Annex 7

REPORT OF THE BILLFISH WORKING GROUP WORKSHOP

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

22-30 March 2016
Busan, Republic of Korea

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 Busan, Republic of Korea during 22-30 March 2016. The goal of this workshop was to conduct modeling analyses for an update of the stock assessment for the Pacific blue marlin (*Makaira nigricans*) stock. These analyses included fitting the base case Stock Synthesis model, running sensitivity analyses and developing stock projections.

Gerard DiNardo, acting as Chair of the BILLWG on behalf of Jon Brodziak, welcomed participants from Chinese Taipei, Japan, Korea, and the United States of America (USA) (Attachment 1). The Chair noted that there were no meeting participants from Canada, China, or Mexico.

2.0 ADOPTION OF AGENDA AND ASSIGNMENT OF RAPPORTEURS

Rapporteuring duties for the working group (WG) were assigned to Rock An, Yi-Jay Chang, Hirotaka Ijima, Mikihiko Kai, Minoru Kanaiwa, Brian Langseth, Hiroaki Okamoto, Chi-Lu Sun, Darryl Tagami, Annie Yau, and Kotaro Yokawa. The draft meeting agenda was adopted on March 22, 2016 with one modification, which was that the WG would convene on Sunday, March 27 and would not meet on Monday, March 28 (Attachment 2).

3.0 COMPUTING FACILITIES

Computing facilities included a shared Google drive named “BlueMarlin_Busan_March2016” 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 NUMBERING OF WORKING PAPERS AND DISTRIBUTION POTENTIAL

Draft working papers were distributed and numbered (Attachment 3). It was agreed that all finalized working papers would be posted on the ISC website and made available to the public. The Chair noted that the draft working papers needed to be finalized by April 8, 2016.

5.0. STATUS OF WORK ASSIGNMENTS

The work assignments to be addressed at the March 2016 workshop as defined in the January 2016 workshop report (ISC 2016) were as follows:

- Check the consistency between updated data and data used in the previous assessment and use the best available scientific data for this assessment by incorporating new or updated data unless it is of poorer quality than the previous data.

- Conduct and agree upon a base case model for the 2016 Pacific blue marlin stock assessment update. At the January 2016 workshop, it was agreed to use the same base case model structure and assumptions as the 2013 benchmark assessment, modifying 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.

- Conduct sensitivity analyses, focusing on the same sensitivity analyses conducted in the last blue marlin assessment in 2013, which are listed in Table 4.5 of ISC (2013) and Table 10.3 of ISC (2016). The first priority was to conduct these sensitivity analyses based on the same scenarios used in the last assessment. Any new scenarios were listed as "proposed" and were to be conducted only if time permitted and through agreement by members.

- Conduct the same stock projections from the 2013 assessment using the same deterministic approach (see Section 6.11 for a description of the four projections).

All work assignments were completed at the workshop, with the addition of several other proposed sensitivity analyses (see Section 6.10).

6.0 PACIFIC BLUE MARLIN STOCK ASSESSMENT MODELING

Two working papers on the topic of Pacific blue marlin stock assessment modeling were presented to the WG by Yi-Jay Chang and Nan-Jay Su. The WG reviewed the working papers, revisited the materials presented at the January workshop, and discussed the presentations.

Most agenda items under Section 6 were addressed in the presentation by Yi-Jay Chang in ISC/16/BILLWG-2/01, "*Stock Assessment Update for Blue Marlin (Makaira nigricans) in the Pacific Ocean through 2014*" by Yi-Jay Chang, Brian Langseth, Hirotaka Ijima, and Mikihiko Kai. Yi-Jay Chang's presentation is summarized in the paragraph below, with detailed discussions noted in the corresponding parts of Section 6.

A presentation was provided on the 2016 preliminary update of the stock assessment for the Pacific blue marlin (*M. nigricans*) stock, which was previously conducted in 2013 by the ISC Billfish Working Group. The assessment update consisted of running a Stock Synthesis model with newly available catch, abundance index, and length and size composition data for 1971-2014. The 2016 model structure and parameters were the same as those used as in the base case run from the 2013 stock assessment. The preliminary results indicated that the population biomass (age 1 and older) of the Pacific blue marlin stock fluctuated around 120,000 metric tons from 1971 until 1984, and thereafter exhibited a long-term decline to the lowest level of 69,720 metric tons in 2009. Since then, population biomass increased to around 78,000 metric tons for the last three years (2012-2014) of the assessment time horizon. Estimated fishing mortality gradually increased from the early 1970s to the mid-2000s, peaked at 0.38 year^{-1} in 2005 in response to higher catches, and declined to average 0.28 year^{-1} during 2012-2014. Compared to MSY-based reference points, the current spawning biomass (SSB_{2014}) was 25% above SSB_{MSY} and the current fishing mortality ($F_{2012-2014}$, the average F during 2012-2014) was 14% below F_{MSY}. The preliminary base case model indicated that the Pacific blue marlin stock was not overfished and was not subject to overfishing relative to MSY-based reference points. The aim of this working paper was to produce the basic update assessment model and to provide the assessment results to the BILLWG.

Nan-Jay Su presented the working paper ISC/16/BILLWG-2/02, "*Catch estimates and size compositions of blue marlin (M. nigricans) from the Taiwanese fisheries in the Pacific Ocean*" by Nan-Jay Su, Chi-Lu Sun, and Su-Zan Yeh. This working paper described previously provided information on the Taiwanese catch and size composition data for Pacific blue marlin. A summary of his presentation is provided in the paragraph below, with discussion documented in Sections 6.3 and 6.5.

Most Taiwanese blue marlin catches were from the domestic-based offshore longline fishery, with annual catches varying between 3,000 mt to 4,500 mt from 1992 to 2014. Catch information for the foreign-based offshore tuna longline fishery, which consists of vessels flagged to Taiwan that fish far from Taiwan, has been collected since 2000. This fishery produced annual catches of 3,066-4,375 mt in the early 2000s but annual catches have decreased to about 2000 mt since

2006. The catch of blue marlin from the distant-water tuna longline fishery has increased to more than 1,000 mt since 2003, except for a 910 mt in 2008. In contrast, a small proportion of blue marlin catch was reported for the offshore and coastal gillnet, set-net, and all the other Taiwanese fisheries in the Pacific Ocean. Size composition data consisting of eye-fork length (EFL) measurements of blue marlin were collected from the Taiwanese distant-water tuna longline fishery in the Pacific Ocean, with sample sizes ranging from 620 for the first quarter of 2014 to 17,705 for all quarters in 2005. Although the smallest and largest blue marlin measured from this fishery varied among years, the mean lengths of measured fish remained relatively stable and ranged from 171.9 to 179.0 cm EFL during 2005-2012, but mean lengths have increased to over 180 cm EFL in 2013 and 2014.

6.1 Use of Life History Information

Yi-Jay Chang presented the blue marlin life history information that was discussed and agreed upon at the January 2016 BILLWG workshop. In particular, the BILLWG agreed to use the same life history parameters for the 2016 assessment update that were used for the 2013 benchmark assessment. The blue marlin life history information included parameters for growth, length-weight relationship, natural mortality, spawning and maturity at length, and stock-recruitment steepness. These life history parameters were summarized in the 2013 assessment report (ISC 2013, Table 4.1) and in the January 2016 BILLWG workshop report (Table 9.0), and are summarized in this report for completeness (Table 6.1.1).

Table 6.1.1. Key life history and stock-recruitment parameters used in the Pacific blue marlin population dynamics model. Boldface text indicates values that were updated based on new information.

Parameter	Value	Comments	Source
Gender	2	Two genders model	ISC(2013)
Natural mortality (M)	Female: 0.42 (age 0) 0.37 (age 1) 0.32 (age 2) 0.27 (age 3) 0.22 (age 4+) Male: 0.42 (age 0) 0.37 (age 1+)	Age-specific natural mortality	Lee and Chang (2013)

Reference age (a1)	1	Fixed parameter	Refit from Chang et al. (2013); ISC(2013)
Maximum age (a2)	26	Fixed parameter	
Length at age a1 (L1) (EFL cm)	Female: 144 Male: 144	Fixed parameter	Refit from Chang et al. (2013); ISC(2013)
Length at age a2 (L2) (EFL cm)	Female: 304.18 Male: 226.0	Fixed parameter	Refit from Chang et al. (2013); ISC(2013)
Growth rate (K)	Female: 0.107 Male: 0.211	Fixed parameter	Refit from Chang et al. (2013); ISC(2013)
Coefficient of Variation (CV) of L1	Female: 0.14 Male: 0.14	Fixed parameter	Chang et al. (2013); ISC(2013)
CV of L2	Female: 0.15 Male: 0.1	Fixed parameter	Chang et al. (2013); ISC(2013)
Weight-at-length	Female: $W=1.844 \times 10^{-5}L^{2.956}$ Male: $W=1.37 \times 10^{-5}L^{2.975}$	Fixed parameter	Brodziak 2013
Length-at-50% Maturity (EFL cm)	179.76	Fixed parameter	Sun et al. (2009); Shimose et al. (2009)
Slope of maturity ogive	-0.2039	Fixed parameter	Sun et al. (2009); Shimose et al. (2009)
Fecundity	Proportional to spawning biomass	Fixed parameter	Sun et al. (2009)
Spawning season	2	Model structure	Sun et al. (2009)
Spawner-recruit relationship	Beverton-Holt	Model structure	Brodziak and Mangel (2011)
Spawner-recruit steepness (*h*)	0.87	Fixed parameter	Brodziak and Mangel (2011); **Brodziak et al. (2015)**
Recruitment variability (σ_R)	0.28; iteratively rescaled	Fixed parameter	Method from ISC (2013)

Initial age structure	5 yrs (1966-1970)	Estimated	ISC (2013)
Main recruitment deviations	1971-2013	Estimated	ISC (2013)
Bias adjustment	1971-2013	Fixed	ISC (2013)

Discussion:

There was a question regarding the use of 0.87 for the stock-recruitment steepness value, because according to the presented analysis, higher steepness values have higher probabilities. It was explained that the median (h=0.87), and not the mean, of the distribution of blue marlin steepness values was used (Brodziak et al. 2015). The WG noted that the steepness value of 0.87 was consistent with the value used in the 2013 benchmark assessment. There was a comment that the ICCAT Atlantic blue marlin stock assessments may be using a lower steepness value of 0.45 but no additional information was provided.

The WG noted that the age-specific natural mortality rates were higher for males than for females. It was explained that females are generally larger than males at a given age and that natural mortality rate estimates were higher for smaller fish, all else equal. Thus, the higher natural mortality rates for males were primarily based on their smaller sizes at age and the allometric scaling of natural mortality with body mass. The WG discussed the caveats of relying on metaanalyses for growth parameters which can average reliable estimates with less reliable estimates. The WG noted, however, that a simple unweighted mean of the individual growth study results was not used. Instead, the metaanlysis of growth studies in Chang et al. (2013) used a weighted mean for determining growth parameters, where the study weights were appropriately based on sample size to account for the relative reliability of the individual studies.

It was suggested further research on the growth model be conducted to account for the possibility that some of the ageing methods may be producing overestimates of blue marlin ages.

