SCIENTIFIC COMMITTEE
NINTH REGULAR SESSION

6-14 August 2013
Pohnpei, Federated States of Micronesia

REPORT OF THE BILLFISH WORKING GROUP WORKSHOP
20-18 May 2013 Shimizu, Shizuoka, Japan

WCPFC-SC9-2013/ SA-IP-13

BILLFISH WORKING GROUP[1]

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

Annex 9

REPORT OF THE BILLFISH WORKING GROUP WORKSHOP

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

20-28 May 2013
Shimizu, Shizuoka, Japan

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 Shimizu, Shizuoka, Japan from May 20-28, 2013. The goals of the workshop were 1) conduct Pacific blue marlin assessment and review, and 2) review swordfish projections requested by the WCPFC Northern Committee.

Joji Morishita, Director of the National Research Institute of Far Seas Fisheries, welcomed participants from the United States of America (USA), Japan, Chinese Taipei, and the Inter-American Tropical Tuna Commission (IATTC) (Attachment 1). The WG noted that no representatives from Canada, China, Mexico, Korea, or the Secretariat of the Pacific Community were present.

2.0 MEETING LOGISTICS

2.1 Standard Meeting Protocol

The BILLWG chair Jon Brodziak noted the efforts of the working group (WG) at this meeting would follow the scientific method with particular emphasis placed on empirical testing, open debate, documentation and reproducibility, reporting uncertainty, and peer review.

2.2 Adoption of Agenda

The meeting agenda was adopted (Attachment 2). It was noted by the WG that data availability would be discussed under agenda item number 5..

2.3 Assignment of Rapporteurs

Rapporteuring duties were assigned to Yi-Jay Chang, Wei-Chuan Chiang, Gerard DiNardo, Michael Hinton, Mikihiko Kai, Minoru Kanaiwa, Ai Kimoto, Hui-Hua Lee, Chi-Lu Sun, Nan-Jay

Su, Lennon Thomas, and Kotaro Yokawa. Lennon Thomas served as lead rapporteur with overall responsibility for assembling the workshop report.

3.0 COMPUTING FACILITIES

Computing facilities included a website for distribution of working papers, meeting documents, and other information and a Wi-Fi wireless network access point to connect to the internet.

4.0 NUMBERING WORKING PAPERS AND DISTRIBUTION POTENTIAL

Working papers were distributed and numbered (Attachment 3). It was agreed that the following working papers would be posted on the ISC website where they will be directly available to the public: ISC/13/BILLWG-2/2, ISC/13/BILLWG-2/4, ISC/13/BILLWG-2/6, ISC/13/BILLWG-2/8, and ISC/13/BILLWG-2/9. The working papers that will not be posted on the ISC website were: ISC/13/BILLWG-2/1, ISC/13/BILLWG-2/3, ISC/13/BILLWG-2/5, ISC/13/BILLWG-2/7, and ISC/13/BILLWG-2/10.

5.0 STATUS OF WORK ASSIGNMENTS

The WG reviewed the status of work assignments from the January 2013 ISC BILLWG workshop and noted that these were:

- Data from Su et al. 2013 and Wang et al. 2006 will be added to the length-weight meta-analysis (Brodziak, ISC/13/BILLWG-1/01).
- Confidence intervals for standardized CPUE of the Japanese offshore and distance longline will be provided updated and corrected data in the late period CPUE
- CPUE standardization and the final HBS analysis will be completed and will include estimates of the variability of standardized CPUE. (Kanaiwa and Hinton, ISC/13/BILLWG-1/05).
- Natural mortality will be estimated using methods from Lorenzen (1996) and the length-weight relationship estimated in the meta-analysis by Brodziak will be used. A combined-sex estimate of M will also be made (Lee and Chang, ISC/13/BILLWG-1/07).
- Purse seine data will be added to WCPFC catch tables (Tagami and Wang, ISC/13/BILLWG-1/11).
- An updated corrected catch history for the Hawaii-based longline fleet from 1995-2011 will be generated using a zero inflated negative binomial model. Estimates in tonnage and numbers will be provided (Walsh, ISC/13/BILLWG-1/13).

- A relationship between whole weight and processed weight will be provided for the Japanese fishery data in order that processed weights can be converted to fish lengths (EFL, cm) for the stock assessment (Kimoto and Yokawa, ISC/13/BILLWG-1/06).

- In addition, catch information on the WCNPO swordfish stock through 2011 will be prepared and tabulated and additional stock projections will be conducted (Tagami).

- Information on North Pacific striped marlin catches by stock area through 2011 will be collected and tabulated at the next WG meeting (Tagami).

- Stock assessment models will be developed and fit to the Pacific blue marlin data by the structured and production modeling working groups and these models will be reviewed at the next intercessional meeting (Brodziak and Lee).

- The WG also recommended that additional analysis on tagging data be conducted by looking at the distance moved and time at liberty in relation to size and by comparing times-at-liberty among fishing years so that annual patterns, if any, may be detected (Sippel et al., ISC/13/BILLWG-1/08).

The BILLWG Chair reported that all of the work assignments were completed except preparation of stock-specific catch information for the WCNPO swordfish and striped marlin stock projections. While swordfish data for the entire north Pacific were provided to the BILLWG, stock-specific catch data for the WCNPO and EPO swordfish stocks were still needed from Japan, IATTC, and the United States. The chairman also reported that stock-specific striped marlin data has not been provided from the WCPFC. The BILLWG Chair noted that stock assessment models had been developed to assess the Pacific blue marlin stock and that substantial progress had been made for the stock assessment.

The issue of assessment data availability was discussed. The WG expressed concerns about the availability of data to all WG members. The BILLWG Chair expressed concerns about the timeliness of data preparations and stressed the importance of meeting data preparation deadlines. The BILLWG Chair emphasized that for future assessments communication between WG members and the BILLWG Chair needs to be improved. In particular to establish a client server process to share and distribute the assessment data. The ISC Chair commented that a formal policy for data sharing will be developed and discussed at the next ISC Plenary meeting and implemented for all working groups in the ISC.

6.0 SWORDFISH CATCH PROJECTIONS

6.1 Review of available Swordfish catch projections requested by the Northern Committee

Swordfish catch projections have not been completed because stock specific data from the USA, Japan, the WCPFC, and the IATTC have not been provided. The WG commented that work is being done to assemble these datasets by the close of this meeting. The BILLWG Chair will complete the swordfish projections when all stock-specific catch data have been received. As of the end of this BILLWG meeting, the WG noted that the BILLWG had received stock-specific provisional catch data from Chinese Taipei, USA, Japan, and the IATTC.

7.0 PACIFIC BLUE MARLIN STOCK ASSESSMENT DATA INPUTS

7.1 Life history information

7.1.1 Vertical and horizontal movements of blue marlin in the northwestern Pacific Ocean determined using pop-up satellite tags presented by Wei-Chuan Chiang (ISC/13/BILLWG-2/3)

Blue marlin is a highly migratory species with a wide distribution ranging from approximately 48°N to 48°S. Blue marlin is the largest of the istiophorid billfishes and a popular game fish because of their size and fighting ability. In the Pacific Ocean, the annual commercial catches of blue marlin usually exceed those of swordfish and other istiophorid billfishes combined. To investigate their movement patterns, pop-up satellite archival tags (PSATs) were deployed on blue marlin using the traditional harpoon fishery of southeastern Taiwan (Taitung). Depth, temperature and ambient light data were recorded by the PSATs.

A total of 10 blue marlin were tagged from February 2010 to July 2012. The PSATs remained affixed on the animals from 26 to 360 days. Linear displacements from deployment to pop-up location ranged from 58 to 1,529 km. Diving depths ranged from the surface to 423 m. Blue marlin were found at times in ambient water temperatures from 30.6°C to as low as 6.8°C, and the distributions of time spent at depth differed significantly between day and night. Tagged blue marlin spent the majority of daytime in the surface mixed-layer to 50 m, and at nighttime were confined to the surface. The depth distribution of blue marlin appeared to be limited by an 8°C change in water temperature from the warmest water layer.

Discussion

The WG commented that the tagging data could be useful for future stock assessments. The WG noted that the tagging results presented did not separate results by size. The WG discussed that the movement pattern and the environmental preference of blue marlin may differ among size groups, but the WG also noted that most of the tagged fish were from the harpoon fishery, which primarily catches larger adult fish. The WG also noted that the tagging sample size was small. Currently, tagging programs are being carried out by different organization and agencies but no information from such studies have been directly incorporated into the Pacific blue marlin stock assessment and most of them were not used in CPUE standardization (ISC/13/BILLWG-1/5). The WG recommended that it would be important to develop a program to gather all of tagging data and also to develop a representative sampling design for future tagging studies.

The WG also noted that pop-up satellite tag studies are expensive. Therefore, the sample size are typically small and individual variation in fish behavior can be substantial. The WG suggested that developing a future study that combined the use of both conventional tags and pop-up satellite tags would be informative and appropriate because larger sample sizes would be attainable. The author showed that the horizontal movements of blue marlin based on PSATs in this study did not reveal mixture with or connections to any blue marlin tagged in the Hawaiian waters. The WG noted that in the long term, inferences about blue marlin movements would be possible through complementary tag deployments in different regions and seasons. Therefore, is the WG thought it would be important to develop an integrated tagging program with a representative sampling design to gather Pacific-wide tagging data. It was also noted that this tagging study was is conducted under a joint Fisheries Research Institute COA, Taiwan Pacific Island Fisheries Science Center, and National Taiwan University collaborative project, and will be encouraged and continued.

7.2 Catch

The published study by Suzuki (1989), which included Japanese catch and CPUE data from 1952-1985, was discussed by the WG. The WG decided that this data would not be used in the stock assessment because there were a number of problems with the data that have since been corrected. During this time period (1952-1985), there were both a large expansion in the Japanese fishing areas and changes in the characteristics of fishing effort, neither of which was accounted for in the CPUE data. One problem consisted of species misidentifications by inexperienced fishing captains, which caused the fraction of the total catch reported as blue marlin to be biased. The WG concluded that Suzuki's catch information and CPUE data would not be used in the stock assessment.

The WG agreed to move forward with the best available blue marlin catch data (Figures 1 and 2), which were completed at the January 2013 BLLWG meeting, and were updated at this meeting to include the best available estimates of blue marlin catches reported to the IATTC.

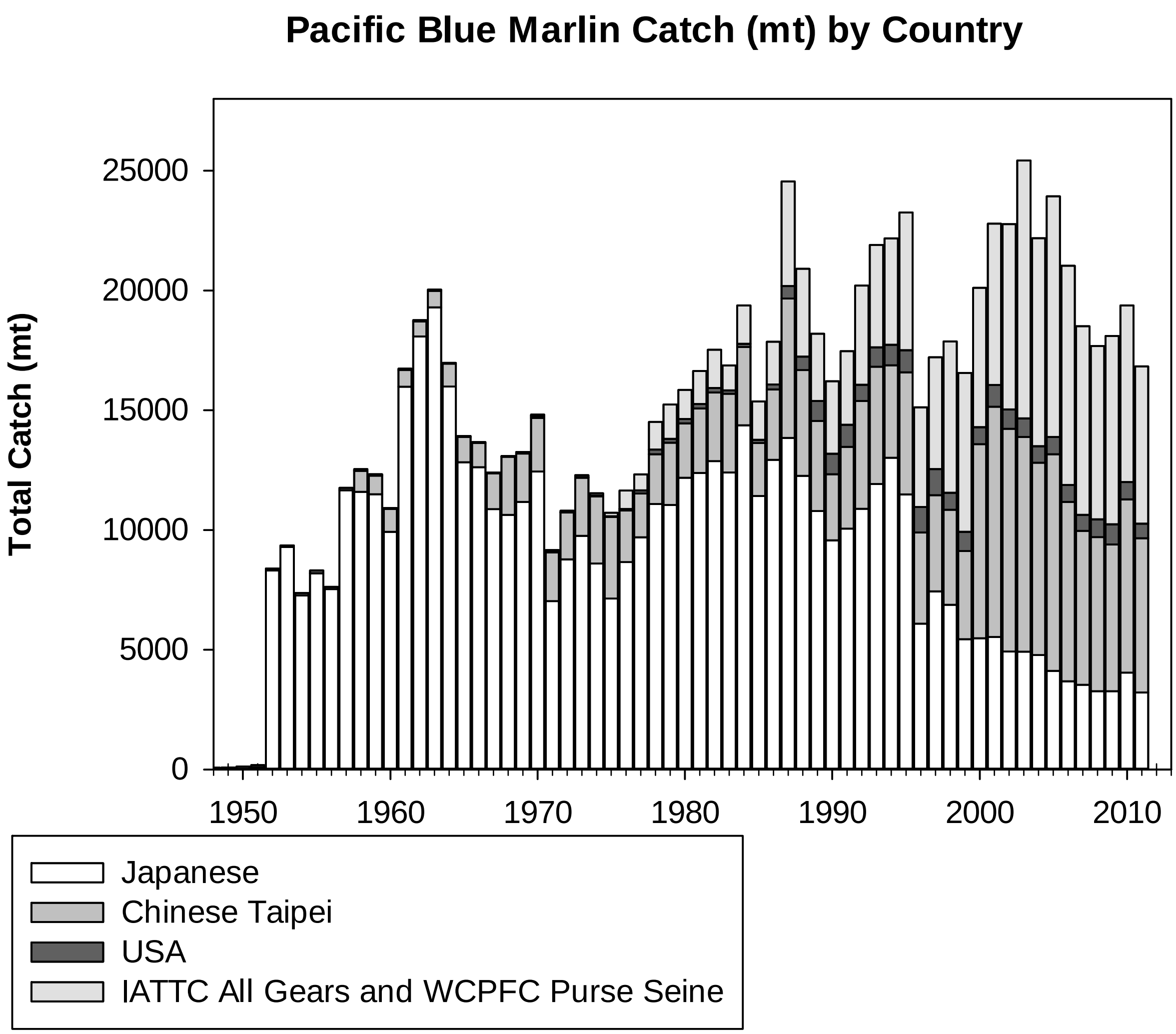


Figure 1: Pacific blue marlin (*Makaira nigricans*) catch (mt) in the Pacific Ocean for Japan, Taiwan-Taipei, U.S., and purse seine catch for other IATTC and WCPFC countries.

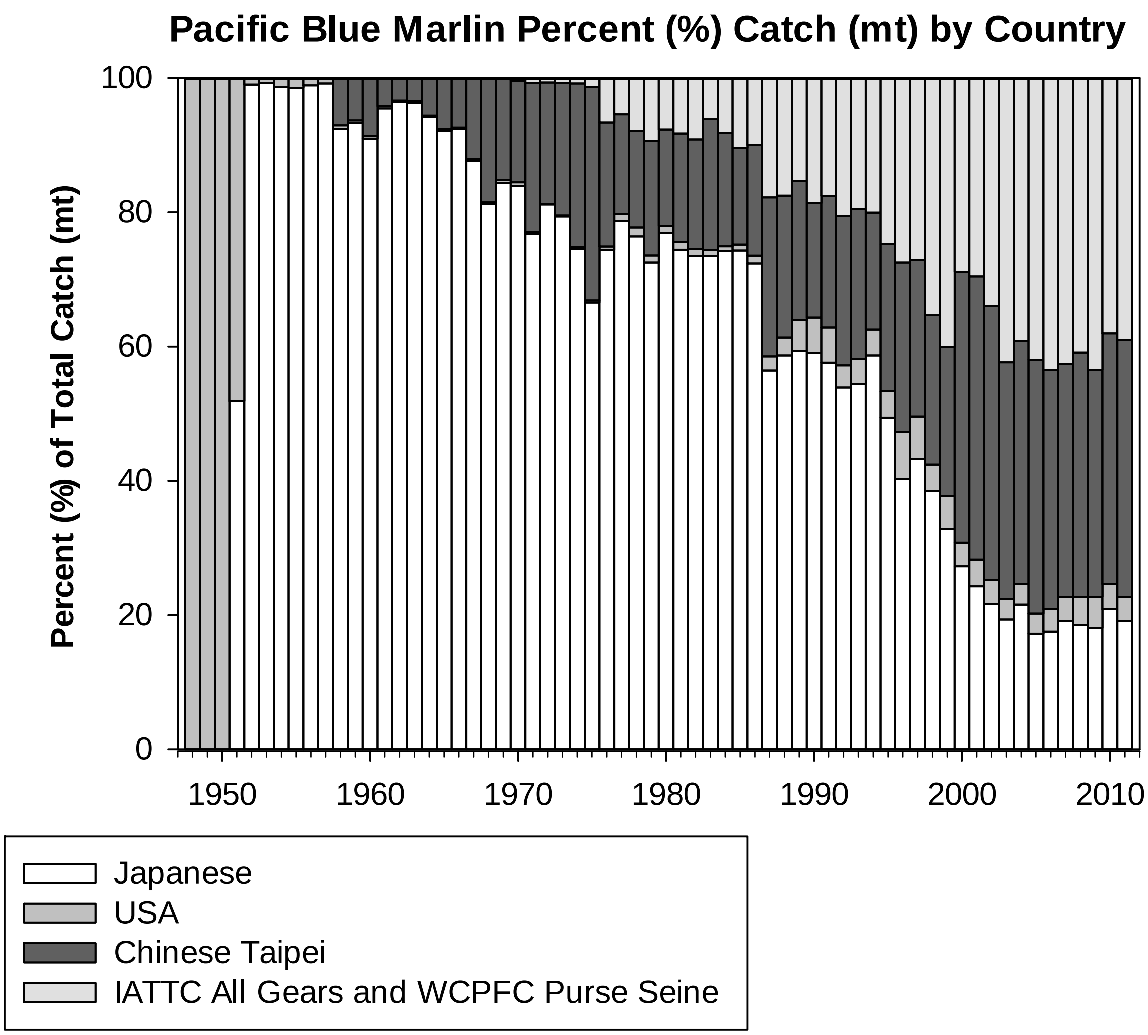


Figure 2: Percent of total blue marlin (*Makaira nigricans*) catch biomass (mt) by country from 1950-2011.

7.3 CPUE time series

The WG agreed to use the estimates of standardized blue marlin CPUE (Figure 3), which were completed at the January 2013 BLLWG meeting.

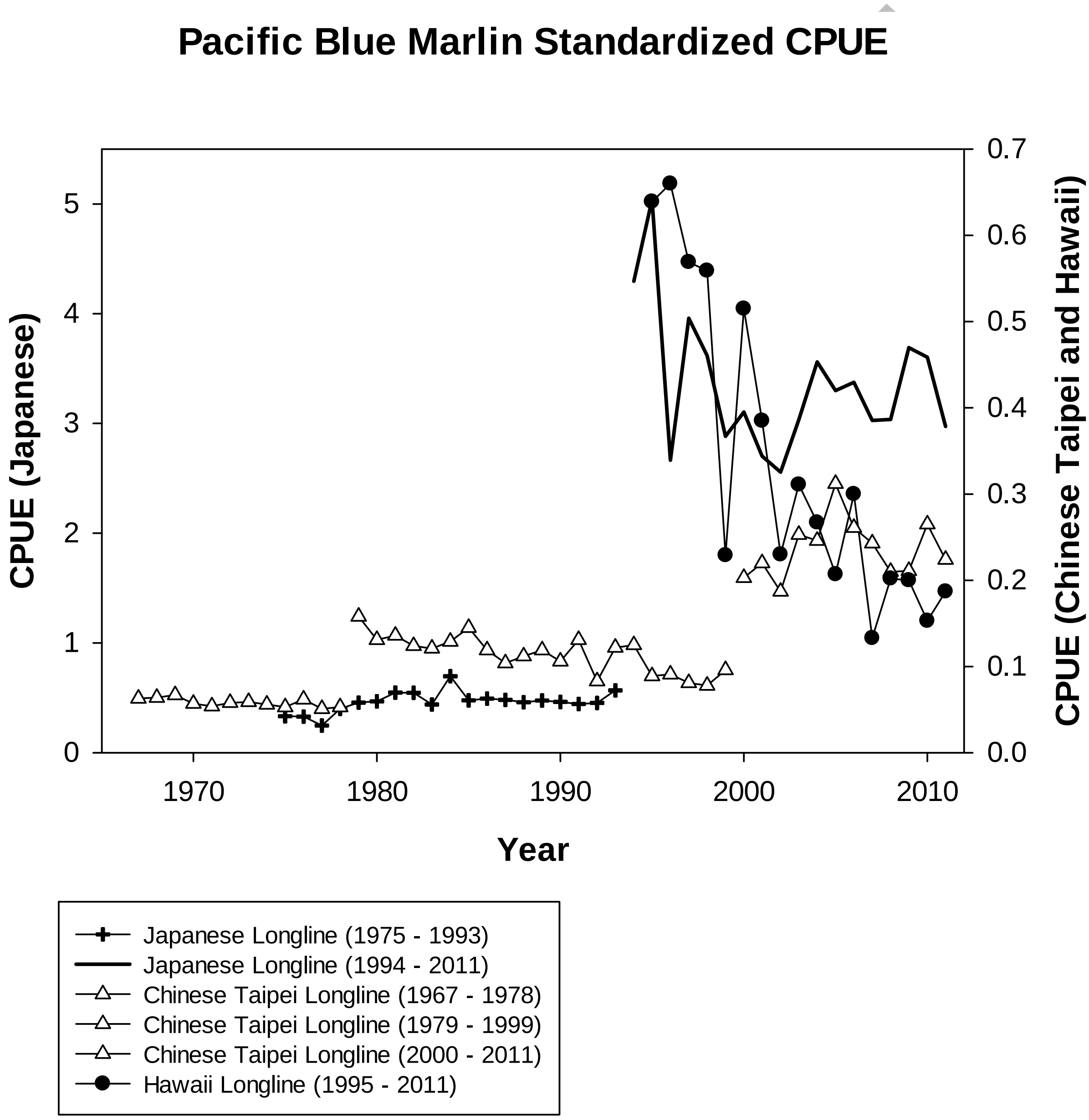


Figure 3: Blue marlin (*Makaira nigricans*) CPUE by country from 1950 – 2011.

7.4 Size compositions

7.4.1 Quarterly summaries of Pacific blue marlin size composition data presented by Jon Brodziak (ISC/13/BILLWG-2/01)

This working document summarizes most of the available size composition data for Pacific blue marlin by year and quarter. The quarterly summaries include histograms and smoothed density plots of the size frequency data and also include the observed sample size (n), the mean size (mean), and the coefficient of variation of size (CV). These graphical summaries are provided for the following size composition data sets: Japanese distant water longline length frequency data (JPLL_cm), Japanese distant water longline weight frequency data (JPLL_kg), Japanese offshore longline length frequency data (JPOLL_cm), Japanese offshore longline weight frequency data (JPOLL_kg), Japanese shallow-set longline length frequency data (JPSLL_cm), Japanese drift net weight frequency data (JP_drift_kg), Taiwanese longline length frequency data (TAIWAN), and Hawaii-based longline length frequency data.

Discussion

The WG confirmed that length and weight composition data of the analysis were from the commercial fishery data. The WG noted that the distant water LL processed weight-frequency data could not be used as input for the stock assessment model without adequate conversion factors which explain time and area variability of length-weight relationship. There may be several factors causing bias in the weight-frequency data. For example, the weight-frequency data of DW LL fleet are collected onboard, whereas the processed weight measurements represent gilled and gutted weight. The relationship between length and processed weight may vary by area and season. The WG also discussed the source of the Chinese-Taipei size data. The WG noted that there is one major source of size data (first 30 samples of the caught fish per operation).The WG noted that similar size sampling protocols were used in Japanese fisheries, but these also included port sampling.

7.4.2 A comparison of the consistency of blue marlin (*Makaira nigricans*) length and weight composition data from the Japanese distant water longline fleet presented by Jon Brodziak (ISC/13/BILLWG-2/02)

This working paper addresses the question of whether the pooled-sex blue marlin length composition data and weight composition data collected from the Japanese distant water longline fisheries provide consistent measures of the size composition of the fishery. To address this question, we applied chi-square goodness of fit tests to the length ($\underline{p}$) and length-converted weight frequency ($\underline{q}$) data by year and quarter. To test the hypothesis $H_0 : \underline{p} = \underline{q}$ that there was no difference between observed length and converted length size composition for each year-quarter combination, blue marlin eye-fork length measurements (cm) were binned into a total of $k = 6$ bins; these were: (0,140], [140,160), [160,180), [180,200), [200,220), and [220,500]. Overall, there were a total of $m = 167$ year-quarter combinations that had no zero counts in a length bin and were hence feasible for statistical comparison using the chi-square test. We tested the hypothesis H_0 for each year-quarter combination at the $\alpha = 0.05$ experiment-wise confidence level using the Bonferroni method with an adjusted $\alpha_i = \alpha / m = 0.0003$ and a critical chi-square value of $X^2_{1-\alpha_i, k-1} = 23.27$. The hypothesis $H_0 : \underline{p} = \underline{q}$ that there was no difference in size composition was rejected in 166 out of 167 or 99% of the tests. The hypothesis was not rejected only in 1975 in quarter 3. As a result, we conclude that the blue marlin length and weight composition data collected from the Japanese distant water longline fishery are not consistent.

<u>Discussion</u>

The WG noted that there is a difference between converted size and observed size. The WG recommended that only the observed length composition data from the Japanese longline fisheries be used in analyses. The weight data can represent a variety of processed conditions, e.g., filleted weight or gilled and gutted weight. The WG concluded that use of the weight size data for the longline fishery was premature at this time.

8.0 PACIFIC BLUE MARLIN STOCK ASSESSMENT MODELING

8.1 Preliminary Pacific Blue Marlin Stock Assessment by Hui-Hua Lee and Yi-Jay Chang (ISC/13/BILLWG-2/04 and ISC/13/BILLWG-2/05)

Life-history parameters and catch and CPUE time series of Pacific Ocean blue marlin data were developed at previous BILLWG meetings. This information was used to fit a length-based/age-structured Stock Synthesis (SS) model assuming a well-mixed pan-Pacific stock structure. Major model structural assumptions included 1) gender-specific natural mortality, growth, and length-weight relationships; 2) an annual time step with observed data fit quarterly; 3) cubic spline and double normal fishery selectivities; 4) time varying selectivity; and 5) an assumption of an initial equilibrium condition relative to an average initial fishery catch level. The sex-ratio at birth was fixed at 1:1. Due to lack of recording of gender in fishery data to inform gender-specific fishery selection, the model was assumed to have equal probability of selection to gender throughout the stock area. In this case, gender-specific natural mortality, size-based selectivity by fishery, and sexually dimorphic growth can result in significant departures from equality due to differential mortality over age and gender.

Likelihood profiling on the unfished recruitment parameter (R0) was used to develop and structure the model. Cubic spline selectivity functions were fit to size composition data for Japanese distant-water and offshore longline and Hawaii longline because they provided a better fit than a double normal selectivity assumption. Changes to the input standardized CPUE data set included separating CPUE data set into two groups of time series based on the internal consistency of model fits to the two groups. Although estimates of catch data series were available from onward 1952, the baseline model was set up to start in 1971 when it was expected that more accurate catch data were available due to misidentification of blue marlin catch by species during 1952-1970. Starting in 1971 also allowed for the model to incorporate the available size composition data which begins in 1975 into the estimation of the initial age structure in 1971. Since the model used separate growth curves for males and females, the spawning output for use in calculating management quantities was based on females only. Results indicated estimates of population biomass exhibited a long-term decline and increased after 2008 resulting from the combination of catch history and recruitment variation.

Discussion

During the meeting, a new time series of catch from the area of overlap between the WCPFC and IATTC fishery regions was extracted from IATTC databases and compared with the original catch data developed during the January 2013 BILLWG meeting, which included estimates of blue marlin catch within the overlap area. The WG noted that the two sets of blue marlin catch data for the overlap area had the same trend and were relatively similar. Thus, WG agreed that the use of original catch data would be acceptable in this stock assessment.

The WG discussed approaches to set the initial CVs for the CPUE indices in order to fit the SS models. The presenter explained that a smoothing approach was used to set the initial CVs. The WG discussed the spatial and temporal coverage of the fisheries that catch blue marlin in the Pacific Ocean. The WG clarified that catchability for each CPUE index was calculated as a derived parameter based on the model fit and was not estimated as a free parameter.

The WG discussed the fits of the SS models to the size composition data. The WG noted there was a temporal change in the size compositions collected from the French Polynesia longline fishery in the earlier period (1996-2002) and the later period (2003-2011). It was also noted that the sample size for 1996-2002 was clearly smaller than for 2003-2011. The WG also clarified the sources of the size composition data from the Japanese fleets that were used in this assessment. The WG noted that the reports of small sized fish were likely due to the fact that the fishing ground of the French Polynesia fleet was close to a blue marlin spawning ground.

The WG discussed the modeling of blue marlin recruitment and noted that the recruitment process for blue marlin was defined to occur in a single season and that recruitment was the number of age-0 fish entering the stock in the 2nd quarter of each year. The WG also noted that there appeared to be several strong recruitment events in the 1980s.

The WG discussed the fit of the size composition data from the Japanese distant-water longline fleet during 1971-1993 using the cubic spline selectivity and agreed that the fit was acceptable based on a visual display of the statistical fit. The WG questioned why cubic spline selectivity was not used for the Japanese distant-water longline fleet during 1994-2011 and noted that the double normal selectivity was appeared to provide a better fit because of changes in the seasonal size composition data during this period.

The WG discussed the fits to the CPUE indices for the four alternative models described in Working Paper 4. The WG noted that the CPUE trends of the fleets were relatively flat, with the exception of the Hawaii longline fleet, but that there were decreasing trends in stock abundance across models. The decreasing trend in abundance was due to the combination of increasing catch and a moderate decline in recruitment since the 1980s. The WG also noted that there appeared to be strong year class in 2009, which led to a slight increase in current stock abundance. It was also noted that the sharp decline in abundance and poorer fit to CPUE time series under Model 3 were attributable to the influence of including the Hawaii longline CPUE. It was also noted that the spatial coverage of the Hawaii longline fishery was near the edge of the distribution of blue marlin in the Pacific and the catch was relatively small compared to the Japanese and Chinese Taipei longline fleets. The WG discussed the conflict between the relative abundance trends from the Hawaii longline CPUE and the other CPUE time series and concluded that the Hawaii longline CPUE was unlikely to be representative of Pacific-wide abundance trends.

The WG discussed the estimation method of effective sample size for size composition. The WG considered the spatial range for the sample size data. The WG noted that the JPLL had large sample sizes of size composition data. The fit of size data for the Japanese late fishery was worse than that for the early fishery. The WG asked for more information about the model fits and further diagnostic analyses. The WG also discussed the availability of size composition data for each fishery. Since age structure was important in modeling the population dynamics of blue marlin, the WG thought it would be useful to gather more size information from the other fleets that catch blue marlin in the Pacific Ocean (e.g., Korea).

The WG requested that the following sensitivity runs be completed and presented to assess the configuration and assumptions of the preferred model in Working Paper 4 (Model 2):

1. One model run that excluded the French Polynesia size composition data. The WG noted that there was no known basis for a time split in selectivity for this fleet.
2. One model run that excluded the Japanese drift net size composition data. The WG noted that the Japanese drift net fishery had relatively low sampling coverage and that the fishing area was near the boundary of the blue marlin distribution.
3. One model run that used a 1952 start date (Model 5). The rationale for this run was that neither stock abundance nor the catch was in equilibrium prior to 1971. The WG also noted that there was an unusual decline in recruitment during 1974-1976 which could be a function of the choice of 1971 as the starting year for the model. For this run, the Japanese blue marlin catch estimates prior to 1952 were used to set the initial catch level and the catch data of all fleets prior to 1970 were included.

The sensitivity analyses that excluded the French Polynesia and Japan drift net size composition data were presented and the resulting model fits to CPUE and size composition data were very similar to those from Model 2. The WG concluded that excluding the French Polynesia and Japan drift net size composition data had no practical effect on the model results, which was expected because the blue marlin catches by these two fleets were relatively small. Thus, the WG agreed to include both size composition data sets in the baseline model.

The WG noted that sensitivity run 3 (a.k.a. Model 5) incorporated more information about the removals from the blue marlin stock in the 1950s-1960s. Accordingly, the WG requested to examine the fits of this model for each likelihood component. The WG requested the information on the quality of size composition fits for each fishery as a model diagnostic, including the estimated values of effective sample size relative to the input sample size.

