Annex 5

REPORT OF THE BILLFISH WORKING GROUP WORKSHOP

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

13-20 January 2016
Honolulu, Hawaii, USA

1.0 INTRODUCTION

An intercessional workshop of the Billfish Working Group (BILLWG) of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC) was convened in Honolulu, Hawaii, USA during 13-20 January 2016. The goal of this workshop was to prepare fishery data for the stock assessment of Pacific blue marlin in 2016 including catch by quarter data, standardized catch-per-unit effort (CPUE), size composition data by quarter, tagging data, and life history parameters.

Jon Brodziak, Chair of the BILLWG, welcomed participants from Japan, the United States of America (USA) and the Inter-American Tropical Tuna Commission (IATTC) (Attachment 1). The Chair noted that there were no meeting participants from China, Chinese Taipei, Korea, or Mexico.

2.0 ADOPTION OF AGENDA AND ASSIGNMENT OF RAPPORTEURS

Rapporteuring duties for the working group (WG) were assigned to Jon Brodziak, Yi-Jay Chang, Russell Ito, Felipe Carvalho, Darryl Tagami, William Walsh, Brian Langseth, Hirotaka Ijima, Mikihiko Kai, and Michael Hinton. The meeting agenda was adopted on January 13, 2016 (Attachment 2).

3.0 COMPUTING FACILITIES

Computing facilities included a Google drive named "BILLWG" for the distribution of working papers and other meeting documents and the transfer of other information as well as a Wi-Fi wireless network access point for connection to the Internet.

4.0 DISTRIBUTION OF WORKING PAPERS AND STATUS OF ASSIGNMENTS

Working papers were distributed and numbered (Attachment 3) and it was agreed that all finalized working papers would be posted on the ISC website and made available to the public.

The work assignments to be addressed at the January 2016 workshop were as follows:

- Submit all outstanding catch, CPUE, and size composition data for the Pacific blue marlin stock assessment to the BILLWG Chair.

- Provide draft working papers, noting that all working papers submitted at this meeting will need to be finalized by February 11, 2016.

- Prepare information, as needed, to make any corrections to the Pacific blue marlin catch, CPUE, and size composition data table for the March 2016 BILLWG stock assessment meeting.

The ISC BILLWG Chair reported that the assignments for submitting all catch, CPUE, and size composition data for the Pacific blue marlin stock assessment were completed, to the extent practicable, through working paper presentations and personal communications. The Chair noted that some ISC member countries did not submit any new blue marlin fishery data. The Chair noted that all data are due to be submitted to the data coordinator Darryl Tagami in electronic format by February 1, 2016.

The ISC BILLWG Chair reported that the assignments for providing draft working papers were completed. The Chair noted that the draft working papers needed to be finalized by February 11, 2016.

5.0 REVIEW OF RECENT FISHERIES

Four working papers on the topic of a review of recent billfish fisheries were presented to the WG by Ito, Tagami, Ijima, and Langseth. The WG reviewed the working papers and discussed the information presented by Ito, Tagami, Ijima, and Langseth.

5.1 U.S. Commercial Fisheries for Marlins in the North Pacific Ocean
Presented by Russell Ito (ISC/16/BILLWG-1/1)

This working paper summarizes historical trends and recent developments for U.S. commercial fisheries taking marlins and related billfish species (Istiophoridae) in the North Pacific Ocean. Five species of marlins are caught by U.S. commercial fisheries in the North Pacific Ocean (Ito 2016). These are striped marlin (*Kajikia audax*), blue marlin (*Makaira nigricans*), shortbill spearfish (*Tetrapturus angustirostris*), sailfish (*Istiophorus platypterus*), and black marlin (*Istiompax indica*). The first two species are predominant in the commercial landings. The description of fisheries in this report will serve as background information for stock assessment and standardization models developed by the ISC Billfish Working Group.

Discussion

During the discussion, a few points about temporal trends in the catch of blue marlin in the Hawaii-based longline fishery were clarified.

Following the presentation, a number of questions were asked to clarify the potential factors influencing marlin catches over time, especially in the Hawaii longline fleet. It was asked if the black marlin is a big part of the “others” category in the total billfish catch. The response was that black marlin does not presently comprise a substantial fraction but of the “others” category but sailfish does. The WG was also informed that data from the recreational fishery based in Hawaii were not included in the statistics, unless the catch was sold. The Chair highlighted that further attention needs to be given to recreational fisheries for future assessments. The WG discussed what could be causing the increase in shortbill spearfish catches; however, there was no clear reason for this increase. Particular attention was given to the statistics from the Hawaii troll fishery. It was asked “What is the percentage of striped marlin caught in the troll fishery?”, and the answer was that striped marlins are not caught very often in the troll fishery because this fishery targets yellowfin tuna as well as blue marlin and other pelagic species such as mahimahi and wahoo. The WG suggested looking into potential changes in targeting by the troll fishery over the years. The WG also noted the similarities between the size composition data from the troll and longline fisheries.

5.2 Updated Blue Marlin Catches (2012-2014) in the North and South Pacific from WCPFC Data
Presented by Darryl Tagami (ISC/16/BILLWG-1/3)

This working paper presents catch summaries and distribution plots of blue marlin in the North Pacific and South Pacific from ISC and non-ISC member countries reported to the WCPFC (Tagami and Wang 2016). The data were provided by the WCPFC for longline catches of blue marlin only. The purpose was to provide the ISC Billfish Working Group with new billfish catch data that were not available in the ISC Billfish Working Group’s data holdings. These blue marlin catch data were made available to the ISC for stock assessment purposes. Total catches of blue marlin in metric tons are presented for each ISC and WCPFC country. Spatial distribution plots for all years and the most recent 3-year period (2012-2014) are also presented for the ISC countries, China, and Indonesia.

Discussion

The WG noted that Taiwan has had the largest annual catches of blue marlin since 2001, while Japan’s and Korea’s annual catches have decreased. A question was raised about what fishing areas of the WCPFC and ISC countries were covered. The presenter clarified that both the WCPFC Category I and Category II datasets covered the WCPFC region in the North and South Pacific Oceans.

A question was raised about any impacts of the territorial disputes in the South China Sea on the reporting of blue marlin catch in this region. It was not clear if there were any impacts, but the WG noted that the WCPFC has improved the quality of catch and other data for the Southeast Asia region in recent years. The WG asked if Taiwan would be able provide its 2012-2014 blue marlin catch data during the meeting, and later in the meeting, the Taiwanese catch data were provided (Nan-Jay Su, pers. comm.). A question was raised about the beginning year of the American Samoa longline time series of annual blue marlin catches. It was answered that this catch time series started in 1996. The WG noted that the reported Indonesian catches of blue marlin in the eastern part of the WCPFC region appeared questionable. This Indonesia catch data was later checked in the WCPFC Category II dataset by the WCPFC and found to be valid (Peter Williams, pers. comm.).

The WG noted that China and Korea did not provide any new catch information to the WG for the 2016 assessment update, but that China had provided catch data for the 2013 assessment. The WG noted that five countries (Japan, Taiwan, Korea, Indonesia, and China, see Table 1 in the Working Paper 3) have caught most of the blue marlin over time. The WG noted the longline catches of these countries would have an important effect on the assessment results.

5.3 A time spatial analysis of Japanese size frequency data of North Pacific striped marlin (*Kajikia Audax*).
Presented by Hirotaka Ijima (ISC/16/BILLWG-1/7)

The spatial and temporal distribution of the size composition of North Pacific striped marlin caught by the Japanese distant-water and offshore longline fishery was reviewed provisionally (Ijima and Shiozaki 2016a). The size composition data showed quarterly, spatial and annual differences. The BILLWG did not have this information available for the 2013 assessment and it is recommended that the BILLWG use this information to reconsider the fishery definitions used for the next North Pacific striped marlin stock assessment.

Discussion

The WG noted that the patterns of size frequency data for striped marlin caught by Japanese longliners were similar to the patterns observed in the Hawaii longline data. The WG also noted that there was an apparent decreasing trend in recruitment suggested by the lower frequency of the smaller fish in the past decade. The WG was interested by the apparent signal of a strong recruitment pulse during quarter 2 in the 1990s. The WG noted that the previous stock assessment considered the shift of selectivity in 1990s by including a time block for fishery selectivity. It was also confirmed that all of the size data for fish smaller than 120 cm were included in the first length bin in the 2013 assessment model. It was noted that the Japanese training research vessels and the Japanese longline fleet fish in different areas so this analysis was only useful to understand the fishery selectivity patterns for striped marlin caught by the Japanese longline fleet. One WG member expressed concern about the relationships between temporal shifts of fishing gear configurations and the size frequency data. Another WG member proposed using quarterly fleet definitions to improve the assessment model fits to the striped marlin size composition data. The WG noted that small striped marlin were caught around Hawaii, while larger fish tended to be caught nearer the equator. It was commented that in recent years, Japanese longliners have fished in equatorial areas of the Eastern Pacific where they tend to catch relatively large striped marlin. Overall, the WG encouraged further work on characterizing the spatial structure of the striped marlin stock through collaborative research among working group members.

5.4 Spatial and temporal patterns in Striped Marlin (*Kajikia audax*) length in the Hawaiian deep-set longline fishery.
Presented by Brian Langseth (ISC/16/BILLWG-1/8)

Spatial and temporal patterns in striped marlin (*Kajikia audax*) length frequency data collected by fishery observers of the Hawaiian deep-set longline fishery were described both visually and quantitatively (Langseth 2016). Statistical analyses of temporal and spatial variation indicated that temporal patterns had a greater influence on striped marlin length than did spatial patterns. Length frequency distributions across quarters had the most differences among the factors considered with smaller mean lengths observed in quarters 4 and 1, which suggested that recruitment to the fishery occurred in quarter 4 and that the new recruits continued to grow over time. Larger mean lengths were observed in quarter 2, which suggested the potential movement of larger adults into the deep-set sector fishing grounds. Yearly patterns in mean length varied over time, with increases observed during 2003-2010, followed by a large drop in 2011. Spatial patterns in mean length were more difficult to discern, but there was a consistent pattern of smaller fish captured near the center of the fishing grounds around the Main Hawaiian Islands, with larger fish found on the edges. Extension of these analyses to include additional length frequency data sets from other longline fleets that capture striped marlin in the North Pacific Ocean would be valuable for better characterizing and understanding the patterns and variability in striped marlin size distributions.

