REPORT OF THE 2018 ICCAT BLUE MARLIN STOCK ASSESSMENT MEETING

(Miami, United States, 18-22 June 2018)

1. Opening, adoption of agenda and meeting arrangements

The meeting was held at the Rosenstiel School of Marine Science, Cooperative Institute of Marine and Atmospheric Studies, at the University of Miami, from 18 to 22 June 2018. Fambaye Ngom (Senegal), the Species Group ("the Group") rapporteur and meeting Chair, opened the meeting and welcomed participants. Dr Miguel Neves dos Santos (ICCAT Assistant Executive Secretary) adressed the Group on behalf of the ICCAT Executive Secretary, welcomed the participants and thanked the United States for hosting the meeting and Dr David Die for making all the necessary local arramegements. He also highlighted the importance of the meeting, since blue marlin is one of the two stocks being assessed in 2018 and with a rebuilding plan in place. The Chair proceeded to review the Agenda, which was adopted with a few minor changes (**Appendix 1**).

The List of Participants is included in **Appendix 2**. The List of Documents presented at the meeting is attached as **Appendix 3**. The abstracts of all SCRS documents presented at the meeting are included in **Appendix 4**. The following served as rapporteurs:

Sections	*Rapporteur*
Items 1, 9	M. Neves dos Santos
Item 2.1	M. Ortiz
Item 2.2	D. Die
Item 2.3	J. Hoolihan
Item 2.4	M. Lauretta
Item 2.5	A. Norelli, B. Gibbs
Item 3.1	M. Lauretta, B. Mourato
Item 3.2, 3.3	M. Lauretta, D. Die
Item 4.1	M. Lauretta, B. Mourato
Item 4.2, 4.3	M. Schirripa
Item 5	M. Schirripa, B. Mourato, M. Ortiz
Item 6	F. Sow, D. Die
Item 7	F. Arocha, D. Die
Item 8	D. Die, M. Neves dos Santos

2. Summary of updated data submitted after the Data Preparatory meeting, before the assessment data deadline

2.1 Catches

The Secretariat presented the latest version of the Task I NC for blue marlin as of 13 June 2018 (**Table 1** and **Figure 1**). The 2017 reporting catches of blue marlin were very preliminary; thus, the Group decided that for the projections the catches of 2016 should be carried over for 2017 and 2018.

The Group looked at the recent catches of blue marlin reported by Morocco that have increased from an average of 10 t in 2010-2016 to 82 t in 2017.

The Group questioned why the reports of dead discards have not increased and or being reported by more CPCs, while the total reported landings have decreased in recent years likely reflecting the implementation of recent regulations regarding retention of billfish species. It was noted that in order to produce an unbiased estimate of fish discarded dead an observer on board is usually required, and studies of post-release mortality are needed to further improve estimates of total discard mortality. Therefore, the Group reiterates the importance f complying with observer coverage and reporting of billfish species by CPCs, both live releases and dead discards.

2.2 Indices of abundance

During the 2018 Blue Marlin Data Preparatory meeting, Anon. (in press) the Group reviewed all updated indices presented to the meeting and the historical ones available. Twelve indices of abundance were agreed to be appropriate for use in the assessment (Tables 13 and 14 of the Report of the 2018 ICCAT Blue Marlin Data Prepartory Meeting): Japan LL, Chinese Taipei LL (early, mid and late), US LL, Ven LL, Bra LL, US Rec, Bra Rec, Ven Rec, Ven Gill, Gha Gill. These indices were all used in the initial runs for SS3, JABBA and ASPIC, presented during the assessment meeting.

The Group noted that some of these indices sometimes represent conflicting trends in relative biomass. It was mentioned that in the past the SCRS has recommended to develop alternative hypotheses about how to select and assign weight to the indices. For instance correlation matrices between indices have been used to establish sets of indices without conflicting trends as plausible scenarios. This method has in the past been promoted to avoid fits to indices that go through the middle of conflicting trends. This assumes that a better representation of the uncertainty is provided by fitting different sets of indices than by using all indices. Similarly, it was proposed that indices should be grouped by gear type, as it is expected that individual gear types may have more consistent selectivity than groups of indices which include all gear types. Proposals for a set of all longline indices and for a set of recreational indices were presented to the Group and partially adopted by modelers as ways to develop sensitivity trials for the production models. The Group objected to the suggestion of developing alternative hypotheses of stock status on the basis of such groupings and preferred to settle on a base case set of indices. Proponents of such approach argued that it is difficult for the Commission to interpret results with strongly different perceptions of stock status and that it is better to integrate uncertainty in one single set of results.