The WG noted that there were no major differences between Model 2 and Model 5 in the CPUE fits for the entire time series, although there were minor differences in 1971, the first year of comparison. The WG also noted that a slight decrease in the abundance trend in the 1970s was apparent when catch data for 1952-1970 were included in the model. This suggested that the initial condition might be important for modeling the population dynamics. However, it was also noted that the patterns of observed catch and predicted catch were very similar for the two models. Some minor differences in fishery selectivity patterns between model 2 and model 5 were discussed but overall, the WG concluded that there was no substantial difference in the estimated selectivity patterns between Model 2 and Model 5. Further, the WG noted that including the catch data during 1952-1970 in the model had no effect on the estimated recruitment deviations. Overall, the WG agreed that the model fits and diagnostics of Model 2 and Model 5 were consistent and that including the catch data from 1952-1970 did not influence model results or interpretations.

8.2 A sensitivity analysis of alternative natural mortality schedule and steepness in the Pacific blue marlin stock assessment by Mikihiko Kai (ISC/13/BILLWG-2/06)

This paper describes an alternative proposal of key input parameters of natural mortality rate (*M*) and steepness (*h*) in Stock Synthesis 3 using sensitivity analyses based on the results of Model 1 provided by Lee et al. (2013).

Discussion

The WG noted that higher *M* and lower *h* tended to increase the estimates of spawning stock biomass (SSB) while lower *M* combined with higher *h* tended to decrease the estimates of SSB. It also appeared that higher adult *M* on ages 2+ could increase the estimates of SSB in the early part of the assessment time series and decrease the estimates of SSB in the later part. The changes in *M* also had an impact on the ratio of SSB in 1971 to the estimate of unfished SSB. In contrast, changes in *h* did not have much of an impact on the SSB ratio. Overall, the results of the sensitivity analysis suggested that the natural mortality rate and stock-recruitment steepness were important life history parameters for measuring trends in blue marlin spawning stock biomass.

8.3 Stock assessment of blue marlin (*Makaira nigricans*) in the Pacific Ocean using an age-structured model by Nan-Jay Su (ISC/13/BILLWG-2/07)

A sex-specific age-structured (AS) population dynamics model was fitted to catch, CPUE, and length-frequency data for blue marlin (*Makaira nigricans*), based on the assumption of a single unit stock in the Pacific Ocean, to examine the current status of this population. CPUE and size-frequency data of blue marlin from the Japanese, Taiwanese, and Hawaiian tuna longline fisheries were included in the analyses, as well as the length data aggregated over all of the fleets that operate in the western and central Pacific Ocean (WCPO). Results indicated that the spawning stock biomass dropped substantially in the 1950s and early 1960s, but stabilized during the 1970s and 1980s. Spawning stock biomass was estimated to have fluctuated around the B_{MSY} level from the early 1990s to the present. Fishing mortality was estimated to have increased gradually and reached its highest level in the early 2000s and then slightly decreased in the past 5 years. The stock assessment results for blue marlin in the Pacific Ocean were robust to the values assumed for steepness (h) and variation in recruitment (σ_R), but were somewhat sensitive to the assumed values of female and male natural mortality rate.

Discussion

The WG requested that a table showing the data used and assumptions made for the age-structured model by Sun et al. (ISC/13/BILLWG-2/07) and SS model (Model 2, ISC/13/BILLWG-2/04) be provided (Table 1). It was confirmed that the same data sources were used for both models. It was also confirmed that both models assumed an equal probability of fishery selectivity by sex was assumed for fitting the size composition data and that both models produced estimates of the number of fish at age by sex through time. As with the SS model, the fit of the AS model to Hawaii longline CPUE was poor and there were patterns in the residuals for Hawaii longline CPUE. The WG confirmed that the initial equilibrium age structure in the AS model was estimated based on the natural mortality rate. It was also confirmed that the multiplicative weights for the likelihood components were 10 for CPUE data and 1 for size composition data. Thus, the CPUE likelihood components had an order of magnitude higher weight for parameter estimation.

The age-structured model and the stock synthesis model showed similar trends of declining stock biomass. The WG concluded that the estimated biomass trends from the SS model and the age-structured model were consistent but differed in the scale of decline from estimated trends based on production models (described below).

Table 1: Table summarizing the input data, biological assumptions, and fishery dynamics for the stock synthesis model and the age-structured model for Pacific blue marlin.

<u>**Input Data**</u>	**Stock Synthesis**	**Age-Structured**
Catch	Seasonal catch from: Japan (1971-2011), US (1971-2011), Taiwan (1971-2011), WCPFC (1971-2011), IATTC (1971-2011)	Annual catch from: Japan (1952-2011), Taiwan (1958-2011), US (1994-2011), WCPFC and IATTC (1992-2011)
CPUE	6 indices: 2 Japan indices (1971-2011), 1 Hawaii index (1994-2011), and 3 for Taiwan (1971-2011)	6 indices: 2 Japan indices (1975-2011), 3 Taiwan indices (1967-2011), 1 Hawaii index (1995-2011)
Size-frequency	Size data: Japan longline (1971-1993), Hawaii longline (1994-2011), Taiwan longline (2005-2010), WCPFC longline (1992-2011), and IATTC pure seine (1991-2011)	Size data: Japan (1970-2011), Taiwan (2004-2010), Hawaii LL (1994-2011), and WCPFC (1992-2011)

Biological Assumptions	**Stock Synthesis**	**Age-Structured**
Gender specificity	Two gender	Two gender
Growth	Length-at-age 1 Female: 144.0 cm Male: 144.0 cm Length-at-age 26 Female: 304.2 cm Male: 226.0 cm Von Bertalanffy_k Female: k=0.107 Male: k=0.211	Female and male growth curves from Chang et al. (2013)
Weight (kg) at length (cm) $W = A \cdot L^B$	Female: *A*=1.844E-05, *B*=2.956 Male: *A*=1.37E-05, *B*=2.975	Same from Brodziak (2013)
Natural mortality (y^{-1})	Female: 0.42 at age 0, 0.37 at age 1, 0.32 at age 2, 0.27 at age 3, 0.22 at age 4+ Male: 0.42 at age 0, 0.37 at age 1+	M = 0.3 for both sexes and all ages
50% maturity	Female: 179.8 cm	Same from Sun et al. (2009)
Spawner-recruit steepness (h)	h=0.87	h=0.85
Standard deviation of recruitment	σ_R=0.32	σ_R=0.4
Initial age structure	Fished equilibrium in 1971 based on 1967-1971 average catch	Unfished equilibrium in 1952
Fishery dynamics	**Stock Synthesis**	**Age-Structured**
Fishery Selectivity	Cubic spline curves for Japanese longline 1975-1993 and Hawaii longline. Double normal curves for Japanese longline 1994-2011, Taiwanese longline, WCPFC longline, IATTC purse seine, and Japanese driftnet	Asymptotic fishery selectivity curves for all fisheries

8.4 Preliminary analysis of stock status for blue marlin in the Pacific Ocean by Bayesian production model by Minoru Kanaiwa (ISC/13/BILLWG-2/08)

A non-equilibrium Bayesian surplus production (BSP) model was applied for Pacific blue marlin. A single stock was assumed for the entire Pacific Ocean. An annual time-series of fishery data from 1950 – 2011 was used for the assessment. Catch and six CPUE indices, i.e. Japanese early and late distant-water and offshore longline, Hawaiian longline, Taiwanese early, middle and late longline, were used. The median estimates for the historical stock biomass declined from 250,000 t to 170,000 t between the late 1980s and mid 2000s and increased after that. The stock biomass of Pacific blue marlin was estimated to be well above the biomass to produce maximum sustainable yield, MSY and was exploited with the fishing rate well below that at MSY (F_{MSY}) during all years.

Discussion

The WG discussed the prior settings of the BSP model. Discussion confirmed that the parameterization of *K* was as ln(*K*) and that the upper bound of the prior, 2,000,000 mt, resulted in a maximum *K* factor 100 times the maximum observed catch. The point was made that the prior was set high to prevent restriction of model solutions due to boundary limits on *K*. A prior of 1,000,000 mt was also tried, and the results were similar. It was also noted that the high coefficient of variation of *K* indicated that there was not much information in the catch rate series on carrying capacity and that there was no association between *r* and *K*.

It was clarified that the prior setting for the coefficient of variation on *r* was the same that was used in the swordfish assessment and that this constrained the model in the fitting. The WG requested runs with coefficients of variation of 100% and 200% to understand the effect of assuming a larger range of variability, and the results showed a small shift in estimates of *r*. The WG further requested plots of standardized residuals for each fishery and tests of the normality of these residuals. The authors provided them to the WG and the *p*-values showed that the distribution of the JPLL-early CPUE residuals was significantly different from a normal distribution with a 5% significance level.

To compare the results from the two production models, the WG discussed how sensitive the results would be if the early HILL and TWLL indices were removed from the BSP model. The WG confirmed that removing these two CPUE indices yielded similar results as the original model. The WG noted that the assessment results in this working paper were different from those from the last assessment (Kleiber et al. 2003); in particular, the biomass estimates were about four times larger. The presenter explained that the assessment model included several model assumptions that differed from those of Kleiber et al. (2003), and these different assumptions affected the assessment results. The presenter also discussed the harvest ratio, and noted that, although blue marlin may not be typically targeted, and despite the fact that the South Pacific contains fewer land masses than the North Pacific Ocean, the harvest ratio was about 50% in the last stock assessment. This was similar to that of swordfish in the North Pacific Ocean, which is a more commonly targeted species. The WG concluded that the other production model described in ISC/13/BILLWG-2/09 produced more stable results relative to changes in the carrying capacity prior.

8.5 Application of a Bayesian Production Model to Assess Pacific Blue Marlin (*Makaira nigricans*) in 2013 presented by Yi-Jay Chang (ISC/13/BILLWG-2/09)

Bayesian surplus production models (BPMs) were developed to assess the Pacific blue marlin population under alternative assumptions about catch-per-unit effort relative abundance indices. Alternative production models were developed and fitted for two treatments of the annual intrinsic growth parameter: a single-*r*, and a time-varying multiple-*r* with a different intrinsic growth rate parameter for each year. Biomass production was modeled with a 3-parameter production model that allowed production to vary from the symmetric Schaefer curve using an estimated shape parameter. Input data included nominal landings of Pacific blue marlin collected from all available sources during 1950–2011. Two alternative catch scenarios were investigated and fit with alternative production models: 1950-2011 and 1971-2011, the latter time period representing the period of the most consistent fishery data. Relative abundance indices for blue marlin consisted of standardized catch-per-unit effort for Japanese, Chinese-Taipei, and USA longline fisheries. Annual coefficients of variation for CPUE were used to weight the annual observation error within each time series of relative abundance indices. Thus, the model fits to CPUE included heterogeneous annual observation errors.

A total of 40 model hypotheses were developed and fit to the alternative catch and CPUE data. Uninformative lognormal prior distributions for intrinsic growth rate and carrying capacity were assumed with coefficients of variation set at 100%. Goodness-of-fit diagnostics were developed for comparing the fits of alternative model configurations based on the root-mean squared error of CPUE fits, the standardized CPUE residuals, and the Deviance Information Criterion. Model selection results indicated that two models provided the most credible and best fits under the 1950-2011 catch scenario; these were the single-*r* and multiple-*r* models under the 1950-2011 catch scenario using the standardized Japanese CPUE estimates from 1975-1993 and 1994-2011 and the standardized Chinese Taipei CPUE estimates from 1979-1999 and 2000-2011.

Model averaging was applied to summarize the results of the two credible models. Biomass estimates were not influenced by different prior mean values for the initial proportion of carrying capacity, P[1]. The biomass status of blue marlin in 2011 was above the biomass (BMSY) needed to produce maximum sustainable yield (MSY) based on the model averaged values, but the unconditional standard error suggests that it may have been slightly below BMSY. However, the model averaged estimates of harvest rate and the standard errors in 2011 did not exceed an overfishing threshold relative to MSY-based reference points. Overall, the production model results suggest that the blue marlin is likely not overfished relative to MSY-based reference points and did not experience overfishing during 1950-2011 with the possible exception of 2000-2006.

Discussion

The WG noted that setup of the K prior value was based on the levels of historical catch; however, the justification for the exact choice of the prior mean of K=150,000 mt was not clear to the WG. It was explained that the prior mean for K was moderately informative and set at a level that was sufficient to produce the observed catch history. In this context, it was explained that the most important feature of the K prior was that it was a lognormal distribution with a coefficient of variation (CV) of 100%. This choice of a CV of 100% for K effectively allowed the MCMC sampling process to substantially alter the mean estimate of K from the prior mean, and as a result, the specific choice of the prior mean was not important.

The WG discussed the resulting parameter estimates of the Gibbs-based model. The WG noted that there was a moderate negative correlation between the *r* and *K* parameter values and that this correlation was somewhat larger in magnitude than that from the SIR-based model. The WG noted that the *r* estimate for the Gibbs-based model was much higher than the *r* value for the SIR-based production model and commented that it was possible to have a high *r* value for blue marlin because of their extremely rapid growth and partial recruitment to the fishery at age 1. The WG requested that four sensitivity analyses be completed for the Gibbs-based model ; these were (1) double the mean value of the *K* prior distribution, (2) halve the mean value of the *K* prior distribution, (3) double the mean value of the *r* prior distribution, and (4) halve the mean value of the *r* prior distribution.

The sensitivity analyses for *r* and *K* were completed and the WG concluded that the changes in the mean values of the priors for *K* and *r* did not appreciably affect the model results. The WG also noted that the 95% C.I. of the *r* and *K* sensitivity runs were similar to those of the original model.

The WG suggested that there may be a sampling issue for the SIR-based production model regarding the value of the variance of the process error. Based on the goodness-of-fit of CPUE data and the time-trend of in the residuals pattern, the Gibbs sampling-based production model provided results. Although the negative correlation between the *r* and *K* parameters in the Gibbs sampling-based production model was a source of concern, it was also pointed out that this type of correlation was to be expected based on the parameterization of production models using *r* and *K* (e.g., Hilborn and Walters 1992).

The WG asked for a comparison in the abundance trend for the early period (1952-1970) from the SS and the hybrid production model (described below). The WG agreed that there was an apparent difference in the estimated biomasses during the 1950s-1970s from the SS and the hybrid production model, which probably results from differences in the model structures and basic assumptions. The WG considered using the historical catch but noted that this information was uncertain due to species misidentifications.

The WG recommended that a hybrid Bayesian production model be developed using the best information from the two production models (Table 2). The posterior distribution of the SIR-based production model was used to set up the prior distribution of the *K* parameters for the hybrid model, which in turn used the Gibbs sampling-based production model structure. The details of the hybrid single-*r* and multiple-*r* Bayesian production models were as follows: the *r* prior (or hyperprior) had a mean value 0.38 with a CV of 100%, the *K* prior had a mean of 305 thousand mt with a CV of 100%, the 1950-1951 catch data were excluded, the initial proportion of carrying capacity P1 had a prior mean value of 0.9 with a 50% CV, and four relative abundance indices included. The WG noted that there was an apparent convergence issue for the multiple-*r* hybrid production model with a CV of 100% for the *K* prior, but reducing the CV to

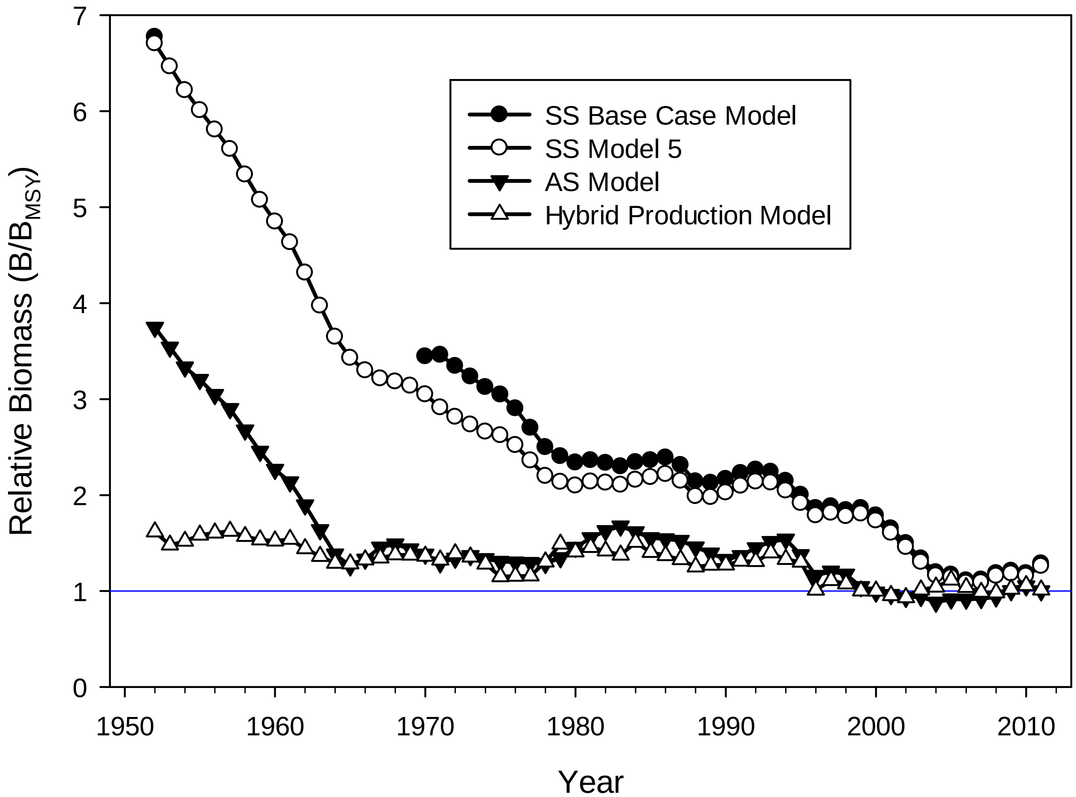
50% eliminated this problem. Based on the DIC, it was suggested that the single-*r* hybrid production model was probably the best available production model for Pacific blue marlin.

The WG observed that the single-*r* hybrid production model provided higher biomass estimates than the original single-*r*, multiple-*r* and model-averaged models. The WG requested additional information for the single-*r* hybrid model. Results indicated that the harvest rate estimates from the single-*r* hybrid production model were slightly lower than those from the Gibbs sampling-based production model, although the values of M, *r*, and *K* were similar. The WG reached consensus that the single-*r* hybrid production model was the best model structure, but noted that trends in relative biomass from the hybrid production model were flatter than those for the base case SS model and the 1952-2011 catch SS models.

Table 2. Comparison of input data and model structure for the alternative production models.

	Blue Marlin Production Models		
Input Data and Model Structure	**Bayesian Surplus Production Model**	**Bayesian Production Model**	**Hybrid Production Model**
Posterior Distribution Sampling Algorithm	Gibbs Sampler	Sampling Importance Resampler	Gibbs Sampler
Catch Data	1950-2011	1950-2011	1952-2011
CPUE Data	Japanese LL CPUE 1975-1993 and 1994-2011, Taiwanese LL CPUE 1979-1999 and 2000-2011	Japanese LL CPUE 1975-1993 and 1994-2011, Hawaii LL CPUE 1994-2011, Taiwanese LL CPUE 1971-1978, 1979-1999, and 2000-2011	Japanese LL CPUE 1975-1993 and 1994-2011, Taiwanese LL CPUE 1979-1999 and 2000-2011
Prior for Initial Proportion of Carrying Capacity P1	P1 is lognormal with mean=0.5 and CV=50%	P1 is lognormal with mean=0.9 and CV=56%	P1 is lognormal with mean=0.9 and CV=50%
Prior for Intrinsic Growth Rate per year (r)	r is Lognormal with mean=0.5 and CV=100%	r is lognormal with mean=0.38 and CV=32.5%	r is Lognormal with mean=0.38 and CV=100(%??)
Prior for Carrying Capacity (K 1000 mt)	K is lognormal with mean=150 and CV=100%	Ln(K) is uniform with Ln(K) ~ U[50,2000]	K is lognormal with mean=305 and CV=100%
Prior for Shape Parameter (M)	M is gamma with mean=1 and CV=71%	Fixed Assumption of Shape with Bmsy/B0=0.5	M is gamma with mean=1 and CV=71%
Observation and Process Error Distributions	Gibbs Sampler Fit to Observation and Process Error with Annual Observation Error CV Proportional to Input CV	Sampling Importance Resampler Iterative Fit for Process Error	Gibbs Sampler Fit to Observation and Process Error with Annual Observation Error CV Proportional to Input CV

Figure 4. Comparison of estimates of relative biomass (B/B_{MSY}) trends of Pacific blue marlin from the Stock Synthesis (SS) Base Case Model, the SS Model 5 using1952-2011 catch, the Age-Structured Model, and the Hybrid Single-*r* Production Model.



8.6 Model selection uncertainty and multi-model inference in generalized fishery production modeling: a simulation study of the Pacific blue marlin stock presented by Yi-Jay Chang (ISC/13/BILLWG-2/10) add age-structure relative biomass.

Despite the prevalence of age-structured population models, production models are one of the simplest methods available that provide for a full fish stock assessment. Recent developments in Bayesian stock assessment and modern computers for parameter estimation have brought about a revival of production models, such as the Bayesian hierarchically structured model to address the temporal variation in population growth rates. The most common practice in fish population modeling is to select *a priori* a single model (or base-case model), and fit it to the data. Inference and estimation of parameters and their precision are based solely on that fitted model. Multi-model inference (MMI) based on information theory is a relatively new paradigm in stock assessment and provides a more robust alternative to account for the model selection uncertainty. To test the efficiency of the MMI approach and the uncertainty from model selection, a simulation study was done based on four Bayesian production models for the Pacific blue marlin stock. The results suggested that there may be a high level of model selection uncertainty and it was recommended that this be considered in future model selection work for billfish stock assessments.

Discussion:

The WG noted that the sequence of simulated DIC values may not be convergent after only a few MCMC iterations and that it the inference about selection uncertainty may depend on the number of MCMC iterations. The WG also noted that there may be a biased trend in the parameter estimates of the estimation model based on the algorithm for simulating the CPUE data, which did not appear to incorporate a correction factor for the expected value of multiplicative lognormal zero mean process error. A detailed evaluation of the algorithm for generating the simulated CPUE data was suggested by the WG because the CPUE were critical for fitting the simulated biomass trends. Although the WG appreciated the methodology of this evaluation study, the conclusions were considered to be preliminary and were not directly used in the blue marlin stock assessment.

9.0 ADOPTION OF BASE CASE ASSESSMENT MODEL FOR PACIFIC BLUE MARLIN

After reviewing all requested runs for each model (see section 8), the WG agreed to adopt the SS model 2 as the base case model to be used for stock status and conservation information. The basis for this decision was the relatively higher amount of assessment information used, the goodness of fit, the lower approximation error of the population dynamics model, and the relative similarity of status results across models. This base case model is described in ISC/13/BILLWG-2/04 as model 2. The base case model used catch data from 1971 to 2011, the available life history information (Table 3), CPUE series for fisheries F1, F2, and F10 (Table 4) and applied cubic spline selectivity curves for F1 and F7 (Table 4) and double normal selectivity curves for all of the other fisheries. Size composition data were available from 1971 to 2011. The specific configuration of the base case model is described in detail below.

9.1 Use of life history information

Life history parameters used in the Pacific blue marlin stock assessment (Table 9.1) were based on previously determined values for growth, weight at length, natural mortality, maturity, and stock-recruitment steepness (BILLWG 2013). The variability of recruitment parameter was an assumed value based on iterative fitting of the SS model to CPUE and size composition data sets.

Table 9.1. Use of life history information in the base case Stock Synthesis model.

	Stock Synthesis
Gender specificity	Two gender
Growth	Length-at-age 1 Female: 144.0 cm Male: 144.0 cm Length-at-age 26 Female: 304.2 cm Male: 226.0 cm Von Bertalanffy_k Female: k=0.107 Male: k=0.211
Weight (kg) at length (cm) $W = A \cdot L^B$	Female: *A*=1.844E-05, *B*=2.956 Male: *A*=1.37E-05, *B*=2.975
Natural mortality (y^{-1})	Female: 0.42 at age 0, 0.37 at age 1, 0.32 at age 2, 0.27 at age 3, 0.22 at age 4+ Male: 0.42 at age 0, 0.37 at age 1+
50% maturity	Female: 179.8 cm
Spawner-recruit steepness (h)	h=0.87
Standard deviation of recruitment	σ_R=0.32

9.2. Fishery definitions and selectivity modeling

Fishery configurations and selectivity assumptions were developed from the available fishery-dependent information (Table 9.2). Fisheries were primarily based on the country of the fishing fleet and the fishing gear used. Further information on the fisheries and the rationale for their treatment in the SS base case model are described in ISC/13/BILLWG-2/04.

Table 9.2. Fishery definitions and selectivity modeling for the Stock Synthesis Base Case Model.

Fishery Label	Fishery	Catch (units)	Composition Information (years)	CPUE (number of series used)	Selectivity Shape (est. or assumed)	Mirrored Fleet (time blocks)
F1	Japan Distant- Water and Offshore Longline	1971-1993 (mt)	Length (1971-1993)	1	Cubic spline (est.)	
F2	Japan Distant-Water and Offshore Longline	1994-2011 (mt)	Length (1994-2011)	1	Double normal (est.)	
F3	Japan Coastal Longline	1971-2011 (mt)		0	Mirrored	2
F4	Japan Drift Net	1972-2011 (mt)	Weight (1977-1980, 1982-1986, 1993, 1998)	0	Double normal (est.)	
F5	Japan Bait Fishing	1971-2011 (mt)		0	Mirrored	4
F6	Japan Other	1971-2011 (mt)		0	Mirrored	2
F7	Hawaii Longline	1994-2011 (mt)	Length (1994-2011)	0	Cubic spline (est.)	
F8	USA Longline	1996-2011 (1,000 s)		0	Mirrored	7
F9	Hawaii Other	1987-2011 (mt)		0	Mirrored	7
F10	Taiwan Distant-water Longline	1971-2011 (mt)	Length (2005-2010)	3	Double normal (est.)	
F11	Taiwan Offshore, Coastal Longline, Other	1971-2011 (mt)		0	Mirrored	10
F12	WCPFC & IATTC Longline	1971-2011 (mt)	Length (1992-2011)	0	Double normal (est.)	
F13	French Polynesia Longline	1990-2010 (mt)	Length (1996-2011)	0	Domed (est.)	(2)
F14	IATTC Purse Seine	1993-2010 (1000 s)	Length (1991-2011)	0	Domed (est.)	
F15	WCPFC Purse Seine	1971-2011 (mt)		0	Mirrored	14
F16	IATTC Other	2006-2011 (mt)		0	Mirrored	14

.

9.3. Pacific blue marlin catch biomass

The total catch biomass data for Pacific blue marlin were gathered from all available sources and were summarized by country (Figure 9.3a) and by fishing gear (Figure 9.3b). The catch data showed a decreasing trend in catches by Japanese fleets and an increasing trend in catches by Taiwanese, WCPFC, and IATTC member countries (Figure 9.3a). Longline gear accounted for the vast majority of blue marlin catch (Figure 9.3b).

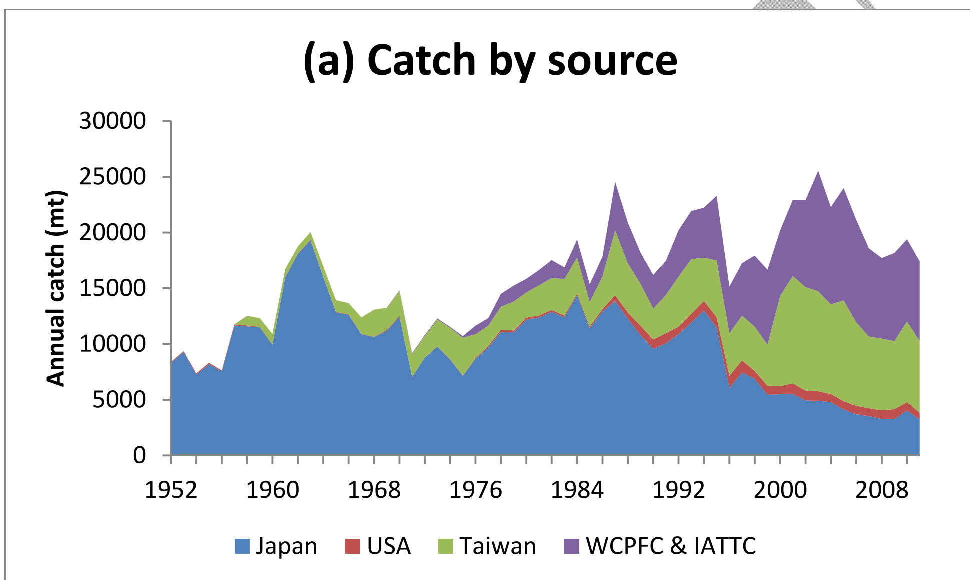


Figure 9.3a. Blue marlin catch (mt) by country from 1952-2011 used in the base case Stock Synthesis model.

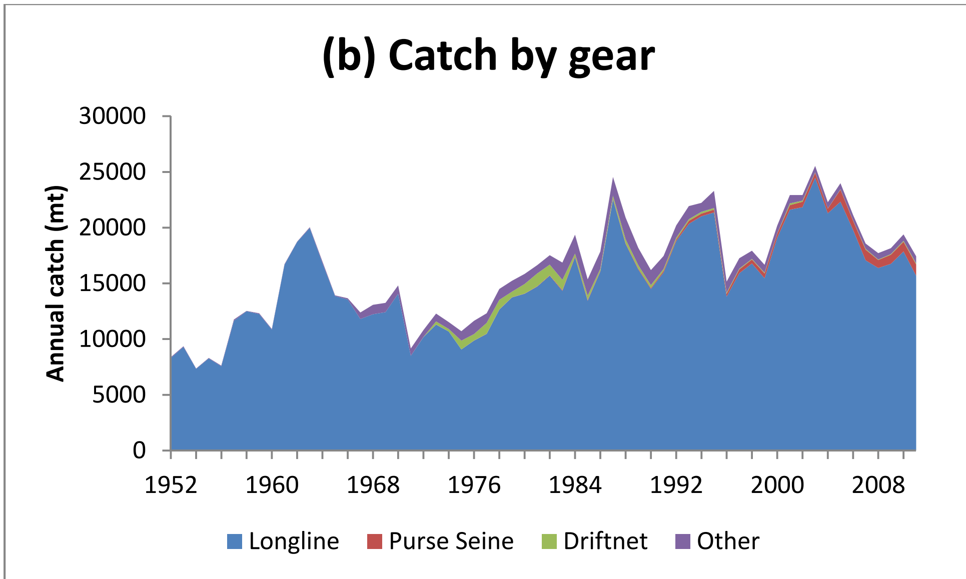


Figure 9.3b. Blue marlin catch (mt) by gear from 1952-2009 used in the base case Stock Synthesis model.

9.4. Model fits to standardized CPUE time series.

The fits of the base case model to standardized relative abundance indices by fishery (Table 9.2) were reviewed and evaluated by the WG (Table 9.4 and Figure 9.4). Here it should be noted that the Hawaii longline CPUE was not included in the likelihood function for fitting the most likely parameter estimates but that the relative fit to the Hawaii CPUE was output for comparison.

Table 9.4. Summary of Stock Synthesis base case model fits to CPUE data by fishery, including the number of CPUE data points (N), the input coefficient of variation (CV), the variance adjustment factor(VAF), the input CV plus the variance adjustment factor, and the root-mean-square error (RMSE).

Fishery	N	CV	VAF	CV+VAF	RMSE
F1	19	0.03	0.11	0.14	0.14
F2	18	0.02	0.12	0.14	0.16
F7	17	0.07	0.07	0.14	*(0.48)*
F10[1]	8	0.64	0	0.64	0.09
F10[2]	21	0.45	0	0.45	0.21
F10[3]	12	0.14	0	0.14	0.17

[1] 1967-1978, [2] 1979-1999, [3] 2000-2011.