6.2 Fishery Definitions and Selectivity Modeling

Yi-Jay Chang presented the sixteen fishery definitions and selectivity of fleets that were agreed upon at the January workshop in the BILLWG workshop report (Table 8.1). These are the same 16 fisheries used in the 2013 benchmark assessment (ISC 2013, Table 3.1), and summarized here in Tables 6.2.1 and 6.2.2. These fishery definitions and selectivity assumptions follow the same naming conventions used in the 2013 benchmark assessment.

Table 6.2.1. Fishery codes, acronyms, fishing fleets, catch time series, total catch (1971-2014, mt) and data sources 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)	Source
F1	JPNEarlyLL	Japanese DWLL & OSLL	1971-1993	210,395	Ijima and Shiozaki (2016)
F2	JPNLateLL	Japanese DWLL & OSLL	1994-2014	80,614	Ijima and Shiozaki (2016)
F3	JPNCLL	Japanese COLL	1971-2014	44,476	Ijima and Shiozaki (2016)
F4	JPNDRIFT	Japanese DRIFT	1972-2014	11,937	Ijima and Shiozaki (2016)
F5	JPNBait	Japanese bait fishing	1971-2014	8,127	Ijima and Shiozaki (2016)
F6	JPNOth	Japanese other gears	1971-2014	5,063	Ijima and Shiozaki (2016)
F7	HWLL	United States (Hawaii) LL	1971-2014	14,273	Ito (2016)
F8	ASLL	United States (American Samoa) LL	1996-2014	2,285	Russell Ito, pers. comm., Jan 13, 2016
F9	HWOth	United States (Hawaii) troll & handline	1987-2014	7,245	Ito (2016)
F10	TWNLL	Taiwanese DWLL	1971-2014	25,150	Nan-Jay Su, pers. comm., Jan 13, 2016
F11	TWNOth	Taiwanese OSLL, COLL, GN & HAR	1971-2014	182,848	Nan-Jay Su, pers. comm., Jan 13, 2016
F12	OthLL	Various flags[1] LL	1971-2014	187,738	Chang et al. (2016); Tagami and Wang (2016)
F13	PYFLL	French Polynesian LL	1990-2014	6,297	Chang et al. (2016)

F14	EPOPS	Various flags[2] PS in IATTC region	1993-2014	3,765	Chang et al. (2016)
F15	WCPFCPS	Various flags[3] in WCPFC region	1971-2014	10,747	Chang et al. (2016)
F16	EPOOth	French Polynesian troll & handline, HAR	2006-2014	1,257	Chang et al. (2016)
ALL	ALL	All Fleets	1971-2014	802,217	

- [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.

Table 6.2.2. Fishery-specific selectivity assumptions for the Pacific blue marlin stock assessment. The selectivity curves for fisheries lacking length composition data were assumed to be the same as (i.e., mirror fleet) closely related fishing fleets or fisheries operating in the same area.

Fishery Number	Reference Code	Selectivity Assumption	Mirror Fleet
F1	JPNEarlyLL	Cubic Spline (nodes=4)	
F2	JPNLateLL	Double-normal	
F3	JPNCLL	Double-normal	F2
F4	JPNDRIFT	Double-normal	
F5	JPNBait	Double-normal	F4
F6	JPNOth	Double-normal	F2
F7	HWLL	Cubic Spline (nodes=3)	
F8	ASLL	Double-normal	F7
F9	HWOth	Double-normal	F7
F10	TWNLL	Double-normal	
F11	TWNOth	Double-normal	F10
F12	OthLL	Double-normal	
F13	PYFLL	Double-normal for 1971-2002; 2003-2014	
F14	EPOPS	Double-normal	
F15	WCPFCPS	Double-normal	F14
F16	EPOOth	Double-normal	F14

Discussion:

The WG discussed the modeling choice that the Japanese longline fishery was separated into early (F1) and late (F2) time series because of significant differences in data reporting and compilation before and after 1994 (Kanaiwa et al. 2013), as well as a shift in the fishing grounds in the early 1990s. Additionally, it was noted the reporting system was changed and more data could be provided after 1994. The decision to separate the fisheries temporally was made by the WG in 2013 during the benchmark assessment. It was also noted that there may be other issues with the Japanese longline data before 1994 (F1) due to species identification problems with marlins.

The WG discussed further improvements of the fleet definitions in the Stock Synthesis (SS) analysis. Some fleets, like the Japanese and Taiwanese longline fleets, cover wide areas. It was noted that Pacific blue marlin might have area- and season-specific size and sex compositions but that those stock characteristics are not accounted for in the current fleet definitions. The WG discussed future collaborative work on the analysis and interpretation of Pacific-wide size and sex data for blue marlin such as conducting spatiotemporal size distribution studies, as well as designing tagging studies.

There was a question about why logistic selectivity was not assumed for some fisheries in comparison to the modeling assumption that double-normal selectivity or cubic spline selectivity were more appropriate. The WG noted that assuming double-normal allows for greater flexibility for the SS model to determine whether a double-normal, logistic, or asymptotic selectivity better fit the data through the possibility of dome-shaped fishery selectivity patterns. Both the double-normal and the cubic spline selectivity functions are flexible and allow the model to fit the plus group abundance information. Overall, the WG concluded that the fishery selectivity models for each fleet would be assumed to be the same as those used in the 2013 benchmark assessment.

6.3 Catch Time Series

The final catch data as discussed and agreed upon at the January workshop were presented by Yi-Jay Chang and summarized here as Table 6.2.1 above and Figure 6.3.1. Nan-Jay Su also presented the Taiwanese catch data (ISC/16/BILLWG-02/02). Yi-Jay Chang also presented comparisons of catch time series used in the 2016 versus 2013 assessment (ISC/16/BILLWG-02/01). There were some minor inconsistencies; there was a small increase of 1.6% more catch on average prior to 2011 compared to the catch data used in the 2013 assessment. Overall, the 2016 catch data were very similar to the catch data used in the 2013 assessment.

Discussion:

It was noted that the OthLL fishery (F12, various flag longline) makes up a considerable portion of total catch, and that in future assessments this fishery should be re-examined to see if 1 or 2 major fishery components could be split apart, possibly with a corresponding catch-per-unit effort (CPUE) or size composition series because of possible historical changes in selectivity. It would be ideal if CPUE and size composition information were available from the major producers (such as China, Indonesia, and Korea) that comprise OthLL. The contribution of individual countries within OthLL should be tracked through time to see if notable changes are occurring, and thus whether a specific country within OthLL should be separated out. The WG noted that changes in catch from the OthLL fishery may also occur through changes in locations where fishing occurs.

It was clarified that Korea has no fisheries targeting billfish, including marlins or swordfish, and as a result, all billfish caught by Korea are bycatch. The 2014 Korean catch of blue marlin was ~800 metric tons, with an average catch in 2005-2014 of 430 metric tons. Since country-specific catches for Korea was not provided directly to the BILLWG, the annual Korean catch of Pacific blue marlin was obtained from the WCPFC and included in the OthLL fishery catch. The WG also asked Korea about the issue of misidentification of black marlin as blue marlin and noted that Korea will be double-checking data from all years (2005-2014) again to address misidentification issues.

The largest catch discrepancies between the 2013 and 2016 catch data series came from the French Polynesia longline fleet (PYFLL). It was explained that the 2016 catch data are likely to be more accurate, since the WCPFC has made ongoing efforts to improve catch data collection and reporting by its member countries.

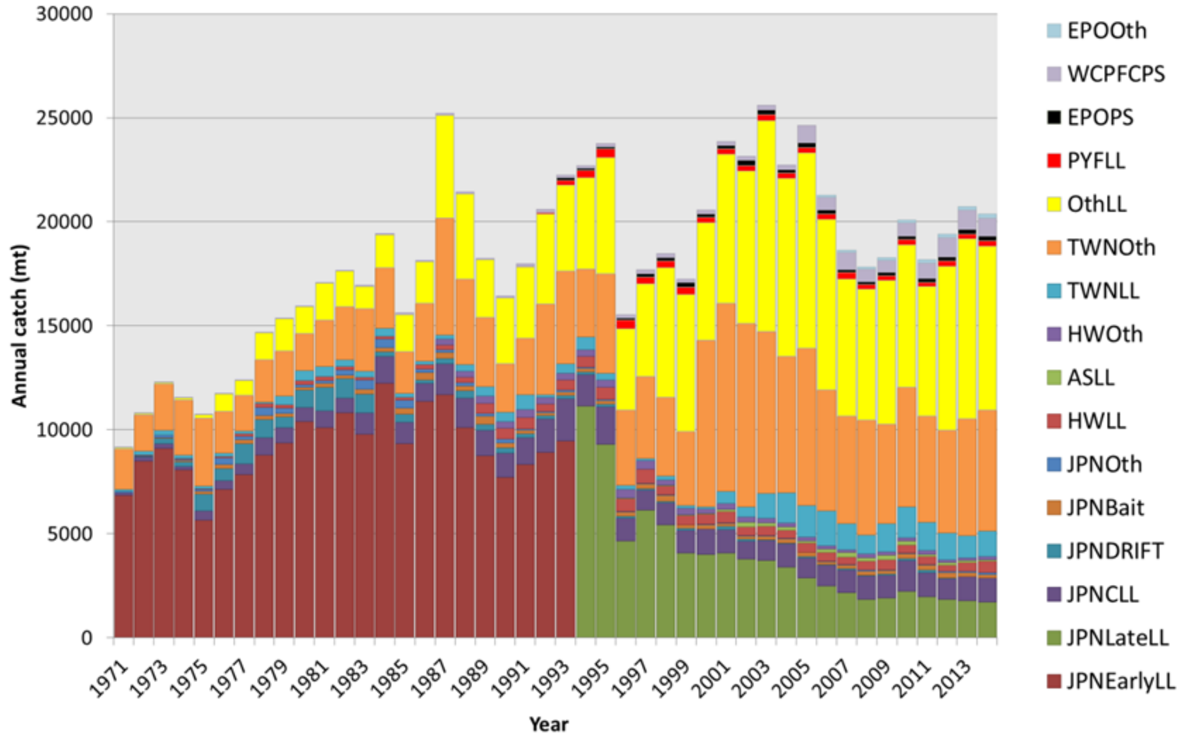


Figure 6.3.1. Catch by fleet for Pacific blue marlin, used in the 2016 stock assessment update. See Table 6.2.1 for fishery definitions.

The working group also discussed information on Japanese catches of blue marlin prior to 1971. Reported blue marlin catches from that period had problems with species identifications partly because Japanese fishing vessels were believed to report any marlin catches prior to 1971 as blue marlin (Kimoto and Yokawa 2012). It was noted that a decision was made in the January 2016 BILLWG meeting to maintain consistency in reporting and therefore to use the blue marlin catch time series beginning in 1971.

The amount of Taiwanese catch data for blue marlin has increased since 2000 due to the availability of catch statistics from foreign-based Taiwanese-flagged longline vessels which fish far offshore. The WG noted that some catch data from this fleet likely occurred prior to 2000, but that reliable information for those years was not available and that the logbook coverage rate was low prior to 2000. The WG requested further information about whether the distribution of foreign-based fishing effort had changed, but it was not known whether any changes had occurred.