<u>Discussion</u>

The WG discussed the differences between the Japanese distant-water and offshore longline and the Hawaii deep-set longline size composition data. Both sets of size data exhibited bimodal distributions by quarter, but their quarterly trends in mean sizes were different. Japanese longliners caught small fish in the first and second quarters, whereas Hawaiian deep-set longliners caught small fish in the first and fourth quarters. Because the Japanese data sets covered a longer time period (1970-2014) and a larger area than the Hawaiian data sets, it was suggested that these data sets should be compared for the same areas and time periods.

When comparing data sets across fisheries, the WG noted that the effects of fishing gear should be included in the GAM analysis to account for differences in fishery operations. The WG also noted that this type of analysis could be applied to other billfish species (e.g., swordfish; blue marlin).

The WG discussed the similarities and differences between the Japanese and Hawaii longline fisheries that captured striped marlin. It was noted that, if two fisheries operated in the same area and caught fish of similar sizes, they might be combined, which may improve the model configuration. In practical terms, the WG concluded that the Japanese and Hawaii longline fisheries that captured striped marlin were not similar enough to be combined and also noted that and fishery operational data were not consistently available for both fisheries.

6.0 FISHERY STATISTICS FOR PACIFIC BLUE MARLIN

Six working papers on the topic of fishery statistics for Pacific blue marlin were presented to the WG by Ijima, Chang, Carvalho, Kai, Langseth and Brodziak for Su, who could not attend. The WG reviewed the working papers and discussed the information presented by Ijima, Chang, Carvalho, Kai, Langseth and Brodziak.

6.1 Japanese catch statistics of the Pacific Blue Marlin (*Makaira nigricans*): Update for a stock assessment
Presented by Hirotaka Ijima (ISC/16/BILLWG-1/2)

Japanese catch statistics of the Pacific blue marlin, i.e. catch amount and size composition data, were one of the important sources of inputs to the stock analysis using stock synthesis conducted by the ISC Billfish Working Group in 2013 (Ijima and Shiozaki 2016b). This document updated these statistics to prepare for the next assessment of this stock. The catch amount data were obtained from Japanese yearbooks and logbooks between 1971 and 2014. These statistics were provided for ten types of fisheries. The reported total catch amount of the Pacific blue marlin by Japanese fisheries was 2,524 metric tons, caught mainly by longline fisheries. The modes of the size composition data, mostly obtained by offshore and distant water longline fisheries in updated years, were roughly similar to previous years.

Discussion

The WG noted that no details were provided on the ratio of blue to black marlin during 1994-1998, which was the time period used to estimate the proportion of blue marlin in the mixed catch during earlier years. It was agreed that this information would be provided in the final working paper. The WG also requested further information on the ratio of blue to black marlin in reported Japanese fisheries catches by year since the 1970s.

The WG noted (see Figure 5 in Working Paper 2) that the variability in size data after 1993 was greater than in previous years. This was said to be due to a change in fisheries definitions resulting from a change in fishing areas for the distant-water longline fishery. The distribution of fishing effort for the distant-water longline fishery showed that the center of effort was near Hawaii after 1995, which reflected a movement of effort towards the area north of 10˚N and west of 160˚W to target albacore. Some of the reduction in catch of blue marlin by the Japanese fleet probably reflected this shift in target and fishing area (see Ijima et al. 2013).

It was explained that data from the Research Project on Japanese bluefin tuna was used to characterize the catch of blue marlin in the Japanese coastal fisheries because this project collected information on species other than bluefin while updating the data for bluefin tuna.

It was also explained that fewer data were collected because of the closure of the large-scale high seas driftnet fishery in the 1990s, which was the main source of blue marlin size composition data for driftnet fisheries. The WG noted that no weight frequency data were available for blue marlin from the driftnet fisheries after 1998; it was clarified that there were insufficient data to characterize the weight frequencies and that a total of three blue marlin captured in this fishery were measured during 1999-2003.

6.2 Summary of Blue Marlin Catch and Size Data from the Western and Central Pacific Fisheries Commission and the Inter-American Tropical Tuna Commission

Presented by Yi-Jay Chang (ISC/16/BILLWG-1/4)

Data on blue marlin (*Makaira nigricans*) catch and length frequency data from member countries were provided by the Western and Central Pacific Fisheries Commission (WCPFC) and Inter-American Tropical Tuna Commission (IATTC) to the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean ISC Billfish Working Group for the purposes of conducting a 2016 stock assessment update (Chang et al. 2016). The aim of this working paper is to provide the preliminary input assessment data to the BILLWG. The Category I (1950-2014), II (1978-2015), and III data (1991-2014) from the WCPFC and Category I data (1954-2014) and III (1990-2013) from the IATTC were tabulated and visualized. We quantified the amount of catch and the size composition in the WCPFC and IATTC overlapping area. Preliminary time series of catches and size compositions from the fleets used in the stock assessment model were developed. Consistency between the two datasets was also evaluated in this working paper. Further in-depth exploration of various data sets will be discussed at the 2016 BILLWG data preparation meeting.

Discussion

The WG noted that the estimated catch of blue marlin by Indonesia during 2011-2014 (Table 4) was very high; this value was checked and corrected later in the meeting. It was also noted that the spatial distribution of the Indonesia catches (Figure 3) from the WCPFC Category II data indicated that blue marlin catches occurred south of the Equator between 145˚W and 160˚W. The WG questioned whether these data were accurate. It was later confirmed that these data were correct and the issue was resolved.

The spatial distribution of blue marlin mean eye fork length (EFL) for Japan from 2011-2014 (Figure 5) from WCPFC Category III data indicated data in only one 5-degree square between 5-10˚N and 140-145˚E. The bubble plot of size frequency for blue marlin for Japan from 1991-2014 also indicated that there were no size data displayed from 2008-2012. Japan confirmed that blue marlin size data were not submitted to the WCPFC during those years, but indicated that size data were provided to the ISC BILLWG for stock assessment.

It was noted that new WCPFC Category I longline catch data were available for Ecuador and Portugal for the 2016 blue marlin assessment update, which were not available for the 2013 assessment. The Ecuadorean catch was not included because it represents other marlins and not blue marlin; only the Portugal longline catch data will be used.

It was verified that the US longline catch in the south of the Equator from the WCPFC Category II data was from the America Samoa longline fleet.

For the overlap area between the WCPFC and IATTC, a total of five countries (Belize, China, Spain, Korea, and Vanuatu) reported longline catch based on the WCPFC Category II data. However, the IATTC Category II data were not available prior to this meeting; only the IATTC Category I and III data were available at the start of the meeting. As a result, IATTC provided longline catch data by numbers of blue marlin caught for the overlap area separately from the remainder of the IATTC convention area during this meeting. IATTC also provided updated purse seine catch data in numbers of blue marlin caught.

Given the new information from IATTC gathered during the meeting, the graph of the preliminary catch time series for OthLL (the Other EPO longline fisheries) was updated from 2011 to 2014. This graph was presented to the WG the following day.

It was noted that no update to the preliminary catch time series for EPOOth (the French Polynesian miscellaneous fisheries in the EPO) was available. This issue was resolved by using the catch for French Polynesia unknown gear from the IATTC data to represent this fleet, as was done in the 2013 assessment.

6.3 Standardized catch rates of blue marlin (*Makaira nigricans*) in the Hawaii-based longline fishery (1995-2014)
Presented by Felipe Carvalho (ISC/16/BILLWG-1/5)

This working paper presents a standardized CPUE series for blue marlin caught in the deep-set sector of the Hawaii-based pelagic longline fishery in 1995–2014 using data from the Pacific Islands Regional Observer Program. CPUE was standardized with Generalized Linear Models (GLMs). The best fitting models were selected on the basis of the Akaike Information Criterion. As in previous analyses, predicted CPUE showed downward trends early in the time series followed by a flat trend since 2002.

Discussion

This working paper presented an update of the CPUE standardization analysis for the Hawaii longline fishery from the 2013 assessment. This differed from the 2013 analysis in that the input data were restricted to the deep-set sector of this fishery for two reasons. First, the vast majority of the blue marlin catch is taken by that sector. Second, the closure of the shallow-set sector during 2001-2004 caused a four-year break in the time series of CPUE data.

The WG asked whether the duration of movement of hooks through the preferred habitat during haul-back was a potential measure of effective fishing effort. It was noted that the duration of hook movement was not directly available but that the number of hooks per set was included in the various standardization models as an offset that provided a direct measure of effective effort.

The WG also asked why the number of hooks between floats was not included as a covariate in the GLMs used to standardize CPUE (delta-lognormal (DLN) and zero-inflated negative binomial models (ZINB)). It was noted that that the number of hooks between floats is used to define the set types (i.e., deep and shallow sets) that are the basis of the management of the Hawaii longline fishery. In response to a WG request for more information, a graphical presentation demonstrated that the number of hooks between floats had remained at approximately the same average level throughout the time period. An additional graphical presentation of the time series of bait types did reveal some changes through time. Sauries (*Cololabis sp.)* were widely used in the deep-set sector of the fleet during the last decade, while a combination of sauries and sardines was the primary bait type in the deep-set sector before the closure of the shallow-set sector. The WG also noted that the habitat-based standardization model (HBS) (Hinton and Nakano 1996) was conceptually similar to the ZINB.

The WG discussed the model diagnostics of the CPUE standardization and noted that a plot of CPUE residuals on SST from the zero process model of the ZINB suggested there was a contraction in the range of the residuals at intermediate levels of SST. It was noted that there were relatively few observations within the intermediate SST range, and that this was related to having fewer residuals to plot in that range.

6.4 Update of Japanese longline CPUE for Blue Marlin (Makaira nigricans) in the Pacific Ocean standardized applying habitat model
Presented by Mikihiko Kai (ISC/16/BILLWG-1/6)

Japanese abundance indices of blue marlin (*Makaira nigricans*) caught by offshore and distant water longline fishery in the Pacific Ocean were updated for 1994 to 2014. We applied a deterministic habitat-based standardization model (Hinton and Nakano 1996) using the same data filtering and assumptions as those used in Kanaiwa et al. (2013). Confidence intervals were estimated using a bootstrap method. Standardized CPUE had rather narrow confidence intervals and showed a generally consistent trend throughout the periods except for the first two years. The annual trend was similar to that in the previous work (Kanaiwa et al. 2013), differing only slightly in 2000s. This difference was attributed to the new temperature at depth data based on the oceanographic data from NOAA and to corrected logbook data. The consistent level of the abundance indices suggests that the abundance of blue marlin in the Pacific Ocean has been relatively stable since 1996.