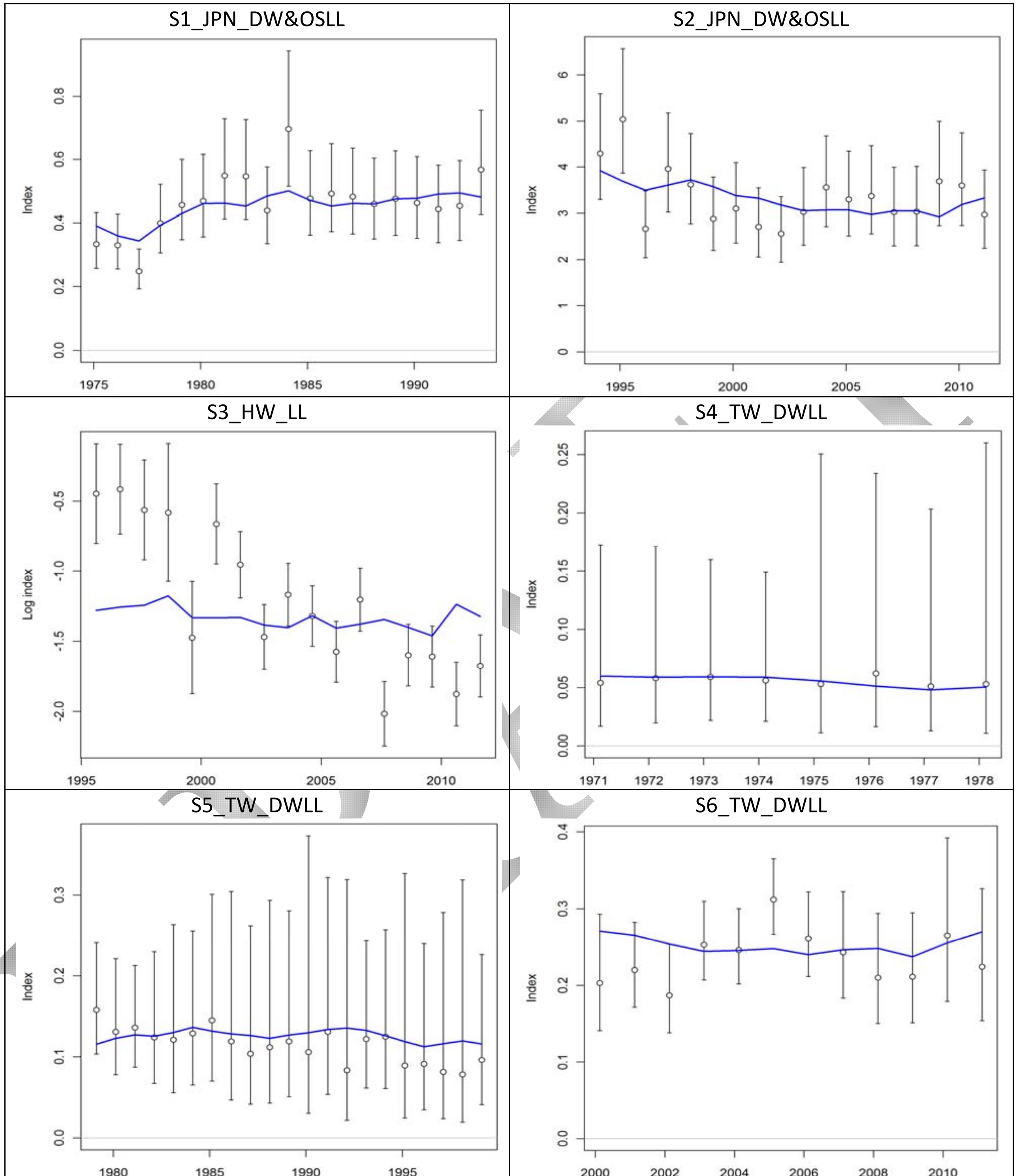


Figure 9.4. Stock Synthesis base case model fits (solid line) to standardized CPUE (open circle with $\pm\sigma$) for the Japanese distant-water and offshore longline fisheries 1971-1993 (S1_JPN_DW&OSLL) and 1994-2011 (S2_JPN_DW&OSLL), the Hawaii longline fishery (S3_HW_LL), and the Taiwanese distant-water longline fisheries 1967-1978 (S4_TW_DWLL), 1979-1999 (S5_TW_DWLL), and 2000-2011 (S6_TW_DWLL).

9.5. Model fits to size composition data.

The fits of the base case model to the blue marlin size composition data were reviewed and evaluated by the WG (Table 9.5 and Figure 9.5). Input effective samples sizes in terms of numbers of fish lengths sampled increased by a factor of three or more in the iterative model fitting process.

Table 9.5. Summary of Stock Synthesis base case model fits to size composition data by fishery, including the number of year-quarter samples of length frequency data (N_L), the assumed input effective sample size (I_E) in units of numbers of fish, and the estimated effective sample size (O_E).

Fishery	NL	I_E	O_E
F1	92	30.0	249.6
F2	72	30.0	122.4
F4	19	30.0	121.7
F7	59	14.5	61.4
F10	23	30.0	408.6
F12	70	26.5	85.1
F13	40	6.95	19.38
F14	82	30.00	209.53

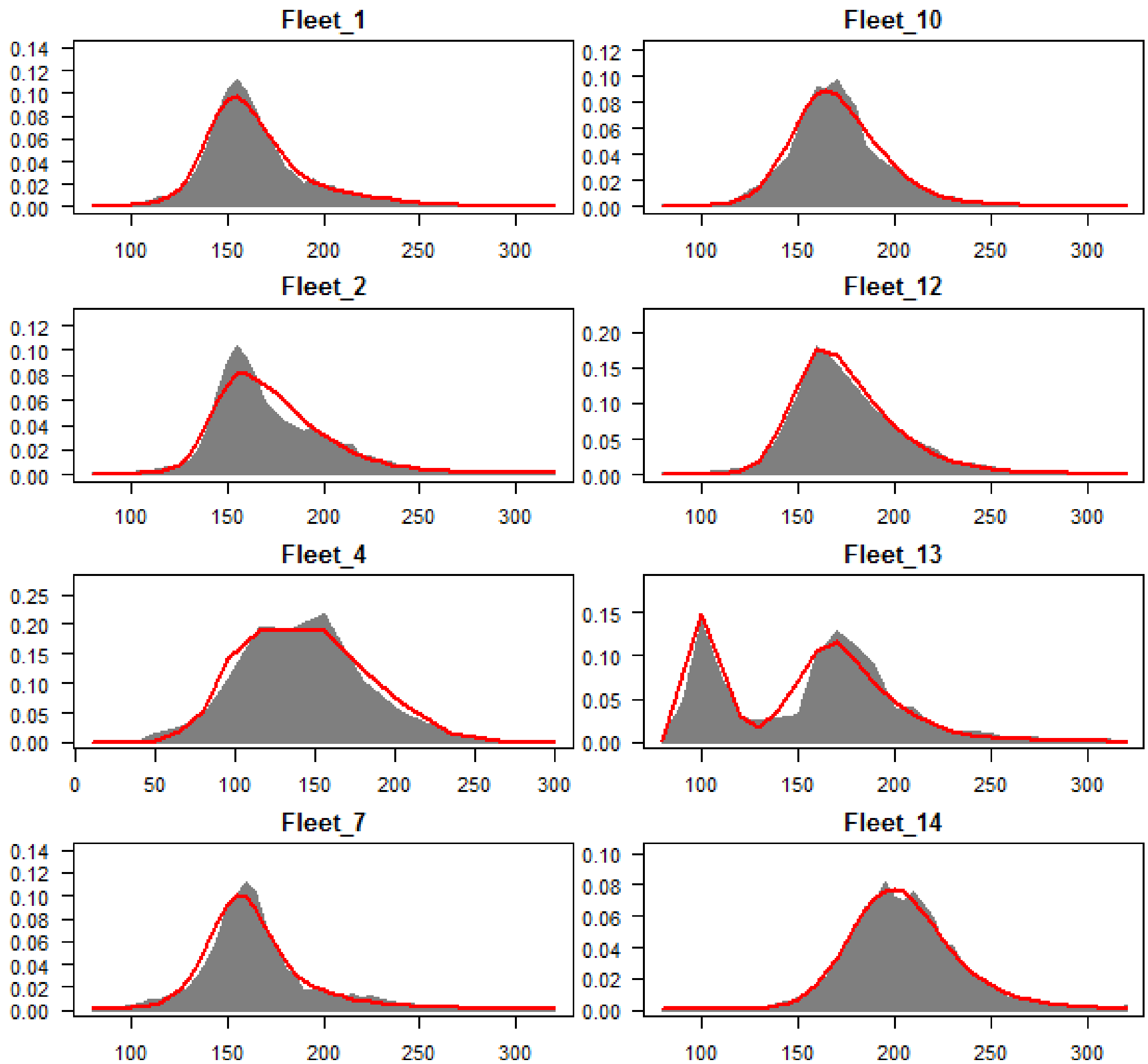


Figure 9.5. Stock Synthesis base case model fits (solid line) to aggregated blue marlin size composition data (shaded area) for the Japanese distant-water and offshore longline fisheries 1971-1993 (Fleet_1) and 1994-2011 (Fleet_2), the Japanese driftnet fishery (Fleet_4), the Hawaii longline fishery (Fleet_7), and the Taiwanese distant-water longline fishery 1967-2011 (Fleet_10), the WCPFC and IATTC longline fisheries (Fleet_12), the French Polynesia longline fishery (Fleet_13), and the IATTC purse seine fishery (Fleet_14).

9.6 Model runs and diagnostics

Model diagnostics for the base case model included a randomization of the initial parameter values based on sampling from a uniform distribution centered at the input parameter values of with upper and lower bounds of +/- 10% and a randomization of the order of phases used in the optimization of likelihood components (Figure 9.6.a). Results indicated that there was convergence to the maximum likelihood estimate of the natural logarithm of unfished recruitment (ln(R0)) (boldface diamond) in most cases for the random initial parameter values and that there was limited change in the maximum likelihood estimate natural logarithm of unfished recruitment (ln(R0)).

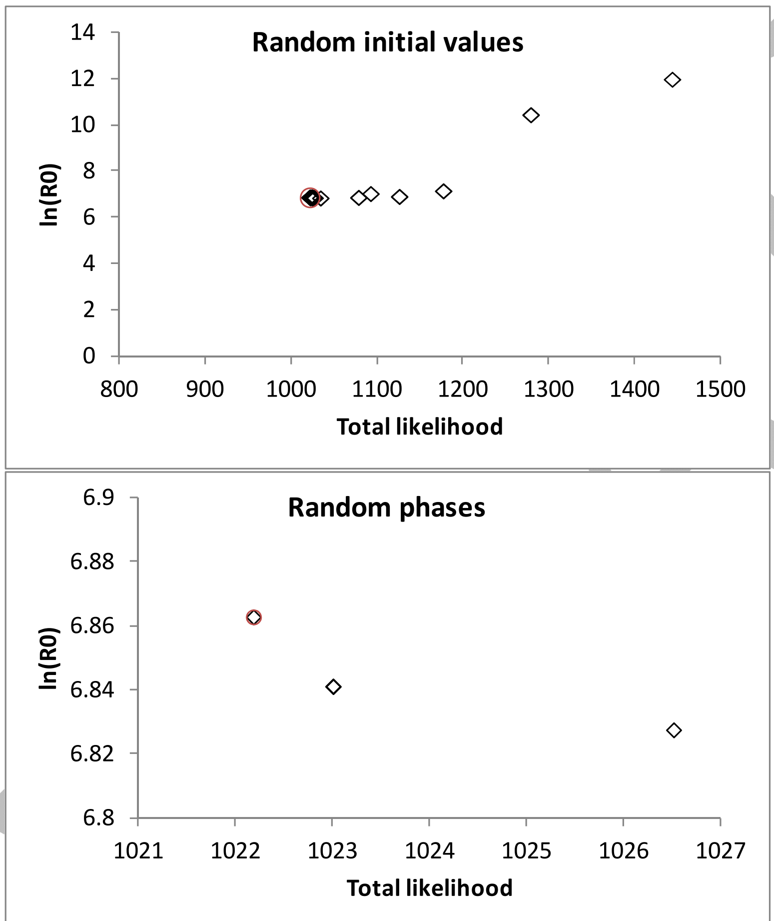


Figure 9.6.a. Results of randomization of initial parameter values and optimization phase analyses for the base case model.

Retrospective analyses for the base case model indicated that there was a moderate retrospective pattern of overestimating spawning biomass and underestimating fishing intensity in recent years (Figure 9.6b).

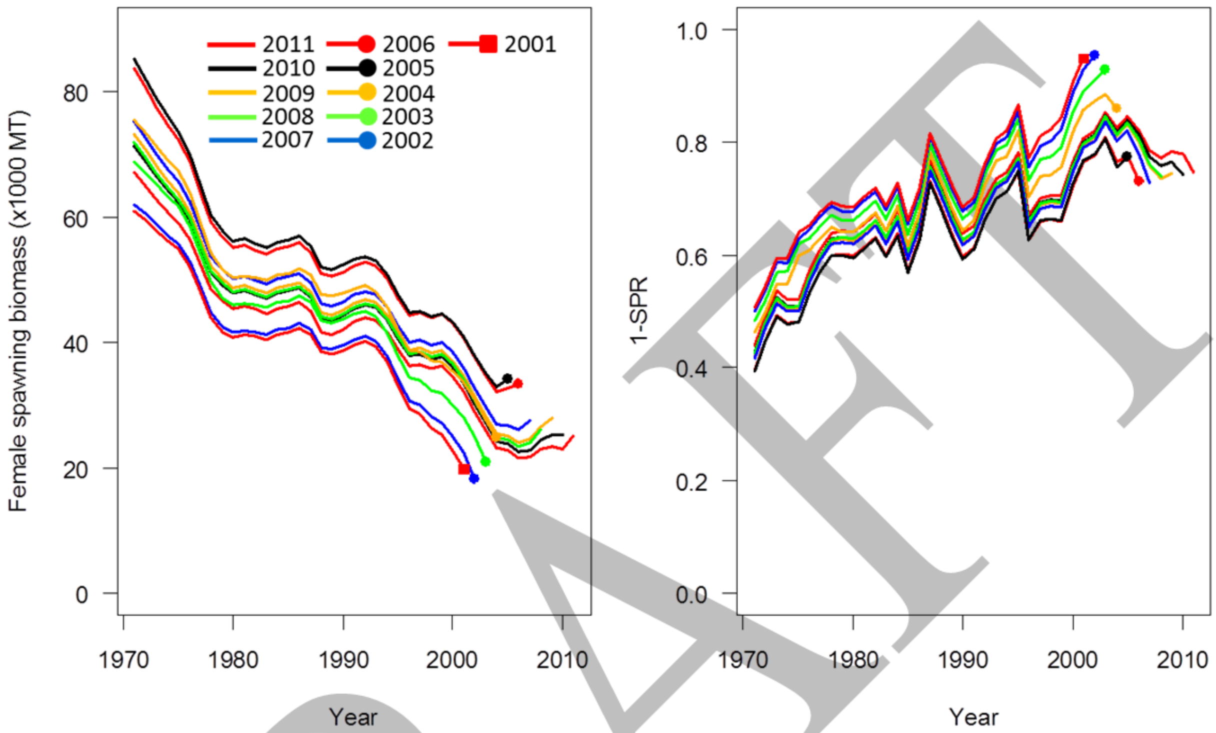


Figure 9.6.b. Retrospective analyses of spawning biomass and fishing intensity (1-SPR) for the Stock Synthesis base case model.

9.7 Model results

Results for the base case model (Table 9.7 and Figure 9.7) were reviewed by the WG and included estimates of total stock biomass (Age 1+ Biomass, mt), female spawning biomass (Female spawning stock biomass, mt), recruitment (Recruitment, thousands), a measure of fishing intensity calculated as 1 minus the spawning potential ratio of the stock (1-SPR), the relative spawning biomass calculated as female spawning biomass divided by the female spawning biomass to produce MSY (SSB Bratio), and the recruitment deviation from the stock recruitment curve (Recruitment dev**).** Overall, the base case model results indicated that there was a decreasing trend in stock abundance and an increasing trend in fishing intensity through time.

Table 9.7. Time series of estimates of abundance, recruitment, fishing mortality and intensity for the base case Stock Synthesis model.

Year	Total Stock Biomass (Age 1+)	Female Spawning Stock Biomass (mt)	Relative Female Spawning Stock Biomass	Recruitment (thousands Age-0)	Fishing Mortality (Average Age 2+)	Relative Fishing Mortality	Expected SPR	Relative SPR	Measure of Fishing Intensity (1-SPR)	Relative Measure of Fishing Intensity (1-SPR)
1971	149878	67223.9	3.46	847.390	0.089	0.28	0.560	3.12	0.440	0.54
1972	140310	64970.3	3.34	806.416	0.104	0.32	0.508	2.83	0.492	0.60
1973	132297	62840.3	3.23	798.282	0.120	0.37	0.464	2.58	0.536	0.65
1974	135401	60704.7	3.12	507.999	0.115	0.36	0.480	2.67	0.520	0.63
1975	136086	59190.7	3.05	595.626	0.114	0.35	0.479	2.67	0.521	0.64
1976	125789	56388.6	2.90	625.332	0.132	0.41	0.429	2.39	0.571	0.70
1977	119212	52452.3	2.70	1020.970	0.146	0.45	0.391	2.18	0.609	0.74
1978	113663	48516.4	2.50	912.000	0.161	0.50	0.361	2.01	0.639	0.78
1979	112529	46697.3	2.40	1063.160	0.168	0.52	0.358	1.99	0.642	0.78
1980	113772	45429.6	2.34	861.210	0.166	0.52	0.360	2.01	0.640	0.78
1981	110886	45870.6	2.36	912.491	0.175	0.54	0.346	1.93	0.654	0.80
1982	107110	45342.1	2.33	1163.020	0.186	0.58	0.328	1.83	0.672	0.82
1983	113535	44657.1	2.30	1000.810	0.168	0.52	0.358	1.99	0.642	0.78
1984	105483	45491.1	2.34	860.052	0.194	0.60	0.321	1.79	0.679	0.83
1985	118707	45907.3	2.36	841.972	0.156	0.49	0.385	2.14	0.615	0.75
1986	106830	46419.3	2.39	1055.990	0.188	0.58	0.329	1.83	0.671	0.82
1987	87447.4	44906.3	2.31	1055.660	0.259	0.80	0.233	1.30	0.767	0.93
1988	96681.8	41604.9	2.14	1050.180	0.224	0.70	0.272	1.51	0.728	0.89
1989	106414	41289.3	2.12	949.333	0.190	0.59	0.323	1.80	0.677	0.83
1990	114542	42069	2.16	1022.740	0.167	0.52	0.363	2.02	0.637	0.78
1991	111442	43297.2	2.23	987.131	0.176	0.55	0.349	1.94	0.651	0.79
1992	102309	43974.2	2.26	950.134	0.203	0.63	0.302	1.68	0.698	0.85
1993	94268.7	43561.4	2.24	907.477	0.228	0.71	0.266	1.48	0.734	0.89
1994	94505.8	41676.9	2.14	810.387	0.234	0.73	0.254	1.42	0.746	0.91
1995	86614	38886.2	2.00	888.768	0.264	0.82	0.220	1.22	0.780	0.95
1996	109382	36193.8	1.86	845.178	0.176	0.54	0.330	1.84	0.670	0.82
1997	103015	36573.6	1.88	994.737	0.198	0.61	0.299	1.66	0.701	0.85
1998	103139	35785.9	1.84	579.929	0.201	0.62	0.294	1.64	0.706	0.86
1999	102511	36200.8	1.86	830.634	0.196	0.61	0.296	1.65	0.704	0.86
2000	89689.5	34689.8	1.78	890.594	0.256	0.79	0.235	1.31	0.765	0.93
2001	80701.8	32093.3	1.65	809.599	0.301	0.93	0.194	1.08	0.806	0.98
2002	78541.5	29092.3	1.50	874.902	0.321	1.00	0.181	1.01	0.819	1.00
2003	71181.9	25971.8	1.34	1026.160	0.382	1.18	0.148	0.82	0.852	1.04
2004	78097.1	23190.4	1.19	785.033	0.328	1.02	0.176	0.98	0.824	1.00
2005	73271.4	22730.4	1.17	913.928	0.362	1.12	0.155	0.86	0.845	1.03
2006	79011.2	21573.7	1.11	888.591	0.325	1.01	0.180	1.00	0.820	1.00
2007	87434.5	21701	1.12	718.142	0.273	0.85	0.215	1.20	0.785	0.96
2008	89876.1	23002.5	1.18	689.358	0.261	0.81	0.228	1.27	0.772	0.94
2009	87074.9	23486.4	1.21	1177.360	0.279	0.87	0.216	1.20	0.784	0.96
2010	88865.9	22987.6	1.18	705.209	0.271	0.84	0.222	1.24	0.778	0.95
2011	95581.1	24989.8	1.29	824.590	0.232	0.72	0.253	1.41	0.747	0.91

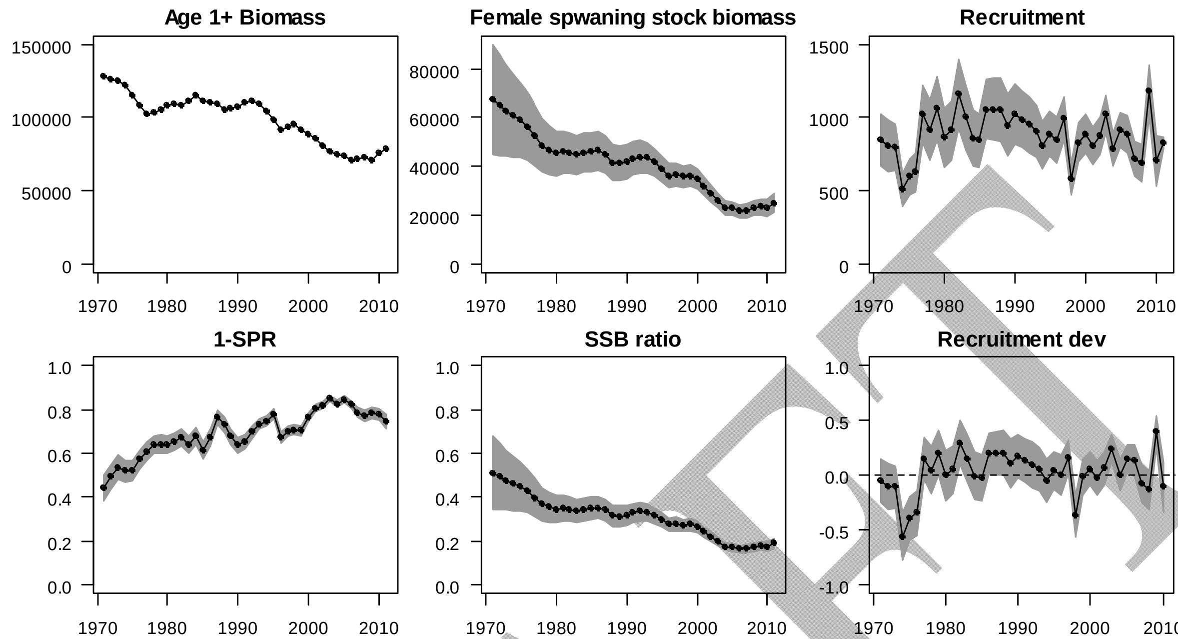


Figure 9.7. Estimation results for the Stock Synthesis base case model (solid circle) with +/- 1 standard deviation shown (shaded area) except for total stock biomass (Age 1+ Biomass).

9.8 Biological reference points

Biological reference points were reviewed by the WG and tabulated and Kobe plots were derived using female spawning biomass and either fishing intensity or fishing mortality (Table 9.8 and Figure 9.8)

Table 9.8. Estimated biological reference points derived from the Stock Synthesis base case model where "MSY" indicates maximum sustainable yield-based reference points, "20%" indicates reference points corresponding to a spawning potential ratio for 20%, F is the instantaneous annual fishing mortality rate, SPR is the annual spawning potential ratio, and SSB is female spawning stock biomass.

Reference point	**Estimate**
$F_{2009\text{-}2011}$ (age 2+)	0.26
$SPR_{2009\text{-}2011}$	0.23
F_{MSY} (age 2+)	0.32
$F_{20\%}$ (age 2+)	0.29
$SPR_{2009\text{-}2011}$	0.23
SPR_{MSY}	0.18
$SSB_{2009\text{-}2011}$	23281 mt
SSB_{MSY}	19436 mt
$SSB_{20\%}$	26323 mt
MSY	19459 mt

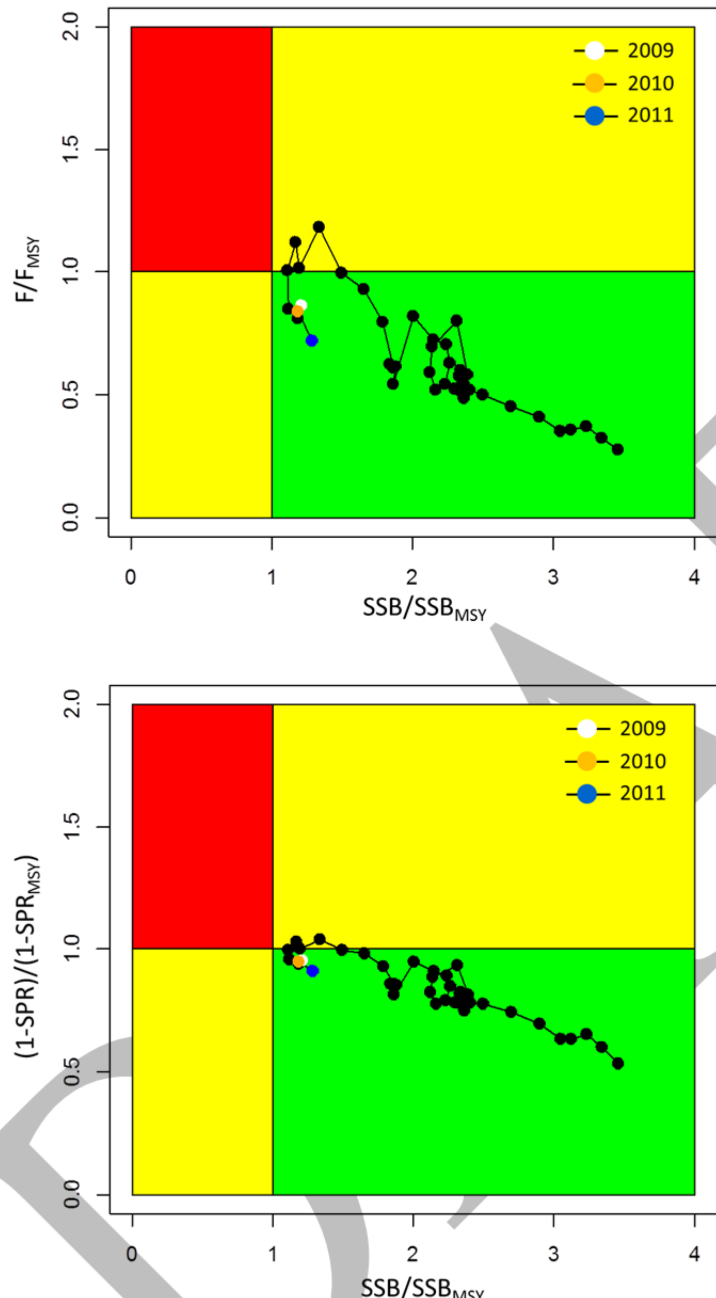


Figure 9.8. Kobe plots showing stock status in relation to MSY-based reference points for the Stock Synthesis base case model.

Based on the reference points and Kobe plots, the WG concluded that the Pacific blue marlin stock is not currently overfished and that the stock is not currently experiencing overfishing.

9.9 Sensitivity Analyses

The WG conducted a number of sensitivity analyses to understand the relative impact of changes in base case model assumptions on model results. In order to simplify the presentation, the WG focused on two key model outputs, spawning biomass and fishing intensity, to judge the relative impacts of changes in model assumptions. The series of sensitivity analyses conducted for the base case model were: (1) sensitivity to the choice of data series (Figure 9.9.1), (2) sensitivity to the natural mortality rate (Figure 9.9.2), (3) sensitivity to the assumed value of stock-recruitment steepness (Figure 9.9.3), (4) sensitivity to growth curve parameters (Figure 9.9.4), and (5) sensitivity to the size at 50% maturity (Figure 9.9.5).

9.9.1 Sensitivity to data series

The sensitivity to data series was evaluated for three alternative data scenarios for the base case model. The first scenario include the Hawaii longline CPUE index. This showed the effects of including a CPUE index with a trend that was inconsistent with the CPUE series used in the base case model. The inclusion of the Hawaii CPUE index produced a declining trend in spawning biomass and an increasing trend in fishing intensity since the early-2000s (Figure 9.9.1). The second and third scenarios evaluated the effects of either excluding the Japanese driftnet size composition data (Model 2_F4_out) or excluding the French Polynesia longline size composition data (Model 2_F13out). Both of these scenarios were investigated because the quality of the size composition data from these sources were considered to be questionable by some WG members. The results showed that the exclusion of the Japanese driftnet or French Polynesia longline size composition data had a negligible effect on estimates of spawning biomass and fishing intensity (Figure 9.9.1).

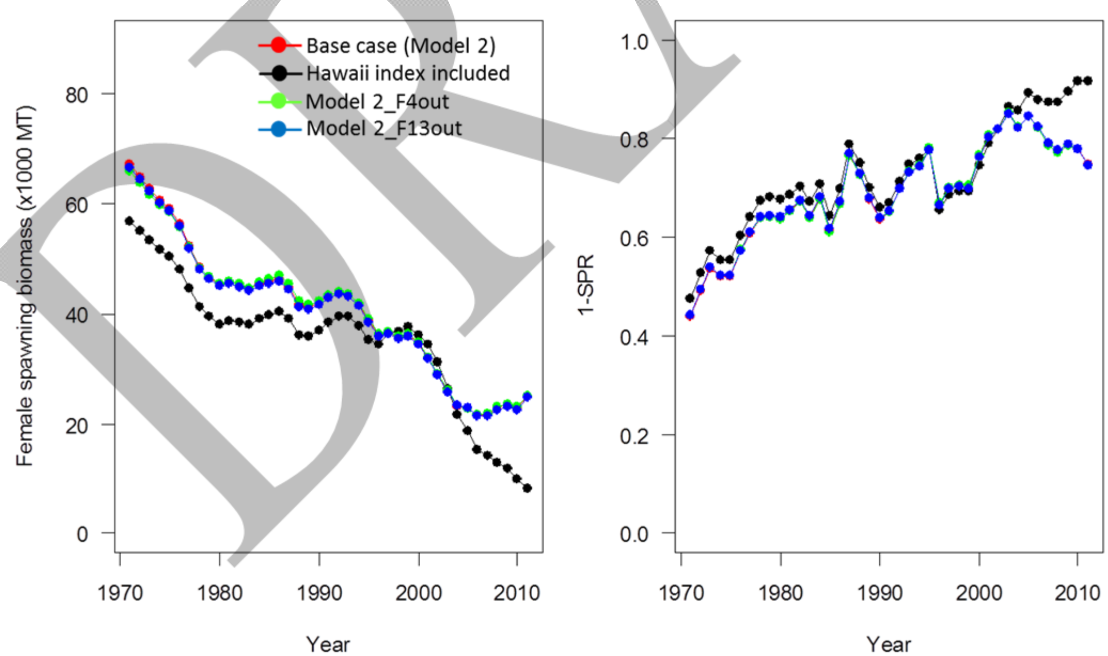


Figure 9.9.1. Sensitivity analysis for the choice of data series for the base case Stock Synthesis model.

9.9.2 Sensitivity to natural mortality rate

The sensitivity to natural mortality rate was evaluated for two alternative natural mortality rate schedules for female and male blue marlin (Figure 9.9.2). The high M scenario increased the natural mortality rates of females and males from the base case model by 10% and the low M scenario decreased the rates by 10%. Results for the high M scenario indicated that there would be a higher level of spawning biomass and a lower level of fishing intensity over the time series. Similarly, the lower M scenario produced a lower level of spawning biomass and a higher level of fishing intensity. Overall, the sensitivity analyses indicated that the base case model results were sensitive to the natural mortality rate.