The WG noted that the catch of Pacific blue marlin used in this 2016 assessment was generally higher than that used in the 2013 assessment, and that the recent upward trend in catch provided moderate contrast for comparing harvest impacts on population dynamics.

6.4 CPUE Time Series

Yi-Jay Chang presented the available standardized CPUE (indices of relative abundance) which were reviewed and discussed at the January 2016 BILLWG workshop. Correlations between CPUE time series were reviewed and the WG noted that the observed correlations were relatively low, in part due to a lack of temporal overlap between some series. The observed correlations indicated that the Japanese CPUE series were generally positively correlated with the Taiwanese CPUE series and negatively correlated with the Hawaii longline CPUE series. The WG also reviewed some comparisons of the abundance indices used in the 2013 assessment with the abundance indices to be used in the 2016 assessment update (Table 6.4.1).

Table 6.4.1. Available standardized CPUE or indices of relative abundance for the 2016 Pacific blue marlin stock assessment. See Table 6.2.1 for fishery codes and acronyms.

Index	Fishery Acronym (Code)	CPUE Time Series	N	CPUE Used?	Source
S1	JPNEarlyLL (F1)	1975-1993	19	Y	Kanaiwa et al. (2013)
S2	JPNLateLL (F2)	1994-2014	21	Y	Kai et al. (2016)
S3	HWLL (F7)	1995-2014	20	N	Carvalho et al. (2016)
S4	TWNLL-Early (F10)	1971-1978	8	Y	Su et al. (2016)
S5	TWNLL-Middle (F10)	1979-1999	21	Y	Su et al. (2016)
S6	TNWLL-Late (F10)	2000-2014	15	Y	Su et al. (2016)

Discussion:

The WG discussed the Hawaii longline CPUE time series and noted that its trend was different from all of the other overlapping CPUE series. There was some indication that the Hawaii longline CPUE series changed around 2004 when the shallow-set fishery sector was closed. The WG discussed whether and how the closure of the shallow-set sector of the longline fishery in Hawaii may have affected the CPUE series. It was noted that the Hawaii longline CPUE series was standardized using only the deep-set longline sector data and that the closure of the shallow-set sector would be expected to have a minimal effect on the deep-set data. Furthermore the WG noted that the closure was not a spatial closure but was specific to the shallow-set gear configuration. Overall, there was no resolution of how the shallow-set closure influenced the fishery dynamics of the deep-set sector.

The WG also discussed the fact that correlations between some CPUE time series were small, but that patterns of association were not clear. For example, the WG noted that the S2 and S3 CPUE series were positively correlated, but that one series (S2) was positively correlated with S6 while the other series (S3) was negatively correlated with S6. Estimated correlations in this case may therefore not be providing much information for identifying whether CPUE indices conflict. This lack of information was likely due to low sample sizes and produced one example of an apparently inconsistent trend noted above. Overall the WG noted this limitation of correlation analyses for comparing CPUE series available for use in the 2016 assessment.

The WG also noted that the CV of Taiwanese early (S4) and middle (S5) CPUE series provided for the 2016 assessment were substantially smaller than the reported CV values provided in the 2013 assessment, although the trends in average CPUE were similar.

6.5 Size Compositions

Yi-Jay Chang presented a summary of the blue marlin length and weight composition data agreed upon at the January 2016 BILLWG workshop. He also showed a comparison of the length and weight composition data used in the 2013 versus 2016 assessment. Few major differences were noted, with the exception of JPNDrift fishery (F4) where the reported average fish weights in the 2016 data were smaller than average fish weights from the 2013 data. Table 6.5.1 provides the length and size composition data used in the 2016 base case stock assessment model for Pacific blue marlin. Nan-Jay Su also presented a summary of the Taiwanese size composition data for Pacific blue marlin.

Table 6.5.1. Summary of the available length and size composition data for Pacific blue marlin by fishery where "N" indicates the observed sample size. See Table 6.2.1 for fishery acronyms and codes.

Fishery Acronym	**Code**	**Fishery Description**	**Unit**	**Bin Size**	**N**	**Time Series**	**Source**
JPNEarlyLL	F1	Japanese offshore and distant-water longline (early period)	EFL, cm	5 cm	92	1971-1993	Ijima and Shiozaki (2016)
JPNLateLL	F2	Japanese offshore and distant-water longline (late period)	EFL, cm	5 cm	84	1994-2014	Ijima and Shiozaki (2016)
JPNDRIFT	F4	High-seas large-mesh driftnet and coastal driftnet	kg	Endpoints set from predicted weights for 5 cm length bins	19	1977-1989; 1993; 1998	Ijima and Shiozaki (2016)
HWLL	F7	Hawaiian longline	EFL, cm	5 cm	70	1994-2014	Langseth and Fletcher (2016)
TWNLL	F10	Taiwanese distant-water longline	EFL, cm	5 cm	23	2005-2010	ISC (2013)
OthLL	F12	Various flags longline	EFL, cm	10 cm	83	1992-2014	Chang et al. (2016)
PYFLL	F13	French Polynesia longline	EFL, cm	10 cm	52	1996-2014	Chang et al. (2016)
EPOPS	F14	Various flags purse seine	EFL, cm	5 cm	95	1990-2014	Chang et al. (2016)

Discussion:

It was clarified to the WG that the Taiwanese length composition data were only updated for 2010-2014. It was also noted that some data was still being processed for 2013 quarter 4, and that for 2014, only some of the quarter 1 data have been processed so far. The lower observed sample sizes were reported to be one of the reasons for the shift in the mode of Taiwanese blue marlin size composition towards larger sizes in recent years. It was explained that the data for quarter 4 in 2010 were preliminary in the last assessment and that these data will be updated for future assessments.

It was explained that Taiwanese size composition data has been collected since 1981 by fishers sampling the first 30 fish from every single distant water set, whether or not they are blue marlin. All vessels in the Taiwanese longline fleet are using the same fishing gear so gear selectivity would be expected to be comparable among vessels. It was noted that the Taiwanese blue marlin size composition data, which was mostly collected by distant water longline fleets, has information on sampling locations. Taiwan intends to provide this information for future assessments. It is uncertain whether the observed shift in the mean size reflects a change in selectivity or spatial distribution of the fleet. The WG discussed that knowing locations of the size samples would be worthwhile to know any potential sampling distribution; however for blue marlin, since the stock is assumed Pacific-wide, spatial structure may be less necessary than for other species.

The WG was noted that Taiwanese size composition data was originally provided by email during the January data workshop but that there were some discrepancies in the mean lengths in comparison to data submitted for the 2013 assessment. As a result, these data were not accepted at the January workshop and the updated Taiwanese size composition data (2011-2014) were not to be used in the 2016 stock assessment update.

The WG agreed to conduct a sensitivity analysis that included the updated 2011-2013 Taiwanese size composition data (see Section 6.10), noting that the input data for the base case model were discussed and finalized at the January 2016 BILLWG workshop.

There was some discussion of the weight composition data for the Japanese driftnet fleets. The WG confirmed that both coastal driftnet and high-seas driftnet components of JPNDRIFT (F4) use large mesh sizes which are presumably similar.

The WG discussed the French Polynesia (PYFLL) size composition data, noting these data included two size modal sizes over time. One possibility for the bimodal fish size pattern is that PYFLL vessels were reflagged and as a result the vessels were able to extend to have a broader distribution and catch larger fish. The WG noted that the fishery selectivity of the PYFLL fishery is time-blocked to account for the apparent changes in the size composition data, but it remained unknown why there was a change in the size distribution over time. Overall, the WG accepted the current approach for modeling with time-blocked sensitivities as being appropriate for the stock assessment update.

6.6 Model Runs

Yi-Jay Chang presented the preliminary base case model for the 2016 stock assessment update of Pacific blue marlin. The base case stock assessment model used the Stock Synthesis version 3.24f software platform and also used the same model structure and parameters as used in the 2013 assessment and described in working paper ISC/16/BILLWG-2/01, with one difference:

The weighting of the size composition data weighting used in the 2013 assessment was not reproducible, and in order to retain the relative data weights based on the between-sample variation, a similar two-stage data weighting method was used for the 2016 assessment. The stages in this weighting approach were as follows:

Stage 1:

- For all of the input observed sample sizes for each fleet with the exception of fleets F4 and F14, divide the input sample size by 10. If the new input sample size is >50, then set the sample size to 50. If the new input sample size is < 2.5 (or < 25 for either F4 or F14), then do not use that season-year size composition data in the base case assessment model.

Stage 2:

- Estimate the effective sample size for compositional data using a single iteration of SS;
- Replace the input sample sizes for fleets with input sample sizes near 50 (in this case, F1, F2, F4, F10, F14) with the estimated effective sample size relative to its mean, and then re-scale this value to have a mean value of 30;
- If the new input sample size > 50, set the sample size to 50. If the rescaled input sample sizes are < 2.5 (or < 25 for either F4 or F14), then do not adjust the input sample size values and retain the size composition data in the model.

<u>Discussion:</u>

The WG noted that the presentation of the updated base case stock assessment model was clear and additional changes to the preliminary model were requested.

6.7 Model Diagnostics

Yi-Jay Chang presented model diagnostics for the preliminary base case model of the 2016 stock assessment update of Pacific blue marlin. These diagnostics included likelihood profiles goodness of fit criteria for abundance indices and size composition data, including root mean squared errors (RMSE) and standard deviations of the normalized residuals (SDNR). The likelihood profiles are provided in Figure 6.7.1, and other diagnostic plots including the jitter analysis are listed in the working paper ISC/16/BILLWG-02/01.

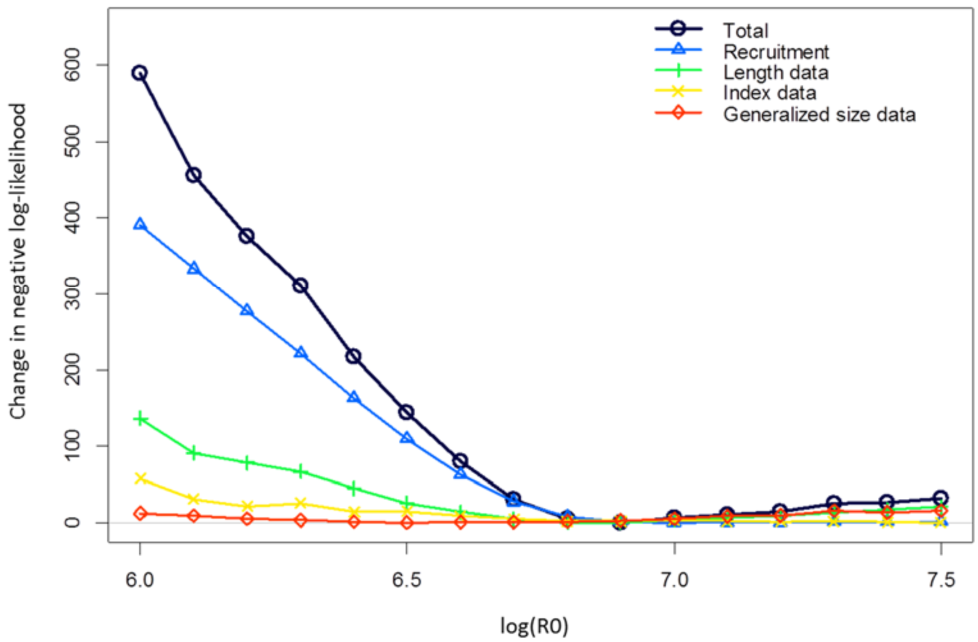


Figure 6.7.1. Likelihood profiles for different input data sources of the 2016 stock assessment update of Pacific blue marlin.