It was pointed out repeatedly that it was best to select indices prior to running assessment models. Eliminating indices on the basis of assessment model diagnostics should be avoided. It is better to retain indices unless justification could be provided regarding the possible presence of biases in the indices. The presence of such possible biases was discussed in regard to the late Chinese Taipei LL index and the USA recreational index. The Group heard from developers of the index at the data preparatory meeting that the Chinese Taipei LL late may be affected by changes in operations during the period when ICCAT introduced the requirement of reducing catches of BUM and releasing live marlins caught in longlines. The Group also noted that the US recreational index may have unknown biases related to changes in operations of fishing tournaments caused by the pressure to change from all catch to all release practices.

At the data preparatory meeting the Group had also agreed to use the standard errors from the CPUE standardized series as weights in the assessment models. Furthermore for SS3 it was agreed that when such standard errors were deemed small and suggested overly precise indices, that a minimum standard error of 0.3 would be given to the index. The Group discussed that in the past other options for weights had also been used, including, equal weighting, area weighting and catch weighting. It was pointed out that area and catch weighting often provide similar fits to the model because such weights are often highly correlated. Ultimately, the Group decided to only use the agreed standard errors in all assessment model runs.

2.3 Biology

SCRS/2018/089 described the catch and biological aspects of blue marlin by-catch from the Mexican LL fishery operating in the Gulf of Mexico during 2013-2016. Distributions of lengths, length-weight relationships, and sex ratio were analyzed. The proportions of sex showed a predominance of males. A total of 4,286 males and 2,433 females were analyzed. The observed maximum length and weight for males were 367 cm LJFL and 292 kg, and 283 cm LJFL and 280 kg for females. Length distributions were evaluated for modal trends that may infer age classes.

The Group expressed some concern that the data reflected that males reached larger sizes than females, which contradicts the current knowledge of this species. The Group requested photographic and biological sampling to confirm sex determination.

Estimating blue marlin growth was addressed in SCRS/P/2018/038 with the objective of describing how sampling protocols may misinform and bias growth models. When considering size and age observations, age assignment is more prone to error than size. However, the relevant error for size is manifested in the mean size at age – an aggregate property of the entire sample. The effects of size-selective sampling biases on estimates of mean size at age and the estimation of the von Bertalanffy (VB) growth parameters were evaluated using simulated growth data. The results of the simulation analyses showed that random and age-stratified sampling provided unbiased estimates of mean size at age and VB parameters. In contrast, sampling strategies that involved collection of size-stratified data or mixtures of random samples supplemented with large individuals strongly biased mean sizes upwards with increasing age. $L\infty$ estimates were also biased upwards while VB k were biased downwards, and the magnitude of the biases can be substantial. Estimates of $L\infty$ derived from blue marlin from the Pacific Ocean are higher than for those values used to represent growth in the Atlantic in previous ICCAT reports, but this difference is smaller compared with the range of the bias observed in the simulation analyses. It is impossible to know the extent to which bias or random sampling error may have in the past affected blue marlin growth estimates available for derivative analyses. Accordingly, while available growth estimates provide guidance they should not overly constrain assessment analyses.

Progress on age and growth analyses for blue marlin from the Venezuelan longline and artisanal fisheries were presented at the 2018 Data Preparatory meeting (Anon. in press). It was noted that maximum ages determined for males and females were 31.3 and 36.7, respectively. At that time the spine samples from the larger individuals had not been completed. Those individuals have now been aged, however it was determined that there were potential sex assignment errors for a group of approximately 300 individuals sampled during 2003-04. The field data sheets needed to validate the sex IDs will not be available until September 2018. For this reason, the researchers questioned the validity of the data and decided not to include the estimated growth in the 2018 stock assessment, however retained the maximum age (37 yrs) for estimating natural mortality parameters.