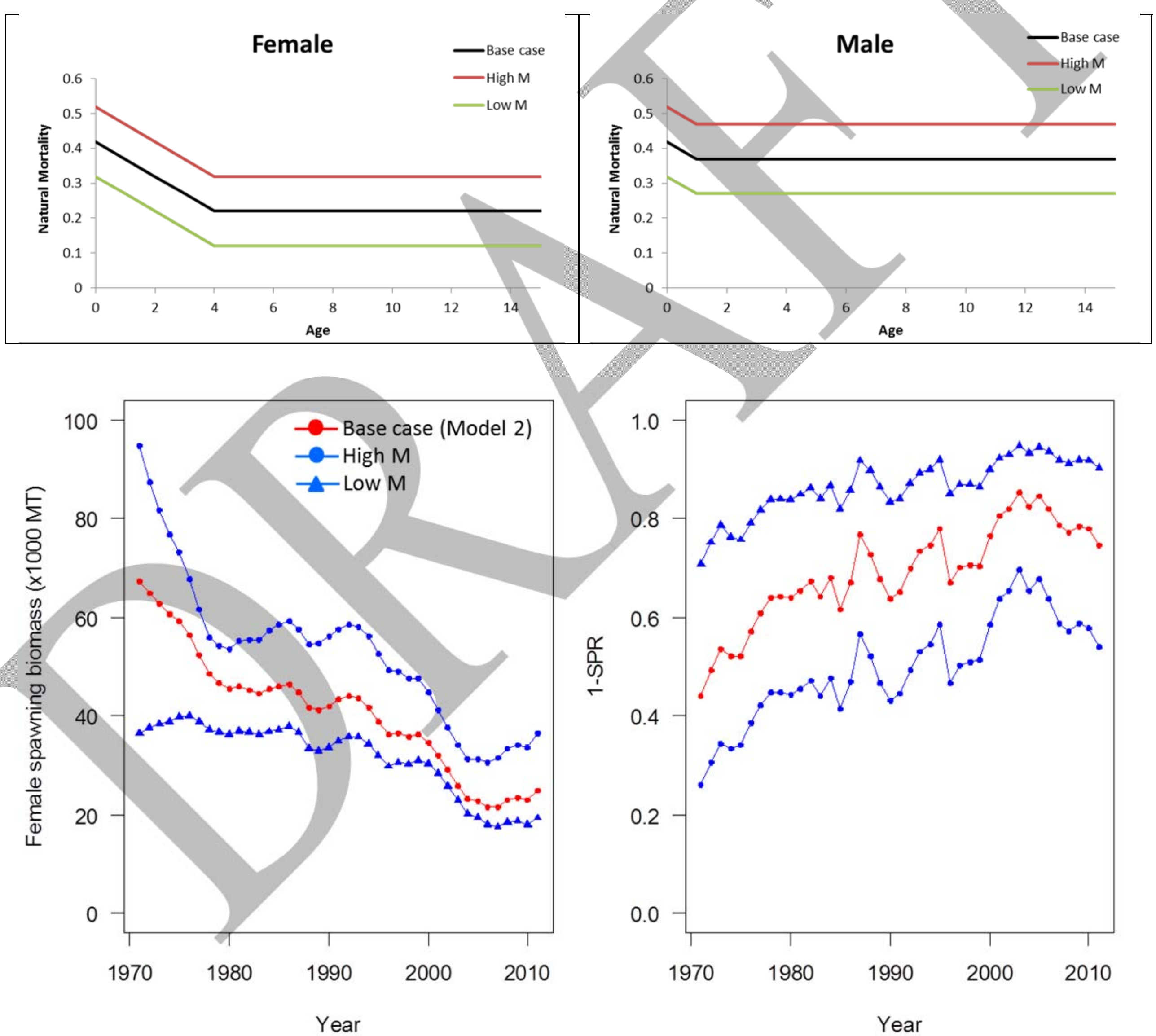


Figure 9.9.2. Mortality (M) sensitivity analysis results for base case Stock Synthesis model.

9.9.3 Sensitivity to stock-recruitment steepness

The sensitivity to stock-recruitment steepness was evaluated in three scenarios, two with lower steepness values (h=0.65 and h=0.75) than the base case (h=0.87) and one with a higher steepness value (h=0.95). Results indicated that lower steepness produced higher estimates of spawning biomass and lower estimates of fishing intensity (Figure 9.9.3). Similarly, a higher steepness produced a lower spawning biomass and higher fishing intensity. Overall, the base case model results showed lower sensitivity to steepness in comparison to natural mortality rate.

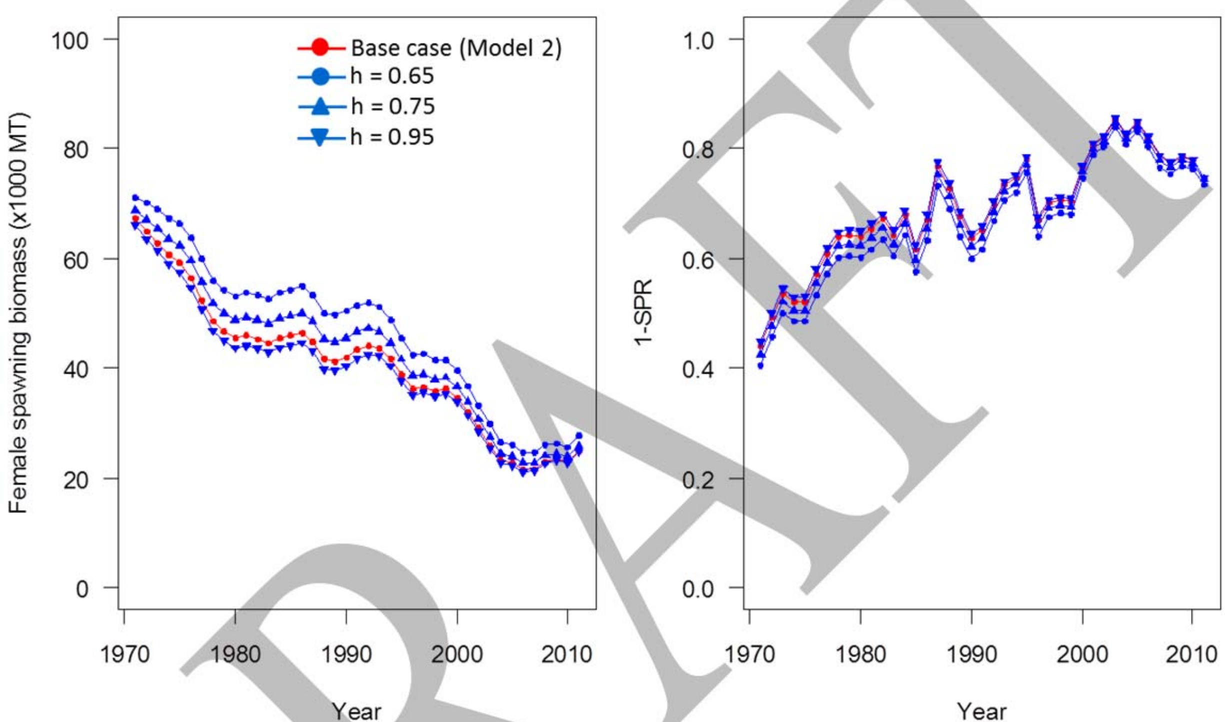


Figure 9.9.3. Results of steepness sensitivity analyses for the base case Stock Synthesis model.

9.9.4 Sensitivity to growth curve parameters

The sensitivity of the base case model to changes in growth curve parameters was evaluated in three scenarios. In the high growth scenario, a 10 % increase in L_{inf} for both females and males and a corresponding 10% decrease in the Brody growth coefficient k was assumed, while in the low growth scenario a 10 % decrease in L_{inf} for both females and males and a corresponding 10% increase in the Brody growth coefficient k was assumed. The third growth scenario assumed that the growth paramaters from Chang et al. (2013) were representative. Results of the sensitivity analysis indicated that spawning biomass was sensitive to the values of L_{inf} and *K* and that the low growth and Chang et al. scenarios would produce higher biomasses and and lower fishing intensities (Figure 9.9.4). Overall, the results indicated that the base case model results were sensitive to the blue marlin growth curve parameters.

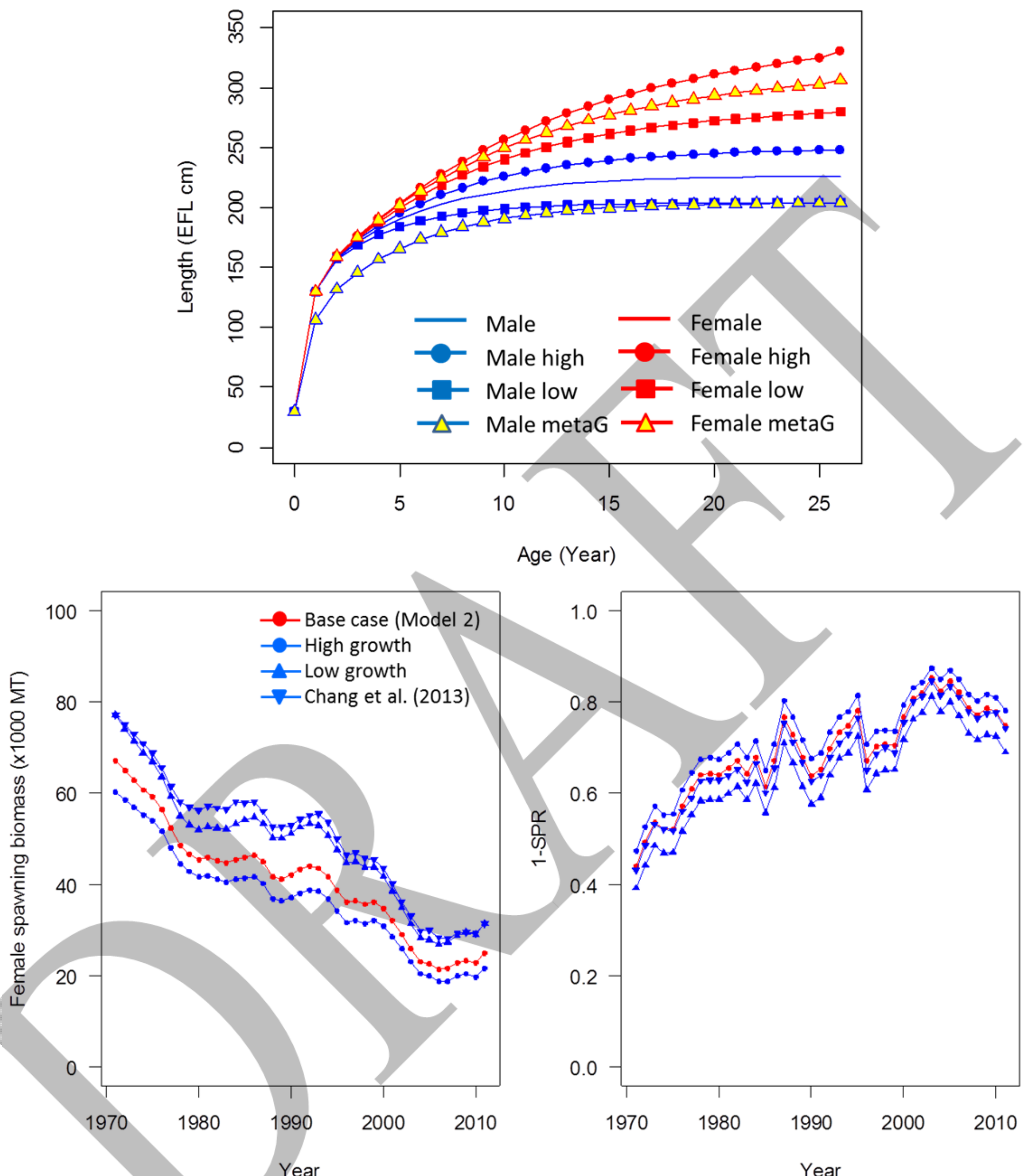


Figure 9.9.4. Results of growth curve sensitivity analysis for base case Stock Synthesis model

9.9.5. Sensitivity to size at 50% maturity

The sensitivity to size at 50% maturity (L50%) was evaluated for two alternative maturity schedules for female blue marlin (Figure 9.9.5). The high L50 scenario increased the size at 50% maturity of females from the base case model by 10% and the low L50 scenario decreased the size at 50% maturity by 10%. Results for the high scenario indicated that a larger size at 50%

maturity reduced spawning biomasses and increased fishing intensities (Figure 9.9.5), while a lower L50% produced higher spawning biomasses and lower fishing intensities. Overall, the results indicated that the base case model results were sensitive to the blue marlin size at 50% maturity.

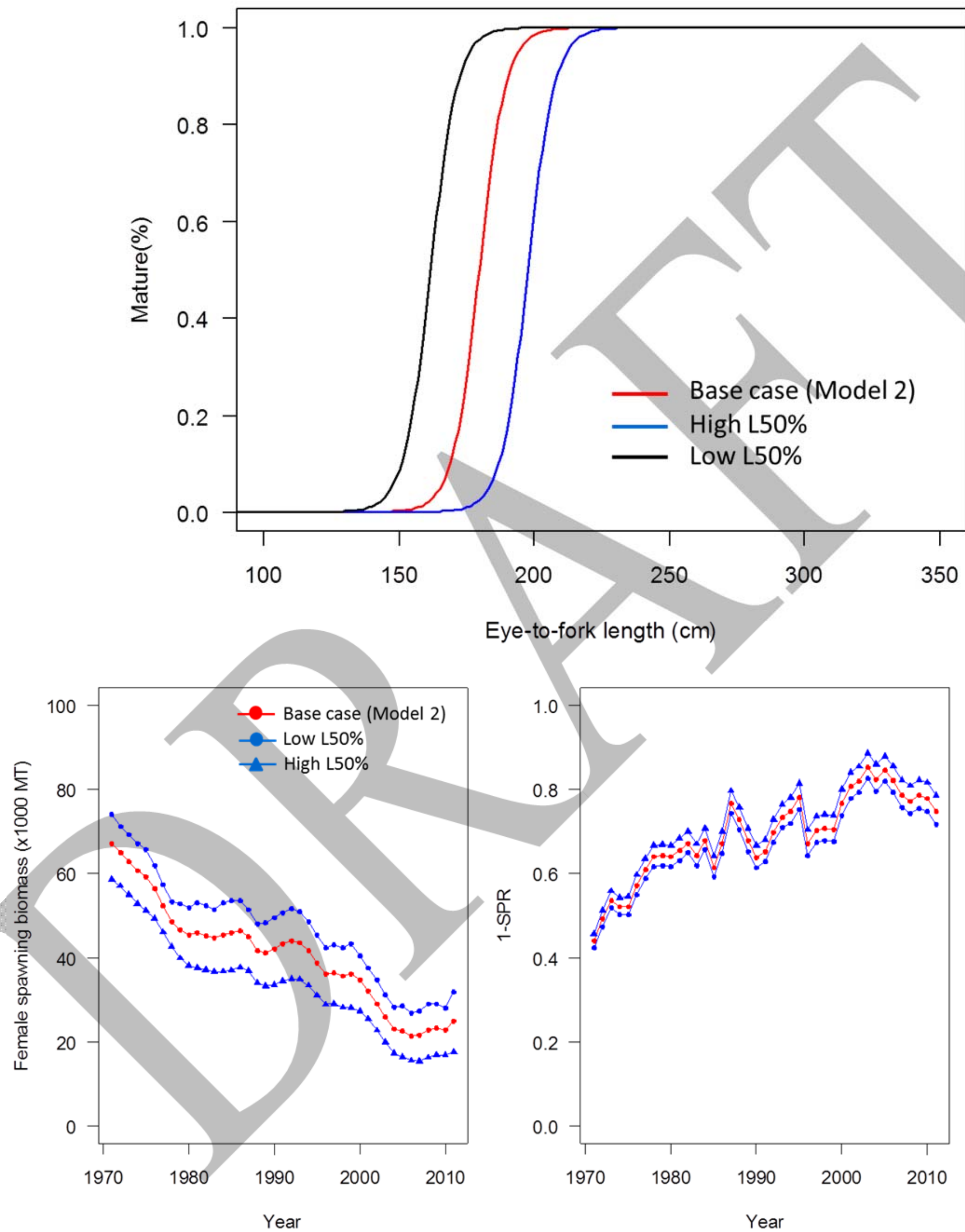


Figure 9.9.5. Results of size at 50% maturity sensitivity analysis for the base case Stock Synthesis model.

9.10 Stock projections

The WG concluded that 3- to 5-year Pacific blue marlin stock projections from the current year (2013) will be completed at a future date and be available for review at the July 2013 Billfish meeting. The WG agreed that these stock projections should characterize the effects of maintaining the current exploitation pattern under future recruitment uncertainty.

10.0NORTH PACIFIC SWORDFISH STOCK ASSESSMENT

10.1 Collaborative partners

Collaboration on the North Pacific swordfish stock assessment was expected to be initiated between ISC Members and Collaborative Partners, except Canada, before the next intercessional meeting of the working group.

10.2Preparation of Assessment Data

Chinese Taipei, Japan, Mexico, and the USA will provide data updates for the next North Pacific swordfish stock assessment. China may also provide updated information.

10.3Assessment of Modeling Approaches

A review of specific points and assumptions need to be considered prior to the next assessment.

Sex-specific size data are not available, but a two-sex model should be considered because it is possible to structure a model in Stock Synthesis with parameters for males and females.

The quality of size-frequency data should be reviewed, including any problems that may arise due to the lack of sex-specific size data. The working group has previously used a production model (in its first swordfish assessment) and developed an age structured model (Stock Synthesis) in its second assessment. The working group noted that a southern boundary at 20°S for a purported northern stock in the eastern Pacific seems unrealistic. The estimation of stock boundaries needs to be reviewed before the end of the next working group meeting. Working group members should provide material related to estimating the swordfish stock areas to the Chairman, and they will be made available to working group members by posting them to the working group website. The Chairman of the ISC stressed that the swordfish stock assessment must be completed by the time of the Plenary meeting in 2014, but this may be a challenge for the WG.

11. OTHER BUSINESS

11.1 Western and Central Pacific swordfish assessment update

The next BILLWG Workshop will focus on updating the western and central swordfish assessment. The meeting will be held in Honolulu (exact location to be determined) from 11-19 February 2014.

11.2 ISC Billfish Working Group Participation

The USA and Chinese Taipei are confirmed participants for the February 2014 BILLWG. Japan noted that their participation may be limited due to scheduling conflicts with the Shark Working Group Workshop. The Chairman emphasized that each country should provide adequate staffing for both the Shark and Billfish Working Groups. The chairman stated that scheduling conflicts with the Shark Working Group should not be an issue.

11.3 International Billfish Symposium

Chi-Lu Sun provided an update on the status of the 5th International Billfish Symposium scheduled for November 4-8, 2013 in Taipei, Taiwan. It was reported that a draft brochure for the symposium has been developed, and it is anticipated that the associated web site will be active by the end of this month. The Symposium is organized jointly by the Institute of Oceanography of the National Taiwan University and the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC). Sponsors and supporters include the National Taiwan University, the National Oceanic and Atmospheric Administration (United States), the National Science Council of Taiwan, the Fisheries Agency (Taiwan), the Bureau of Foreign Trade (Taiwan), the Fisheries Research Institution (Taiwan), and The Billfish Foundation. Additional sponsors are welcome and encouraged. It was pointed out that the ISC endorsed the Billfish Symposium at ISC12, and Members were encouraged to discuss funding opportunities (sponsorship) within their agencies. The BILLFISH WG Chairman reiterated the importance of the symposium and looks forward to a successful symposium.

12.0 ADJOURNMENT

The workshop was adjourned at 3:00 pm on 28 May 2013. The BILLWG Chair expressed his appreciation to the rapporteurs and all participants for their contributions and cooperation in completing a successful meeting.

REFERENCES

Brodziak, J. 2013. Combining information on length-weight relationships for Pacific Blue Marlin (ISC/13/BILLWG-1/01).

Chang, Y., Brodziak, J., Lee, H., DiNardo, G., and Sun, C. 2013. A Bayesian hierarchical meta-analysis of blue marlin (*Makaira nigricans*) growth in the Pacific Ocean (ISC/13/BILLWG-1/02).

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Sun, C, Chang, Y., Yeh, S., and Su, N. 2012. A review of life history parameters for the Pacific Blue Marlin (ISC/12/BILLWG-1/6).

Suzuki, Z. 1989. Catch and fishing effort relationships for striped marlin, blue marlin, and black marlin in the Pacific Ocean, 1952−1985. *in* Planning the Future of Billfishes. Proceedings of the Second International Billfish Symposium, Kailua-Kona, Hawaii, August 1-5, 1988. pp. 165−177. R. Stroud, editor.

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 ANNOUNCEMENT

Meeting Site: National Research Inst. of Far Seas Fisheries
5-7-1 Orido, Shimizu
Shizuoka, Japan 424-8633

Meeting Dates: May 20-28, 2013

Goals: Conduct Pacific blue marlin stock assessment and review swordfish projections requested by the WCPFC Northern Committee.

Attendance Deadline: Please let Lennon Thomas know (email Lennnon.Thomas@noaa.gov) if you will be attending this meeting by **Monday, April 29, 2013.**

Working Paper Deadline: Working papers must be submitted to Lennon Thomas (email Lennon.Thomas@noaa.gov) by **Monday, May 13, 2013.** Authors who submit working papers later than the Monday, May 13, 2013 deadline will be responsible for bringing their own copies on the first day of the meeting.

Local Contact: Kotaro Yokawa
National Research Inst. of Far Seas Fisheries
5-7-1 Orido, Shimizu
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81-54-336-6035, 81-54-335-9642 (fax)
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AGENDA

May 20 (Monday), 930-1030 – Registration

May 20 (Monday), 1030-1700

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

2. Adoption of Agenda and Assignment of Rapporteurs

3. Computing Facilities
   a. Access

   BILLWG Website URL and Access Information:
   URL: http://conference.nmfs.hawaii.edu/
   Username: BILLWG
   Password: Billfish#0213

   b. Security Issue

4. Numbering Working Papers and Distribution Potential

5. Status of Work Assignments

6. Swordfish Catch Projections
   a. Review of Available Swordfish Catch Projections Requested by Northern Committee

7. Pacific Blue Marlin Stock Assessment Data Inputs
   a. Life History Information Sources
   b. Catch
   c. CPUE Time Series
   d. Size Compositions

8. Pacific Blue Marlin Stock Assessment Modeling (if time permits)
   a. Use of Life History Information
   b. Fishery Definitions and Selectivity Modeling
   c. Catch Time Series
   d. Fitting CPUE Time Series

May 21 (Tuesday), 930-1700

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

May 22 (Wednesday), 930-1700

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

May 23 (Thursday), 930-1700

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

May 24 (Friday), 930-1700

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

May 25 (Saturday), 930-1700

8. Assessment Modeling: As Needed
    a. Use of Life History Information

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

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

May 26 (Sunday), No Meeting

May 27 (Monday), 930-1700

9. Adoption of Base Case Assessment Model for Pacific Blue Marlin

10. North Pacific Swordfish Stock Assessment
    a. Collaborative Partners
    b. Preparation of Assessment Data
    c. Assessment Modeling Approaches

11. Other Business
    a. Western and Central Pacific Swordfish Assessment Update
    b. ISC Billfish Working Group Participation
    c. International Billfish Symposium

12. Rapporteurs and Participants Complete Report Sections

13. Complete Workshop Report and Circulate; WG Reviews Report

May 28 (Tuesday), 930-1300

14. Clearing of Report

15. Adjournment

Attachment 3. Working Papers and Presentations

WORKING PAPERS

ISC/13/BILLWG-2/01	Quarterly summaries of Pacific blue marlin size composition data. Jon Brodziak and Eric Fletcher (Jon.Brodziak.noaa.gov)
ISC/13/BILLWG-2/02	A comparison of the consistency of blue marlin (*Makaira nigricans*) length and weight composition data from the Japanese distant water long line fleet. Jon Brodziak (Jon.Brodziak@noaa.gov)
ISC/13/BILLWG-2/03	Vertical and horizontal movements of blue marlin in the northwestern Pacific Ocean determined using pop-up satellite tags. Wei-Chuan Chiang, Chi-Lu Sun, Michael Musyl, Gerard DiNardo, Hsiao-Min Hung, Hsien-Chung Lin, Nan-Jay Su, Su-Zan Yeh2,Wen-Yie Chen, Don-Chung Liu, Chin-Lau Kuo (wcchiang@mail.tfrin.gov.tw)
ISC/13/BILLWG-2/04	Preliminary blue marlin stock assessment in the Pacific Ocean. Hui-Hua Lee, Yi-Jay Chang, Kevin Piner, Michael Hinton, Darryl Tagami, Ian Taylor (Hui-Hua.Lee@noaa.gov)
ISC/13/BILLWG-2/05	Use of likelihood profiling over a global scaling parameter to structure the population dynamics model: an example using blue marlin in the Pacific Ocean. Hui-Hua Lee and Kevin Piner (Hui-Hua.Lee@noaa.gov)
ISC/13/BILLWG-2/06	A sensitivity analysis of alternative natural mortality schedule and steepness in the Pacific blue marlin stock assessment. Mikihiko Kai and KotaroYokawa (kaim@affrc.go.jp)
ISC/13/BILLWG-2/07	Stock assessment of blue marlin (*Makaira nigricans*) in the Pacific Ocean using an age-structured model. Chi-Lu Sun, Nan-Jay Su, Su-Zan Yeh, Wei-Chuan Chiang (chilu@ntu.edu.tw)

ISC/13/BILLWG-2/08	Preliminary analysis of stock status for blue marlin in the Pacific Ocean by Bayesian production model. Minoru Kaniwa, Ai Kimoto, Norio Takahashi, Kotaro Yokawa (m3kanaiw@bioindustry.nodai.ac.jp)
ISC/13/BILLWG-2/09	Application of a Bayesian Production Model to Assess Pacific Blue Marlin (*Makaira nigricans*) in 2013. Jon Brodziak, Joseph O'Malley, Annie Yau, Yi-Jay Chang. (Jon.Brodziak@noaa.gov)
ISC/13/BILLWG-2/10	Model selection uncertainty and multi-model inference in generalized fishery production modeling: a simulation study of the Pacific blue marlin stock. Yi-Jay Chang, Jon Brodziak, Hui-Hua Lee, Gerard DiNardo, Chi-Lu Sun (Yi-Jay.Chang@noaa.gov)

BACKGROUND PAPERS

Brodziak, J. 2013. Combining information on length-weight relationships for Pacific Blue Marlin (ISC/13/BILLWG-1/01).

Chang, Y., Brodziak, J., Lee, H., DiNardo, G., and Sun, C. 2013. A Bayesian hierarchical meta-analysis of blue marlin (*Makaira nigricans*) growth in the Pacific Ocean (ISC/13/BILLWG-1/02).

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Appendix 1. Updated Japanese swordfish and striped marlin catch data.

Table A1.1. Updated Swordfish data from Japan from 2007-2012

Year	Offshore and distant-water logline	Coastal longline	Other longline	Squid drift net	Drift net	Bait fishing	Net fishing	Trap net	Others[1)]	Total
2007	6109	2014	2	–	829	367	1	2	122	9446
2008	4402	1785	2	–	648	349	0	3	173	7363
2009	4400	1536	1	–	682	249	0	3	239	7110
2010	4240	1084	2	–	483	230	0	8	110	6156
2011[2)]	3046	870	2	–	189	233	0	2	10	4352
2012[2)]	3129	614	0	–	300	200	0	0	100	4343

1); It contains trolling and harpoon but majority of catch obtianed by harpoon.
2); Catch between 2011 and 2012 are preliminary, and some data in Tohoku area were not available due to the earthquake in 2011.

Table A1.2. Updated Striped Marlin data for Japan from 2007-2012

	Offshore and distant-water logline	Coastal longline	Other longline	Squid drift net	Drift net	Bait fishing	Net fishing	Trap net	Others[1)]	Total
2007	306	860	5	–	970	38	–	21	20	2220
2008	390	609	10	–	1302	28	–	26	43	2408
2009	166	451	21	–	821	39	–	17	34	1550
2010	187	641	42	–	899	36	–	20	26	1850
2011[2)]	319	698	55	–	333	26	–	30	32	1493
2012[2)]	302	505	0	–	500	0	0	100	0	1407

1); It contains trolling and harpoon but majority of catch obtianed by harpoon.
2); Catch between 2011 and 2012 are preliminary, and some data in Tohoku area were not available due to the earthquake in 2011.

Appendix 2. Pacific blue marlin stock projections.

Objectives of projections

1. Develop a deterministic projection to describe expected trends in future spawning biomass and yield

2. Evaluate the impact of various levels of fishing intensity and management options

Deterministic projection model

- Use Stock Synthesis (SS)

- SS calculates the absolute future recruitment based on the spawner-recruitment relationship and then estimates spawning biomass and yield that would occur if fishing intensity were maintained at this rate.

- These calculations use all the multi-fleet, multi-season, size- and age-selectivity, and complexity in the estimation model, so produces results that are entirely consistent with the assessment result.

Deterministic projection model

- These calculations use all the multi-fleet, multi-season, size- and age-selectivity, and complexity in the estimation model, so produces results that are entirely consistent with the assessment result.

Model Structure	Stock Assessment and projection
Dynamics calculated	Quarterly
Year	Jan-December
Spawning biomass calculated	April
Recruitment	Season 2
Selectivity Patterns (num, basis)	16, length
Age based M changes	January 1st

Annual forward projection

Age / Yr	0	1	2	…	a
2011	$N_{11,0}$	$N_{11,1}$	$N_{11,2}$	$N_{11,\ldots}$	$N_{11,a}$
2012	$N_{12,1}$	$N_{12,1}$	$N_{12,2}$	$N_{12,\ldots}$	$N_{12,a}$
2013	$N_{13,0}$	$N_{13,1}$	$N_{13,2}$	$N_{13,\ldots}$	$N_{13,a}$
…	$N_{\ldots,0}$	$N_{\ldots,1}$	$N_{\ldots,2}$	$N_{\ldots,\ldots}$	$N_{\ldots,a}$
y	$N_{y,0}$	$N_{y,1}$	$N_{y,2}$	$N_{y,\ldots}$	$N_{y,a}$

Z

Future recruitment

States of nature: future recruitment process

- Spawner-Recruit deviation around the Beverton and Holt SR relation (SR):

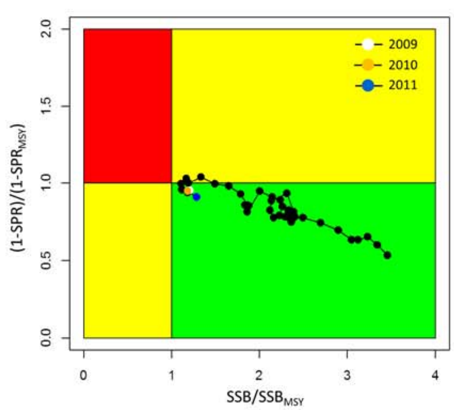
$$R_y = \frac{4hR_0SB_y}{SB_0(1-h)+SB_y(5h-1)}$$

- Internally consistent in the assessment model assuming a particular form of SR model

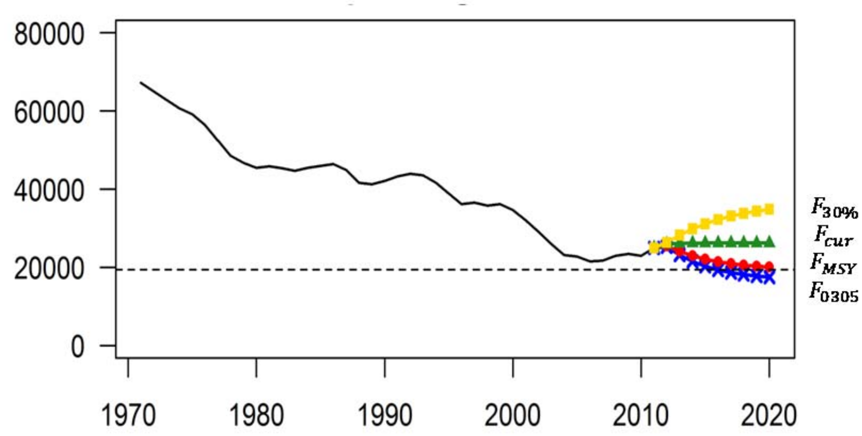
Harvest scenarios

Constant $F_{X\%}$ levels (4 levels) from 2012 to 2020:

- average during 2003-2005: $F_{16\%}$
- F_{MSY}: $F_{18\%}$
- average during 2009-2011 defined as current: $F_{23\%}$
- $F_{30\%}$

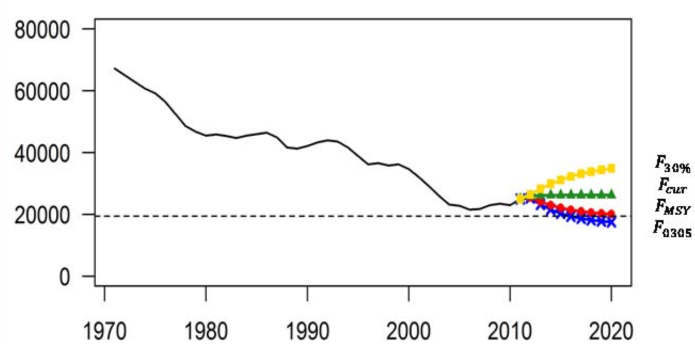


Projected spawning biomass



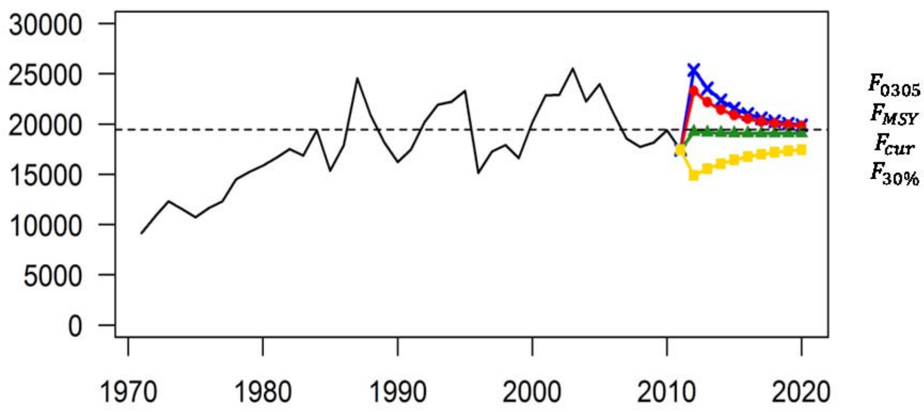
spawning biomass (SSB) at MSY = 19,437 t

Projected spawning biomass



- When current ($F_{2009-2011} = F_{23\%}$) level is maintained, the stock is projected to be stable at roughly 26,200 t by 2020 (above spawning stock biomass at *MSY* level)
- If fishing increases to *MSY* level, the projected *SSB* is estimated to have gradually decreased and by 2020, it is about spawning stock biomass at *MSY* level.
- If fishing further increases to the 2003-2005 level ($F_{16\%}$), the projected *SSB* would be below spawning stock biomass at *MSY* level by 2015.
- If fishing reduces to $F_{30\%}$, the projected *SSB* would gradually increase.