Discussion:

There was a request to conduct a retrospective analysis for the last 5 years. The WG completed the requested retrospective analysis during the meeting. The results of the retrospective analysis are shown in Figure 6.7.2. The trajectories of estimated spawning stock biomass and the index of fishing intensity (i.e., One minus the Spawning Potential Ratio, or 1-SPR) showed a slight retrospective pattern but there was no consistent trend of over- or under-estimating spawning stock biomass or fishing intensity. The WG noted that the 1971-2013 retrospective peel showed a different pattern than the other 4 peels. It was not known why this occurred. Given the small magnitude of the retrospective pattern, the WG accepted the retrospective analysis and noted that the retrospective pattern was negligible and did not affect the assessment results.

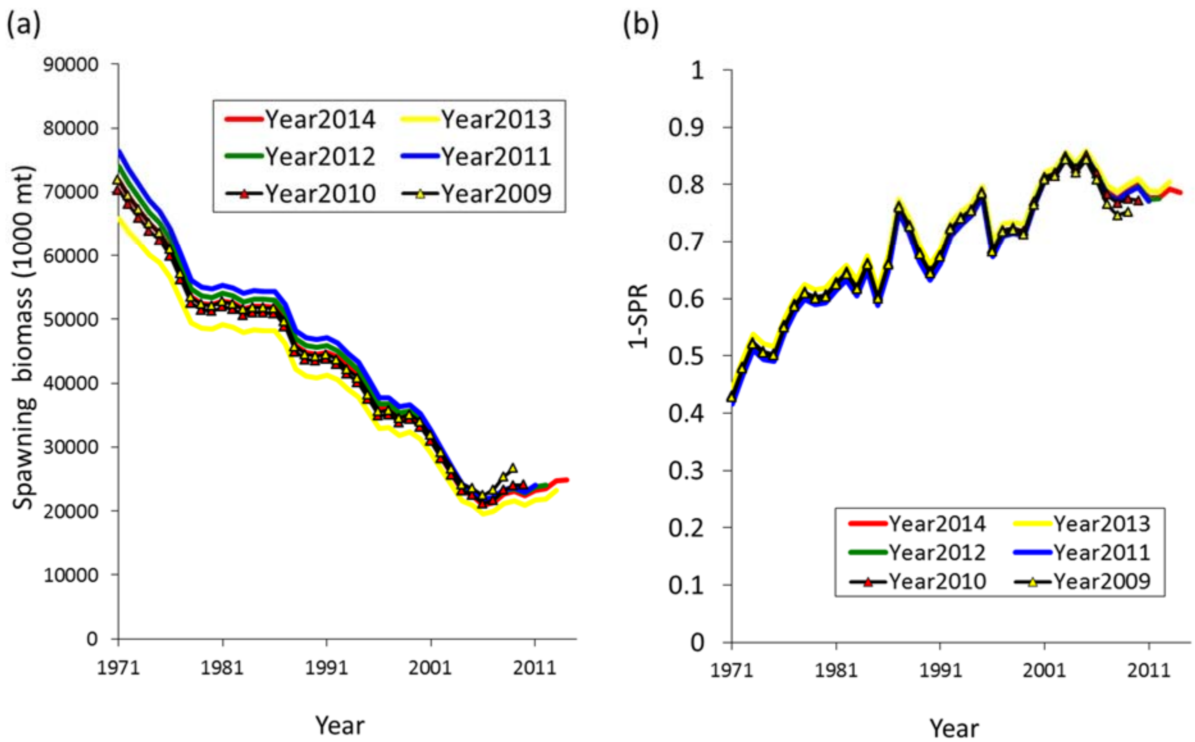


Figure 6.7.2. A 5-year retrospective analysis (a) spawning biomass and (b) fishing intensity for the base case model for Pacific blue marlin as conducted in the 2016 stock assessment update. The label "Year2014" indicates the base case model results. The label "YearTTTT" indicate the retrospective results from the retrospective peel that includes data through the year "TTTT".

The WG noted that the model diagnostics indicated a similar goodness of fit and better performance compared to the 2013 benchmark stock assessment. As a result, the WG agreed that the preliminary model was the base case model for the 2016 update of the Pacific blue marlin stock assessment.

6.8 Model Results

Yi-Jay Chang presented the model results from the agreed-upon base case model of the 2016 stock assessment update for Pacific blue marlin to the WG. This model results included trends in estimates of total stock biomass, spawning stock biomass, recruitment, and fishing mortality (Figure 6.8.1), along with a Kobe plot indicating stock status over time (Figure 6.8.2).

Stock Status:

Estimates of total stock biomass (age-1 and older) averaged roughly 130,965 metric tons in 1971-1975, exhibited a long-term decline to 70,419 mt in 2006, before increasing to 78,082 metric tons in 2014 (Figure 6.8.1). Spawning stock biomass declined from approximately 71,807 mt in 1971 to 20,972 mt in 2006, before increasing to 24,809 mt in 2014. Fishing mortality on the stock (average F for ages 2 and older) averaged roughly F = 0.28 during 2012-2014. The predicted value of the current spawning potential ratio (SPR, the predicted spawning output at current F as a fraction of unfished spawning output) was $SPR_{2012-2014}$ = 21%. The annual recruitment (numbers of age-0 fish) during 2009–2014 averaged approximately 884,000 fish. While the overall pattern of recruitment from 1971-2014 was variable, there was no apparent long-term trend. (Figure 6.8.1). Relative to MSY-based reference points, the Pacific blue marlin stock is currently not overfished and is not subject to overfishing (Figure 6.8.2). The Pacific blue marlin spawning stock biomass decreased to roughly the MSY level in the mid-2000s, and since then has increased slightly.

Conservation Advice:

Based on the results of the stock assessment, the stock is not currently overfished and is not experiencing overfishing. The stock is nearly fully exploited. Spawning stock biomass has declined since the 1970s but has been stable since the mid-2000s with a slight recent increase. Because Pacific blue marlin is mostly caught as bycatch, direct control of the annual catch amount through the setting of a total allowable catch may be difficult. The WG recommends that fishing mortality not be increased from the current level to conserve spawning stock biomass and to avoid overfishing.

Special Comments:

The WG noted that the lack of sex-specific size data and the simplified treatment of the spatial structure of Pacific blue marlin population dynamics remained as two important sources of uncertainty for improving future assessments.

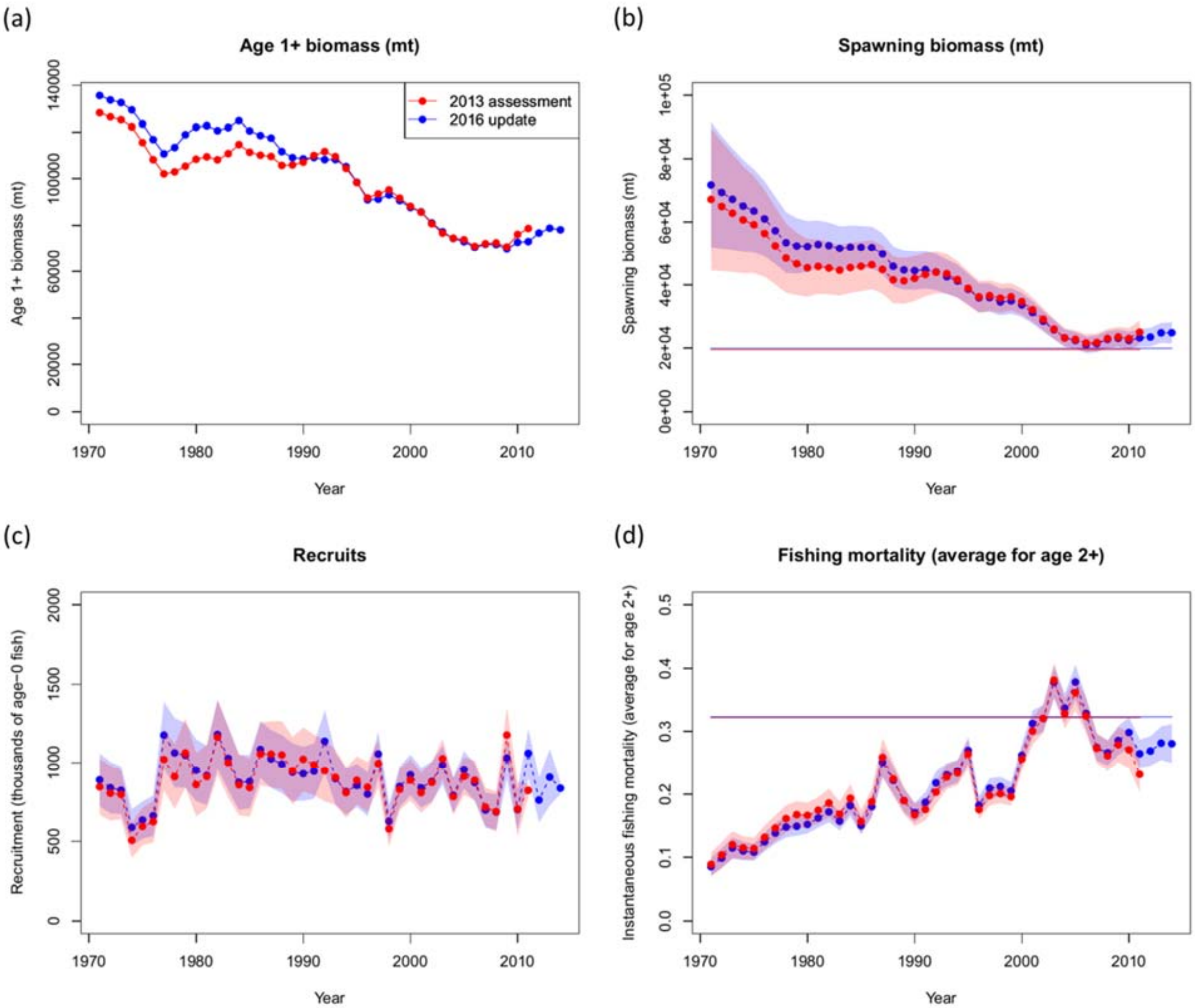


Figure 6.8.1. Comparison of time series of (a) total stock biomass (age 1 and older), (b) spawning stock biomass, (c) age-0 recruitment, and (d) instantaneous fishing mortality (year^{-1}) for Pacific blue marlin between the 2013 stock assessment (red) and the 2016 update (blue). The solid line with circles represents the maximum likelihood estimates for each quantity and the shadowed area represents the uncertainty of the estimates (± 1 standard deviations). The solid horizontal lines indicated the MSY-based reference points.