Discussion

Longline data from Japan were presented, spanning two time periods, 1971-1993 and 1994-2014. The HBS model was applied to standardize CPUE during the latter time period, 1994-2014. It was explained that one model factor, the prefecture, was used as a fleet identifier.

The use of telemetry data from a total of nine tagged fish to characterize habitat preferences of blue marlin was discussed. Although this sample size was small, no other data were available for this analysis and other models (such as a delta lognormal model) were not considered. The WG suggested that exploratory analyses of hook distributions in relation to spatiotemporal factors would be informative.

The WG discussed the HBS in the context of measuring effective fishing effort. It was noted that the HBS provided no estimate of variation for the probabilities associated with the predictions for depths. It was clarified that the CVs were assumed to be very small. The WG also discussed the potential use of data weighting, and it was also suggested that the effects of spatiotemporal aggregation may be important and should be investigated.

6.5 CPUE Standardization of Blue Marlin (*Makaira nigricans*) for the Taiwanese Distant-Water Tuna Longline Fishery in the Pacific Ocean
Presented by Jon Brodziak for Nan-Jay Su (ISC/16/BILLWG-1/10)

Catch-per-unit effort data of blue marlin caught in the Taiwanese distant-water tuna longline fishery in the Pacific Ocean were standardized using generalized linear models. Category II data (aggregated into 5°×5° grids) from 1967 to 2014 and the subset of data with hooks per basket (HPB) information for 2000-2014 were used for the standardization of CPUE (catch-per-unit effort) in this study. The CPUE standardization analyses were conducted based on three time periods, 1967-1978, 1979-1999 and 2000-2014, due to changes in the available data and in the fishery operations such as targeting. Results show that the standardized CPUE of blue marlin was generally stable over 1979-1999, but has noticeably increased since then. The effect of HPB was statistically significant in the CPUE standardization. However, the CPUE trend with HPB information included in the model for 2000-2014 had a similar trend to the CPUE fit without HPB during 2000-2014. The standardized CPUE of blue marlin has exhibited an increasing trend in recent years (i.e., 2008 until 2014). The standardized CPUE estimates for blue marlin derived in this study could be used as a relative abundance index for stock assessment.

Discussion

This presentation of this working paper consisted primarily of descriptions and explanations of the tabular and graphical information from the Taiwanese distant-water longline CPUE standardization. Two models were compared for the third period (2000-2014) of the CPUE time series, one with and one without HPB information. The improvement in the model fit using HPB was evident in the analyses of deviance and in the diagnostic quantile-quantile plots. As a result, the WG noted that the use of a single CPUE time series (1967-2014) did not seem justifiable. Annual catch sources were also discussed and it appeared that the catches of the Taiwanese offshore longline fishery were not included, which may have resulted from a lack of information on fishing operations and HPB. The WG Chair noted that this was a case where having direct participation in BILLWG meetings was important and vital for developing the best available scientific information.

6.6 Size composition for Blue marlin (*Makaira nigricans*) in the Hawaii-based pelagic longline fishery, 1994-2014
Presented by Brian Langseth (ISC/16/BILLWG-1/9)

This working paper presents size composition data for blue marlin *Makaira nigricans* caught in the Hawaii longline fishery during 1994–2014 using data collected by the Pacific Islands Regional Observer Program. This information is intended to support the stock assessment update of blue marlin by the ISC Billfish Working Group. Measurements of blue marlin eye to fork lengths (EFL, in cm) are summarized by region, quarter, and fishery sector. The shallow-set sector of the fishery occurred more northerly and caught larger blue marlin (mean EFL of 176.9

cm) than the deep-set sector (mean EFL of 165.3 cm), although the Hawaii-based longline fishery is treated as a single fleet in the stock assessment. Mean sizes by year show an increasing trend in blue marlin mean length since 2000, with a peak in 2013 of 180.9 cm across both sectors. Length frequency distributions were similar across quarters, although observed lengths in quarter 1 have had a smaller range since 2007 and had lower sample size compared to other quarters. Overall, size frequency distributions available for the update assessment were very similar to those used for the 2013 assessment using data from 1994-2011.

Discussion

The WG made the following comments and observations on the WP and Hawaii longline size frequency data: (i) the mean size of blue marlin appears to be increasing; (ii) recent recruitment may be less than in the past based on the changes in observed sizes;(iii) future assessment modelling should consider the effect of regulatory changes during 2000-2004. The WG discussed how CPUE and mean weight could have opposite trends, i.e., there was a decreasing trend for CPUE and an increasing mean weight over the same time period. The WG noted that there were multiple explanations of why this pattern was observed and that modelling and model diagnostics may help to identify the causes of the opposite trends. The WG raised several questions about the data: e.g., how many samples were used to calculate mean weight; why was there so much variability in the mean size of the shallow-set sector of the longline fishery; and how are the recruits (blue marlin <120 cm EFL) going to be treated in the assessment modeling? Each of these questions was addressed through additional presentations made during the meeting.

7.0 REVIEW OF LIFE HISTORY PARAMETERS FOR PACIFIC BLUE MARLIN AND OTHER BILLFISHES

Four presentations on the best available information on life history parameters of Pacific billfishes were presented to the WG. Brodziak presented life history information for Pacific blue marlin from the 2013 assessment based on existing summaries of life history parameters (i.e., Table 4.1 and Figures 4.1-4.4 in ISC (2013)). Chang and Brodziak presented preliminary blue marlin results computed using a method to characterize the uncertainty about stock-recruitment steepness that had previously been developed for striped marlin. In another presentation by Brodziak, some recent collaborative work on ageing swordfish between NOAA Fisheries and CSIRO was discussed. Lutcavage and Lam presented information on the practical application of PSAT and conventional tagging to better understand the life history characteristics of tunas and marlins. The WG reviewed and discussed the presentations by Brodziak, Chang, Lutcavage and Lam.

7.1 Review of Life History Parameters for Pacific Blue Marlin
Presented by Jon Brodziak (Presentation only)

Discussion

The WG discussed the life history parameters to be used for the blue marlin stock assessment update. It was suggested that parameters from the benchmark assessment be used for the update, and the WG reviewed and discussed each group of life history parameters from the 2013 assessment. The WG noted that future research on blue marlin growth was recommended, particularly development of a single growth function spanning the full range of blue marlin sizes including information on early life history stage growth of age-0 and age-1 fish.

7.2 Incorporating Uncertainty about Steepness in the Stock-Recruitment Relationship for Stock Assessment
Presented by Yi-Jay Chang (Presentation only)

Discussion

The WG discussed the presentation describing an approach to use prior information on steepness to account for uncertainty in this parameter within an integrated assessment model. The WG noted that applying this approach would be an interesting and informative sensitivity analysis that might be conducted if time permitted. The WG discussed why the results were similar among the three specific models. The presenter explained that the assessment data provided consistent information about the most likely value of stock-recruitment steepness. It was noted that a detailed diagnostic examination might be used to better explain the results.

7.3 NOAA-CSIRO Hobart Swordfish Age and Growth Collaboration
Presented by Jon Brodziak for Robert Humphreys (Presentation only)

CSIRO Hobart scientists Jessica Farley and Naomi Clear visited the NOAA IRC during January 2015 to collaborate with Ed DeMartini and Bob Humphreys (PIFSC Life History Program) on resolving possible methodological differences in estimates of age and length at 50% maturity (L_{50}) of swordfish sampled from waters off Hawaii and the western South Pacific near Australia. Anal fin spine and otolith sections were re-examined for age estimation, and gonad histology slides were evaluated for maturity status. Based on a re-examination of 100 sectioned spine images used previously in an inter-calibration ageing exercise between four regional laboratories, there appears to be no major methodological differences between CSIRO and NOAA age estimates for swordfish. Unlike NOAA, CSIRO has conducted age estimates based on annuli counts appearing in sectioned otoliths. Separate growth curves based on spine and otolith sections by CSIRO show significant differences with higher maximum ages based on otolith age estimates of Australia fish. The basis for these differences remains to be determined. It was also concluded that assignment of the first annulus in spine sections could be ambiguous and subject to error unless additional protocols were developed. Further work will be conducted by CSIRO

Hobart to develop revised growth curves for Australia and to understand the basis for higher age estimates using otolith annuli counts.

A re-examination of gonad histology classification schemes used for Australia and Hawaii maturity studies indicated that methodological differences (i.e., previous frozen storage of gonad samples in the Australian study) had affected the results. Hence, the maturity classification scheme for the Australian samples was adjusted to use alternate oocyte features less susceptible to the effects of freezing that could still differentiate between immature and mature reproductive states. A preliminary maturity ogive using this modified classification for the Australian samples indicates a revised female maturity ogive and L_{50} estimate closer to the Hawaii estimates. Further work will be conducted by CSIRO Hobart to develop a revised female maturity ogive and L_{50} estimate for the Australian histology samples.

Discussion

The WG discussed the information from Bob Humphreys describing work with CSIRO Hobart in Australia on swordfish age and maturity. The WG noted that the CSIRO work validated the BILLWG's use of age estimates from anal spines, yet also noted that if otolith and anal spine estimates differed in the South Pacific, then such estimates may also differ in the North Pacific. The WG agreed that there is a vital need for further life history studies of swordfish and that ideally there should be ongoing collaboration between assessment and life history programs to better characterize swordfish life history parameters.

The WG discussed whether individual countries used recommendations from the ISC as part of their research planning. If recommendations were followed, then the BILLWG could request future support from ISC countries to accomplish research goals in specific geographical areas. In particular, the WG noted that it would be very important to collect further information from the WCNPO and EPO to better characterize the stock structure of swordfish in the Pacific.