Projected Yield



- Fishing at the current level ($F_{23\%}$) or *MSY* level ($F_{18\%}$) provide an expected safe level of harvest, where the average projected catch between 2012 and 2020 is approximately about MSY.

Appendix 3. Executive summary of the Pacific blue marlin stock assessment.

ISC/13/BILLWG-3/1

Executive Summary: Pacific Blue Marlin Stock Assessment

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Abstract
This working paper describes the Executive Summary for the 2013 assessment of the Pacific blue marlin stock conducted by the Billfish Working Group of the International Scientific Committee on Tuna and Tuna-Like Species in the North Pacific. The Executive Summary summarizes assessment information on stock status, stock projections, and potential conservation advice, as well as providing information on stock identification and distribution, catches, data and assessment, biological reference points, and special comments.

Executive Summary: Pacific Blue Marlin Stock Assessment

Stock Identification and Distribution: The Pacific blue marlin (*Makaira nigricans*) stock area consisted of all waters of the Pacific Ocean and all available fishery data from this area were used for the stock assessment. For the purpose of modeling observations of CPUE and size composition data, it was assumed that there was an instantaneous mixing of fish throughout the stock area on a quarterly basis.

Catches: Pacific blue marlin catches exhibited an increasing trend from the 1950's to the 1980's and then fluctuated without trend. In the 1990's the catch by Japanese fleets (Figure 1) decreased while the catch by Taiwanese, WCPFC, and some IATTC member countries increased (Figure 1). Overall, longline gear has accounted for the vast majority of Pacific blue marlin catches since the 1950's (Figure 2).

Data and Assessment: Catch and size composition data were collected from ISC countries (Japan, Taiwan, and USA), some IATTC member countries, and the WCPFC (Table 1). Standardized catch-per-unit effort data used to measure trends in relative abundance were provided by Japan, USA, and Chinese Taipei. The Pacific blue marlin stock was assessed using an age-, length-, and sex-structured assessment Stock Synthesis 3 (SS) model fit to time series of standardized CPUE and size composition data. Sex-specific growth curves and natural mortality were used because of the known sexual dimorphism of adult blue marlin. The value for steepness was $h = 0.87$. The assessment model was fit to relative abundance indices and size composition data in a likelihood-based statistical framework. Maximum likelihood estimates of model parameters, derived outputs, and their variances were used to characterize stock status and to develop stock projections. The BILLWG also conducted several sensitivity analyses to evaluate the effects of changes in model parameters, including the data series used in the analyses, the natural mortality rate, the stock-recruitment steepness, the growth curve parameters, and the female age at 50% maturity.

Table 1. Reported catch (mt), population biomass (age-1 and older, mt), female spawning biomass (mt), relative female spawning biomass (SSB/SSB_{MSY}), recruitment (thousands of age-0 fish), fishing mortality (average F, ages-2 and older), relative fishing mortality (F/F_{MSY}), and spawning potential ratio of Pacific blue marlin.

Year	2005	2006	2007	2008	2009	2010	2011	Mean[1]	Min[1]	Max[1]
Reported Catch	23,962	21,100	18,554	17,709	18,147	19,388	17,430	17,792	9,160	25,510
Population Biomass	73,812	70,945	72,102	72,453	70,694	76,089	78,663	99,151	70,694	128,228
Spawning Biomass	22,730	21,574	21,701	23,003	23,486	22,988	24,990	40,723	21,574	67,224
Relative Spawning Biomass	1.17	1.11	1.12	1.18	1.21	1.18	1.29	2.10	1.11	3.46
Recruitment (age 0)	914	889	718	689	1177	705	825	879	508	1177
Fishing Mortality	0.36	0.32	0.27	0.26	0.28	0.27	0.23	0.21	0.09	0.38
Relative Fishing Mortality	1.12	1.01	0.85	0.81	0.87	0.84	0.72	0.66	0.28	1.18
Spawning Potential Ratio	15%	18%	21%	23%	22%	22%	25%	31%	15%	56%

[1] During 1971-2011

Status of Stock: Estimates of total stock biomass show a long term decline. Population biomass (age-1 and older) averaged roughly 123,523 mt in 1971-1975, the first 5 years of the assessment time frame, but then declined by approximately 40% to an average of 78,663 mt in 2011 (Figure 3). Female spawning biomass was estimated to be 24,990 mt in 2011. Fishing mortality on the stock (average F, ages 2 and older) averaged roughly F = 0.26 during 2009-2011. The predicted value of the spawning potential ratio (SPR, the predicted spawning output at current F as a fraction of unfished spawning output) is currently $SPR_{2009\text{-}2011}$ = 23%. The annual average in 2007–2011 was about 823×10^3 recruits, and there was no apparent long-term recruitment trend. The overall trends in spawning stock biomass and recruitment indicate a long-term decline in spawning stock biomass and suggest a fluctuating pattern without trend for recruitment (Figure 3). Kobe plots depict the stock status in relation to MSY-based reference points (see below) from the base case SS model (Figure 4). The Kobe plots indicate that the Pacific blue marlin spawning stock biomass decreased to the MSY level in the mid-2000's, and since then has increased slightly. The base case assessment model indicates that the Pacific blue marlin stock is currently not overfished and is not subject to overfishing relative to MSY-based reference points. The population biomass of Pacific blue marlin was also estimated with three alternative stock assessment models (Figure 5). An age-structured, pooled-sexes model (AS) and an age-, length-, and sex-structured SS model were fitted to catch data from 1952 through 2011 and both models indicated that relative biomass declined by about 50% during the first 10 years of the time series. A hybrid production model indicated that relative biomass exhibited a more moderate decline throughout the 60-year period. Results from each of the alternative models were similar at the end of the assessment time series, which demonstrated the robustness of the assessment results. Overall the results of the alternative assessment models were consistent and showed that Pacific blue marlin biomass has declined but that the stock is not overfished and is not experiencing overfishing in recent years.

Projections: Deterministic stock projections were conducted in Stock Synthesis (SS) to evaluate the impact of various levels of fishing intensity on future female spawning stock biomass and yield for blue marlin in the Pacific Ocean. The future recruitment was based on the stock-recruitment curve. These calculations used all the multi-fleet, multi-season, size- and age-selectivity, and complexity in the assessment model to produce consistent results. Projections started in 2012 and continued through 2020 under 4 levels of fishing mortality ($F_{30\%}$ corresponds to the fishing mortality that produces 30% of the spawning potential ratio): (1) constant fishing mortality equal to the 2003-2005 average ($F_{2003-2005} = F_{16\%}$); (2) constant fishing mortality equal to $F_{MSY} = F_{18\%}$; (3) constant fishing mortality equal to the 2009-2011 average defined as current ($F_{23\%}$); and (4) constant fishing mortality equal to $F_{30\%}$. Results showed projected female spawning stock biomass and the catch for each of the four harvest scenarios (Table 2 and Figure 6).

Table 2. Projected values of Pacific blue marlin spawning stock biomass (mt) and catch (mt) under alternative harvest rate scenarios during 2012-2020.

Year	2012	2013	2014	2015	2016	2017	2018	2019	2020
Scenario 1: constant $F = F_{2003-2005}$									
Spawning biomass	25,269	23,193	21,518	20,263	19,354	18,689	18,195	17,823	17,540
Catch	25,374	23,546	22,353	21,548	20,985	20,576	20,272	20,042	19,865
Scenario 2: constant $F = F_{MSY}$									
Spawning biomass	25,490	24,142	22,996	22,106	21,452	20,968	20,605	20,331	20,121
Catch	23,296	22,173	21,412	20,887	20,519	20,252	20,055	19,906	19,793
Year	2012	2013	2014	2015	2016	2017	2018	2019	2020
Scenario 3: constant $F = F_{2009-2011}$									
Spawning biomass	25,924	26,112	26,169	26,177	26,188	26,200	26,212	26,221	26,229
Catch	19,235	19,154	19,106	19,078	19,066	19,061	19,060	19,061	19,062
Scenario 4: constant $F = F_{30\%}$									
Spawning biomass	26,368	28,264	29,845	31,139	32,207	33,078	33,782	34,347	34,799
Catch	14,900	15,542	16,048	16,442	16,749	16,988	17,174	17,318	17,430

Biological Reference Points: Biological reference points were computed with the Stock Synthesis base case model (Table 3). The point estimate of maximum sustainable yield was MSY = 19,459 mt. The point estimate of the spawning biomass to produce MSY (adult female biomass) was SSB_{MSY} = 19,437 mt. The point estimate of F_{MSY}, the fishing mortality rate to produce MSY (average fishing mortality on ages 2 and older) was F_{MSY} = 0.32 and the corresponding equilibrium value of spawning potential ratio at MSY was SPR_{MSY} = 18%. The point estimate of $F_{20\%}$ was 0.29 and the corresponding estimate of $SSB_{20\%}$ was 26,324 mt.

Table 3. Estimated biological reference points derived from the Stock Synthesis base case model where "MSY" indicates maximum sustainable yield-based reference points, "20%" indicates reference points corresponding to a spawning potential ratio of 20%, F is the instantaneous annual fishing mortality rate, SPR is the annual spawning potential ratio, and SSB is female spawning stock biomass.

Reference point	**Estimate**
$F_{2009\text{-}2011}$ (age 2+)	0.26
$SPR_{2009\text{-}2011}$	23%
F_{MSY} (age 2+)	0.32
$F_{20\%}$ (age 2+)	0.29
SPR_{MSY}	18%
SSB_{2011}	24,990 mt
SSB_{MSY}	19,437 mt
$SSB_{20\%}$	26,324 mt
MSY	19,459 mt

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. Stock biomass has declined since the 1970's and has been stable since the mid- 2000's with a slight recent increase. Because blue marlin is mostly caught as bycatch the direct control of catch amount is difficult. The WG recommend that the fishing mortality should not be increased from the current level 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 were important sources of uncertainty.

Figure 1. Pacific blue marlin (*Makaira nigricans*) catches (mt) in the Pacific Ocean by country for Japan, Chinese-Taipei, the U.S.A., as well as other countries.

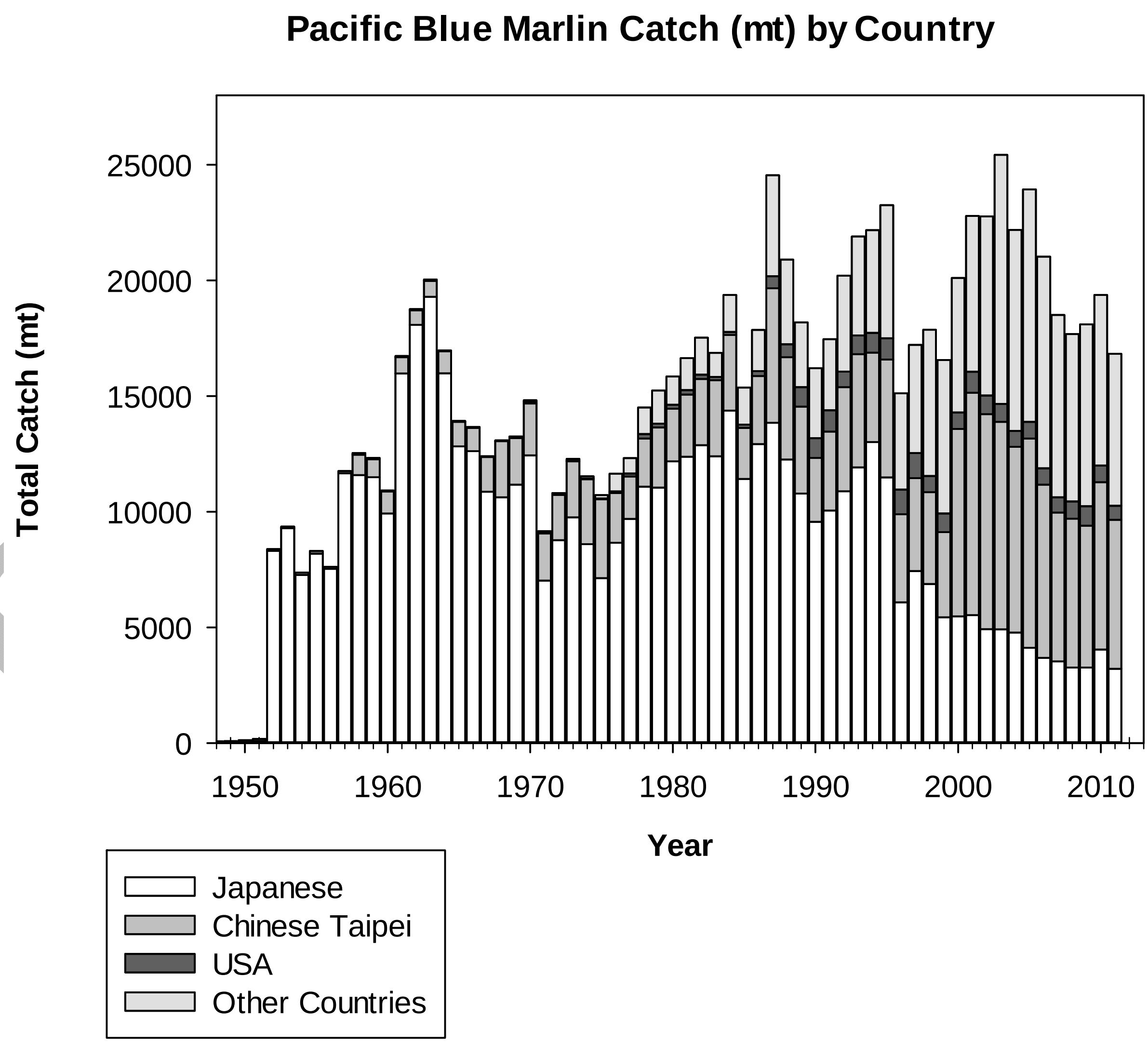


Figure 2. Blue marlin (*Makaira nigricans*) catch data (mt) by fishing gear from 1952-2011 used in the base case Stock Synthesis model.

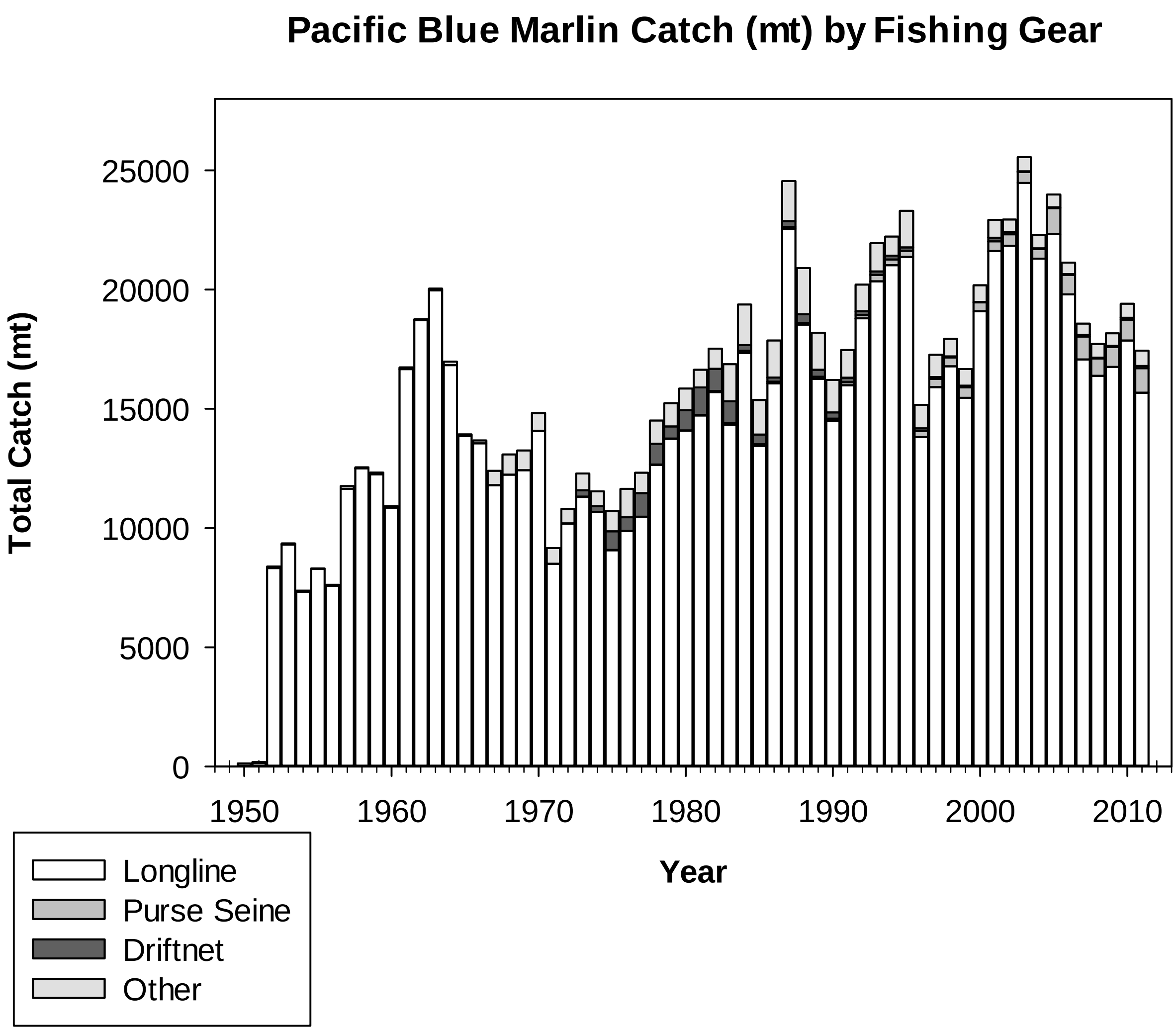


Figure 3. Estimates of female spawning stock biomass (top left panel), recruitment (top right panel), fishing mortality (bottom left panel) and fishing intensity (bottom right panel) from the Stock Synthesis base case model (point estimate, solid circle) with +/- 1.96 standard deviation shown (shaded area).

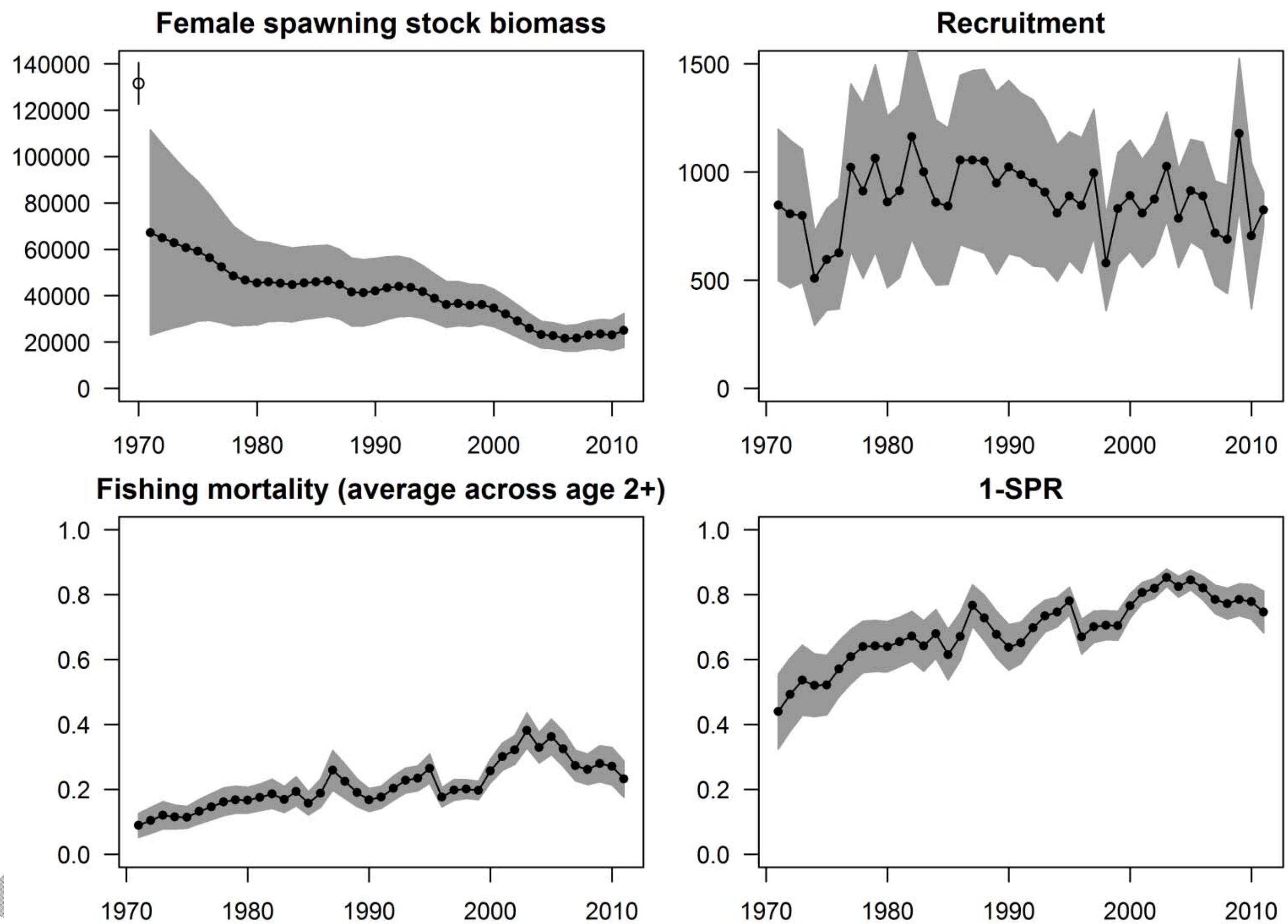
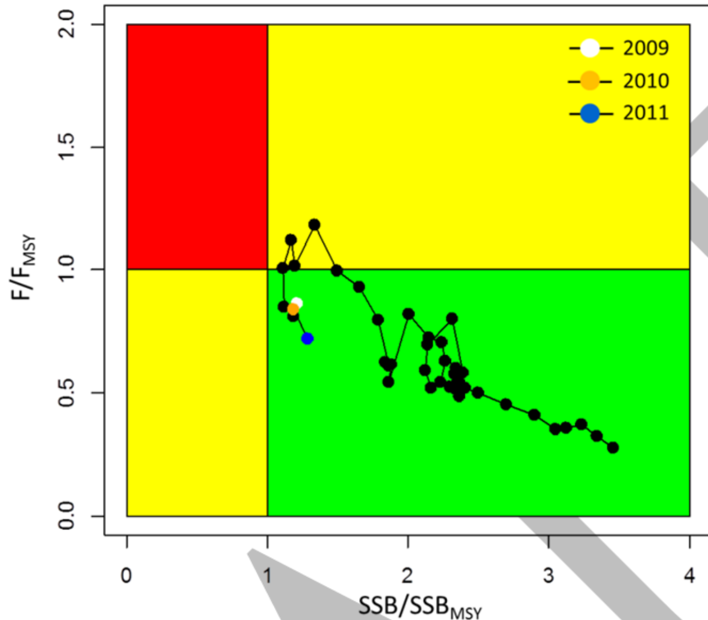


Figure 4. Kobe plots showing Pacific blue marlin stock status in relation to MSY-based reference points for the Stock Synthesis base case model with respect to relative fishing mortality (top panel) and relative SPR-based fishing intensity (bottom panel).



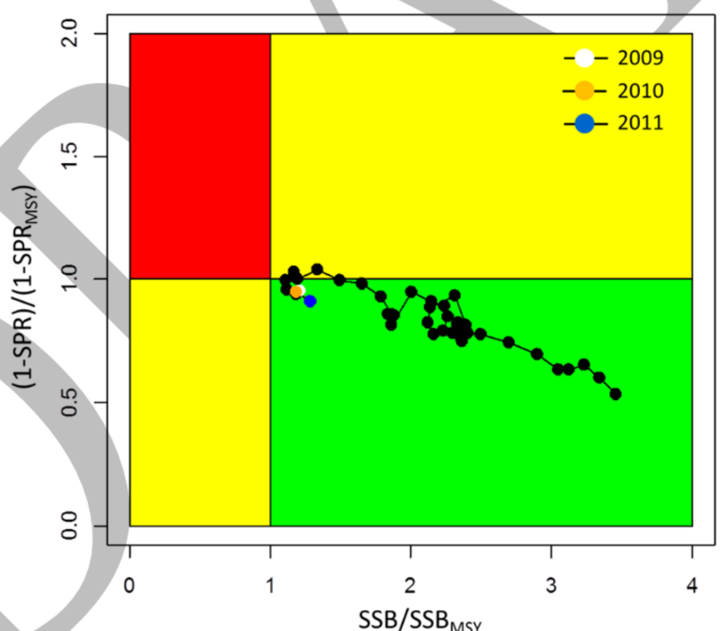


Figure 5. Comparison of estimates of relative spawning stock biomass (SSB/SSB_{MSY}) trends of Pacific blue marlin *Makaira nigricans* from the Stock Synthesis (SS) Base Case Model, the SS Model 5 using 1952-2011 catch data, the Age-Structured (AS) Model, and the Hybrid Production Model.

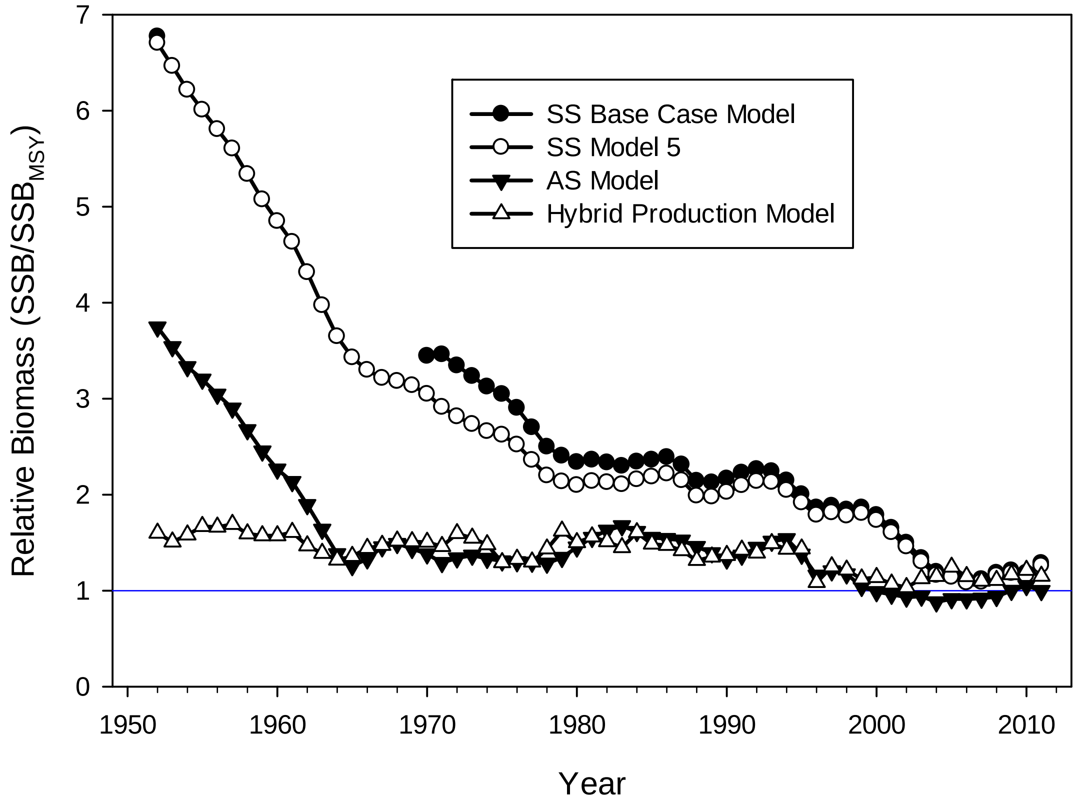
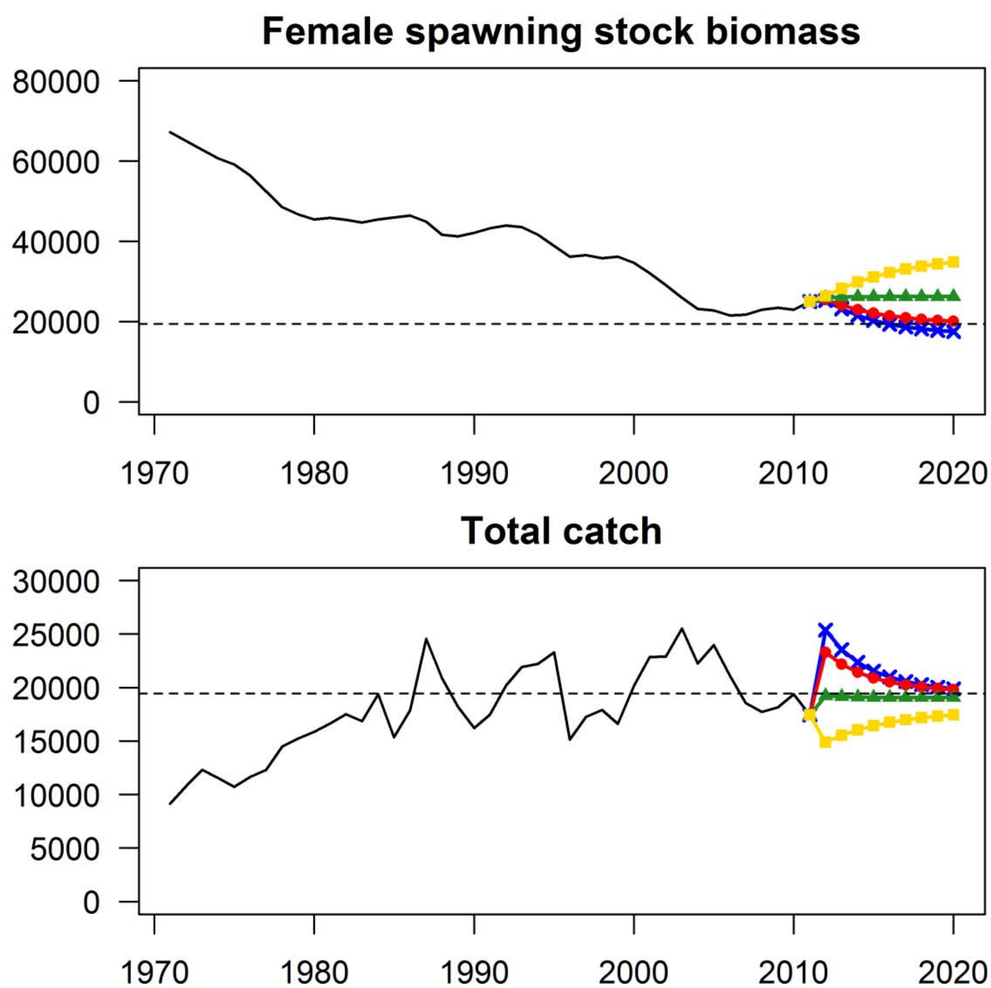


Figure 6. Historic and projected trajectories of female spawning stock biomass (SSB) and total catch from the Pacific blue marlin base case model. The solid black line shows the female spawning stock biomass estimates (top panel) and the catch biomass (bottom panel), and the projected estimates after 2012 show the predicted values if fishing intensity ($F_{X\%}$) were to continue at (1) the average fishing intensity during 2003-2005 ($F_{2003-2005} = F_{16\%}$) indicated by blue line with cross symbols, (2) the fishing intensity at MSY ($F_{MSY} = F_{18\%}$) indicated by red line with circles, (3) the average fishing intensity during 2009-2011 ($F_{2009-2011} = F_{23\%}$) indicated by green line with triangles, and (4) the fishing intensity at $F_{30\%}$ indicated by yellow line with squares. The dashed horizontal lines show the associated MSY levels of female spawning stock biomass and catch biomass.