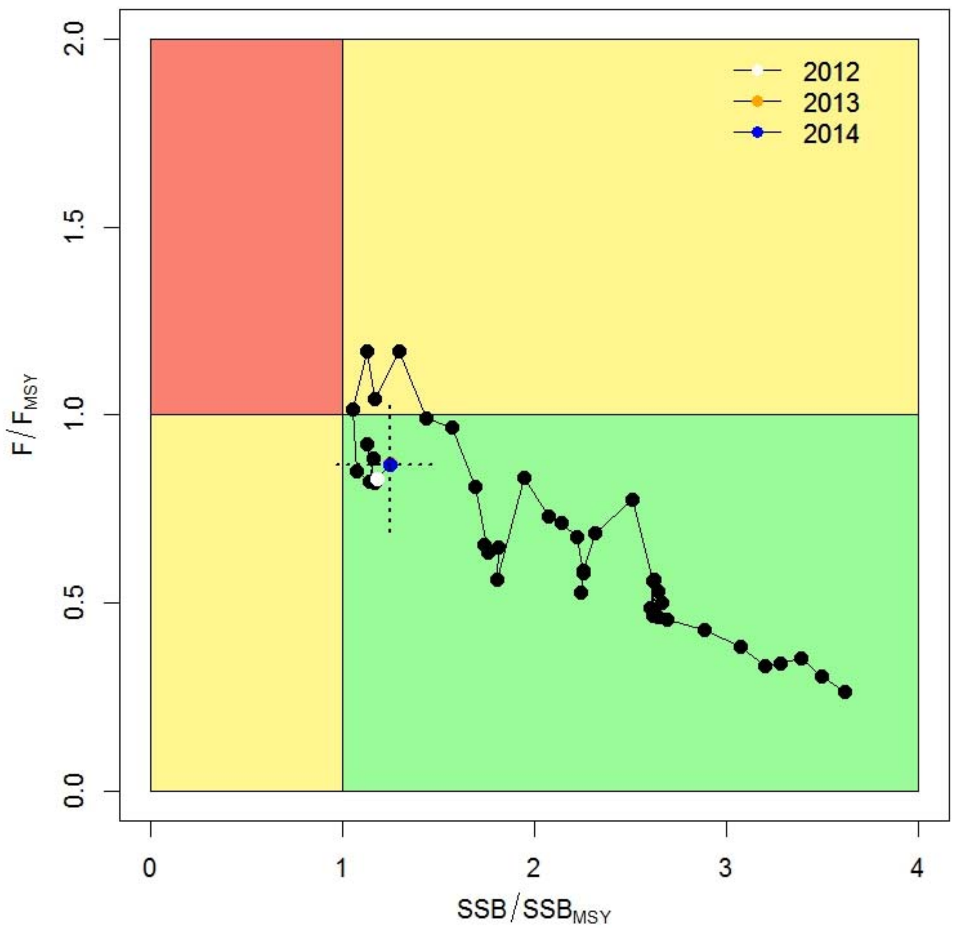


Figure 6.8.2. Kobe plot indicating stock status of Pacific blue marlin as estimated in the 2016 stock assessment update. The dotted lines denote the 95% confidence intervals for relative status in 2014.

Discussion:

The WG noted a minor difference between the 2013 estimates and 2016 assessment estimates of biomass during the 1980s. A sensitivity analysis was suggested that may explain this difference. The WG suggested that the value of $SSB_{current}/SSB_0$ (as a reference point for relative spawning biomass depletion) be included in the 2016 stock assessment report. Overall, based on the discussion and analyses presented, the WG confirmed its acceptance of the model presented in ISC/16/BILLWG-02/01 to be used as the base case model for the 2016 Pacific blue marlin stock assessment update.

6.9 Biological Reference Points

Biological Reference Points:

Biological reference points were computed with the Stock Synthesis base case model. Since most life history parameters for Pacific blue marlin, including steepness, are reasonably well defined, the WG recommends that MSY-based biological reference points be used to assess stock status (Table 6.9.1). The point estimate of maximum sustainable yield was MSY = 19,901 metric tons. The point estimate of the spawning stock biomass to produce MSY was SSB_{MSY} = 19,853 metric tons. The point estimate of F_{MSY}, the fishing mortality rate to produce MSY on ages 2 and older fish was F_{MSY} = 0.32 and the corresponding equilibrium value of spawning potential ratio at MSY was SPR_{MSY} = 18%.

Table 6.9.1. Estimated biological reference points derived from the Stock Synthesis base case model for Pacific blue marlin where F is the instantaneous annual fishing mortality rate, SPR is the annual spawning potential ratio, SSB is spawning stock biomass, MSY indicates maximum sustainable yield, $F_{20\%}$ indicates the F that produces an SPR of 20%, $SSB_{20\%}$ is the corresponding equilibrium SSB at $F_{20\%}$,.

Reference point	Estimate
$F_{2012\text{-}2014}$ (age 2+)	0.28
$SPR_{2012\text{-}2014}$	0.21
F_{MSY} (age 2+)	0.32
$F_{20\%}$ (age 2+)	0.30
SPR_{MSY}	0.18
SSB_{2014}	24,809
SSB_{MSY}	19,853
$SSB_{20\%}$	22,727
MSY	19,901

Discussion:

The WG agreed that the use of MSY-based biological reference points, SSB_{MSY} and F_{MSY}, was appropriate for the 2016 assessment update for Pacific blue marlin. Assessment results showed that based on stock status relative to these MSY-based reference points, the stock is not overfished and is not experiencing overfishing.

There was some discussion about whether to recommend these MSY-based biological reference points as limit reference points to the ISC Plenary. The WG noted that the WCPFC has not established limit reference points or target reference points for the Pacific blue marlin stock, although it has established limit reference points (but not target reference points) for tropical tunas and albacore. In the past, the ISC has proposed to the WCPFC Northern Committee and Scientific Committee, some general rules for setting limit reference points and encouraged setting such reference points to facilitate accurate stock assessment results. However, no decisions regarding reference points for billfish stocks have been made. This topic will be discussed in further detail at the July 2016 meeting of the Billfish WG.

It was noted that while F_{MSY} is used as a biological reference point in the 2016 assessment, and can be used as a limit reference point, some consider it to be a target reference point but not a limit reference point.

The WG noted a minor difference in estimated SSB levels during the 1980s between this 2016 assessment and the 2013 assessment, and suggested this discrepancy be documented in the stock assessment report. One suggested reason for the difference were the changes in the magnitudes of the CVs of Taiwanese CPUE estimates. The WG attempted to address one hypothesis for this change by conducting a sensitivity analysis as described under Section 6.10.

6.10 Sensitivity Analyses

In the January 2016 BILLWG workshop, the WG agreed on 13 sensitivity analyses to be conducted in the 2016 assessment update (Table 10.3 of ISC 2016, also here as Table 6.10.1) in order to examine the effects of plausible alternative model assumptions and data input. The WG agreed that the same sensitivity analyses conducted in the 2013 benchmark assessment (ISC 2013, Table 4.5) would be conducted for this 2016 assessment update. The WG agreed that the first priority would be to conduct the same 13 sensitivity analyses. In addition, 6 new sensitivity analyses were proposed, for a total of 19 sensitivity analyses (Table 6.10.1). During the meeting, all 19 sensitivity analyses were completed and the results were presented and reviewed. The WG noted that 6 of the sensitivity runs were from the WCPFC SC9's request for sensitivity runs for 3 alternative levels of steepness; inclusion of the Hawaii longline CPUE series; and for two alternative adult natural mortality rates, one high and one low rate (WCPFC 2013).

For each sensitivity run, comparisons of spawning stock biomass and fishing intensity (1-SPR) trajectories were completed (Figures 6.10.1). Additionally, the WG produced the Kobe plot requested by WCPFC SC9 showing the trajectory of base case and terminal year estimates for the key sensitivity runs (Figure 6.10.2).

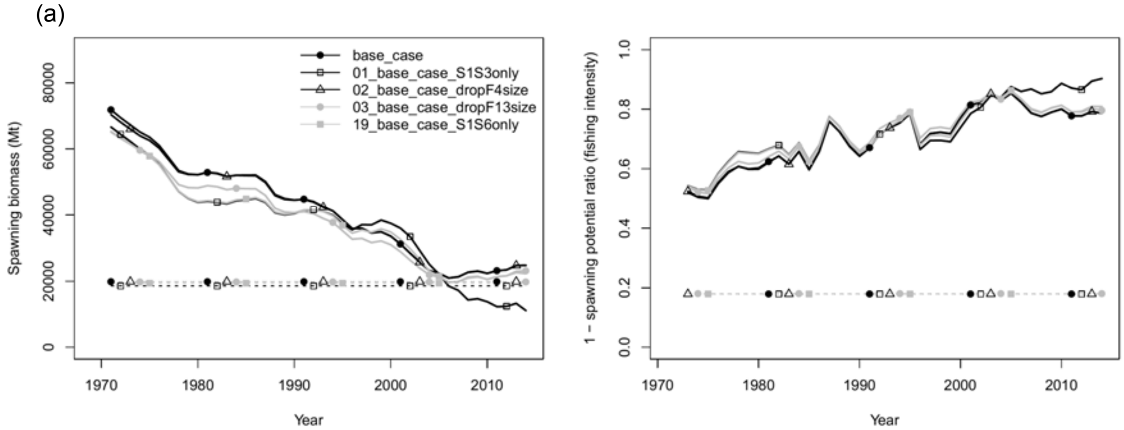
Table 6.10.1. Complete list of sensitivity runs conducted for the 2016 stock assessment update of Pacific blue marlin. Sensitivity analyses listed in boldface text were added and conducted at the

March 2016 workshop, and other runs were from the sensitivity analyses completed for the 2013 benchmark assessment.

