2,730	1	21[8]	3[8]	18,146
2012	1,421	1		210			3		43	617	6,667	1	21[8]	3[8]	15,270

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

5 US in 1952-1958 contains catch from other countries - primarily Mexico. Other includes catches from gillnet, troll, pole-and-line, and longline.

6 Catches by NZ are derived from the Ministry of Fisheries, Science Group (Compilers) 2006: Report from the Fishery Assessment Plenary, May 2006: stock assessments and yield estimates. 875 p. (Unpublished report held in NIWA library, Other countries include AUS, Cooks, Palau and so on. Catches derived from Japanese Imort Statistics as minimum estimates.

7 Other countries include AUS, Cooks, Palau and so on. Catches derived from Japanese Imort Statistics as minimum estimates.

8 Catches in New Zealand and Other countries since 2007 are carry-overs of those in 2006.

Catches in shaded cells are provisional.