7.4 Identifying Stock Connectivity in Data Poor Regions of the North Pacific: Striped Marlin Cooperative PSAT and Conventional Tagging for Hawaii and the Mariana Islands. Presented by Molly Lutcavage and Tim Lam (Presentation only)

Discussion

Drs. Molly Lutcavage and Tim Lam presented an overview of the tuna-tagging research conducted by the Large Pelagic Research Center (LPRC). Their presentation focused on showing how tagging information has been used to provide scientific advice for the management of tunas in the Atlantic Ocean. During the past 17 years, the LPRC has tested and deployed a variety of satellite tags in a number of species with a primary focus on Atlantic bluefin tuna. It was emphasized that there is an urgent need to improve tagging technology because we are still using technology developed for satellite tags in 1996. Consequently, the information collected from satellite tagging programs has had limited practical application for stock assessment.

The WG discussed how deploying satellite tags on blue marlin caught off Hawaii could help address questions about stock structure and mixing as well as address the association of these species with environmental factors such as sea surface temperature. Some preliminary results on a striped marlin tagging study conducted in collaboration with Australia, New Zealand, Mexico, the U.S., were also presented and reviewed. The tag recovery data included individuals tagged in different regions of the Pacific Ocean, including Hawaii. Information on the new collaborative tagging project between the LPRC and the Pacific Islands Fisheries Group (PIFG) was also discussed and the WG noted that the goal of this project was to increase our understanding of the spatial movements and behavioral ecology of striped marlin.

The WG acknowledged the efforts made by the LPRC and PIFG to improve scientific knowledge of billfishes in the Pacific Ocean and expressed its interest in using information from tagging studies in the future.

8.0 FINALIZE PACIFIC BLUE MARLIN FISHERY STATISTICS

8.1 Fishery Catch

The WG discussed and agreed upon the fishery catch statistics to be used for the stock assessment of the Pacific blue marlin stock by fishing fleet (Table 8.1). The WG produced a summary of the current status of the fishery catch data by fishery and by country (Table 8.1).

Annual catch of Pacific blue marlin by country and fleet

1. **China**
    - Chinese catch data were not provided by China. Catch tables for China were updated from fishery statistics submitted to the WCPFC and described in Working Paper 4 (Chang et al. 2016).

2. **Chinese Taipei**
    - Catch tables for Chinese Taipei were updated by correspondence (Nan-Jay Su, pers. comm. 15-Jan-2016).

3. **Japan**
    - Catch tables for Japan were updated from catch statistics described in Working Paper 2 (Ijima and Shiozaki 2016).
4. **Korea**
    - Korean catch data were not provided by Korea. Catch tables for Korea were updated from fishery statistics submitted to the WCPFC and described in Working Paper 4 (Chang et al. 2016).

5. **Mexico**
    - Mexican catch data were not provided by Mexico. Catch tables for Mexico were updated from fishery statistics submitted to the WCPFC and described in Working Paper 4 (Chang et al. 2016).

6. USA

- Catch tables for the USA were updated via correspondence for the Hawaii longline fishery (Russell Ito, pers. comm.) and described in Working Paper 1 (Ito 2016).

7. Non-ISC countries

Catch tables for Non-ISC countries were updated by correspondence (Yi-Jay Chang, pers. comm.) and were described in Working Paper 4 (Chang et al. 2016).

Table 8.1. Fishery codes, acronyms, fishing fleets, catch time series, and total catch (1971-2014, mt) by fleet used in the stock assessment of Pacific blue marlin by fishing fleets and gears: DWLL is distant water longline; OSLL is offshore longline; COLL is coastal and other longline; DRIFT is high seas large-mesh driftnet and coastal driftnet; LL is longline; GN is gillnet; HAR is harpoon; PS is purse seine.

Fishery Code	Acronym	Fishing Fleets in Fishery	Catch Time Series	Total Catch (mt
F1	JPNEarlyLL	Japanese DWLL & OSLL	1971-1993	210,395
F2	JPNLateLL	Japanese DWLL & OSLL	1994-2014	80,614
F3	JPNCLL	Japanese COLL	1971-2014	44,476
F4	JPNDRIFT	Japanese DRIFT	1972-2014	11,937
F5	JPNBait	Japanese bait fishing	1971-2014	8,127
F6	JPNOth	Japanese other gears	1971-2014	5,063
F7	HWLL	United States (Hawaii) LL	1971-2014	14,273
F8	ASLL	United States (American Samoa) LL	1996-2014	34
F9	HWOth	United States (Hawaii) troll & handline	1987-2014	7,245
F10	TWNLL	Taiwanese DWLL	1971-2014	25,150
F11	TWNOth	Taiwanese OSLL, COLL, GN & HAR	1971-2014	182,848
F12	OthLL	Various flags[1] LL	1971-2014	187,738
F13	PYFLL	French Polynesian LL	1990-2014	6,297
F14	EPOPS	Various flags[2] PS in IATTC region	1993-2014	29
F15	WCPFCPS	Various flags[3] in WCPFC region	1971-2014	10,747
F16	EPOOth	French Polynesian troll & handline, HAR	2006-2014	1,257
ALL	ALL	All Fleets	1971-2014	796,230

- [1]Australia, Belize, China, Cook Islands, Costa Rica, Fiji, Indonesia, Kiribati, Korea, Marshall Islands, Mexico, Federated States of Micronesia, New Caledonia, Niue, New Zealand, Papua New Guinea, Philippines, Samoa, Senegal, Spain, Solomon Islands, Tonga, Tuvalu, Vanuatu, and Vietnam.
- [2] Ecuador, Honduras, México, Nicaragua, Panamá, El Salvador, Spain, Venezuela, Vanuatu, and USA.

- [3] Australia, China, Ecuador, Federated States of Micronesia, Indonesia, Kiribati, Marshall Islands, Mexico, New Zealand, Papua New Guinea, Philippines, Solomon Islands, El Salvador, Spain, Tuvalu, Vanuatu, Korea, Japan, and USA.

Discussion

The WG noted that the Japanese blue marlin catches in 2014 were preliminary and incomplete. The yearbook data of 2014 is very preliminary because there are no data for some fisheries; hence Japanese catch data estimated by yearbook (Table 2 in Working Paper 2) were replaced with 2013 catch data.

The WG requested that the catch of blue marlin by the American Samoa longline fishery be confirmed and that the units of catch be reported in 1000's of fish. The American Samoa longline catch was confirmed and was reported in unit of thousands of fish during the meeting.

The WG requested that the catch of blue marlin by the Indonesian longline fishery in the eastern part of the WCPFC area be confirmed. The Indonesian longline catch statistics were confirmed (Peter Williams, SPC, pers. comm.) during the meeting.

The catch data provided at this meeting were accepted by the WG as the best available scientific information for use in the 2016 Pacific blue marlin stock assessment. For countries that did not attend this meeting and did not directly submit updated catch data to the BILLWG, catch data from annual submissions to the WCPFC and IATTC were used.

8.2 Fishery CPUE

The WG produced a summary of the standardized CPUE time series that were available for the previous 2013 stock assessment (Table 8.2) including whether the standardized CPUE data were used in the base case assessment model.

Annual standardized CPUE of Pacific blue marlin by country and fleet

1. **China**
    - Standardized CPUE series for China were not provided.

2. **Chinese Taipei**
    - Standardized CPUE series for Chinese Taipei (1971-1978, 1979-1999, 2000-2014) were provided in Working Paper 10 (Su et al. 2016).

3. **Japan**
    - Standardized CPUE series for Japan (1994-2014) were provided in Working Paper 6 (Kai et al. 2016). Standardized CPUE in the early period (1975-1993) was not revised from that used in the last stock assessment (ISC 2013).

4. **Korea**

- Standardized CPUE series for Korea were not provided.

5. **Mexico**
    - Standardized CPUE series for Mexico were not provided.

6. **USA**
    - Standardized CPUE series for the USA (1995-2014) were provided in Working Paper 5 (Carvalho et al. 2016).

7. **Non-ISC countries**
    - Standardized CPUE series from non-ISC countries were not available.

Table 8.2. Available standardized indices of relative abundance (CPUE) for Pacific blue marlin, where boldface indicates the five abundance indices that were used and fitted in the SS3 base-case assessment model. See Table 8.1 for fishery codes and acronyms.

Index	Fishery Acronym (Code)	Time Series	Source
S1	**JPNEarlyLL (F1)**	**1975-1993**	**Kanaiwa et al. (2013)**
S2	**JPNLateLL (F2)**	**1994-2014**	**Kai et al. (2016)**
S3	HWLL (F7)	1995-2014	Carvalho et al. (2016)
S4	**TWNLL-Early (F10)**	**1971-1978**	**Su et al. (2016)**
S5	**TWNLL-Middle (F10)**	**1979-1999**	**Su et al. (2016)**
S6	**TNWLL-Late (F10)**	**2000-2014**	**Su et al. (2016)**

<u>Discussion</u>

It was noted that China, Korea, and Mexico also did not provide any CPUE time series for the 2013 ISC stock assessment for Pacific blue marlin. The standardized CPUE data provided at this meeting were accepted by the WG as the best available scientific information for use in the 2016 Pacific blue marlin stock assessment.

8.3 Fishery Size Composition

The WG produced a summary of the fishery size composition data previously available for the 2013 stock assessment (Table 8.3) and a consensus summary of the current status of the size composition data by country.

<u>Size composition data for Pacific blue marlin by country and fleet</u>

1. **China**
    - Chinese size composition data were not provided for the 2013 assessment.
    - The ISC Billfish Working Group will formally request size data from China for the next assessment.

2. **Chinese Taipei**
    - Chinese Taipei size composition data by quarter for 2011-2014 were provided to the WG via correspondence (Nan-Jay Su, pers. comm., Jan-2016).

3. **Japan**
    - Japanese size composition data were provided in Working Paper 2 (Ijima and Shiozaki 2016).

4. **Korea**
    - Korean size composition data were not provided for the 2013 and 2016 assessments.
    - The ISC Billfish Working Group will formally request size data from Korea for the next assessment.

5. **Mexico**
    - Mexican size composition data were not provided for the 2013 and 2016 assessments.
    - The ISC Billfish Working Group will formally request size data from Mexico for the next assessment.

6. **USA**
    - USA size composition data were provided in Working Paper 9 (Langseth and Fletcher 2016).

7. **Non-ISC countries**
    - Size composition data (Category III) for longline fleets were received from the WCPFC prior to the meeting and were described in Working Paper 4 (Chang et al. 2016).