The Group agreed to use the size at age estimates suggested by Shimose *et al.* (2015) and Goodyear (2015) for the 2018 blue marlin stock assessment analyses. The Group also agreed to test the following natural mortality rates: M = 0.139 (30 yrs) for continuity testing with 2011 assessment (Hoenig, 1983); M = 0.122 (37 yrs) and M = 0.100 (45 yrs) for sensitivity testing (Hewitt and Hoenig, 2005).

2.4 Length compositions

The Group reviewed the length composition data presented at the Data Preparatory meeting. The size frequency samples were extracted from the blue marlin size data, aggregated for the fleet-structured of the SS model, year and main gear type (ART, LL, RR, mFAD). A minimum of 50 measured fish was imposed for a given strata size frequency and a minimum of 5 years of size sampling per fleet/fishery. In addition, size data from some artisanal fleets that have been recently provided were excluded as their size frequency substantially departs from other similar fleets in the western Africa region, and doubts were raised considering species identification. Effective sample size for the SS model was adjusted to the *log* of number of fish measured and scaled to a maximum of 100. Based on the evaluation of the length data, the longline and recreational fleet selectivities were assumed to be asymptotic for parameterization of the SS model. Distinct shifts in the size compositions of the catch of the recreational fleets were discussed, as this presents a potential shift in fleet retention.

The Group determined that time-blocking selectivity in SS between the periods showing different length composition was warranted.

The Group asked about the information from the Chinese Taipei size data, which for other species in the past have shown a sharp cutoff of sampled sizes below minimum size regulations. The Secretariat informed that after the Data Preparatory meeting this was addressed by the Chinese Taipei scientists that revised the data submitted and corrected size information based on the observer program data and updated size data was included in the length composition information provided to the Group.

2.5 Other relevant data

A presentation was given (SCRS/P/2018/039) that summarized the Caribbean Billfish Project as regards achievements and developing plans. Grenada and the Dominican Republic were used as pilot test countries for the Caribbean Billfish Project. Both of these countries landed substantially larger amounts of billfish relative to other Caribbean nations, yet their numbers were largely unreported to ICCAT. The fishing culture also varied between the two countries as Grenada has primarily longline fisheries while the Dominican Republic maintains primarily recreational and artisanal fisheries.

The Group discussed the socio-economic aspects of the Caribbean Billfish Project including a willingness to pay study (an economic valuation method based on how much the user is willing to pay for an additional fish). Noting that American sport fishermen responded the most to the willingness to pay surveys conducted in the Dominican Republic and generally expressed interest in government issued billfish licenses. The Group expressed interest in future collaborations with the economic experts of the Caribbean Billfish Project in the Caribbean to increase interdisciplinary studies like these.

The Group was informed that since Grenada has become a member of ICCAT, an improvement regarding the provision of billfish statistics is expected. In some cases some countries have previously reported some of these statistics to the FAO but not to ICCAT. It was noted that including more Caribbean countries in ICCAT discussions would encourage more reporting by the region on exploited species. Many countries have willing scientists capable of compiling the data and completing analyses. However, a lack of incentive and necessary software prevented effective and complete reporting. In addition, while many Caribbean nations are able to record fisheries data by hand, this method is inefficient and therefore it was noted the need to make available software because it must be coordinated with regional databases prepared by WECAFC for the digital records required for modern billfish analysis.

Finally, the Group was informed that the main issue with propelling the Caribbean Billfish Project forward is the lack of funds, from external or government sources, to properly outfit all Caribbean nations with the proper tools.

3. Methods relevant to the assessment

3.1 Production models

Two surplus assessment models (SPM) were applied to the time series of blue marlin landings and indices, ASPIC and JABBA. The development of prior distributions on population growth rate (r) for the Bayesian surplus production models (JABBA/ASPIC) was based on an algorithm developed by Winker *et al.* in SCRS/2018/092.

The approach applied an age-structured equilibrium model to translate the set of life history parameters (growth, natural mortality, maturity, stock recruitment steepness) selected for the Stock Synthesis (SS) model into a functional distribution of r (fitted gamma distribution). The effects of key input parameters, natural mortality M and the steepness h of the spawning recruitment relationship, on the SPM parameters r and m were demonstrated. The functional form of a yield curve for an age- and sex-structured assessment model (e.g., SS) can be closely approximated by the two-parameter Pella surplus production curve. Based on the three steepness scenarios modeled (h = 0.4, h = 0.5 and h = 0.6) and including uncertainty about M, three sets of priors for r were estimated for the SPMs. Lognormal distributions were then fitted to the estimated gamma distributions for input into JABBA.