RUN	NAME	DESCRIPTION
	Alternative Input Data	
1	01_base_case_S1S3only	Alternative CPUE trends, S1 and S3 only
2	02_base_case_dropF4size	Drop F4 weight composition data
3	03_base_case_dropF13size	Drop F13 length composition data
4	**04_base_case_newTWsize_reW30**	**Include the updated F10 length composition data**
5	**05_base_case_oldTWcv**	**Alternative S4 and S5 input log(SE)**
6	**06_base_case_scalar10**	**Alternative mean input effective sample size for F1, F2, F4, F10, and F14, rescale by a scalar of 10**
7	**07_base_case_scalar40**	**Alternative mean input effective sample size for F1, F2, F4, F10, and F14, rescale by a scalar of 40**
8	**08_base_case_scalar20**	**Alternative mean input effective sample size for F1, F2, F4, F10, and F14, rescale by a scalar of 20**
19	**19_base_case_S1S6only**	**Alternative CPUE trends, S1 and S6 only**
	Alternative Life History Parameters: Natural Mortality Rates	
9	09_base_case_lowM	Alternative natural mortality rates, lower M, adult female M=0.12, adult male M=0.27, juvenile M rescaled
10	10_base_case_highM	Alternative natural mortality rates, higher M, adult female M=0.32, adult male M=0.47, juvenile M rescaled
	Alternative Life History Parameters: Stock-Recruitment Steepness	
11	11_base_case_h065	Alternative stock-recruitment steepness, lower h, h = 0.65
12	12_base_case_h075	Alternative stock-recruitment steepness, lower h, h = 0.75
13	13_base_case_h095	Alternative stock-recruitment steepness, higher h, h = 0.95
	Alternative Life History Parameters: Growth Curves	
14	14_base_case_small_Amax	Alternative growth curves, 10% smaller maximum size for each sex, change K to be consistent with size at age-1 from the base case model

15	15_base_case_large_Amax	Alternative growth curves, 10% larger maximum size for each sex, change K to be consistent with size at age-1 from the base case model
16	16_base_case_ChangGrowth	Alternative growth parameters, based on Chang et al. (2013)
	Alternative Life History Parameters: Maturity Ogives	
17	17_base_case_high_L50	Alternative maturity ogives, L_{50} = 197.7 cm
18	18_base_case_low_L50	Alternative maturity ogives, L_{50} = 161.8 cm

(a)



(b)

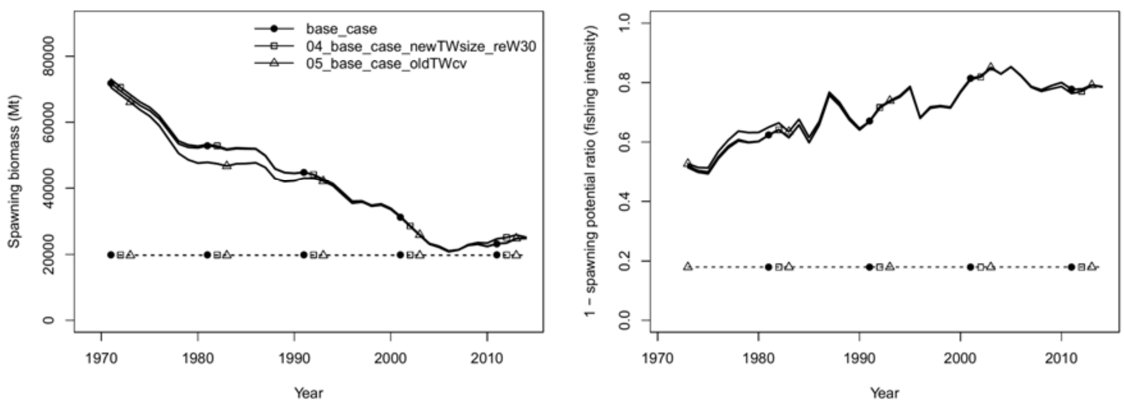
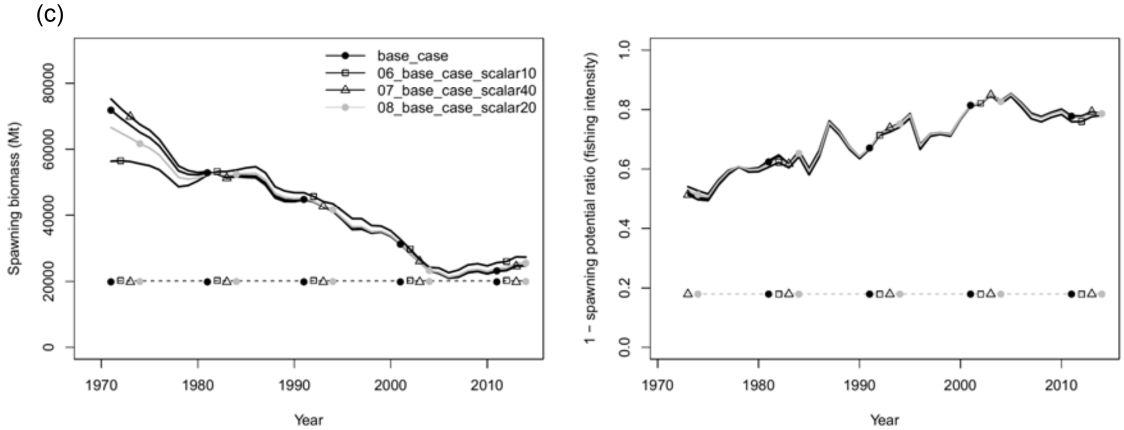
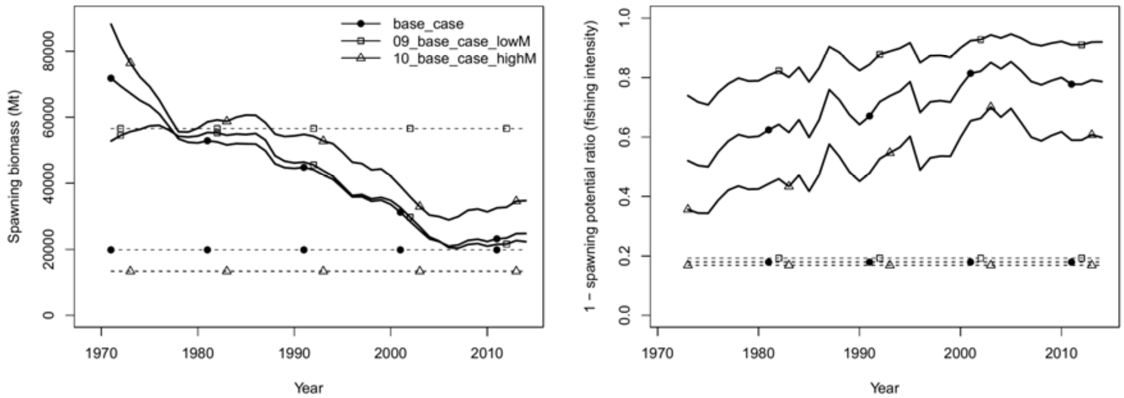


Figure 6.10.1. Spawning stock biomass and fishing intensity (1-spawning potential ratio) trajectories from 19 sensitivity analyses listed in Table 6.10.1, compared to the base case model. Dashed-points lines denote MSY-based reference points. (a) Runs 1, 2, 3, and 19, alternative input data; (b) Runs 4 and 5, alternative input data for Taiwan; (c) Run runs 6, 7, and 8, alternative input data size compositions data weighting; (d) Run runs 9 and 10, alternative natural mortality rates; (e) Run runs 11, 12 and 13, alternative stock-recruitment steepness; (f) Run runs 14,15, and 16, alternative growth curves; (g) Run runs 17 and 18, alternative maturity ogives.

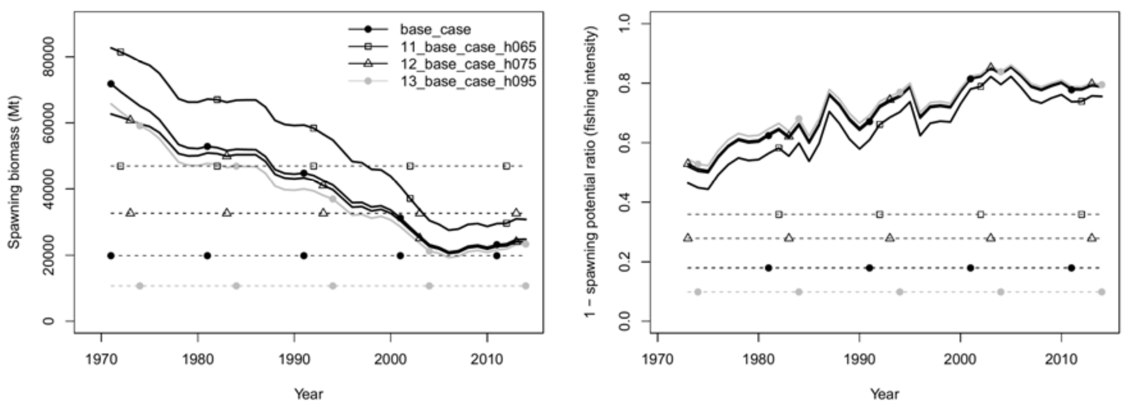
(c)



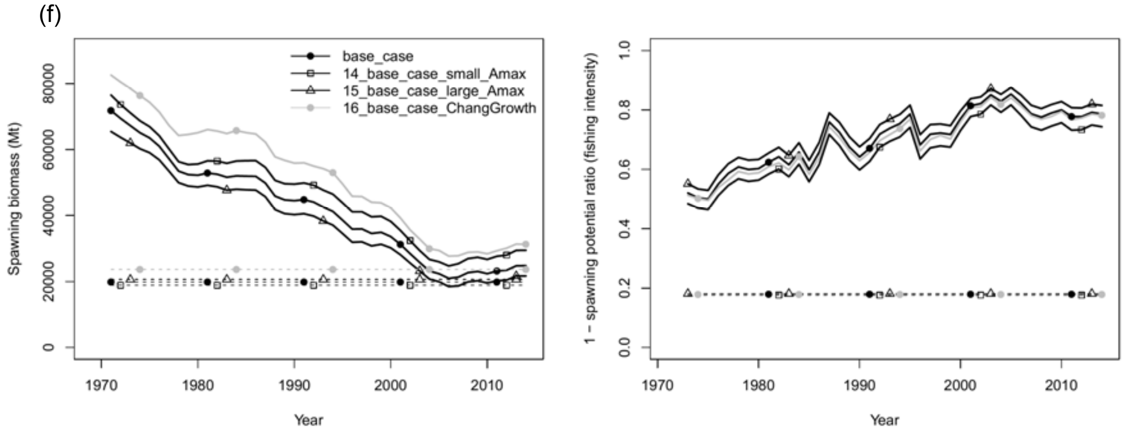
(d)


base_case
09_base_case_lowM
10_base_case_highM
Spawning biomass (Mt)
1 − spawning potential ratio (fishing intensity)
Year
Year

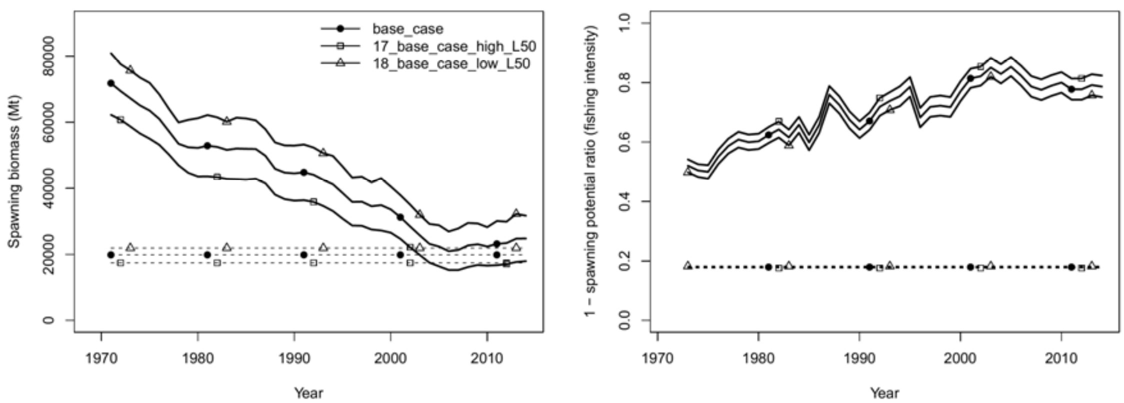
(e)


base_case
11_base_case_h065
12_base_case_h075
13_base_case_h095
Spawning biomass (Mt)
1 − spawning potential ratio (fishing intensity)
Year
Year