Table 8.3. Available size composition data for Pacific blue marlin by fishery. See Table 8.1 for fishery acronyms and codes.

Size Composition Index	Fishery Acronym (Code)	Time Series	Source
C1	JPNEarlyLL (F1)	1975-1993	Kanaiwa et al. (2013)
C2	JPNLateLL (F2)	1994-2014	Ijima and Shiozaki (2016)
C3	HWLL (F7)	1994-2014	Langseth and Fletcher (2016)
C4	TWNLL-Late (F10)	2005-2014	Nan-Jay Su (pers. comm., Jan-2016)
C5	EPOPS (F14)	1991-2014	Chang et al. (2016)
C6	JPNDrift (F4)	1977-1980, 1982-1987, 1988-1989, 1993,1998	Yokawa et al. (2015)
C7	OthLL (F12)	1992-2014	Chang et al. (2016)
C8	PYFLL (F13)	1996-2014	Chang et al. (2016)

Discussion

The WG noted that the fishery statistics were provided in several working papers. The WG agreed that all blue marlin catch by country and fleet, standardized CPUE, and size composition data would be provided in electronic format to Darryl Tagami, the WG's data coordinator, either by the end of this meeting or by 1-February-2016 via email.

The size composition data provided by countries and submitted at this meeting were also accepted. For those countries that did not attend this meeting and did not submit size data, data from RFMO submissions would be used. The WG noted that the mean size of Taiwan longline blue marlin in 2014 was substantially higher than the long-term mean and this discrepancy needs an explanation for the information to be credible.

The raw size data of the Japan distant water and offshore longline after 1992 were updated. This was a minor update because there was only a small difference in the number of blue marlin size records from the previous assessment. The updated recent Japanese longline size composition data were also similar to the number of records from the previous assessment and will be used in the 2016 assessment.

The WG noted that the IATTC size data after 2008 had more records than in the previous 2013 assessment and also noted that the number of size samples from French Polynesia was similar to the previous data submission in 2013.

8.4 Comparison of Updated and Previous Fishery Statistics for Pacific Blue Marlin

The WG compared the updated 2016 and previous 2013 fishery statistics (ISC 2013) gathered for the Pacific blue marlin stock assessment. This was done to check the consistency of the input data sources used for stock assessment. The consistency check had three components: a visual comparison consisting of a graph showing the updated and previous time series; a correlation analysis of the updated and previous time series; and a graph or table showing the percent difference (or relative percent difference) between the updated and the previous time series. These checks were applied to the total blue marlin catch series, the standardized CPUE series scaled to mean CPUE, and the mean size of the size composition time series. The WG suggested that these comparisons should become a standard part of working papers providing updated data for stock assessments conducted by the BILLWG.

The comparison of updated and previous fishery catch statistics for Pacific blue marlin indicated that the input data for the stock assessment were very consistent. The comparison of the total catch time series showed negligible differences for the most part (<1% difference per year). The catch series for individual fleets also showed negligible differences between the updated and previous annual catch amounts. For example, the WCPFC purse seine fleet showed a maximal percent difference of 2.5% in annual catch in 2004 with a correlation of $\rho=0.9$ between the updated and previous total catch time series. This discrepancy was considered to be small and was less than the 10% rule of thumb suggested for characterizing percent differences that were important enough to warrant further investigation, with the exception of the French Polynesia longline fleet, which had differences greater than 15% in 1994 and 2002. For this fleet the correlation between old and updated data was $\rho = 0.84$ and the WG found that the updated and previous catch data were consistent enough given that the blue marlin catches from this fleet were relatively small in comparison to other fleets. Overall, the WG judged that the updated catch data series were consistent with the 2013 data and also concluded that the updated 2016 catch series was the best available scientific information for conducting the 2016 stock assessment.

The comparison of the updated and previous standardized CPUE series showed similarly high levels of consistency. While the Japanese late period longline CPUE series showed some differences above 10% in a few years, the WG noted that this series was recalculated in 2015. In particular, this recalculation included both corrections to the original data used in 2013 and an improved source of SST information. As a result, some differences in the two series were to be expected. The Hawaii longline fishery CPUE also showed a few years in which the differences between the updated and previous annual values exceeded 10%. However, the WG noted that the new Hawaiian CPUE series did not use the data from the shallow-set sector (< 15 hooks per float) for standardization, and this would also lead to some expected differences in estimates of standardized CPUE. Overall, the WG accepted the updated standardized CPUE series as being consistent with the previous data and as the best available scientific information to conduct the 2016 stock assessment.

The comparison of updated and previous size composition time series also showed similarly high levels of consistency. While the updated size composition data for the Japan drift net fishery were selected for use, the WG noted that there were some inconsistencies found in the previous 2013 series. In total, six of the seven size composition datasets were highly consistent with the data used in 2013 and the WG accepted the updated size composition data as the best available scientific information for the 2016 stock assessment. Overall, the WG considered the updated set of fishery statistics to be the best available scientific information and finalized the set of input data for the base case assessment model.

9.0 FINALIZE PACIFIC BLUE MARLIN LIFE HISTORY PARAMETERS

The WG discussed and reached consensus on the set of life history parameters to be used for the stock assessment of Pacific blue marlin. The WG accepted the growth parameters, length-weight relationship, maturity, natural mortality, and stock-recruitment relationship as summarized in the 2013 benchmark assessment (ISC 2013, Table 4.1) and listed here (Table 9.0). As a result, the same parameters used for the 2013 benchmark assessment were agreed on for use in the 2016 assessment update.

9.1 Growth

In the 2013 assessment, growth was observed to be rapid in both sexes (BILLWG 2013). It was assumed that there is little sexual dimorphism in the first year of growth based on otolith microstructure counts (Shimose 2008, unpublished PhD dissertation). Sex-specific length-at-age relationships for ages greater than one year were based on meta-analyses of growth studies (Chang et al. 2013). The hierarchical model with homogeneous variance (HBHV) for females from Chang et al. (2013) was used in the assessment because the estimate of size-at-age 1-year (144.0 cm) was very close to the estimated mean size (146.0 cm, CV = 7%) from Shimose (2008, unpublished PhD dissertation). Size-at-age 1-year using the HBHV model for males was underestimated, and as a result, the HBHV model for males was refitted with the size-at-age 1-year constrained to the fitted value for females (Figure 9.1). In the SS3 model, the relationship between eye fork length (cm) at age for Pacific blue marlin (*L*(age)) was parameterized as:

$$L(A_{max}) = L_{\infty} + \left(L(A_{min}) - L_{\infty}\right)e^{-k(A_{max}-A_{min})}$$

where $L(A_{min})$ and $L(A_{max})$ are the predicted lengths for the youngest A_{min} and oldest A_{max} ages represented in the growth model, L_{∞} is the theoretical maximum length, and *k* is the Brody growth coefficient. In this assessment, $L(A_{min})$ was 144.0 cm for both sexes at age 1. The $L(A_{max})$ values were 304.2 cm for females and 226.0 cm for males at age 26. The *k* values were *k*=0.107 and *k*=0.211 for females and males, respectively. The L_{∞} of the von Bertalanffy curve for the SS3 parameterization was calculated as:

$$L_{\infty} = L(A_{min}) + \frac{L(A_{max}) - L(A_{min})}{1 - e^{-k(A_{max}-A_{min})}}$$

Table 9.0. Key life history, recruitment, and selectivity parameters used in the blue marlin population dynamics model. The column labeled "Estimated ?" identifies if the parameters were estimated within the assessment model (estimated), fixed at a specific value, i.e., not estimated (fixed), or iteratively re-scaled to match the predicted variance (re-scaled).

Parameter (units)	**Value**	**Estimated ?**
Natural mortality (M, age-specific^{-yr})	Female: M(0) = 0.42, M(1) = 0.37, M(2) = 0.32, M(3) = 0.27, and M(4+) = 0.22 Male: M(0) = 0.42 and M(1+) = 0.37	fixed
Length_at_1 yr (EFL cm)	Female: L(1) = 144 Male: L(1) = 144	fixed
Length_at_26 yr (EFL cm)	Female: L(26) = 304.2 Male: L(26) = 226.0	fixed
VonBertalanffy_k	Female: k = 0.107 Male: k = 0.211	fixed
$w=aL^b$ (kg)	Female: a = 1.844E-05 and b = 2.956 Male: a = 1.37E-05 and b = 2.975	fixed
Size at 50-percent maturity (EFL cm)	Female: L_{50} = 179.8	fixed
Stock-recruitment steepness (h)	h = 0.87	fixed
Unfished log-scale recruitment Ln(R0)		estimated
Standard deviation of recruitment (σ_R)	σ_R = 0.32[1]	rescaled
Initial age structure (5 years)		estimated
Recruitment deviations (1971-2010)		estimated
Selectivity		estimated
Catchability		estimated

1 The input value for σ_R = 0.6 and this value was rescaled to σ_R = 0.32 in the 2013 assessment. The same input value and rescaling procedure will be used in the 2016 assessment noting that this will probably produce a different rescaled σ_R value.

In the 2013 assessment, the female and male growth parameters *k*, $L(A_{min})$ and $L(A_{max})$ were fixed in the SS3 model. The CV for the size-at-age of an age-1 fish was assumed to be 0.14 for both sexes to account for variability in the sizes of fish observed, extra variance of disparate timing of recruitment, and regional and inter-annual variability in growth. The sex-specific CVs for the size at age of an age-26 year fish were assumed to be 0.15 and 0.1 for females and males, respectively. The assumption of a larger relative variance in the length at age of older fish was consistent with the ageing study of Hill (1986).