Appendix 4. Western and Central North Pacific swordfish stock projections.

ISC/13/BILLWG-3/2

Projections for the Western and Central North Pacific Swordfish Stock Under Alternative Harvest Rates and Reference Points

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ABSTRACT

This working paper addresses a request of the Northern Committee (NC) of the Western and Central Pacific Fisheries Commission to the ISC Billfish Working Group to conduct stock projections for the Western and Central North Pacific (WCPO) swordfish stock. The requested projections included information on expected yields and their variability under alternative harvest rates and biological reference points. Updated catch information for WCPO swordfish through 2012 was gathered from ISC member countries and all other available sources. . The potential limit reference points to set the harvest rate scenarios for the NC request included three scenarios: (1) the most recent 3-year average harvest rate (scenario 1), (2) the harvest rate set at fractions of HMSY ranging from 0.5 to 1.5 in multiples of 0.25 (scenarios 2.1 to 2.5), and (3) the harvest rate set at the maximum historic harvest rate during 1951-2012 (scenario 3). Parameters of the WCPO production model were reevaluated using the updated catch data during 2007-2012 (Figure 1.1). Revised estimates of biological reference points were virtually identical to those

from the 2009 stock assessment: MSY = 14.4 thousand mt, BMSY = 57.3 thousand mt, and HMSY = 0.26. Estimates of the exploitable biomass of WCPO swordfish showed the same trends as in the 2010 stock assessment (Figure 1.2). Exploitable biomass in 2012 was estimated to be 80.8 thousand mt (±26.4), or 41% above BMSY. Similarly, estimates of the harvest rate of WCPO swordfish also exhibited the same trends as in the 2010 stock assessment (Figure 1.3). The harvest rate in 2012 was estimated to be 12% (±5%), or about 54% below HMSY. Overall, the updated stock status information indicated that the WCPO swordfish stock was not overfished or experiencing overfishing in 2012 relative to MSY-based reference points. Projection results indicated that expected WCPO yields would increase under most of the alternative harvest rate scenarios and that expected WCPO biomass would be reduced to below BMSY in 2017 (Table 3 and Figure 2.2) under some of the harvest rate scenarios. Projection results for the probabilities of breaching biomass depletion reference points indicated that the there was a high probability that exploited biomass would be reduced to below BMSY in 2017 for some of the higher harvest rate scenarios.

MATERIALS AND METHODS

This working paper addresses the request of the Northern Committee (NC) of the Western and Central Pacific Fisheries Commission to the ISC Billfish Working Group to conduct stock projections for the Western and Central North Pacific (WCPO) swordfish stock. The NC request was made at the 8th regular session of the Northern Committee and was listed in Attachment F of the summary report of that meeting (available at http://www.wcpfc.int/node/4588) and states that

For the purpose of the NC's consideration of biological reference points for swordfish in the northwest Pacific Ocean, the NC requests information and advice from the ISC on the following:

"1. If a production model is used to assess the status of the stock:

a. Is there an adequately precise estimate of intrinsic growth rate available?

2. If an age-structured model is used to assess the status of the stock:

a. Is there an adequately precise estimate of steepness available?

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

3. For the purpose of evaluating the suitability of specific candidate limit reference points:

a. For each of the following levels of F, expected yields, with measures of variability of those expected yields, over the course of 15-year projections, the probabilities of breaching (in at least one year of the projection period) each of the depletion levels SB10%, SB20%, SB30%, and SB40%:

i) Most recent 3-year average F

ii) 0.5FMSY, 0.75FMSY, FMSY, 1.25FMSY, 1.5FMSY

iii) Maximum historically observed single-year F

4. The implications, with respect to any limit reference points that may have been adopted while using a production model, of changing to the use of an age-structured model."

The last assessment of the North Pacific swordfish population was conducted by the BILLWG in 2009 (BILLWG 2009) using catch data through 2006. This assessment was conducted for two stocks: the WCPO and the Eastern North Pacific swordfish stock using Bayesian production models (BILLWG 2009, Brodziak and Ishimura 2010a). The EPO swordfish assessment was updated in 2010 to account for additional information on swordfish catches (BILLWG 2010). The results of the 2009 WCPO assessment indicated that estimates of intrinsic growth rate were adequately precise to conduct stock projections ($r = 0.58 \pm 0.21$) for item 1 of the NC request. Biological reference points for the WCPO swordfish stock were summarized by Brodziak and Ishimura (2010b): maximum sustainable yield (MSY) was MSY = 14.4 thousand mt, biomass to produce MSY (BMSY) was BMSY = 57.3 thousand mt, and harvest rate to produce MSY (HMSY) was HMSY = 0.25. Point estimates of these reference points were updated using the updated information on swordfish catches during 2007-2012 for the projection analyses described below.

Updated catch information for WCPO swordfish through 2012 was gathered from ISC member countries and all other available sources (Table 1.1). Catch information for the WCPO swordfish stock area was not available for 2007-2008 and 2012 for the Inter-American Tropical Tuna Commission and other sources. These missing catches were estimated using the average proportion of IATTC and other sources catches of the total WCPO swordfish catch during the period 2009-2011; this proportion was 0.21% (Table 1.2). Catch information for the WCPO swordfish area was also not available for Taiwanese longline and other fleets in 2012 (Table 1.1). The missing Taiwanese catch biomass in 2012 was estimated from the ratio of the Taiwanese to Japanese catch in 2011 times the Japanese catch in 2012 (Table 1.2). This estimator was used to account for recent changes in the ratio of Taiwanese to Japanese swordfish catches in 2011 given the impact of the March 11, 2011 earthquake on the effective effort of the Japanese fishing fleet targeting WCPO swordfish.

Parameters of the WCPO production model were reevaluated using the updated catch data during 2007-2012 (Figure 1.1). Revised estimates of biological reference points were virtually identical to those from the 2009 stock assessment: MSY = 14.4 thousand mt, BMSY = 57.3 thousand mt, and HMSY = 0.26. Estimates of the exploitable biomass of WCPO swordfish showed the same trends as in the 2010 stock assessment (Figure 1.2). Exploitable biomass in 2012 was estimated to be 80.8 thousand mt (±26.4), or 41% above BMSY. Similarly, estimates of the harvest rate of WCPO swordfish also exhibited the same trends as in the 2010 stock assessment (Figure 1.3). The harvest rate in 2012 was estimated to be 12% (±5%), or about 54% below HMSY. Overall, the updated stock status information indicated that the WCPO swordfish stock was not overfished or experiencing overfishing in 2012 relative to MSY-based reference points.

Performance measures for the NC request included the expected yields of WCPO swordfish and the probabilities of breaching (falling below in at least one year of the projection period) the biomass depletion levels of 10% (B10), 20% (B20), 30% (B30), and 40% (B40) of the estimated carrying capacity. The potential limit reference points to set the harvest rate scenarios for the NC request included three scenarios: (1) the most recent 3-year average harvest rate (scenario 1), (2) the harvest rate set at fractions of HMSY ranging from 0.5 to 1.5 in multiples of 0.25 (scenarios 2.1 to 2.5), and (3) the harvest rate set at the maximum historic harvest rate during 1951-2012 (scenario 3). The values of these reference points were tabulated (Table 2.1) and applied in stochastic projections to assess the projected performance measures for each scenario. A total of 3 Markov Chain Monte Carlo chains were simulated for each scenario using a total of 31000 simulations for each chain using a burnin of 1000 simulations and a thinning rate of 3, numerical values that were similar to those used in the 2010 WCPO stock assessment.

Projection results indicated that expected WCPO yields would increase under most of the alternative harvest rate scenarios (Table 3). Expected yields would be higher than recent average yields under the higher harvest rate scenarios (HMSY, 125% of HMSY, 150% of HMSY, and Maximum historic H). Expected yields would slightly increase under the 75% of HMSY scenario and would decrease under the 50% of HMSY and recent 3-year average scenarios (Figure 2.1). In this context, note that the 50% of HMSY and recent 3-year average H scenarios were virtually identical.

Projection results for exploited biomass indicated that the expected WCPO biomass would be reduced to below BMSY in 2017 (Table 3 and Figure 2.2) under some of the harvest rate scenarios (125% of HMSY, 150% of HMSY, and Maximum historic H). Fishing at the

HMSY level would lead to an expected biomass near BMSY in 2017 as expected, while the lower harvest rate scenarios would maintain expected biomasses above BMSY (75% of HMSY, 50% of HMSY, and recent 3-year average H scenarios).

Projection results for the probabilities of breaching biomass depletion reference points indicated that the there was a high probability that exploited biomass would be reduced to below BMSY in 2017 (Table 3 and Figure 2.3) for some of the higher harvest rate scenarios (125% of HMSY, 150% of HMSY, and Maximum historic H). In contrast, for the lower harvest rate scenarios (75% of HMSY, 50% of HMSY, and recent 3-year average H scenarios) there were relatively low probabilities of breaching any of the potential biomass depletion reference points (Table 3 and Figure 2.3). For the 10% and 20% biomass depletion levels, it was very unlikely that these depletion levels would be breached by 2017 given current WCPO stock conditions. We also note that the corresponding annual probabilities of breaching the biomass depletion reference points have been tabulated along with other simulation results and that this additional information will be provided upon written request to the author.

With respect to item 4, changing to the use of an age-structured model will have limited effect on the interpretation of production model reference points based on MSY. When moving to an age-structured model from a production model it is important to note that the stock-recruitment steepness and natural mortality rate will effectively determine the fraction of unfished spawning biomass that produces MSY (Mangel et al. 2013). In the production model, the fraction of unfished biomass to produce MSY is effectively determined by the shape parameter M. Thus, there is an analogous interpretation of MSY-based reference points for a general age-structured model and production model but different parameters determine the biomass to produce MSY. For reference points based on spawning potential ratio (SPR), there is an analogous interpretation of the fraction of unfished spawning biomass per recruit as an analogue of a fraction of unfished exploitable biomass, again with the recognition that the scaling of spawning biomass to produce a specific fraction of SPR will differ from the biomass scale of an equivalent fraction of unfished exploitable biomass. One other major point to note is that while changing to an age-structured model will change the scale of estimates of biomass, it should be emphasized that it is the value of ratio biomass to the reference point that is important for stock status determination.

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Table 1.1. Updated estimates of WCPO swordfish catch biomass (thousand mt) by source during 2007-2012.

Year	ISC 2013 Subarea1 Swordfish Catch Biomass Estimates (1000 mt)	USA Subarea1 Swordfish Catch (1000 mt)	Japan Subarea1 Swordfish Catch (1000 mt)	IATTC and Other Sources Subarea1 Swordfish Catch (1000 mt)	Taiwan Subarea1 Swordfish Catch (1000 mt)
2007		1.735	9.131		3.935
2008		1.980	6.766		3.605
2009	11.403	1.818	6.200	0.003	3.382
2010	9.811	1.671	5.467	0.058	2.615
2011	8.872	1.625	3.726	0.001	3.520
2012		0.904	3.989		

Table 1.2. Estimates of WCPO swordfish catch biomass (thousand mt) by source during 2007-2012 used for conducting stock projections under alternative harvest rates and reference points.

Year	ISC 2013 Subarea1 Swordfish Catch Biomass Estimates	USA Subarea1 Swordfish Catch (1000 mt)	Japan Subarea1 Swordfish Catch (1000 mt)	IATTC and Other Sources Subarea1 Swordfish Catch	Taiwan Subarea1 Swordfish Catch (1000 mt)
2007	14.832	1.735	9.131	0.031	3.935
2008	12.377	1.980	6.766	0.026	3.605
2009	11.403	1.818	6.200	0.003	3.382
2010	9.811	1.671	5.467	0.058	2.615
2011	8.872	1.625	3.726	0.001	3.520
2012	8.680	0.904	3.989	0.001	3.769

Table 2.1. The three scenarios of potential limit reference points to set the harvest rate for WCPO swordfish projections in the NC request.

SCENARIO 1: 3-YEAR AVERAGE HARVEST RATE FOR 2010-2012

Variable	mean	sd	CV	PRECISION
H[60]	0.144	0.052	0.364	364.9
H[61]	0.127	0.049	0.385	418.2
H[62]	0.121	0.051	0.424	383.4
3-YEAR AVERAGE HARVEST RATE	0.130	0.051	0.389	387.9

SCENARIO 2: MULTIPLES OF HMSY HARVEST RATE

Variable	mean	sd	CV	PRECISION
0.5*HMSY	0.130	0.031	0.237	1047.7
0.75*HMSY	0.196	0.046	0.237	465.6
HMSY	0.261	0.062	0.237	261.9
1.25*HMSY	0.326	0.077	0.237	167.6
1.5*HMSY	0.391	0.093	0.237	116.4

SCENARIO 3: MAXIMUM OBSERVED HARVEST RATE

Variable	mean	sd	CV	PRECISION
MAX H	0.326	0.082	0.253	147.4

Table 3. WCPO swordfish projection results by harvest scenario for expected catch biomass (Mean, thousand mt) and its standard deviation (Stdev), expected exploitable biomass (Mean, thousand mt) and its standard deviation (Stdev), and the probability of breaching biomass depletion reference points of B10, B20, B30, B40, and BMSY.

	Scenario S1		Scenario S2.1		Scenario S2.2		Scenario S2.3		Scenario S2.4		Scenario S2.5		Scenario S3	
Variable	Mean	Stdev	Mean	Stdev	Mean	Stdev	Mean	Stdev	Mean	Stdev	Mean	Stdev	Mean	Stdev
Catch 2013	10.68	5.367	10.68	4.098	16.1	6.166	21.44	8.215	26.78	10.26	32.12	12.31	26.78	10.56
Catch 2014	10.64	4.989	10.64	3.629	14.98	5.093	18.56	6.339	21.44	7.405	23.63	8.329	21.44	7.697
Catch 2015	10.66	4.838	10.67	3.414	14.4	4.595	17.07	5.493	18.83	6.164	19.76	6.658	18.82	6.442
Catch 2016	10.67	4.737	10.69	3.275	14.03	4.278	16.13	4.973	17.2	5.437	17.39	5.731	17.19	5.701
Catch 2017	10.71	4.689	10.73	3.192	13.81	4.08	15.52	4.655	16.12	5.008	15.82	5.208	16.11	5.261
Biomass 2013	82.15	23.85	82.15	23.85	82.15	23.85	82.15	23.85	82.15	23.85	82.15	23.85	82.15	23.85
Biomass 2014	81.87	19.86	81.87	19.57	76.45	18.26	71.11	17.11	65.77	16.15	60.43	15.4	65.77	16.33
Biomass 2015	82.01	17.5	82.07	17.04	73.46	15.25	65.4	13.79	57.75	12.62	50.53	11.71	57.73	12.84
Biomass 2016	82.25	15.93	82.35	15.37	71.66	13.33	61.86	11.8	52.82	10.67	44.53	9.84	52.78	10.9
Biomass 2017	82.49	14.91	82.62	14.29	70.5	12.08	59.5	10.6	49.48	9.623	40.49	8.96	49.43	9.866
Pr(Breach B10)	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.03	0.00	0.04	0.00	0.03
Pr(Breach B20)	0.00	0.05	0.00	0.05	0.00	0.05	0.00	0.06	0.01	0.09	0.04	0.19	0.01	0.09
Pr(Breach B30)	0.01	0.10	0.01	0.10	0.01	0.11	0.02	0.14	0.08	0.27	0.28	0.45	0.08	0.28
Pr(Breach B40)	0.03	0.18	0.03	0.18	0.04	0.20	0.11	0.32	0.36	0.48	0.70	0.46	0.38	0.48
Pr(Breach BMSY)	0.09	0.29	0.09	0.28	0.13	0.34	0.40	0.49	0.77	0.42	0.94	0.23	0.77	0.42

Figure 1.1. Estimates of catch biomass of WCPO swordfish during 1951-2012 used for stock projections.

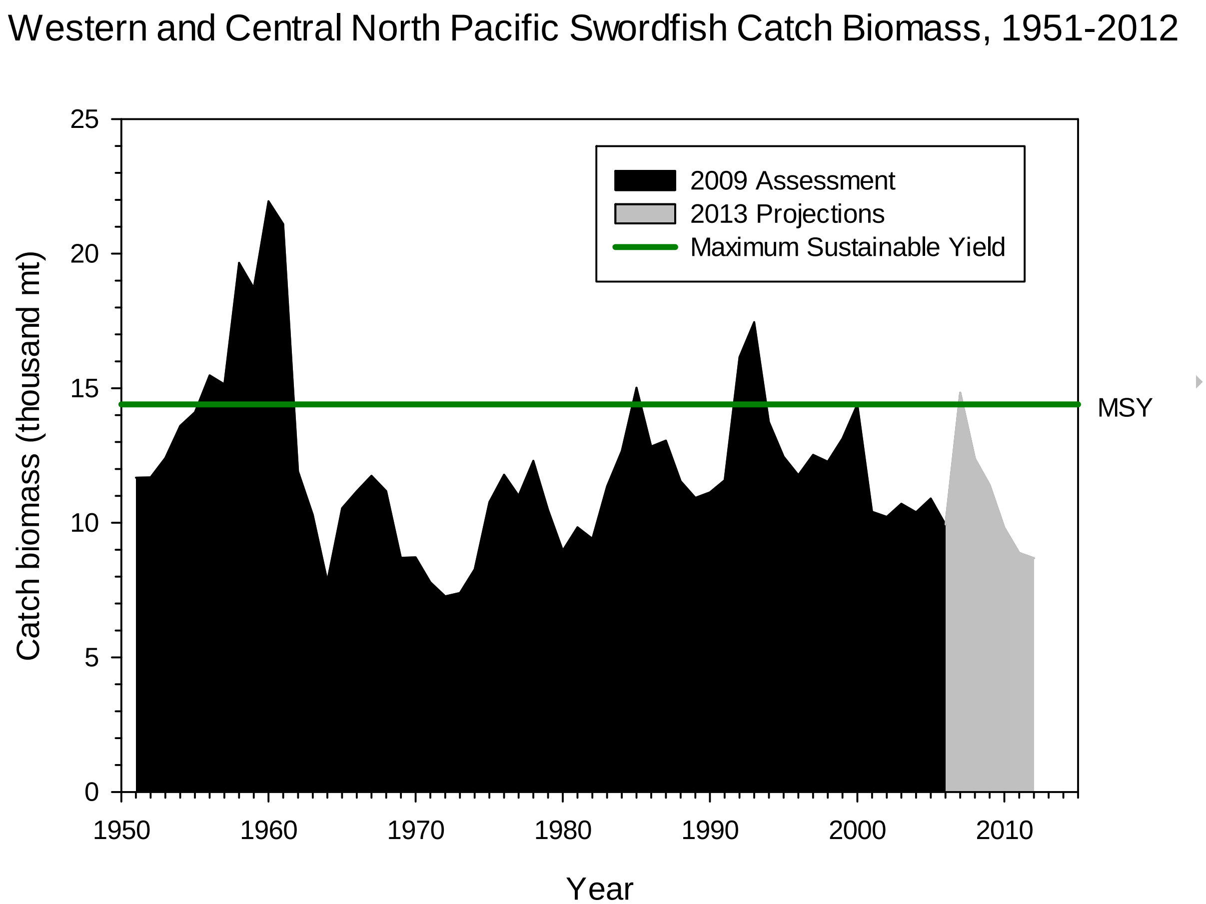


Figure 1.2. Estimates of exploitable biomass for WCPO swordfish (± 1 standard error) during 1951-2012 used for stock projections.

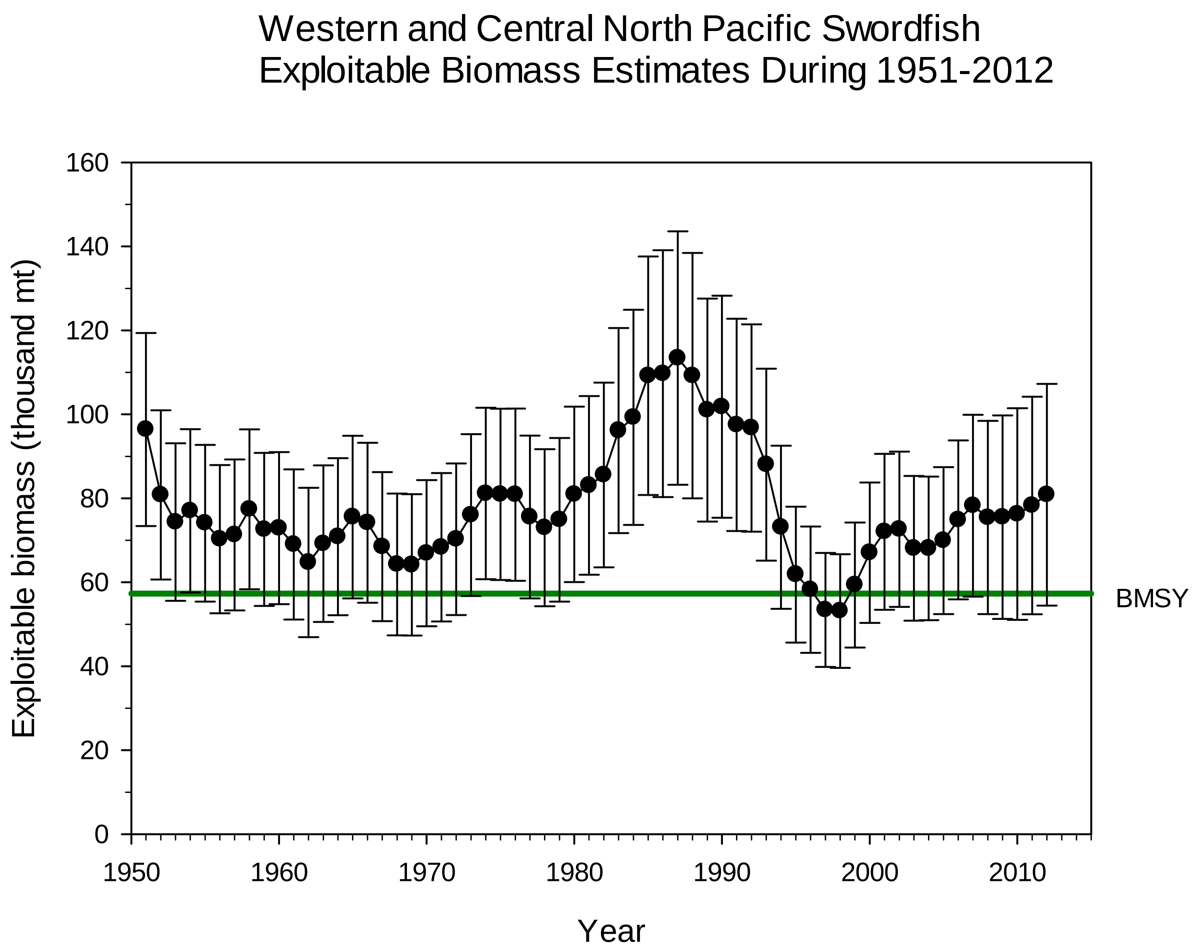


Figure 1.3. Estimates of harvest rates for WCPO swordfish (± 1 standard error) during 1951-2012 used for stock projections.

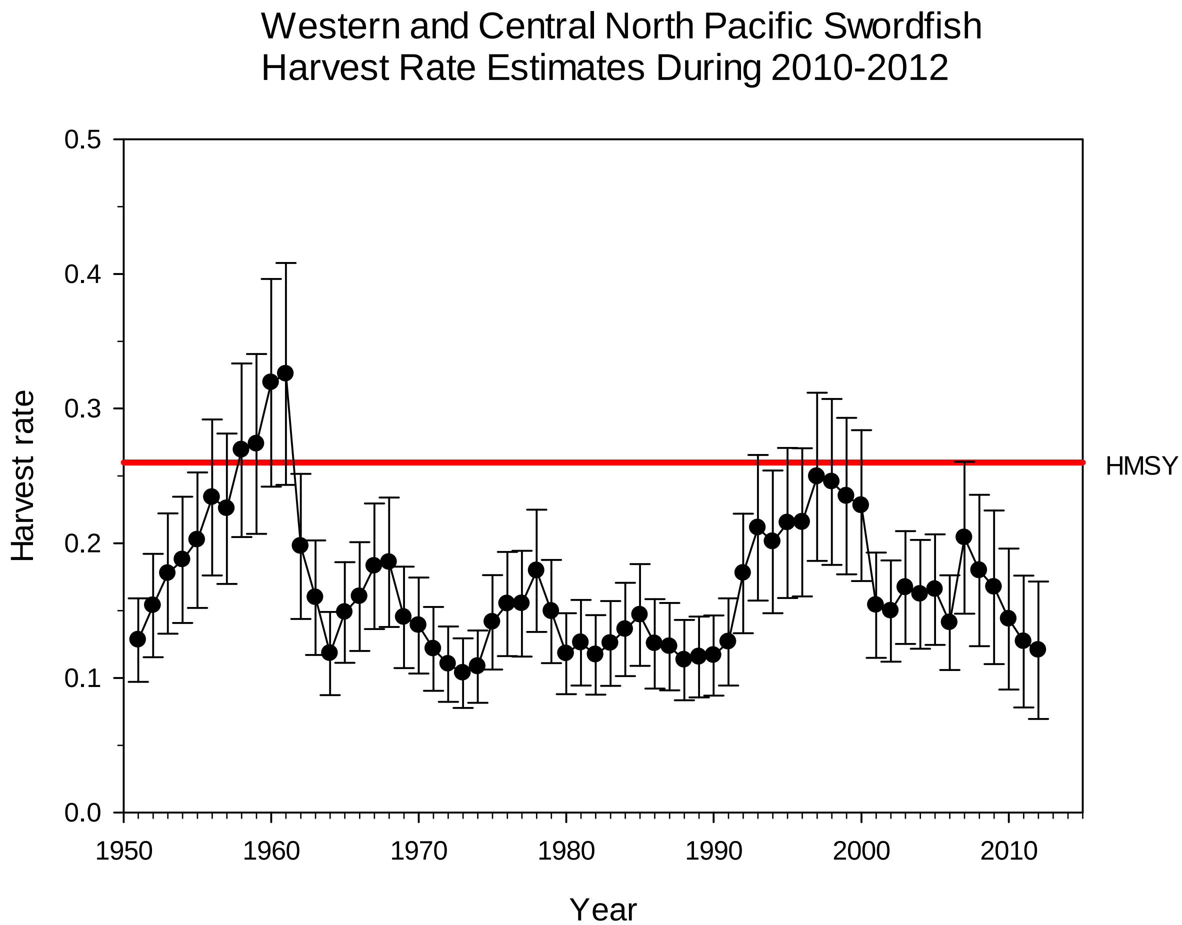


Figure 2.1. Projections of expected catch biomasses of WCPO swordfish during 2013-2017 under alternative harvest scenarios.

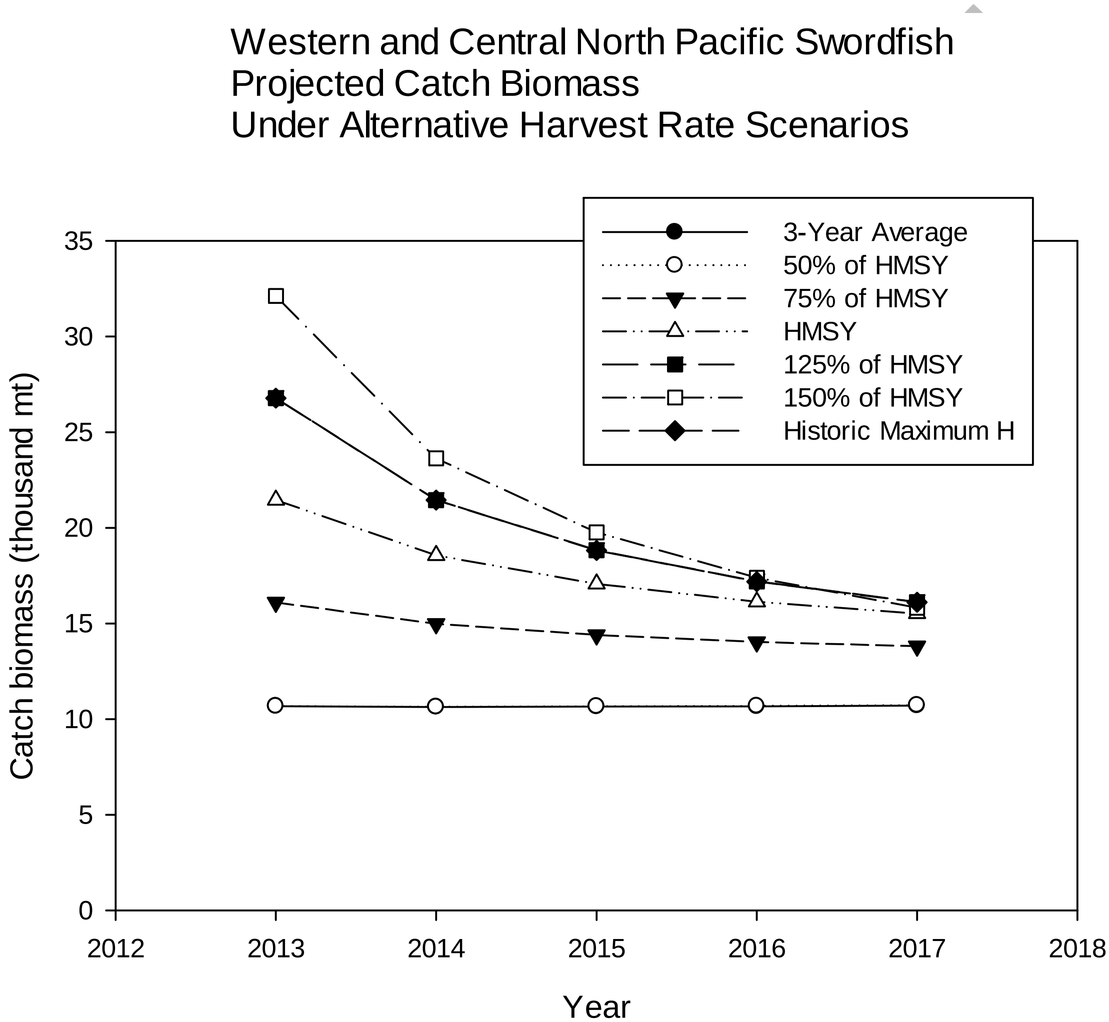


Figure 2.2. Projections of expected exploitable biomasses of WCPO swordfish during 2013-2017 under alternative harvest scenarios.