(f)


base_case
14_base_case_small_Amax
15_base_case_large_Amax
16_base_case_ChangGrowth
Spawning biomass (Mt)
1 − spawning potential ratio (fishing intensity)
Year
Year

(g)



base_case
17_base_case_high_L50
18_base_case_low_L50
Spawning biomass (Mt)
0
20000
40000
60000
80000
1970
1980
1990
2000
2010
Year
1 − spawning potential ratio (fishing intensity)
0.0
0.2
0.4
0.6
0.8
1.0
1970
1980
1990
2000
2010
Year

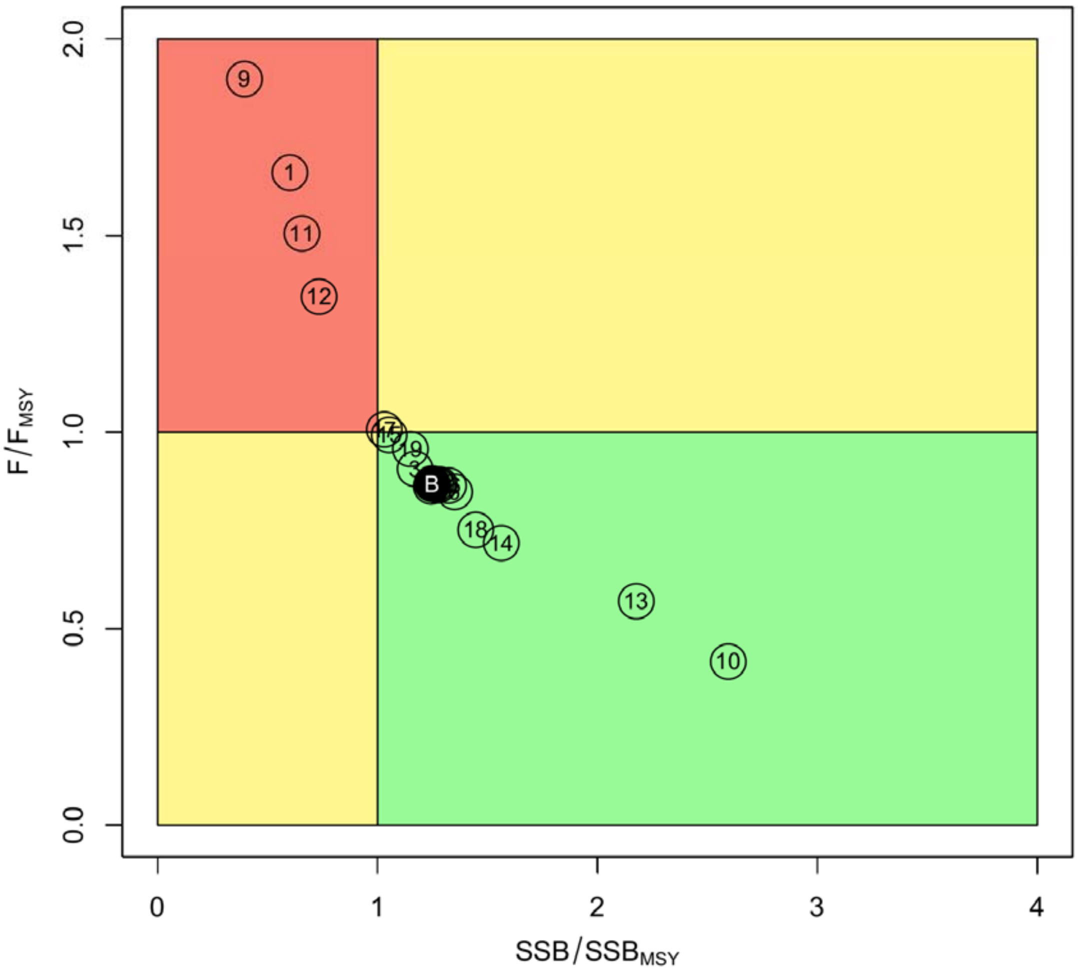


Figure 6.10.2. Kobe plot showing terminal year stock status for the base case model (B) and the sensitivity runs as indicated by numbers. For a list of sensitivity runs, see Table 6.10.1.

Discussion:

For 4 of the 19 sensitivity runs, the stock status was estimated to be in the red section of the Kobe plot indicating that the stock was overfished and experiencing overfishing. These were: Run 1 (S1 and S3 CPUE only), Run 9 (lower natural mortality rate), Run 11 (lowest stock recruitment steepness value), and Run 12 (lower middle stock recruitment steepness value). For all the other sensitivity analyses, the stock was estimated at MSY or in the GREEN section of the Kobe plot, indicating stock was not overfished and not experiencing overfishing.

The WG noted that 3 of the 4 sensitivity runs resulting in a poor stock status (Runs 9, 11, and 12) used assumed life history parameter values that were less likely to be biologically reasonable. Since assuming a lower natural mortality was expected to increase fishing mortality, and assuming a lower steepness was expected to decrease stock productivity, the pessimistic stock status results were not surprising. However, the base case model parameters for natural mortality and steepness are more probable and reliable than the values assumed in these sensitivity runs (i.e., natural mortality was estimated from several empirical equations, and steepness was estimated from life history parameters).

For the sensitivity Run 1, using S1 and S3 CPUE only, it was noted that the model did not fit the Hawaiian longline (S3) CPUE well in the early years of this time series during 1995-2000. The WG noted that there was low and inconsistent observer coverage for the S3 series during that period.

The WG suggested that it would be informative if the stock assessment report could display a horizontal line for MSY-based reference points on the time series for each sensitivity analysis plot, to see how the value of these reference points changed under each sensitivity run. It was also suggested that the sensitivity plots use the same y-axis scales to better allow visual comparison, perhaps removing the virgin biomass estimates to facilitate production of these plots. These additions were agreed to be added to the final stock assessment report.

The WG also suggested that the stock assessment report document the values used for the alternative growth curve sensitivity runs. It was noted that the values of L(Amax) from Table 4.5 of ISC (2013) were misreported, and differed from what was described in the text of that document. The WG verified that the values used for sensitivity Runs 14 and 15 in the 2016 assessment were the same values used in the 2013 benchmark assessment.

Overall, the results of the sensitivity analyses confirmed the robustness of the base case model, and the WG concluded that other sensitivity runs were not necessary.

6.11 Stock Projections

Projections:

Deterministic stock projections were conducted using the Stock Synthesis software platform and the base case model to evaluate the impact of various levels of fishing intensity on future spawning stock biomass and yield for blue marlin in the Pacific Ocean. The future recruitment pattern was based on the estimated stock-recruitment curve. The projection calculations employed model estimates for the multi-fleet, multi-season, size- and age-selectivity, and structural complexity in the assessment model to produce consistent results. Projections started in 2015 and continued through 2024 under 4 levels of fishing mortality. The four stock projection scenarios were:

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.
2. **F_{MSY} Scenario**: Apply the estimate of the F_{MSY} fishing mortality rate to the stock estimates beginning in 2015.
3. **Status Quo F Scenario**: This will be the average F during 2012-2014 ($F_{2012-2014}$).
4. **Low F Scenario**: $F_{30\%}$.

Results showed projected spawning stock biomass and the catch for each of the four harvest scenarios (Tables 6.11.1-6.11.2 and Figure 6.11.1).

Table 6.11.1. Projected trajectory of spawning stock biomass (SSB in metric tons) for alternative projected harvest scenarios. Harvest scenarios are based on the fishing mortality rate that would produce a spawning potential ratio of x% ($F_{x\%}$) and these were: $F_{16\%}$ (average 2003-2005), F_{MSY} ($F_{18\%}$), $F_{2012-2014}$ ($F_{21\%}$) (average 2012-2014 defined as current), and $F_{30\%}$. Green blocks indicate the projected SSB is greater than MSY level (SSB_{MSY} =19,853 metric tons).

Harvest scenario	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Average
1. $F_{2003-2005}$ ($F_{16\%}$)	24545	22683	21163	20014	19167	18546	18086	17741	17481	17283	19671
2. F_{MSY} ($F_{18\%}$)	24810	23850	22972	22260	21710	21295	20982	20745	20564	20426	21961
3. $F_{2012-2014}$ ($F_{21\%}$)	25114	25242	25217	25144	25063	24995	24942	24901	24869	24845	25033
4. $F_{30\%}$	25638	27797	29585	31042	32212	33151	33903	34506	34985	35367	31819

Table 6.11.2. Projected trajectory of yield (metric tons) for alternative projected harvest scenarios. Fishing mortality ($F_{x\%}$) alternatives are based on $F_{16\%}$ (average 2003-2005), F_{MSY} ($F_{18\%}$), $F_{2012-2014}$ ($F_{21\%}$) (average 2012-2014 defined as current), and $F_{30\%}$. MSY = 19,901 metric tons.

Harvest scenario	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Average
1. $F_{2003-2005}$ ($F_{16\%}$)	25688	24044	22890	22089	21522	21111	20806	20576	20402	20268	21940

2. F_{MSY} ($F_{18\%}$)	23194	22336	21693	21234	20905	20667	20491	20359	20259	20182	21132
3. $F_{2012-2014}$ ($F_{21\%}$)	20267	20162	20047	19958	19895	19852	19822	19800	19785	19774	19936
4. $F_{30\%}$	15015	15802	16386	16833	17177	17442	17648	17808	17932	18028	17007