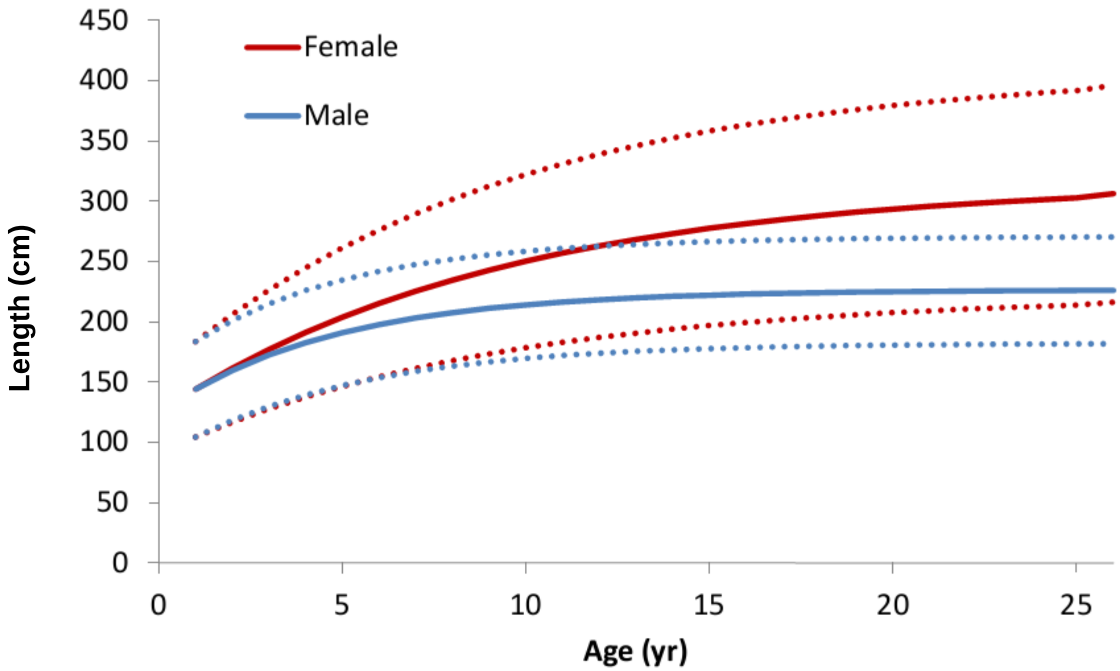

Figure 9.1. Plot of the WG length at age based on Shimose's otolith microstructure studies (2008, unpublished PhD dissertation) and meta-analyses from Chang et al. (2013) where red lines represent females and blue lines represent males. The dotted lines represent the inputted CV of length at age 1 and length at age 26 in the stock assessment model.

9.2 Length-Weight Relationship

In the 2013 assessment (BILLWG 2013) length-weight relationships are used to convert between fish length and fish weight. A metaanalysis of length-weight relationships for Pacific blue marlin indicated that eye-fork length (cm) to weight (kg) relationships were different by sex (Brodziak 2013). The estimated sex-specific length-weight relationships from Brodziak (2013) were:

Females: $W(L) = 1.844 \cdot 10^{-5} L^{2.956}$

Males: $W(L) = 1.370 \cdot 10^{-5} L^{2.975}$

where $W(L)$ is the predicted fish weight at length L. These length-weight relationships were used as fixed inputs for the base case SS3 model (Figure 9.2).

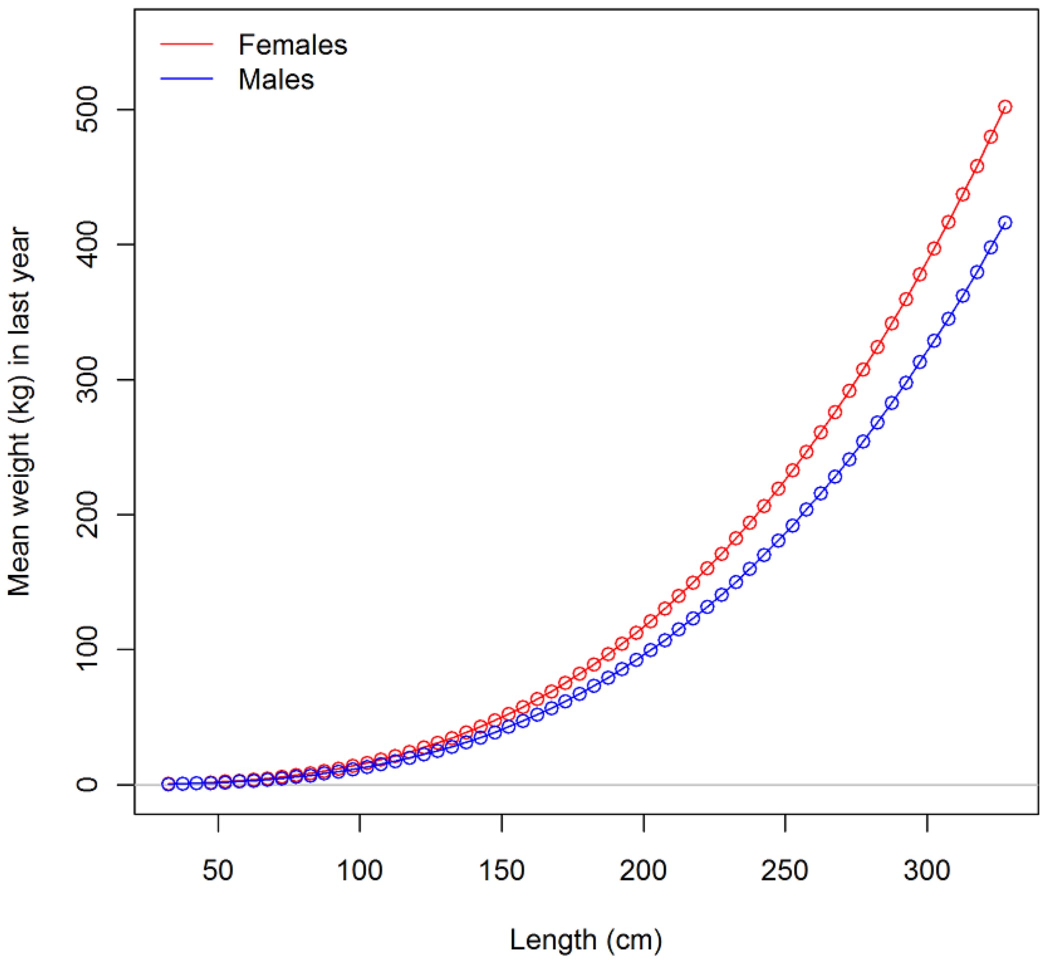

Figure 9.2. Weight at length used in the stock assessment model where the red line represents females and the blue line represents males.

9.3 Spawning and Maturity at Length

For the purposes of the 2013 assessment (ISC 2013), spawning of Pacific blue marlin was observed by Shimose et al. (2009) and Sun et al. (2009) to occur from late spring throughout summer (May-September) based on gonadal examination of females. In the base case SS3 model, spawning was assumed to occur at the beginning of the second quarter of the calendar year, which corresponds to the beginning of spawning season. The maturity ogive used in the 2013 assessment was based on Sun et al. (2009) but was reparameterized for input to the SS3 model (Figure 9.3), where the female size at 50-percent maturity was $L_{50} = 179.76$ cm and the slope of the logistic function was $\sigma_L = -0.2039$. Recruitment timing was assumed to occur in the second quarter (April-June) of the base case SS3 model.

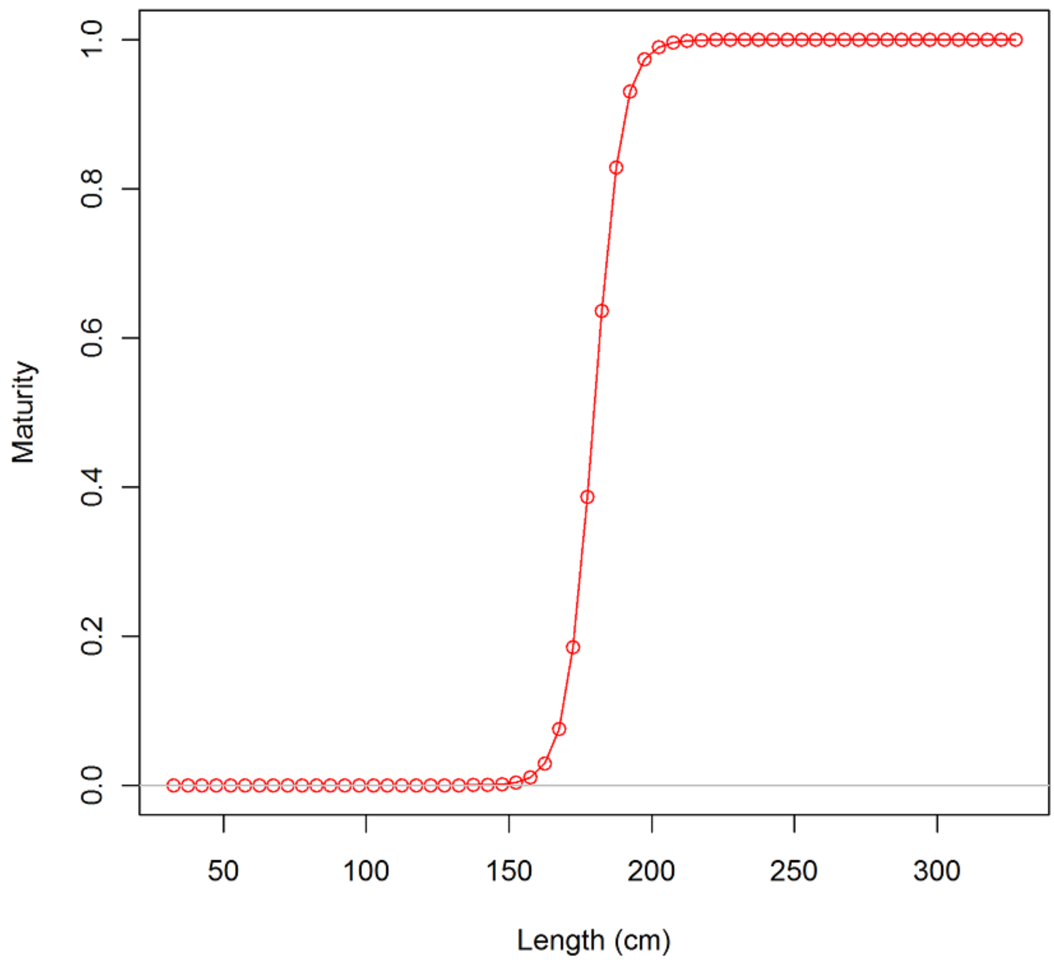

Figure 9.3. Maturity at length (eye fork length) for female Pacific blue marlin used in the base case assessment model where the size at 50-percent maturity was 179 cm.