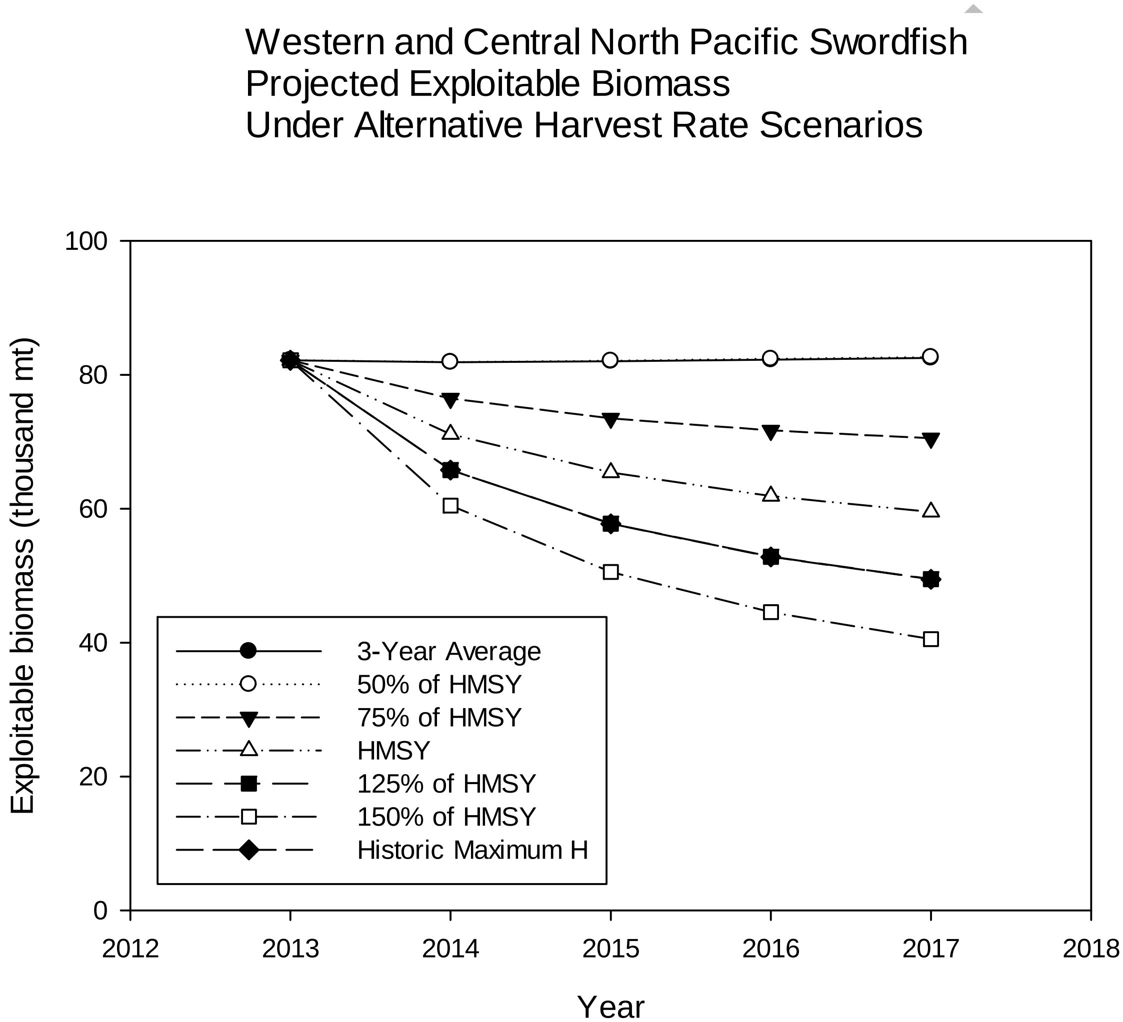
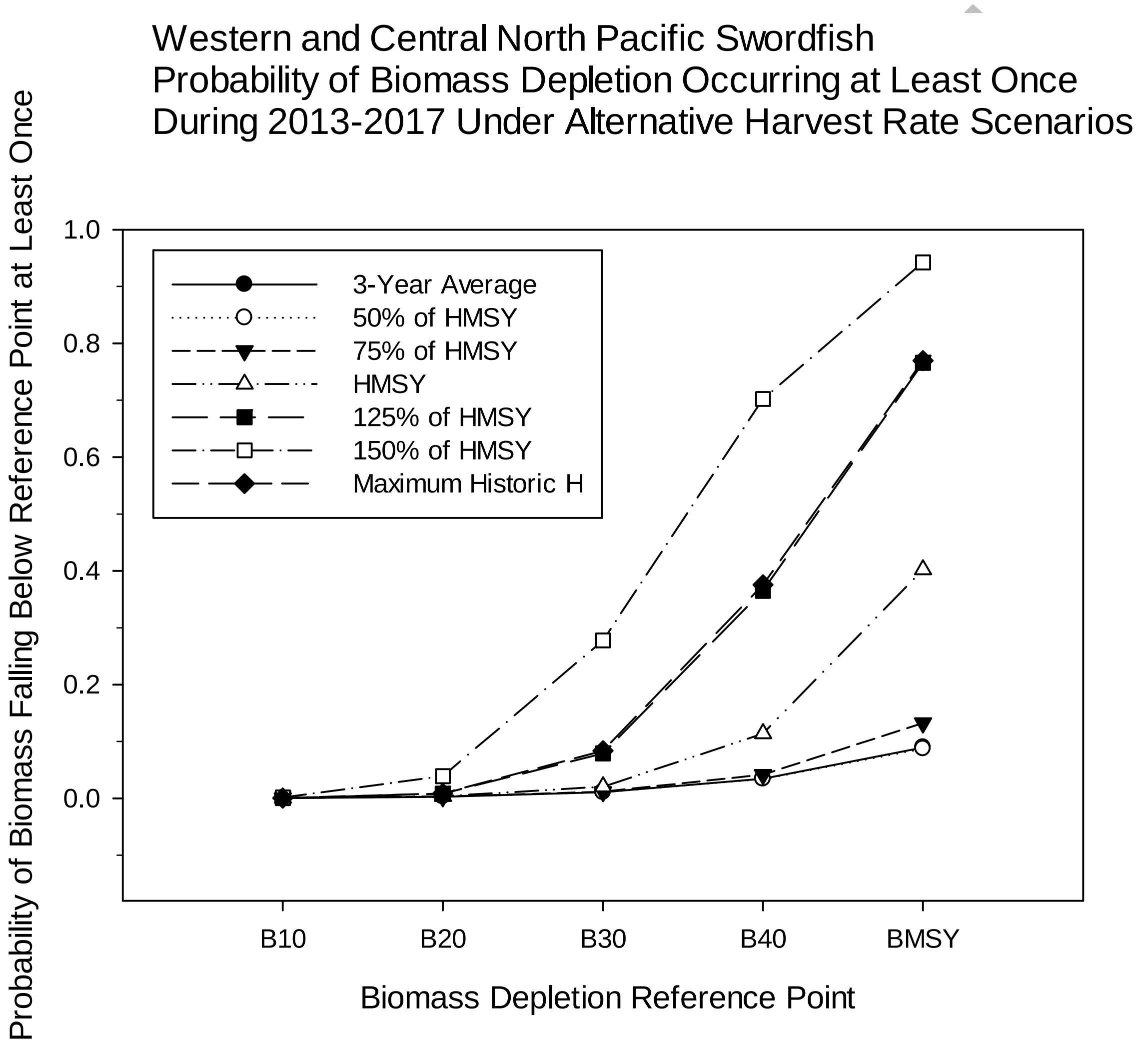


Figure 2.3. Projected probabilities of breaching biomass depletion levels for WCPO swordfish during 2013-2017 under alternative harvest scenarios.



Appendix 5. Eastern North Pacific swordfish stock structure and boundary.

The ISC Billfish Working Group (WG) reviewed information on the stock structure of the swordfish population in the eastern North Pacific provided by background papers distributed at the May meeting (Kume and Joseph 1969, Hinton and Deriso 1998, Hinton 2003, and Hinton 2008) at its July 14-15 2013 meeting. In light of this information, the WG concluded that there was uncertainty about the stock boundaries of the existing eastern Pacific swordfish stock management unit. The WG also agreed to use the existing stock definition of the eastern Pacific swordfish stock management unit for the purposes of stock assessment in the absence further information to resolve the uncertainties.

Appendix 6. Updated effort, catch, and size composition tables for the Mexican recreational fisheries for billfishes in the Pacific.

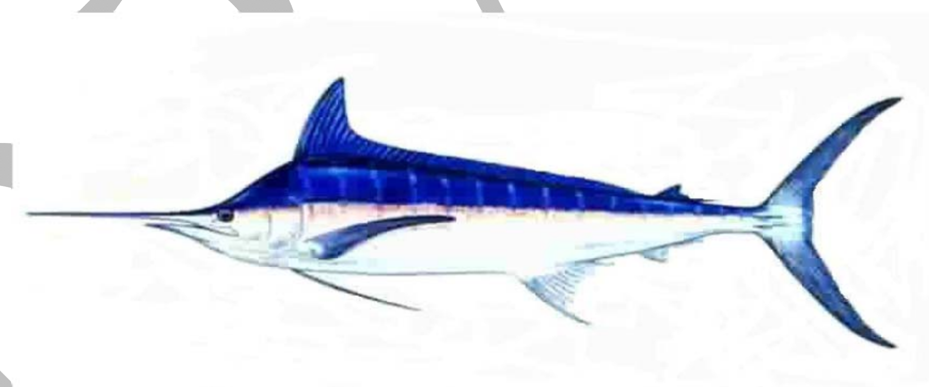
The ISC Billfish Working Group (WG) reviewed updated information on the Mexican recreational fisheries for billfishes in the Pacific through 2011. The WG noted that there were maps depicting the fishing ground of the three main sport fisheries in one or more historic ISC documents and that it would be useful to gather this information for future work. The WG also discussed additional information on the acronyms and units and clarified the meaning of terms used in the updated tables (below). In Table 2, it was noted that "MARLIN" was "striped marlin". It was also noted that all billfish length measurements were in units of centimeters of lower-jaw for length and that all weights were whole body weights in units of kilograms. The WG discussed the length-weight data and suggested that it would be appropriate to determine appropriate length-weight relationships of billfish captured in the Mexican recreational fisheries for billfishes.

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

MEXICAN UPDATE TABLES ON THE RECREATIONAL FISHERIES FOR BILLFISHES

Prepared as a contribution for the Working Group annual meeting.

(Busan, Korea July 14-15, 2013)



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Data Category I

Table1. Total and average number of sport fishing trips at the three main sport fisheries locations at the Mexican Pacific coast: Los Cabos, Buenavista, B.C.S. and Mazatlán, Sin. Mexico, from 1990-20011*. Data for 2011 still is preliminary

YEAR	Los Cabos	Buenavista	Mazatlán	Areas Combined
1990	13,589	9,276	8,649	31,514
1991	19,462	10,157	5,715	35,334
1992	16,576	9,127	4,320	30,023
1993	15,385	9,313	4,545	29,243
1994	14,845	9,961	4,421	29,227
1995	13,472	8,619	3,216	25,307
1996	15,315	9,365	4,368	29,048
1997	20,611	9,694	2,318	32,623
1998	23,501	8,106	3,321	34,928
1999	25,783	9,948	4,313	40,044
2000	28,211	9,555	4,074	41,840
2001	24,939	9,300	3,793	38,032
2002	27,618	12,909	3,828	44,355
2003	34,651	9,361	3,622	47,634
2004	32,780	12,522	3,554	48,856
2005	37,434	15,288	4,038	56,760
2006	40,888	11,408	3,679	55,975
2007	40,600	11,619	3,226	55,445
2008	37,612	10,155	2,352	50,119
2009	33,452	7,829	2,019	43,300
2010	32,771	4,345	1,779	38,895
2011	31,883	5,672	NA	> 37,555
AVERAGE	26,426	9,706	3,864	39,929

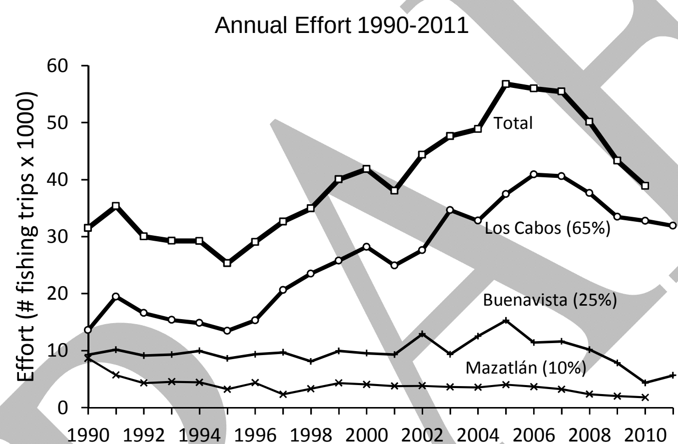

Fig. 1. Number of sport fishing trips at the three main locations at the Mexican Pacific coast: Los Cabos, Buenavista, B.C.S. and Mazatlán, Sin. Mexico, from 1990-2011*. data from 2011 still is preliminary.

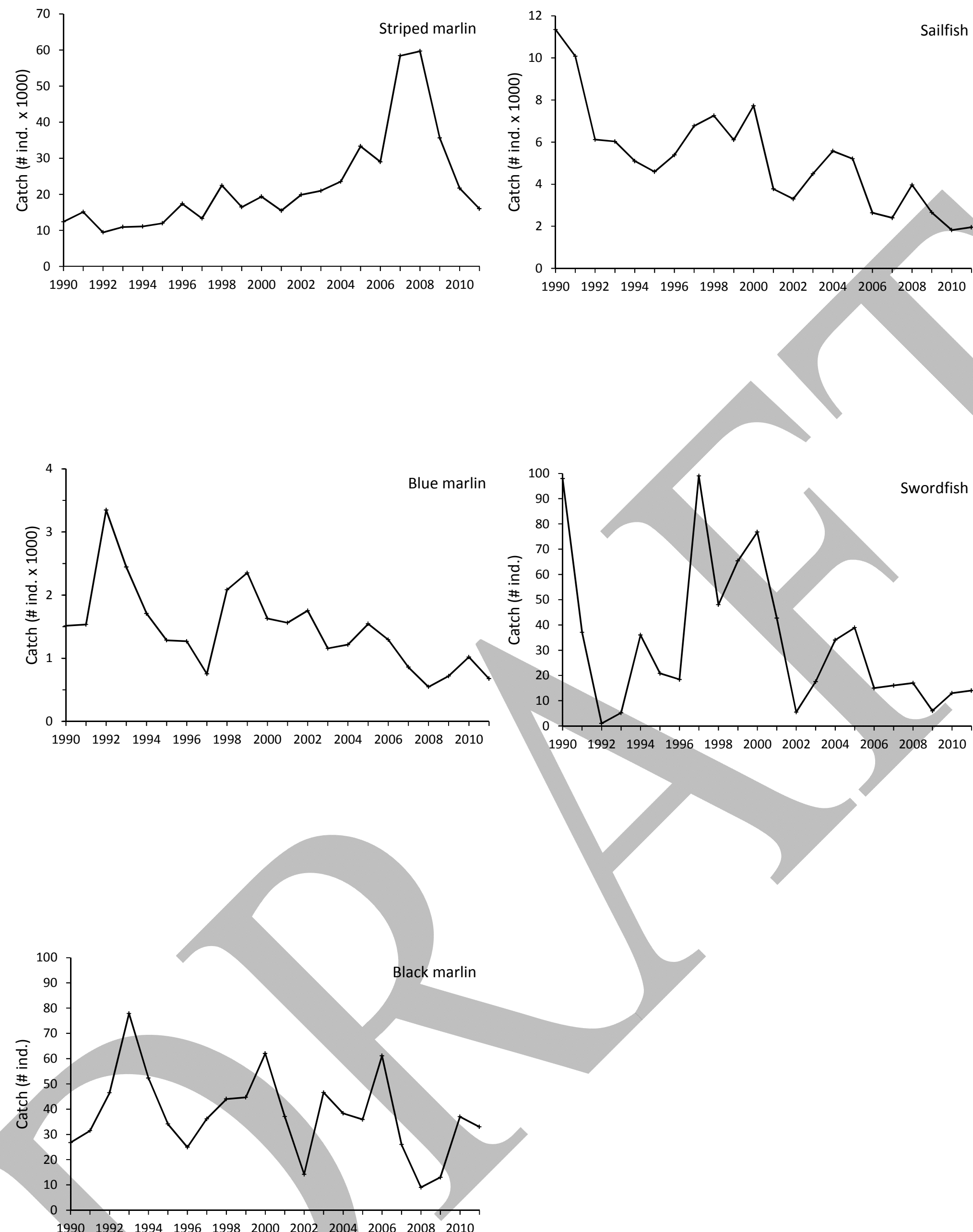

Fig.2. Number of <u>all billfishes species caught</u> at the three main locations combined in the Mexican Pacific from 1990-2011.*data from 2011 still preliminary.

Table 2. Number of billfish caught by species at the three main locations at the Mexican Pacific coast: Los Cabos, Buenavista, B.C.S. and Mazatlán, Sin. Mexico, from 1990-2011. *data from 2011 still preliminary.

YEAR	MARLIN	BLUE MARLIN	SAIL FISH	BLACK MARLIN	SWORD FISH
1990	12,375	1,514	11,345	27	98
1991	15,120	1,535	10,079	31	37
1992	9,463	3,347	6,117	46	1
1993	10,950	2,444	6,031	78	5
1994	11,083	1,709	5,101	52	36
1995	11,974	1,285	4,592	34	21
1996	17,354	1,268	5,389	25	18
1997	13,302	752	6,771	36	99
1998	22,458	2,083	7,257	44	48
1999	16,465	2,351	6,107	45	65
2000	19,350	1,630	7,728	62	77
2001	15,468	1,561	3,775	37	43
2002	19,864	1,754	3,300	14	5
2003	20,977	1,156	4,492	47	18
2004	23,546	1,214	5,577	38	34
2005	33,318	1,544	5,209	36	39
2006	29,010	1,293	2,643	61	15
2007	58,409	858	2,403	26	16
2008	59,656	546	3,963	9	17
2009	35,635	718	2,653	13	6
2010	21,691	1,020	1,823	37	13
2011*	16,005	677	1,954	33	14

*Data from 2011 do not include catches from Mazatlan

Biological Data (Category III Data):

Table 3. Longitudes (Max and Min) of the striped marlins caught in Los Cabos by the sport fisheries activities in Pacific Mexican waters form 1990-2011. Data for 2011 still is preliminary.

Año	N	Tmin	Tmax	Media	s	Conf. Int.
90	714	163	257	208.5	11.547	0.847
91	665	154	246	207.6	12.584	0.956
92	466	166	244	210.0	12.974	1.178
93	352	156	256	206.5	11.975	1.251
94	400	152	244	204.9	14.685	1.439
95	513	136	247	200.7	17.652	1.528
96	648	157	243	199.2	13.869	1.068
97	392	142	241	203.1	13.081	1.295
98	373	163	238	202.7	14.204	1.441
99	235	171	244	204.6	12.057	1.542
00	236	163	240	203.9	14.852	1.895
01	205	160	234	202.2	13.173	1.803
02	230	156	239	201.5	13.509	1.746
03	279	153	245	200.2	13.343	1.566
04	241	161	245	194.7	15.917	2.010
05	342	148	261	193.2	17.054	1.807
06	317	151	237	193.0	14.309	1.575
07	292	141	238	194.6	15.913	1.825
08	282	160	239	197.2	13.528	1.579
09	111	173	242	199.1	13.038	2.425
10	339	143	248	196.0	18.639	1.984
11	189	160	227	191.0	15.040	2.144

Table 4. Median weights of the striped marlin caught by the sport fisheries activities in Pacific Mexican waters form 1985-2011. Data from 2011 still is preliminary).

Año	N	Media	S	Conf. Int.
85	3489	51.6	12.709	0.422
86	5741	52.8	11.501	0.298
87	788	52.9	11.863	0.828
88	600	52.8	11.640	0.931
89	550	60.0	13.444	1.124
90	692	56.6	9.844	0.733
91	567	56.9	10.079	0.830
92	433	53.2	10.397	0.979
93	319	49.9	9.796	1.075
94	363	48.8	11.940	1.228
95	485	52.1	14.939	1.330
96	616	52.2	10.714	0.846
97	380	52.0	9.911	0.996
98	360	47.7	10.646	1.100
99	235	50.0	9.474	1.211
00	236	49.7	12.200	1.557
01	195	48.9	10.290	1.444
02	227	49.9	11.513	1.498
03	278	47.1	10.279	1.208
04	238	43.5	11.994	2.208
05	340	41.1	13.038	1.386
06	309	41.4	10.782	1.202
07	277	41.2	11.401	1.343
08	282	43.3	10.731	1.252
09	110	42.5	11.340	2.119
10	332	38.5	11.974	1.288
11	183	38.4	11.116	1.611

Table 5. Longitudes of the male striped marlin caught by the sport fisheries activities in Pacific Mexican waters form 1987-2011. *Data from 2011 still is preliminary.

MALES	STRIPED	MARLIN	LENGTHS			
Año	n	Tmin	Tmax	Tmed	S	Conf. Int.
87	431	166	239	203.0	12.828	1.211
88	207	159	235	199.8	12.187	1.660
89	268	167	232	205.4	10.665	1.277
90	396	163	234	206.3	11.013	1.085
91	371	164	234	206.1	11.196	1.139
92	273	166	238	209.2	11.868	1.408
93	196	175	233	205.8	10.897	1.526
94	191	157	235	204.6	13.949	1.978
95	260	136	236	199.0	16.617	2.020
96	304	157	232	197.2	13.494	1.517
97	214	142	226	199.9	12.561	1.683
98	190	163	238	200.5	12.225	1.738
99	128	171	228	202.8	10.871	1.883
00	132	164	234	200.5	12.937	2.207
01	128	171	234	203.9	12.580	2.179
02	137	156	234	199.6	13.329	2.232
03	160	161	229	198.8	12.112	1.877
04	128	161	235	192.9	14.207	2.461
05	186	155	228	193.4	15.614	2.244
06	193	155	228	191.5	13.397	1.890
07	137	151	234	192.0	14.833	2.484
08	147	160	235	196.0	12.966	2.096
09	66	174	222	196.4	10.835	2.614
10	183	151	245	195.7	16.449	2.383
11	98	160	221	191.4	15.424	3.054

Table 6. Weights of the male striped marlin caught by the sport fisheries activities in Pacific Mexican waters form 1987-2011.* Data from 2011 still is preliminary.

MALE	STRIPED	MARLIN	WEIGHTS	
Año	n	Pmed	s	Conf. Int.
87	431	51.7	10.689	1.009
88	208	48.6	10.366	1.409
89	266	58.4	11.893	1.429
90	385	54.4	9.575	0.956
91	356	54.9	8.985	0.933
92	264	51.3	8.900	1.074
93	186	48.9	8.196	1.178
94	182	47.9	10.471	1.521
95	257	50.0	13.238	1.618
96	293	51.1	10.094	1.156
97	206	49.9	8.795	1.201
98	186	46.1	9.151	1.315
99	128	48.5	8.396	1.455
00	132	46.7	10.406	1.775
01	120	50.5	10.001	1.789
02	137	47.9	10.497	1.758
03	160	45.8	8.794	1.363
04	124	41.8	10.157	1.788
05	184	40.4	11.026	1.593
06	189	40.1	9.320	1.329
07	130	39.3	10.764	1.850
08	146	43.0	9.666	1.568
09	65	41.7	9.011	2.191
10	179	38.1	10.383	1.521
11	96	38.2	10.670	2.134

Table 7. Longitudes of the female striped marlin caught by the sport fisheries activities in Pacific Mexican waters form 1987-2011. *Data from 2011 still is preliminary.

FEMALES	STRIPEd	MARLIN	LENGHTS			
Año	n	Tmin	Tmax	Tmed	s	Conf. Int.
90	310	165	257	211.5	11.526	1.283
91	283	154	246	209.4	13.867	1.616
92	176	174	244	213.9	13.887	2.052
93	139	156	256	207.7	13.578	2.257
94	192	152	244	205.4	15.150	2.143
95	231	151	247	203.7	18.194	2.346
96	328	159	243	201.3	13.986	1.514
97	176	167	241	206.9	12.789	1.889
98	176	167	236	205.2	15.500	2.290
99	105	171	244	206.4	12.886	2.465
00	104	163	240	208.1	15.038	2.890
01	77	160	234	199.2	13.668	3.053
02	91	173	239	204.7	13.180	2.708
03	118	153	245	202.0	14.703	2.653
04	112	161	245	196.9	17.549	3.250
05	156	148	261	193.0	18.676	2.931
06	122	151	237	195.6	15.387	2.730
07	153	141	238	196.8	16.579	2.627
08	133	164	239	198.7	14.030	2.384
09	44	173	242	203.5	14.792	4.371
10	156	143	248	196.4	20.966	3.290
11	88	162	227	190.2	14.839	3.100

Table 8. Weights of the female striped marlin caught by the sport fisheries activities in Pacific Mexican waters form 1987-2011. Data from 2011 still is preliminary.

FEMALE	STRIPED	MARLIN	WEIGHTS	
Año	n	Pmed	s	Conf. Int.
87	347	54.3	13.106	1.379
88	180	51.6	11.428	1.669
89	275	61.8	14.507	1.715
90	303	60.0	11.445	1.289
91	271	59.0	12.58	1.498
92	168	56.1	11.901	1.800
93	132	51.4	11.56	1.972
94	177	49.6	13.304	1.960
95	224	54.8	16.4	2.148
96	319	53.4	11.182	1.227
97	173	54.7	10.564	1.574
98	173	49.6	11.796	1.758
99	107	51.7	10.385	1.968
00	104	53.7	13.104	2.518
01	74	46.3	10.35	2.358
02	91	52.9	12.353	2.538
03	118	48.9	11.809	2.131
04	112	45.5	13.519	2.504
05	156	41.8	15.076	2.366
06	120	43.5	12.526	2.241
07	145	42.8	11.797	1.920
08	134	43.7	11.823	2.002
09	44	44.1	14.069	4.157
10	153	38.9	13.624	2.159
11	86	38.4	11.521	2.435

Table 9. Longitudes (Max and Min) of blue marlin caught by the sport fisheries activities in Pacific Mexican waters form 1985-2011. Data from 2011 still is preliminary.

BLUE	MARLIN	LONGITUDES				
Año	n	Tmin	Tmax	Media	s	Conf. Int.
90	110	190	307	229.2	19.744	3.690
91	77	193	280	231.7	23.068	5.152
92	153	180	321	231.5	25.662	4.066
93	97	183	339	230.9	27.742	5.521
94	124	189	365	229.9	29.776	5.241
95	65	172	310	224.9	26.903	6.540
96	105	183	357	232.9	27.035	5.171
97	47	191	275	228.0	18.951	5.418
98	104	179	308	223.1	25.63	4.926
99	59	195	269	220.8	15.096	3.852
00	60	200	284	234.3	18.761	4.747
01	31	191	319	228.8	23.857	8.398
02	54	173	275	221.4	19.07	5.086
03	21	191	273	229.9	25.541	10.924
04	18	209	284	236.7	24.843	11.477
05	29	180	250	215.6	18.895	6.877
06	35	180	310	224.6	27.432	9.088
07	13	188	270	226.5	26.844	14.592
08	8	206	254	226.1	17.707	12.270
09	6	203	291	240.8	32.326	25.866
10	40	202	288	236.5	22.344	6.924
11	24	198	270	222.7	20.133	8.055

Table 10. Median weights of the blue marlin caught by the sport fisheries activities in Pacific Mexican waters form 1985-2011.Data from 2011 still is preliminary.

BLUE	MARLIN	WEIGHTS		
Año	n	Media	s	Conf. Int.
90	113	110.0	35.416	6.530
91	75	119.8	40.142	9.085
92	146	110.2	47.253	7.665
93	86	107.9	46.883	9.909
94	109	106.9	52.841	9.920
95	42	100.9	41.007	12.402
96	101	117.3	42.167	8.224
97	47	109.5	26.955	7.706
98	104	98.5	40.398	7.764
99	59	97.2	21.339	5.445
00	59	110.9	31.276	7.981
01	31	107.7	47.444	16.701
02	54	93.8	23.532	6.276
03	21	109.2	41.89	17.916
04	18	117.2	32.394	14.965
05	29	80.8	22.784	8.292
06	35	94.7	48.432	16.045
07	13	93.0	30.537	16.600
08	8	92.8	27.912	19.342
09	6	126.5	62.829	50.273
10	37	110.2	40.147	12.936
11	24	89.6	27.134	10.856

Table 11. Available longitudes of the male blue marlin caught by the sport fisheries activities in Pacific Mexican waters form 1987-2011 Detailed data from some years is not available.

MALE	BLUE	MARLIN	LONGITUDES			
Año	n	Tmin	Tmax	Tmed	s	Conf. Int.
90	4	211	227	216.3	7.274	7.128
91	3	207	219	211.3	6.658	7.534
92	7	210	231	220.9	7.625	5.649
93	1	-	-	226.0	-	-
94	3	197	249	215.7	28.937	32.745
95	6	213	223	217.8	3.488	2.791
96	3	213	235	222.7	11.240	12.719
97	2	223	229	226.0	4.243	5.880
98	-	-	-	-	-	-
99	-	-	-	-	-	-
00	2	201	231	216.0	21.213	29.399
01	-	-	-	-	-	-
02	-	-	-	-	-	-
03	-	-	-	-	-	-
04	-	-	-	-	-	-
05	-	-	-	-	-	-
06	2	197	243	220.0	32.527	45.079
07	-	-	-	-	-	-
08	-	-	-	-	-	-
09	1	-	-	223.0	-	-
10	-	-	-	-	-	-
11	-	-	-	-	-	-

Table 12. Available weights of the male blue marlin caught by the sport fisheries activities in Pacific Mexican waters form 1987-2011. (Detailed data from some years is not available).

MALE	BLUE	MARLIN	WEIGHTS	
Año	N	Pmed	s	Conf. Int.
87	9	96.1	18.274	11.939
88	9	89.7	66.669	43.556
89	4	91.3	26.998	26.458
90	4	80.0	9.201	9.017
91	2	97.5	10.607	14.700
92	7	86.9	16.807	12.451
93	1	90.0		
94	3	90.7	42.736	48.359
95	6	90.8	13.258	10.608
96	3	93.7	16.042	18.153
97	2	106.5	16.263	22.539
98	-	-	-	-
99	-	-	-	-
00	2	87.5	17.678	24.500
01	-	-	-	-
02	-	-	-	-
03	-	-	-	-
04	-	-	-	-
05	-	-	-	-
06	2	82.0	32.527	45.079
07	-	-	-	-
08	-	-	-	-
09	1	82.0	-	-
10	-	-	-	-
11	-	-	-	-

Table13. Available longitudes of the female blue marlin caught by the sport fisheries activities in Pacific Mexican Waters form 1987-2011. *Data from 2011 still is preliminary.

FEMALE	BLUE	MARLIN	LONGITUDES			
Año	n	Tmin	Tmax	Tmed	s	Conf. Int
87	116	173	301	223.4	22.491	4.093
88	75	176	321	221.5	24.928	5.642
89	193	186	302	225.2	18.580	2.621
90	104	190	307	228.8	19.179	3.686
91	73	193	280	232.1	23.073	5.293
92	141	180	321	232.3	26.471	4.369
93	85	183	339	230.8	28.864	6.136
94	113	189	365	228.7	28.703	5.292
95	151	172	310	225.8	27.971	4.461
96	102	183	357	233.2	27.329	5.304
97	44	191	275	228.0	19.583	5.786
98	104	179	308	223.1	25.630	4.926
99	59	195	269	220.8	15.096	3.852
00	56	200	284	235.2	18.827	4.931
01	31	191	319	228.8	23.857	8.398
02	54	173	275	221.4	19.07	5.086
03	21	191	273	229.9	25.541	10.924
04	18	209	284	236.7	24.843	11.477
05	29	180	250	215.6	18.895	6.877
06	33	180	310	224.9	27.66	9.437
07	13	188	270	226.5	26.844	14.592
08	8	206	254	226.1	17.707	12.270
09	5	203	291	244.4	34.797	30.500
10	40	202	288	236.5	22.344	6.924
11	24	198	270	222.7	20.133	8.055

fsTable14. Available weights of the female blue marlin caught by the sport fisheries activities in Pacific Mexican waters form 1987-2011. *Data from 2011 still is preliminary.