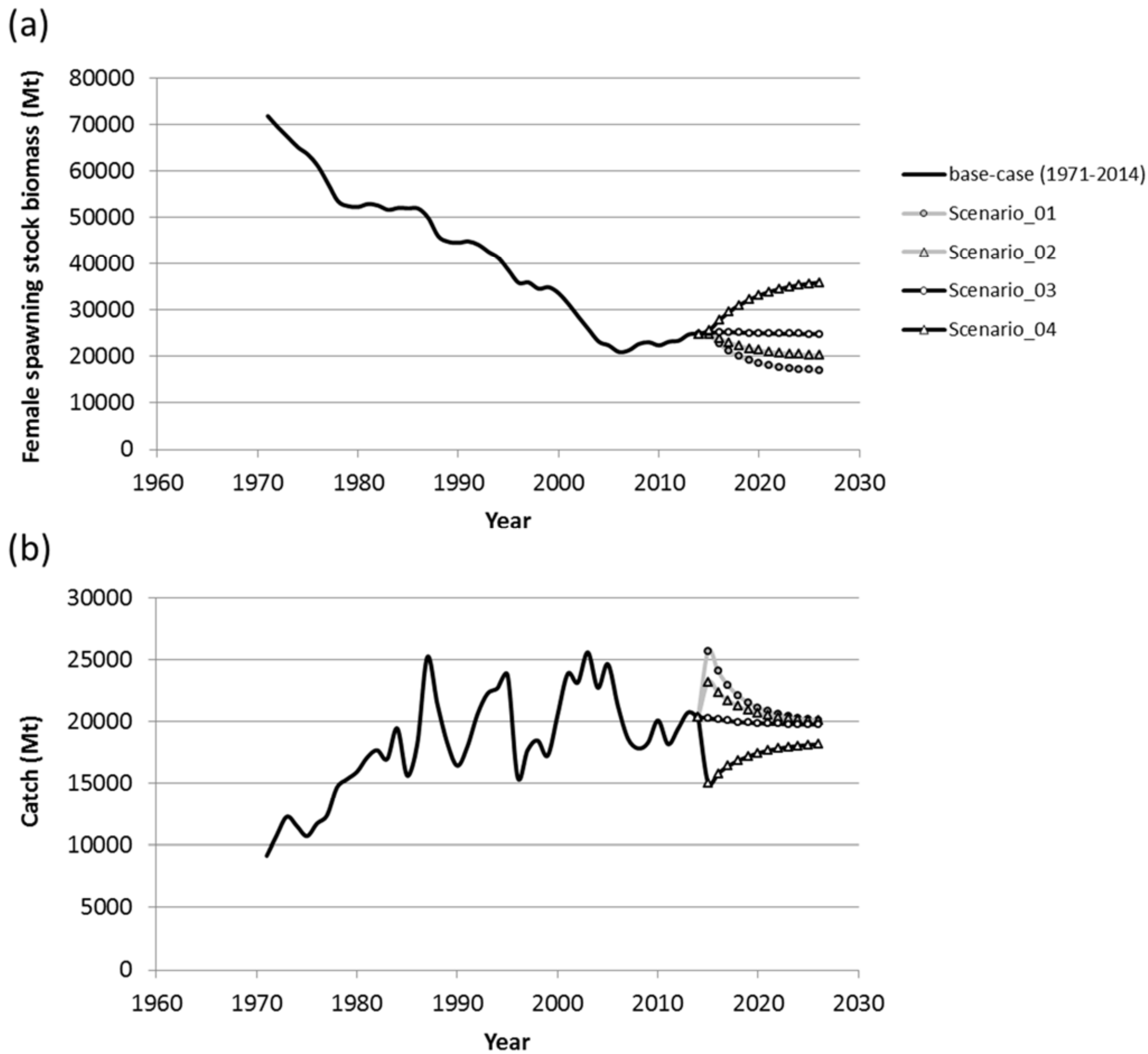


Figure 6.11.1. Historical and projected trajectories of (a) spawning stock biomass and (b) total catch from the Pacific blue marlin base case model. Scenario 1 = average fishing intensity during 2003-2005 ($F_{2003–2005}$= $F_{16\%}$); Scenario 2 = F_{MSY} ($F_{18\%}$); Scenario 3 = average fishing intensity during 2012-2014 ($F_{2012–2014}$= $F_{21\%}$); Scenario 4 = $F_{30\%}$.

Discussion:

The WG recommended exploring the use of a stochastic projection approach for future assessments to more fully characterize the uncertainty of the projection results for risk analysis.

7.0 OTHER BUSINESS

7.1 Future Meetings

The ISC Billfish WG will meet on 13 July 2016 in Sapporo, Japan, prior to the ISC 2016 Plenary meeting. Tentative dates for the next 2016-2017 winter meeting are 13-20 January 2017, in Honolulu, Hawaii, USA. Taiwan agreed to host the next spring 2017 meeting in Keelung, Taiwan, the dates to be determined.

7.2 Work Assignments

The WG discussed and agreed upon the following work assignments.

Working papers: Working papers are to be finalized and sent to the ISC Billfish WG Chair (Jon Brodziak) by 8 April 2016. Authors of working papers have agreed to allow final working papers to be posted for public access on the ISC website.

Stock assessment report: The stock assessment report describing the 2016 stock assessment update of Pacific blue marlin, including sensitivities and projections, should be completed and sent to the ISC Chair by 1 June 2016. To facilitate meeting of this deadline, it was suggested that a completed draft of the report be completed by early May to allow time for circulation for comments and edits. The ISC Billfish WG Chair, along with the authors of ISC/16/BILLWG-02/01 (Yi-Jay Chang, Brian Langseth, Mikihiko Kai, and Hirotaka Ijima), will contribute to completion of the stock assessment report to be reviewed at ISC16.

7.3 Other Items

The WG noted that much progress on the base case assessment update was made during intersessional work conducted by Yi-Jay Chang, Brian Langseth, Mikihiko Kai, Hirotaka Ijima, Jon Brodziak, and other participants, and the WG thanked them for their collaborative efforts which advanced the assessment modeling work considerably and facilitated the timely completion of all work assignments at this meeting.

The WG also thanked Gerard DiNardo for acting as Chair of the Billfish WG for this workshop.

As Chair of the ISC, Gerard DiNardo indicated that he is asking all WGs of the ISC to vote on a Vice Chair for their WG at their July meetings prior to the ISC16 Plenary in Sapporo, Japan. The WG requested further information from the ISC Chair regarding the process by which a Vice Chair is to be elected, and the role and duties of the Vice Chair.

7.3.1 Future Work

The WG discussed future work. It was noted that the WG has been very productive in completing a stock assessment every year for the past few years, but that also these efforts have allowed less time to explore other important research topics. It was suggested that the WG focus on research topics during the next year, such as improvement of biological information, stock structure, catch and effort information, biological reference points and fleet definitions for stock assessments, rather than conduct another billfish stock assessment. One possibility to allow more time for research would be to delay the next stock assessment for North Pacific swordfish by one year, or possibly conducting the assessment as a strict update. This topic will be explored further at the July 2016 BILLWG meeting.

The WG agreed to collaborate to try to gather the data to refine and verify a method for billfish sex identification by using morphology, i.e. by counting the number of pores and comparing these counts to verified sex identification methods using gonad maturity.

The modeling team for the 2016 blue marlin stock assessment (Yi-Jay Chang, Brian Langseth, Hirotaka Ijima, and Mikihiko Kai) proposed developing a simulation framework and operating models to help inform the best approaches for dealing with the model misspecification in billfish stock assessments. However, of the WG noted that work on this project will depend on the future work plan to be discussed at the July 2016 BILLWG meeting.

8.0 ADJOURNMENT AND CLEARING OF REPORT

The WG cleared the report and adjourned the meeting at 0930 on 30 March 2016. The acting BILLWG Chair expressed thanks and appreciation to the rapporteurs and all participants for their contributions and cooperation in completing a successful meeting.

9.0 REFERENCES

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Attachment 2. Meeting Announcement and Agenda

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

BILLFISH WORKING GROUP (BILLWG)

INTERCESSIONAL WORKSHOP ANNOUNCEMENT
and AGENDA

Meeting Site: Novotel Busan Ambassador Hotel
292, Haeundaehaebyeon-ro, Heaundae-gu
Busan, 48099, Republic of Korea
Tel: (+82)51-743-1234 Fax: (+82)51-743-1250
http://www.novotel.com/gb/hotel-6554-novotel-busan-ambassador/index.shtml

Meeting Dates: March 22-30, 2016

Goals: Conduct Pacific blue marlin stock assessment modeling analyses which include fitting the base case Stock Synthesis model, running sensitivity analyses and developing stock projections.

Meeting Attendance: Please respond to Gerard DiNardo (Email: Gerard.DiNardo@noaa.gov) if you plan on attending this meeting

Working Papers: Submit working papers to Gerard DiNardo by **Thursday March 17th**. Authors who miss the March 17 deadline must bring 15 hard copies to the meeting.

Local Contact: Youjung Kwon
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BILLWG Contact: Gerard DiNardo, ISC Chairman and Acting BILLWG Chairman
Director, Fisheries Resources Division
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Southwest Fisheries Science Center

8901 La Jolla Shores Drive, La Jolla, CA 92037-1508, USA
Email: Gerard.DiNardo@NOAA.GOV Tel: (+1)858-546-7106

AGENDA

March 22 (Tuesday), 930-1000 – Registration

March 22 (Tuesday), 1000-1630

1. Opening of Billfish Working Group Workshop
   a. Welcoming Remarks
   b. Introductions
   c. Standard Meeting Protocols

2. Adoption of Agenda and Assignment of Rapporteurs

3. Computing Facilities
   a. Access
   b. Security Issues

4. Numbering Working Papers and Distribution Potential

5. Status of Work Assignments

6. Pacific Blue Marlin Stock Assessment Modeling
   a. Use of Life History Information
   b. Fishery Definitions and Selectivity Modeling
   c. Catch Time Series
   d. CPUE Time Series
   e. Size Compositions

March 22 (Tuesday), 1830-2100

Welcome Reception at Novotel Busan Ambassador Hotel

March 23 (Wednesday), 930-1700

6. Assessment Modeling: Continued
   a. Use of Life History Information
   b. Fishery Definitions and Selectivity Modeling
   c. Catch Time Series
   d. CPUE Time Series

e. Size Compositions
f. Model Runs
g. Model Diagnostics
h. Model Results
i. Biological Reference Points
j. Sensitivity Analyses
k. Stock Projections

March 24 (Thursday), 930-1700

6. Assessment Modeling: Continued
    a. Use of Life History Information
    b. Fishery Definitions and Selectivity Modeling
    c. Catch Time Series
    d. CPUE Time Series
    e. Size Compositions
    f. Model Runs
    g. Model Diagnostics
    h. Model Results
    i. Biological Reference Points
    j. Sensitivity Analyses
    k. Stock Projections

March 25 (Friday), 930-1700

6. Assessment Modeling: Continued
    a. Use of Life History Information
    b. Fishery Definitions and Selectivity Modeling
    c. Catch Time Series
    d. CPUE Time Series
    e. Size Compositions
    f. Model Runs
    g. Model Diagnostics
    h. Model Results
    i. Biological Reference Points
    j. Sensitivity Analyses
    k. Stock Projections

March 26 (Saturday), 930-1700

6. Assessment Modeling: Continued
    a. Use of Life History Information

b. Fishery Definitions and Selectivity Modeling
c. Catch Time Series
d. CPUE Time Series
e. Size Compositions
f. Model Runs
g. Model Diagnostics
h. Model Results
i. Biological Reference Points
j. Sensitivity Analyses
k. Stock Projections

March 27 (Sunday), 930-1700

6. Complete All Work

7. Adoption of Assessment Model for Pacific Blue Marlin
    a. Use of Life History Information
    b. Fishery Definitions and Selectivity Modeling
    c. Catch Time Series
    d. CPUE Time Series
    e. Size Compositions
    f. Model Runs
    g. Model Diagnostics
    h. Model Results
    i. Biological Reference Points
    j. Sensitivity Analyses
    k. Stock Projections

8. Other Business
    a. Future meetings
    b. Work assignments
    c. Other items

9. Rapporteurs Complete Report Sections

March 28 (Monday), No meeting March 29 (Tuesday), 930-1700

10. Complete Workshop Report and Circulate; WG reviews Report

March 30 (Wednesday), 930-1500

11. Clearing of report

12. Adjournment

Attachment 3. Working Papers

ISC/16/BILLWG-2/01	Stock Assessment Update for Blue Marlin (*Makaira nigricans*) in the Pacific Ocean through 2014. Yi-Jay Chang, Brian Langseth, Hirotaka Ijima, and Mikihiko Kai. yi-jay.chang@noaa.gov
ISC/16/BILLWG-2/02	Catch estimates and size compositions of blue marlin (*Makaira nigricans*) from the Taiwanese fisheries in the Pacific Ocean. Nan-Jay Su, Chi-Lu Sun, and Su-Zan Yeh nanjay@ntou.tw.edu