9.4 Natural Mortality Rate

In the 2013 assessment (ISC 2013), instantaneous natural mortality (M) was assumed to be age- and sex-specific. Age-specific estimates of M for Pacific blue marlin were derived from a metaanalysis of nine estimators based on empirical and life history methods to represent adult fish (Lee and Chang 2013). Age-specific estimates of M were fixed in the base case SS3 model as 0.42 year-1 for age 0, 0.37 year-1 for age 1, 0.32 year-1 for age 2, 0.27 year-1 for age 3, and 0.22 year-1 for age above 4 for female and 0.42 year-1 for age 0, 0.37 year-1 for age above 1 for male in this assessment (Figure 9.4).

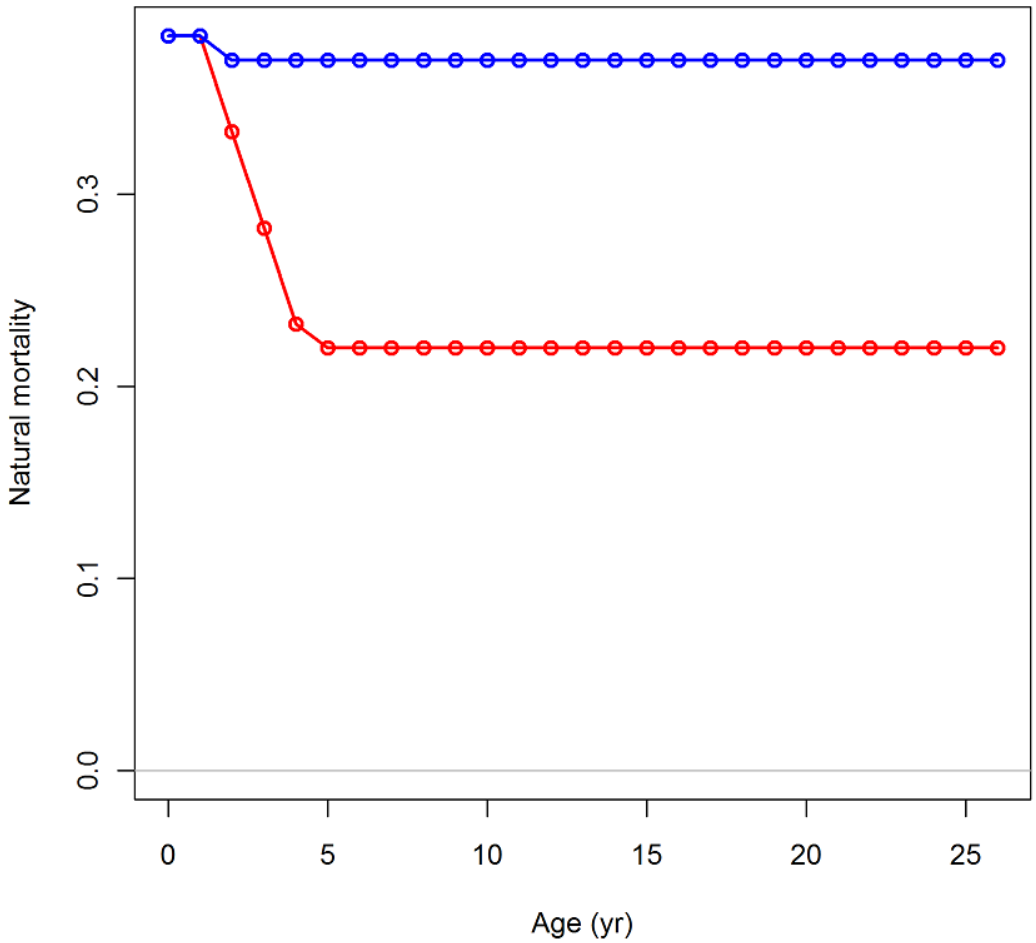

Figure 9.4. Natural mortality at age assumed in the population dynamics model where the red line represents females and the blue line represents males.

9.5 Stock-Recruitment Resilience

The WG agreed to use a Beverton-Holt stock-recruitment curve as the basis for predicting expected recruitment, as in the 2013 assessment (ISC 2013). The WG also agreed to use the same value of steepness for Pacific blue marlin based on the similarity of the life history parameters for blue marlin and striped marlin. The WG noted that the new median estimate of steepness from Brodziak et al. (2015) was equal to the same steepness value assumed in the 2013 Pacific blue marlin stock assessment. Overall, the WG agreed to use the same steepness value of h=0.87 in the 2016 stock assessment.

No new information about recruitment variability (σ_R) was available, so the WG agreed to use the same recruitment variability used in the previous 2013 assessment in this assessment. That is, a Beverton-Holt stock-recruitment curve with $\sigma_R = 0.6$ will be used as initial input with the value iteratively rescaled in the final model to match expected variability. The time period for estimating recruitment deviations will be modified to be the time period 1966-2013.

9.6 Life History Parameter Summary Table

Overall, the WG agreed that the table of life history parameters to be used in the 2016 stock assessment was the best available scientific information (Table 9.0).

10.0 WORK ASSIGNMENTS FOR PACIFIC BLUE MARLIN

10.1 Base Case Model Inputs

The WG discussed the input data for the base case stock synthesis model used to assess Pacific blue marlin. The WG consensus was to use the fishery statistics information agreed upon in agenda item 8 and the life history information agreed upon in agenda item 9 for the base case assessment. The WG also recommended that:

- Consistency checks be done between updated data and data used in previous assessments
- Use the best available scientific data. In particular, incorporate new or updated data unless it is of poorer quality than the previous data.

10.2 Base Case Model Structure for the Assessment Update

The WG noted that the 2016 Pacific blue marlin stock assessment was to be an update of the 2013 benchmark assessment. The WG discussed exactly what the base case model for an assessment update was intended to be. After these discussions, the WG concluded that, for the Pacific blue marlin assessment update, the base case would incorporate the following features:

- Use the same base case model structure and assumptions.
- Modify the model structure only if it is necessary, for example, based on a lack of convergence or a severely degraded model fit to the observed data.

10.3 Sensitivity Analyses for the Base Case Model

The WG discussed the sensitivity analyses to be carried out in the next stock assessment. The WG agreed that the same sensitivity analyses conducted in the last blue marlin assessment in 2013 must be conducted for this 2016 update. The WG noted that these sensitivity analyses are listed in Table 4.5 of ISC (2013). The contents of Table 4.5 remain pertinent to present tasks, and for this reason, it was agreed that it should be re-produced in the stock assessment update report (Table 10.3). The WG agreed that the first priority would be to conduct sensitivity analyses using the same scenarios from the last assessment. New scenarios will be listed as “proposed” and would be conducted only if time permits.

To this end, one additional sensitivity analysis was discussed to augment those that had been run in 2013. This sensitivity analysis, which would include the CPUEs from late Taiwan and early Japan only (CPUE for fleets S1 and S6), might be important as catches from Taiwan have increased in the last few years and the WG proposed to run this sensitivity analysis to characterize the influence of the Taiwanese fishery information. This remained as a suggestion, and no commitment was made to perform the additional sensitivity analysis work during the March 2016 stock assessment meeting.

Table 10.3. Sensitivity analyses to characterize the effects of alternative assumptions about input data and life history parameters used in the base case model for the 2016 stock assessment of Pacific blue marlin.

Sensitivity Analyses for Input Data

1. **Alternative CPUE trends**. Fit the model to only the Japanese distant water longline early period fishery (JPNEarlyLL, S1) and Hawaiian longline fishery (HWLL, S3) CPUE time series.
2. **Drop weight composition data**. Fit the model without the weight composition data for the Japanese driftnet fishery (JPNDRIFT, F4).
3. **Drop length composition data**. Fit the model without the length composition data for the French Polynesian longline fishery (PYFLL, F13).

Sensitivity Analyses for Life History Parameters

4. **Alternative natural mortality rates (*M*)**. Lower natural mortality rate. Fit the model using an adult *M*=0.12 for females and an adult M=0.27 for males, where juvenile M is scaled as in the base case. Higher natural mortality rate. Fit the model using an adult *M*=0.32 for females and an adult *M*=0.47 for males, where juvenile M is scaled as in the base case.
5. **Alternative stock-recruitment steepness (*h*)**. Fit the model using steepness values of *h*=0.65, *h*=0.75, and *h*=0.95.
6. **Alternative growth curves**. Smaller maximum size. Fit the model with the length at the maximum reference age set to be $L(A_{max})$=205 cm using a Brody growth coefficient *k* that is consistent with the size-at-age 1 in the base case. Larger maximum size. Fit the model with the length at the maximum reference age set to be $L(A_{max})$=225 cm using a Brody growth coefficient *k* that is consistent with the size-at-age 1 in the base case. Alternative growth parameters. Fit the model using only the growth parameters for males from Chang et al. (2013).
7. **Alternative maturity ogives**. Fit the model using L_{50}=197.7 cm and L_{50}=161.8 cm as the length at 50% probability of maturity values.

10.4 Stock Projections for the Base Case Model

The WG noted that the projections conducted in the last blue marlin stock assessment were developed using SS3, and were deterministic (ISC 2013). The WG discussed the possibility of using new approaches to conduct the projections, which could potentially include deviations in recruitment. It was suggested that fishery managers would be better informed about the risk of alternative decisions if stochastic projections, instead of the deterministic projections, were provided. Nonetheless, the working group decided to conduct the projections using the same approach from last assessment. In particular, the WG agreed to update the four deterministic projections from the 2013 assessment as listed below:

1. **High F Scenario**: Select the 3-year time period with the highest average F (age 2+) and apply this fishing mortality rate to the stock estimates beginning in 2015. This was $F_{16\%}$ in the 2013 assessment.
2. **F_{MSY} Scenario**: Apply the estimate of the F_{MSY} fishing mortality rate to the stock estimates beginning in 2015. This was $F_{18\%}$ in the 2013 assessment.
3. **Status Quo F Scenario**: This will be the average F during 2012-2014 ($F_{2012\text{-}2014}$). This was $F_{23\%}$ in the 2013 assessment for 2009-2011.
4. **Low F Scenario**: $F_{30\%}$

However, as noted above, if time permits, the WG would like to develop a stochastic projection approach using the bootstrap function built into SS3.