FEMALE	BLUE	MARLIN	WEIGHTS	
Año	n	Pmed	s	Conf Int..
87	117	91.87	33.554	6.080
88	74	91.23	36.856	8.397
89	196	101.74	28.409	3.977
90	104	108.808	33.46	6.431
91	72	118.472	37.376	8.633
92	136	112.618	48.212	8.103
93	84	108.464	47.295	10.114
94	105	106.143	51.971	9.941
95	135	101.037	41.734	7.040
96	124	125.387	44.731	7.873
97	44	110.25	27.432	8.105
98	104	98.529	40.398	7.764
99	59	97.203	21.339	5.445
00	57	110.614	32.994	8.565
01	31	107.677	47.444	16.701
02	54	93.778	23.532	6.276
03	21	109.238	41.89	17.916
04	18	117.222	32.394	14.965
05	29	80.759	22.784	8.292
06	33	95.424	49.484	16.883
07	13	93.000	30.537	16.600
08	8	92.75	27.912	19.342
09	5	135.4	65.881	57.746
10	37	110.162	40.147	12.936
11	24	89.583	27.134	10.856

Table 15. Longitudes (Max and Min) of sail fish caught by the sport fisheries activities in Pacific Mexican waters form 1985-2011. *Data from 2011 still is preliminary.

SAIL	FISH	LONGITUDES				
Año	n	Tmin	Tmax	Media	s	Conf. Int.
85	17	183	209	187.294	14.294	6.795
86	45	142	220	191	22.569	6.594
87	33	106	222	187.545	25.384	8.661
88	11	176	215	194.273	12.817	7.574
89	227	154	227	196.289	11.981	1.559
90	242	156	227	196.471	11.868	1.495
91	145	159	224	196.021	12.994	2.115
92	103	150	232	194.835	17.069	3.296
93	87	161	224	195.4	12.831	2.696
94	59	162	223	191.237	13.33	3.401
95	60	158	223	186.45	15.912	4.026
96	28	174	223	193.5	12.983	4.809
97	139	156	222	189.137	12.818	2.131
98	98	161	220	186.602	12.946	2.563
99	18	124	220	186.278	21.152	9.772
00	39	154	211	184.641	13.992	4.391
01	15	164	205	189.533	11.445	5.792
02	19	169	212	191.158	14.112	6.345
03	14	174	220	198.929	12.731	6.669
04	28	157	233	189.857	17.333	6.420
05	24	165	214	190.375	13.367	5.348
06	19	156	213	186.368	16.249	7.306
07	5	163	193	176.4	11.082	9.714
08	17	159	208	190.353	13.62	6.474
09	6	160	201	184.833	14.865	11.894
10	7	181	212	197.429	13.986	10.361
11	21	170	221	190.905	12.498	5.345

Table 16. Median weights (Max and Min) of sail fish caught by the sport fisheries activities in Pacific Mexican waters form 1985-2011. *Data from 2011 still is preliminary.

WEIGHTS	SAIL	FISH		
Año	n	Media	S	Int.Conf.
85	151	29.789	8.354	1.332
86	197	31.471	19.045	2.659
87	35	28.4	11.059	3.664
88	15	28.731	12.817	6.486
89	236	32.322	9.042	1.154
90	225	31.462	5.329	0.696
91	135	32.914	6.269	1.057
92	92	30.198	9.364	1.913
93	74	31.892	7.269	1.656
94	50	30.24	6.678	1.851
95	55	28.436	9.293	2.456
96	27	37.481	9.293	3.505
97	127	30.378	6.694	1.164
98	95	27.168	5.263	1.058
99	18	29.111	11.386	5.260
00	38	26.211	6.564	2.087
01	15	30.267	6.974	3.529
02	19	29.211	6.443	2.897
03	14	33.857	8.17	4.280
04	27	30.852	8.113	3.060
05	23	28.217	7.61	3.110
06	18	26.722	8.18	3.779
07	5	22.4	6.841	5.996
08	17	26.176	4.599	2.186
09	6	25.667	10.231	8.186
10	7	28.574	8.059	5.97
11	21	27.238	5.813	2.486

Table 17. Available lengths of the male sail fish caught by the sport fisheries activities in Pacific Mexican waters form 1987-2011.*Data from 2011 still is preliminary.

MALES	SAIL	FISH	LENGTHS			
Año	n	Tmin	Tmax	Tmed	s	Int.Conf.
87	8	152	197	174.000	13.137	9.103
88	2	175	201	188.000	18.385	25.480
89	70	154	218	194.000	12.326	2.887
90	108	169	227	192.833	11.592	2.186
91	45	159	223	191.068	14.307	4.180
92	36	169	232	193.111	14.723	4.809
93	28	161	214	191.000	13.219	4.896
94	17	162	205	185.000	12.510	5.947
95	26	158	206	179.039	12.334	4.741
96	9	174	195	185.220	7.379	4.821
97	65	164	212	185.877	11.459	2.786
98	56	161	220	183.750	11.803	3.091
99	4	170	202	189.500	14.526	14.235
00	19	161	206	182.000	12.188	5.480
01	7	181	200	191.857	7.290	5.400
02	1	193	193	193.000		
03	6	174	193	187.500	6.892	5.515
04	9	157	206	188.000	16.651	10.878
05	8	170	214	188.375	14.030	9.722
06	6	172	208	189.167	13.630	10.906
07	1	173	173	173.000		
08	4	174	208	191.250	17.727	17.372
09	-	-	-	-	-	-
10	1	182	182	182.000	-	-
11	4	186	186	180.250	7.042	6.901

Table 18. Available weights of the male sail fish caught by the sport fisheries activities in Pacific Mexican Waters form 1987-2011. *Data from 2011 still is preliminary and detailed data from some years is not available.

MALE	SAIL	FISH	WEIGHTS	
Año	n	Pmed	S	Int.Conf.
87	8	21.5	4.751	3.292
88	2	28	7.071	9.800
89	71	31.592	6.95	1.617
90	106	29.264	5.088	0.969
91	42	30.571	8.5	2.571
92	34	27.882	8.903	2.993
93	25	29.44	6.665	2.613
94	16	28.063	6.213	3.044
95	25	24.88	7.801	3.058
96	9	33.778	6.261	4.090
97	63	28.937	5.954	1.470
98	54	26.056	4.973	1.326
99	4	27.25	3.862	3.785
00	19	24.684	4.738	2.130
01	7	29	2.582	1.913
02	1	28	-	-
03	6	27.833	5.536	4.430
04	9	30.778	8.074	5.275
05	7	27.429	7.721	5.720
06	5	26.8	6.34	5.557
07	1	20	-	-
08	4	26.308	4.733	4.638
09	0	-	-	-
10	1	22	-	-
11	4	23.75	3.202	3.138

Table 19. Available lengths of the female sail fish caught by the sport fisheries activities in Pacific Mexican waters form 1987-2011. *Data from 2011 still is preliminary).

FEMALE	SAIL FISH	FISH	LENGHTS			
Año	n	Tmin	Tmax	Tmed	s	Int.Conf.
87	24	142	222	195.458	20.633	8.255
88	15	175	214	195.733	11.841	5.992
89	150	154	227	198.187	11.560	1.850
90	129	165	219	199.256	11.697	2.018
91	97	166	224	198.454	11.803	2.349
92	63	150	230	195.476	18.551	4.581
93	56	165	224	197.714	12.116	3.173
94	40	168	223	194.425	12.914	4.002
95	31	158	223	193.065	15.319	5.393
96	18	177	223	198.333	13.110	6.056
97	68	156	222	193.044	13.349	3.173
98	42	165	216	190.405	13.554	4.099
99	14	124	220	185.357	23.070	12.085
00	20	154	211	187.150	15.401	6.750
01	8	164	205	187.500	14.363	9.953
02	18	169	212	191.056	14.514	6.705
03	8	196	220	207.500	8.435	5.845
04	19	160	233	190.737	18.024	8.104
05	16	165	209	191.375	13.376	6.554
06	13	156	213	185.077	17.689	9.616
07	4	163	193	177.250	12.354	12.107
08	13	159	208	190.077	12.977	7.054
09	6	160	201	184.833	14.865	11.894
10	6	181	212	200.000	13.387	10.712
11	17	175	221	193.412	12.283	5.839

Table 20. Available weights of the female sail fish caught by the sport fisheries activities in Pacific Mexican waters form 1987-2011. *Data from 2011 still is preliminary.

FEMALE	SAIL	FISH	WEIGHTS	
Año	n	Pmed	s	Int.Conf.
87	24	32.083	10.782	4.314
88	15	30.6	5.552	2.810
89	152	33.684	6.512	1.035
90	126	32.071	5.396	0.942
91	95	32.084	5.414	1.089
92	60	31.65	9.589	2.426
93	49	33.143	7.309	2.046
94	34	31.265	6.73	2.262
95	29	31.931	9.215	3.354
96	18	39.333	10.238	4.730
97	64	31.797	7.114	1.743
98	41	28.634	5.333	1.632
99	14	29.643	12.834	6.723
00	19	27.737	7.823	3.518
01	8	31.375	9.41	6.521
02	18	29.278	6.623	3.060
03	8	38.375	6.844	4.743
04	18	30.889	8.366	3.865
05	16	28.563	7.789	3.817
06	13	26.692	9.022	4.904
07	4	23	7.746	7.591
08	13	26.308	4.733	2.573
09	6	25.667	10.231	8.186
10	6	29.667	8.238	6.592
11	17	28.059	6.046	2.874

Table 21. Longitudes (Max and Min) of black marlin caught by the sport fisheries activities in Pacific Mexican waters form 1987-2011. Detailed data from some years is not available.

BLACK	MARLIN	LONGITUDES				
Año	n	Tmin	Tmax	Media	s	Int.Conf.
87	1	208	208	208	-	-
88	5	210	261	231.6	25.56	22.404
89	4	204	260	235.25	23.258	22.792
90	3	246	272	259.333	13.013	14.725
91	1	270	270	270	-	-
92	2	194	198	196	2.828	3.919
93	7	183	272	214	27.923	20.685
94	3	219	295	257.667	38.018	43.021
95	4	206	279	235.25	31.127	30.504
96	8	216	321	281.5	32.807	22.734
97	1	220	220	220	-	-
98	1	214	214	214	-	-
99	4	202	283	253.5	35.949	35.229
00	1	192	192	192	-	-
01	1	288	288	288	-	-
02	-	-	-	-	-	-
03	-	-	-	-	-	-
04	1	226	226	226	-	-
05	-	-	-	-	-	-
06	1	196	196	196	-	-
07	-	-	-	-	-	-
08	-	-	-	-	-	-
09	-	-	-	-	-	-
10	2	263	277	270	9.9	13.720
11	-	-	-	-	-	-

Table 22. Weights (Max and Min) of black marlin caught by the sport fisheries activities in Pacific Mexican waters form 1987-2011. Detailed data from some years is not available.

BLACK	MARLIN	WEIGHTS		
Año	n	Media	s	Int.Conf.
87	1	98	-	-
88	5	108.8	33.395	29.271
89	4	122	25.528	25.017
90	4	180.5	24.31	23.823
91	1	184	-	-
92	2	60	0	-
93	7	84.857	33.652	24.929
94	3	198.333	140.301	158.763
95	4	134	70.347	68.939
96	8	193.5	45.925	31.824
97	1	105	-	-
98	1	127	-	-
99	4	170	66.833	65.495
00	1	65	-	-
01	1	272	-	-
02	-	-	-	-
03	-	-	-	-
04	1	118	-	-
05	-	-	-	-
06	1	72	-	-
07	-	-	-	-
08	-	-	-	-
09	-	-	-	-
10	2	170	16.971	23.520
11	-	-	-	-

Table 23. Available lengths of the male black marlin_caught by the sport fisheries activities in Pacific Mexican waters form 1992-1993 and1995. Detailed data from more recent years is not available.

MALES	BLACK	MARLIN	LENGTHS			
Año	n	Tmin	Tmax	Tmed	s	Conf. Int.
92	1	198	198	198.000	-	-
93	4	183	212	201.250	13.251	12.986
94	-	-	-	-	-	-
95	2	206	232	219.000	18.385	25.480

Table 24. Available lengths of the female black marlin caught by the sport fisheries activities in Pacific Mexican waters form 1988-2011. Detailed data from some years is not available.

FEMALES	BLACK	MARLIN	LENGTHS			
Año	n	Tmin	Tmax	Tmed	s	Int.Conf.
88	1	215	215	215.000		
89	4	204	260	235.250	23.258	22.792
90	3	246	272	259.333	13.013	14.725
91	1	270	270	270.000		
92	1	194	194	194.000		
93	3	203	272	231.000	36.290	41.065
94	3	219	295	257.667	38.018	43.021
95	2	224	279	251.500	38.891	53.899
96	8	216	321	281.500	32.807	22.734
97	1	220	220	220.000		
98	1	214	214	214.000		
99	4	202	283	253.500	35.949	35.229
00	1	192	192	192.000		
01	1	288	288	288.000		
02						
03						
04	1	226	226	226.000		
05						
06	1	196	196	196.000		
07						
08						
09						
10	2	263	277	270	9.9	13.720
11						

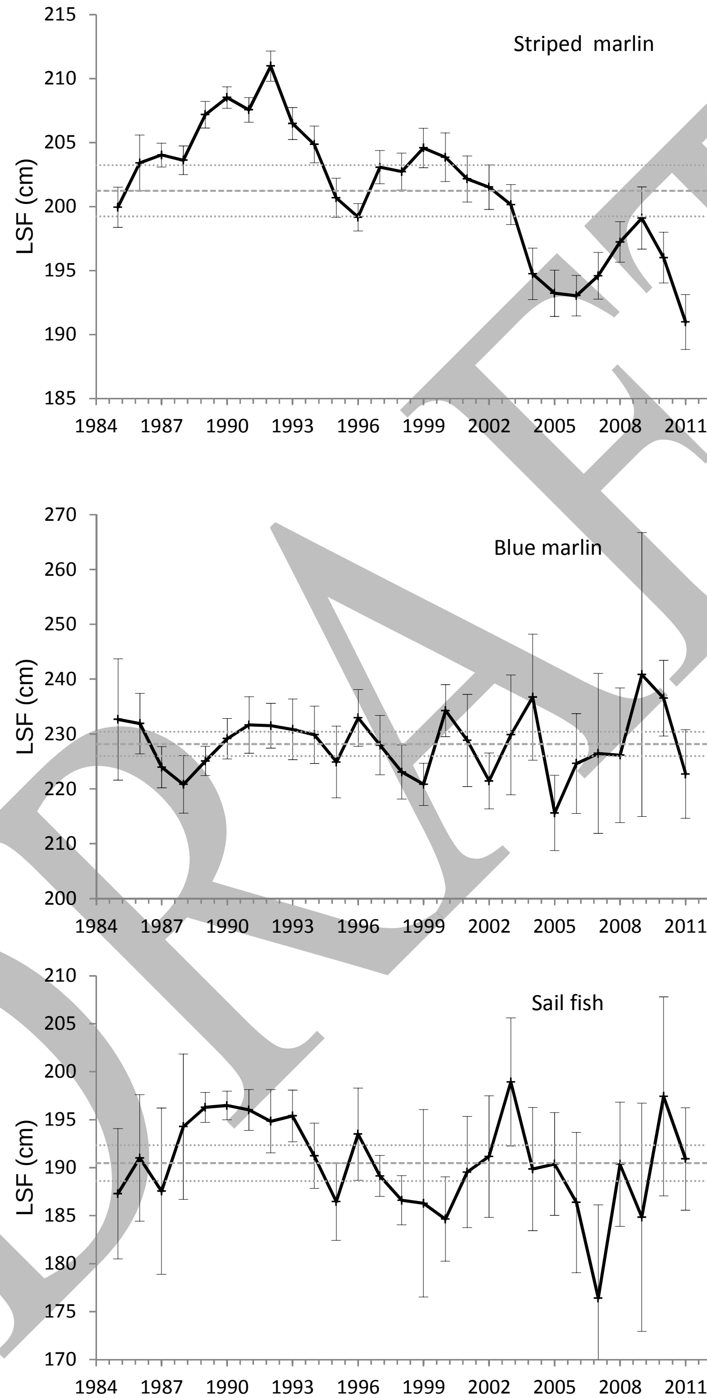

Fig. 3. Longitudes from <u>lower jaw to fork</u> of the different species of billfishes caught in the sport fisheries operations from 1985-2011.

Tables 25 and 26 shows for data on catch and release data derived from the sport fishery at the two main fishing areas of Mexico. This data encompass 10 years of monitoring the comparative analysis between the catch and release rates reported by the fleets and the data collected directly by the SFMP-INAPESCA-CRIP-LA PAZ from 1998-2008. The overall average from both sources combined is of **78.25%.** However, the fleets reported separately and average of 80.19% and respectively, the monitored data 75.62% for los Cabos area. For los Barriles the reported rate by the fleets was higher 81.42%. At the present there is not information on the survival rate of the fish released. With this information Figure 4 is constructed and it shows, the tendency of the fleets data to report a little higher than the sampling data collected directly during the monitoring operations.

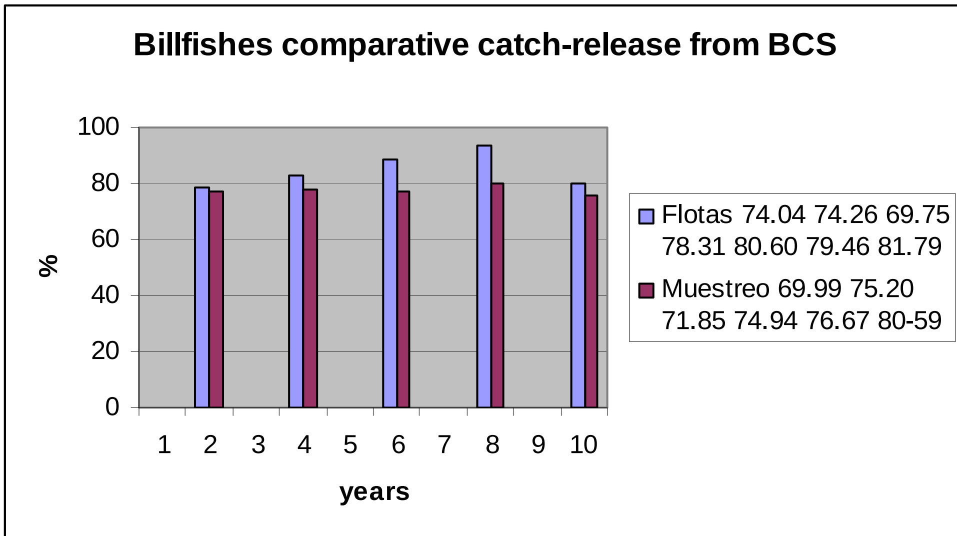

Fig. 4 Comparative catch and release rates for the different billfishes caught in the Los Cabos, BCS, Mexico from 1998-2008. (Fleet data compared with monitored data).

Table 25. Comparative catch and release rates for the different billfishes caught in Los Cabos, BCS, Mexico from 1998-2011.

	Cabo San Lucas						
Año	Fuente	*M. Rayado*	*M. Azul*	*P. Vela*	*M. Negro*	*P.Espada*	Total
1998	Rep Flotas	76.10	39.87	74.97	12.50	28.57	74.04
1999	Rep Flotas	76.49	59.90	74.17	31.25	23.53	74.26
	Muestreo	72.42	51.97	70.83	33.33	33.33	69.99
2000	Rep Flotas	72.59	35.66	72.44	32.26	25.00	69.75
	Muestreo	77.26	29.07	83.51	0.00	0.00	75.20
2001	Rep Flotas	80.32	59.12	74.58	80.00	0.00	78.31
	Muestreo	72.98	43.86	78.08	50.00	0.00	71.85
2002	Rep Flotas	82.22	63.91	75.13	50.00	0.00	80.60
	Muestreo	78.01	33.71	61.54	0.00	0.00	74.94
2003	Rep Flotas	80.91	56.84	72.69	22.22	60.00	79.46
	Muestreo	77.98	8.33	53.13	0.00	100.00	76.67
2004	Rep Flotas	82.54	60.45	84.29	41.67	14.29	81.79
	Muestreo	82.47	28.00	54.84	0.00	0.00	80.59
2005	Rep Flotas	79.01	65.63	80.14	62.50	27.27	78.59
	Muestreo	79.42	27.66	51.43	0.00	0.00	77.47
2006	Rep Flotas	84.87	48.20	77.54	41.18	0.00	83.08
	Muestreo	79.01	51.39	65.67	0.00	0.00	77.90
2007	Rep Flotas	88.82	63.49	91.40	66.67	50.00	88.63
	Muestreo	76.92	54.17	78.26	0.00	0.00	76.80
2008	Rep Flotas	93.98	64.44	86.90	0.00	40.00	93.59
	Muestreo	79.74	74.07	82.61	0.00	0.00	79.74
2009	Rep Flotas	90.77	54.31	75.45	33.33	0.00	89.77
	Muestreo	81.49	46.34	69.79	0.00	0.00	80.62
2010	Rep Flotas	89.15	84.18	89.07	66.67	0.00	88.90
	Muestreo	73.30	43.86	62.16	0.00	0.00	72.27
2011	Rep Flotas	79.40	58.56	88.10	0.00	33.33	79.23
	Muestreo	78.69	25.81	63.93	100.00	---	76.34

Table 26. Comparative catch and release rates for the different billfishes caught in Los Barriles, BCS, Mexico, from 1998-2011.

	Buena Vista						
Año	**Fuente**	***M. Rayado***	***M. Azul***	***P. Vela***	***M. Negro***	***P.Espada***	**Total**
1998	Rep Flotas	78.18	63.54	89.02	10.00	0.00	79.46
1999	Rep Flotas	76.17	66.67	87.60	20.00	11.11	78.02
2000	Rep Flotas	80.28	67.15	93.19	66.67	0.00	84.78
2001	Rep Flotas	77.19	65.28	89.70	14.29	0.00	80.02
2002	Rep Flotas	82.01	59.54	76.95	100.00	0.00	79.27
2003	Rep Flotas	79.27	65.69	89.31	54.55	0.00	81.78
2004	Rep Flotas	81.62	66.21	91.40	50.00	100.00	83.59
2005	Rep Flotas	85.95	66.33	86.67	66.67	0.00	85.36
2006	Rep Flotas	80.95	71.15	89.15	85.71	0.00	81.99
2007	Rep Flotas	84.02	63.37	95.00	50.00	0.00	84.14
2008	Rep Flotas	76.12	45.65	85.26	100.00	0.00	77.25
2009	Rep Flotas	71.92	63.64	88.36	0.00	0.00	77.80
2010	Rep Flotas	87.04	100.00	82.14	-	-	85.88
2011		75.44	54.29	86.03	100.00	50.00	78.32

Appendix 7. Rapporteur's notes on the July 14-15 2013 ISC Billfish Working Group Meeting.

ISC/13/BILLWG-2 Meeting Rapporteur's Notes
July 14, 2013

General Comments
The ISC/13/BILLWG-2 meeting in Busan, Korea was called to order by the chairman, Dr. Jon Brodziak of the US National Marine Fisheries Service, at 10:00 h on July 14, 2013. Scientists from Japan, Korea, Mexico, Taiwan and the United States were in attendance.
William A. Walsh was chosen to serve as the session rapporteur. Lennon R. Thomas transcribed revisions to a draft version of an Executive Summary of the May 2013 BILLWG meeting as it was discussed by the BILLWG. The Chairman expressed his appreciation to both individuals.

Introductory Remarks
The Chairman greeted the attendees and asked all present to introduce themselves by name and affiliation. The Chairman then stated that the Northern Committee of the Western and Central Pacific Fisheries Commission (NC), the Western and Central Pacific Fisheries Commission (WCPFC), and possibly the Western and Central Pacific Regional Fishery Management Council (WCPRFMC) are likely to benefit from the efforts of the BILLWG. The Chairman added that reviews of past work will be appended to the May 2013 BILLWG meeting report.

Scope of the Discussion
The Chairman described the general areas to be discussed. These included reviews of swordfish *Xiphias gladius* projections and the Pacific blue marlin *Makaira nigricans* stock assessment, including its projections, preparation for the ISC Plenary meeting, and reviews of previously formulated conservation advice for swordfish and striped marlin *Kajikia audax*. Conservation advice for either or both species is to be updated if necessary.

Meeting Protocols and Logistics
The Chairman requested submission of abstracts from new documents by 17:00 h on July 15. Abstracts submitted after this deadline will be held in abeyance until the next BILLWG meeting. The Chairman reported that there is no URL for this meeting. Hence, file transfers must be performed via email or with flash drives.
The Chairman reminded all participants of the importance of following certain rules of order. These included adherence to the scientific method, emphasis upon empirical testing, open and respectful discussion without *ad hominem* attacks and avoidance of unnecessary distractions.

Agenda
The Chairman presented the Agenda to the participants. There were no objections raised or apparent confusion concerning the scope or purpose of work.

Swordfish Catch Data and Projections
A working paper by Jon Brodziak addressed a request from the NC to conduct stock projections for the Western and Central Pacific Ocean (WCPO) stock of swordfish under several scenarios defined by ranges of harvest rates and biological reference points. It was noted that catch data from Korea were not included in the updated estimates of the swordfish catch biomass in 2007–

2012. Nonetheless, the Chairman opined that Korean participation in the BILLWG activities was a very positive development and encouraged a continuing involvement. In addition, it was stated by C.-L. Sun that preliminary catch data for Taiwan are provided in the National Report, but these data are aggregated into 5°×5° squares rather than the sub-areas used by other nations and the Inter-American Tropical Tuna Commission (IATTC) for their data submissions. The author explained the use of ratios to complete the catch biomass table so as to complete the projections (see Tables 1.1 and 1.2).

The long-term (1951–2012) catch history for WCPO swordfish indicated that the catch biomass and harvest rates have usually remained below the MSY and H_{MSY} levels, respectively, whereas the estimates of exploitable biomass have usually remained above the B_{MSY} level.
The projections indicated that catch biomass would decrease by about one-half between 2013 and 2017 at 150% of H_{MSY} and by about one-third if the average harvest rate from 2009–2012 was maintained. Harvest rates of 50% and 75% of H_{MSY} were projected to result in stable catch biomass below that at H_{MSY}. Conversely, exploitable biomass at 50% and 75% of H_{MSY} remained above the H_{MSY} levels. Finally, the probability of biomass depletion was very low at 50% and 75% of H_{MSY} (ca. 10%), but exceeded 90% at 150% of H_{MSY} and was approximately 40% at H_{MSY}. It was noteworthy that the projection results obtained with the 3-year average and the 125% of the H_{MSY} level were nearly identical.

A question was raised about the decrease in the USA 2012 catch in subarea 1. The Chairman explained that the limit for interactions with protected sea turtles was exceeded in 2012, which led to a closure of the shallow-set sector of the Hawaii-based longline fishery.

A second question was raised about the necessity for a new swordfish stock assessment in 2014 in light of the ongoing but as yet incomplete recovery of the Japanese fisheries from the effects of the 2011 East Japan Earthquake and Tsunami. The Chairman agreed that this was a reasonable question, especially because certain other billfishes (e.g., shortbill spearfish *Tetrapturus audax*; black marlin *Istiompax indica*) have never been assessed. Because there is no requirement for assessments to be conducted at 3-year intervals, it was agreed to present this matter to the Plenary Session for consideration.

<u>Blue Marlin Catch Projections</u>
A series of deterministic projections were computed with the Stock Synthesis model. The projections were expected to be comparable to the stock assessment results, which were generated for multiple fleets and seasons, and with size- and age-specific selectivities.
The numbers alive at specific ages in the terminal year were of interest. The spawner/recruit relationship was used to obtain the estimates. The harvest scenarios involved use of four levels of fishing mortality (F) from 2012 to 2020. Results indicated that spawning stock biomass would remain above S_{BMSY} at the current F (23%). A slight decline in spawning stock biomass below MSY by 2015 was projected at the average F from 2003–2005. The spawning stock biomass at MSY was estimated to be 19,437 mt.

A request was made for further evaluation of the projected harvest at the highest fishing intensity. This would compare results to the 2020 B_{MSY} level.

The discussion considered whether the projections were realistic and useful. It was stated that blue marlin is essentially a bycatch species in longline fisheries so it is difficult to control effort. There was additional discussion concerning the use of the spawning potential ratio (SPR) or 1-SPR to express the status. The Chairman stated that 1-SPR is often used because it may be more comprehensible to stakeholders than the SPR itself.

A draft Executive Summary was also reviewed by the BILLWG. It was stated by the Chairman that Conservation Advice and Projection Tables would be added. The Chairman added that some graphs could be developed from the projections. Although the content would come from the tables, facilitating comprehension of results among stakeholders would justify such repetition. The BILLWG then went through the draft Executive Summary sentence by sentence. Changes were incorporated by Ms. Thomas. Most changes were minor and editorial in nature.
The BILLWG discussed whether to use 5- or 3-year averages or the most recent year as a point estimate to represent the current situation. There was additional discussion of the projections and a table to summarize results was described.
The session ended after reviewing the work needed to complete the Executive Summary.

ISC/13/BILLWG-2 Meeting
July 15, 2013

Swordfish Stock Structure

The Chairman initiated a discussion of swordfish stock structure in the Pacific Ocean in response to a request from Dr. Michael Hinton, IATTC representative to the ISC. There were no recent working papers submitted to the BILLWG addressing this matter. Instead, the discussion focused on an ISC working paper from 2009 (Courtney & Wagatsuma, ISC/09/BILLWG-2/1), and earlier papers by Kume and Joseph (1969), Hinton and D'Eriso (1998) and Hinton (2003). The underlying question is whether the swordfish stock should be considered as a single panmictic stock or two stocks as indicated by catch per unit effort analyses and population genetics. Examination of catch maps from these documents did not provide unambiguous indications of stock boundaries. The maps suggested that there is some mixing of fish across the equator.
The current southern boundary under the two-stock hypothesis is 20°S. The Chairman asked whether the evidence supported a northward boundary shift to 5°S or the equator. One response was that if the southern boundary were to be changed, it might actually be preferable to move it southward as far as 40°S or 45°S.

The discussion then proceeded in light of possible geographical overlap between the IATTC and ISC and the desire to avoid duplication of effort. It was agreed by the BILLWG to raise this matter at the Plenary Session in light of limited resources and the breadth of responsibilities.
The Chairman summed up the discussion by stating that there was no convincing information to warrant a boundary change. It was then suggested and agreed that the Mexican delegation might present some recommendations because of their close proximity to sub-area 2.

Data Submission from Mexico

A document containing numerous figures and tables summarizing recreational effort and catches of five billfishes (swordfish, blue marlin, striped marlin, black marlin, sailfish) from 1990 through 2011 was submitted by the Mexican delegation and reviewed by the BILLWG. The Chairman noted that the data were sex-specific and this was very positive. Another noteworthy feature of the data was a correction for release vs. retention based upon the work of fishery observers. A question was raised as to whether the sizes of retained and released billfishes were comparable; the Mexican delegation committee to checking on this matter in the near future. Another question was raised about the availability of weight data. This appears to be nearly complete, and this was also regarded as positive by the BILLWG. The data were then discussed from the perspective of the needs of the STATWG. It appeared that the Mexican data might be readily convertible to summary forms that would meet the international requirements. Finally, the Mexican delegation requested some formal recognition of their contribution because their agency is undergoing reorganization. The Chairman agreed that this request was appropriate, and suggested that the document might be added in its entirety as an appendix to the May 2013 report. The Mexican delegation expressed their satisfaction and reiterated a strong interest in cooperation and participation.

Final Review of the Executive Summary

The principal result of the review of the main body of the document was addition of an extra figure to improve clarity for stakeholders. There was also some discussion of the fishing mortality levels chosen for the blue marlin projections. The remaining changes in the blue marlin section were minor edits.

The most recent conservation advice was also reviewed. In keeping with the earlier comments about avoidance of effort duplication with the IATTC, the advice was abridged to refer exclusively to the WCPO stock.
The most recent conservation advice for striped marlin was also reviewed. The Chairman stated that the comments from this meeting would be titled “Conservation Information” because the WCPFC passed a separate management measure for striped marlin in 2010. The overall trend in the results was that a reduction in fishing mortality would be expected to lead to increased recruitment.

Data Revision for Taiwan

The 2012 swordfish catch biomass taken by Taiwan in sub-areas 1 and 2 were provided today by C.-L. Sun. The catches were 4,414 mt in subarea1 and 1,084 mt in subarea 2.

Other Business

The Chairman raised the possibility of holding another intercessional meeting. The next expected BILLWG meeting is likely to be held in February 2014, possibly in Hawaii.

Adjournment

The documents as well as summary notes describing the discussions and analyses conducted during this meeting will be added to the May 2013 BILLWG report as an appendix. There will be no separate report from this meeting.