10.5 Working Subgroup for Assessment Modeling

The WG proposed the designation of Yi-Jay Chang as the lead assessment modeling person for the Pacific blue marlin stock assessment update. Mikihiko Kai and Hirotaka Ijima were also designated to provide direct support for the modeling efforts; further support for the stock assessment modeling and projections will also be provided by Jon Brodziak, Felipe Carvalho, and Brian Langseth, conditioned on their availability.

11.0 OTHER BUSINESS

The WG discussed other business, including future assessments, future meetings, and other issues.

11.1 Future Assessments

The WG Chair suggested that a North Pacific swordfish stock assessment update would be due in 2017 based on past patterns of the WG. It was also suggested that the WG consider the further development of an age-structured assessment for swordfish in the Western and Central North Pacific or alternatively conducting a management strategy evaluation for a billfish-like life history type.

11.2 Future Meetings

The next meeting of the ISC Billfish Working Group will be held in Busan, Korea. The purpose of this meeting is to conduct the modeling needed to complete the assessment update for the Pacific blue marlin stock. This meeting is planned for March 22-30, 2016 and will be held at the Novotel Busan Ambassador Hotel in Busan, Korea.

11.3 Other Issues

The WG members present at the meeting considered the issue of appointing an acting Working Group Chair in the event that the Chair cannot attend a meeting. It was suggested that the acting Chair could be assigned at the ISC Plenary meeting, or alternatively the acting Chair could be assigned at each prior meeting. The preferred alternative seemed to be having the ISC Plenary involved in the determination of an acting Chair, and it was proposed that this idea be presented at the next ISC Plenary meeting, while noting that other working groups would have similar needs. It was suggested that the ISC Plenary Chair could serve as an acting chair in the event the current Chair is unable.

The travel costs associated with stock assessment work underlay suggestions from the PIFSC that teleconferences and similar means of communication might reduce or eliminate the need for group meetings. The attendees unanimously disagreed with this premise. The extreme geographic dispersal of the participants is associated with large time zone differences that preclude effective communication.

Last, the WG expressed its sincere appreciation and thanks to Dr. William Walsh for his scientific contributions and many years of service to the ISC Billfish Working Group.

12.0 ADJOURNMENT

The workshop was adjourned at 2:45 PM on 20 January 2016. The BILLWG Chair expressed his appreciation to the rapporteurs and to all participants for their contributions to completing a successful meeting.

13.0 REFERENCES

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Attachment 1. List of Participants

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Attachment 2. Meeting Agenda

INTERNATIONAL SCIENTIFIC COMMITTEE FOR TUNA AND TUNA-LIKE SPECIES IN THE NORTH PACIFIC

BILLFISH WORKING GROUP (BILLWG)

INTERCESSIONAL WORKSHOP AGENDA

Meeting Site:	NOAA Fisheries Honolulu Service Center[1] at Pier 38 1139 North Nimitz Highway, Suite 220 Honolulu, HI 96817, USA
Meeting Dates:	January 13-20, 2016
Goals:	The BILLWG is holding an intercessional meeting to complete data preparation for the Pacific blue marlin stock assessment including catch by quarter data, CPUE standardization, size frequency data, tagging data, and life history parameters. The goal is to finalize all Pacific blue marlin stock assessment data for a 2016 stock assessment at this meeting.
Working Paper Deadline:	Working papers must be submitted to Jeffrey Jones (email Jeffrey.Jones@noaa.gov) and Jon Brodziak (Jon.Brodziak@noaa.gov) by **Wednesday, January 6, 2016.** Authors who submit a working paper later than the January 6, 2016 deadline must provide 12 copies of that working paper on the first day of the meeting.
Local Contact:	Jon Brodziak, ISC BILLWG Chair Pacific Islands Fisheries Science Center 1845 Wasp Boulevard, Honolulu, HI 96818, USA Email: Jon.Brodziak@NOAA.GOV Tel: 808-725-5617

[1] Note: the meeting will be held in the NOAA conference room on the second floor above Uncle's Fish Market and Grill.

AGENDA

January 13 (Wednesday), 9:15-10:00 – Registration and Opening of Meeting

1. Opening of Billfish Working Group (BILLWG) Workshop
    a. Welcome and Opening of Meeting
    b. Introductions

January 13 (Wednesday), 10:30-17:30

2. Meeting Logistics
    a. Standard Meeting Protocols
    b. Computing Facilities

    BILLWG Google Drive URL and Access Information: TBD

    c. Adoption of Agenda
    d. Assignment of Rapporteurs

3. Numbering Working Papers and Distribution Potential

4. Status of Work Assignments

5. Review of Recent Fisheries
    a. Review of Recent Developments and Issues
    a. Review of Availability of 2013-2015 Fishery Data
    b. Review of Information on BILLWG Web Page:
    http://isc.ac.affrc.go.jp/working_groups/billfish.html

6. Fisheries Statistics for Pacific Blue Marlin and Other Billfishes, as Time Permits
    a. Fishery Data and Definitions
        (1) ISC Countries
        (2) Non-ISC Sources
    b. Pacific Blue Marlin Catch by Fishery
        (1) ISC Countries
        (2) Non-ISC Sources
    c. Standardized CPUE by Fishery
        (1) ISC Countries
        (2) Non-ISC Sources
    d. Other Biological Information

January 14 (Thursday), 9:30-17:30

6. Fisheries Statistics for Pacific Blue Marlin and Other Billfishes
   a. Fishery Data and Definitions
   b. Blue Marlin Catch by Fishery
   c. Standardized CPUE by Fishery
   d. Size Composition by Fishery
   e. Other Biological Information
      (1) Sex Ratios
      (2) Tagging

7. Review Life History Parameters for Pacific Blue Marlin and Other Billfishes, as Time Permits
   a. Growth
   b. Length-Weight Relationship
   c. Maturity and Fecundity
   d. Natural Mortality Rate
   e. Stock-Recruitment Relationship

6:30 PM. Reception Hosted by the Pacific Islands Fisheries Group
Empress Restaurant
100 North Beretania Street #304
Chinese Cultural Plaza
Honolulu, Hawaii 96817

January 15 (Friday), 9:30-17:30

7. Review Life History Parameters for Pacific Blue Marlin and Other Billfishes
   a. Growth
   b. Length-Weight Relationship
   c. Maturity and Fecundity
   d. Natural Mortality Rate
   e. Stock-Recruitment Relationship

January 16 (Saturday), 9:30-17:30

8. Finalize Summaries of Pacific Blue Marlin Fishery Statistics
   a. Catch Table
   b. Standardized CPUE Table
   c. Size Composition Table

6. Fisheries Statistics for Pacific Blue Marlin and Other Billfishes
   e. Other Biological Information
   (2) Tagging
      Pacific Islands Fisheries Group Research Presentation: "*Identifying Stock Connectivity in Data Poor Regions of the North Pacific: Striped Marlin Co-operative PSAT and Conventional Tagging for Hawaii and Mariana Islands*"
      by Dr. Molly Lutcavage, Director of the Large Pelagics Research Center

9. Finalize Life History Parameters for Pacific Blue Marlin
    a. Growth
    b. Length-Weight Relationship
    c. Maturity and Fecundity
    d. Natural Mortality Rate
    e. Stock-Recruitment Relationship
    f. Life History Parameter Summary Table

January 17 (Sunday), No Meeting

January 18 (Monday), 9:30-17:30

8. and 9. Complete All Work, as Needed

10. Work Plan and Assignments
    a. Update Assessment Models for Blue Marlin
    b. Approaches for BILLWG Assessment
    c. Definition of Work Groups for Assessment Modeling

11. Other Business
    a. Future Meetings
    b. World Fisheries Congress
    c. Group Photo
    d. Other Issues

12. Rapporteurs and Participants Complete Report Sections

January 19 (Tuesday), 9:30-13:00

13. Complete Workshop Report and Circulate; WG Reviews Report

January 20 (Wednesday), 9:30-15:00

14. Clearing of Report

15. Adjournment

Attachment 3. Working Papers

ISC/16/BILLWG-1/01	U.S. Commercial Fisheries for Marlins in the North Pacific Ocean. Russell Y. Ito russell.ito@noaa.gov
ISC/16/BILLWG-1/02	Japanese catch statistics of the Pacific Blue Marlin (*Makaira nigricans*): Update for a stock assessment. Hirotaka Ijima and Ko Shiozaki ijima@affrc.go.jp
ISC/16/BILLWG-1/03	Updated Blue Marlin Catches (2012-2014) in the North and South Pacific from WCPFC Data. Darryl T. Tagami and Haiyang Wang Darryl.tagami@noaa.gov
ISC/16/BILLWG-1/04	Summary of Blue Marlin Catch and Size Data from the Western and Central Pacific Fisheries Commission and the Inter-American Tropical Tuna Commission. Yi-Jay Chang, Annie Yau and Jon Brodziak yi-jay.chang@noaa.gov
ISC/16/BILLWG-1/05	Standardized catch rates of blue marlin (*Makaira nigricans*) in the Hawaii-based longline fishery (1995-2014). Felipe Carvalho, William Walsh and Yi-Jay Chang felipe.Carvalho@noaa.gov
ISC/16/BILLWG-1/06	Update of Japanese longline CPUE for Blue Marlin (*Makaira nigricans*) in the Pacific Ocean standardized applying habitat model. Mikihiko Kai, Hiroaki Okamoto, Ko Shiozaki and Michael Hinton kaim@affrc.go.jp
ISC/16/BILLWG-1/07	A time spatial analysis of Japanese size frequency data of North Pacific striped marlin (*Kajikia Audax*). Hirotaka Ijima and Ko Shiozaki ijima@affrc.go.jp
ISC/16/BILLWG-1/08	Spatial and temporal patterns in Striped Marlin (*Kajikia audax*) length in the Hawaiian deep-set longline fishery. Brian Langseth brian.langseth@noaa.gov

ISC/16/BILLWG-1/09 — Size composition for Blue marlin (*Makaira nigricans*) in the Hawaii-based pelagic longline fishery, 1994-2014.
Brian Langseth and Eric Fletcher
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ISC/16/BILLWG-1/10 — CPUE Standardization of Blue Marlin (*Makaira nigricans*) for the Taiwanese Distant-Water Tuna Longline Fishery in the Pacific Ocean.
Nan-Jay Su, Chi-Lu Sun and Su-Zan Yeh
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