Document SCRS/2018/091 presented preliminary results and the model formulation of the blue marlin assessment using the JABBA surplus production model (for details see **Appendix 5**).

For the JABBA model additional runs were requested by the Group (SCRS/P/2018/042), based on sensitivity analysis (**Figure 2**), which includes:

- **S1_All -** a base case model (h = 0.5 with r prior fitted by a lognormal distribution with mean 0.098 and standard deviation of 0.18), including all CPUE series;
- **S2_drop2 -** same r prior (h = 0.5), excluding TAI-LL late and US-Rec and;
- **S3_LL -** same r prior (h= 0.5), using all longline CPUE indices, excluding all TAI-LL CPUE series.

The ASPIC model used in the previous assessment was updated with the revised time series to develop a continuity run. The continuity model included 10 indices; Chinese Taipei early and mid-series were joined into one series, and the Chinese Taipei late series was excluded. An updated ASPIC (ver 7.0) model was then developed to include the 12 indices selected at the data prep meeting, as well as to allow for the inclusion of priors on estimated parameters. The base parameterization of ASPIC7 included the following assumptions: B1/K fixed at 1, Schaeffer logistic production curve assumed, and included an uninformative prior on *r* (uniform distribution from 0.01 to 1). The estimated parameters were *r*, *MSY*, and fleet specific catchabilities (*q*, 12 parameters).

3.2 Length-based age-structured models: Stock Synthesis

Document SCRS/2018/097 provided a description of the provisional Stock Synthesis (SS) parameterization and results.

The Group reviewed the SS set-up, diagnostics, and sensitivities and recommended several additional sensitivities of the SS model, including: 1) removing the USA RR and CTP LL late period series (which were shown in the jackknife and each have a strong influence on model results and concern over index representativeness; see section 2.2); 2) exclusion of CPUE series that start after 2008 (to explore the influence of removing those series on the model retrospective pattern, **Figure 3**), and estimation of natural mortality and steepness. In particular, the Group discussed the model retrospective pattern in detail which indicated that trends in stock biomass changed with each additional year of data added from 2009 to 2016 (**Figure 3**). Many configurations of SS were explored to identify the cause of the retrospective pattern. None of the model treatments removed the retrospective pattern in the recent period. However, removal of the two aforementioned indices demonstrated improved stability in the estimates of historical biomass.

The Group determined that the SS base case model would remove both the USA rod & reel CPUE and the Chinese Taipei late series, use a lower length at 50% maturity of 206 cm LJFL, and estimate both M and h. The base SS model configuration included five fleets: (1) artisanal-gillnet, (2) longline, (3) purse seine, (4) rod & reel, and (5) Fish Aggregation Device (FAD) fleet. The range of observational data used in the base model is shown in **Figure 4**.

3.3 Other methods

A simulation study that explored using maximum size based metrics in respect to various levels of fishing mortality was presented (Goodman, 2015). The method is based on the principle that the size distribution of the catch is an important characteristic of a population considered in stock assessments. The mean and maximum sizes are readily understood indicators of population health. The mean is clearly defined and easily understood, but properties of the maximum make it a less suitable reference parameter to be included in stock assessments. NZ50 is the smallest number of observations which will include fish ≥ a defined large threshold half the time. The concept is extended to define LNZ50,N, the smallest maximum length (L) expected in half of sets of N observations each.

Comments were provided on the potential effects of density dependent growth, mortality, fecundity, and cohort strength. Cohort strength was not thought to be as big a factor since most of the variation of size is due to individual variation in growth and not greatly influenced by cohort strength at larger sizes. A comparison of the method against data rich stock assessments would be useful to evaluate the utility. The definition of sample unit might be an important consideration, for example, trophy fisheries, where the total number of fish caught to achieve the threshold can be measured. The method provides a good indicator of changes in fishing mortality, as it is more sensitive than the mean length estimator. The performance in relation to targeting, and specifically selectivity changes over time, deserve further analysis. The maximum length estimator is expected to be sensitive to changes in selectivity, and one potential solution is to monitor a part of the fishery that targets large fish and is therefore less likely to observe a change in selectivity, or in any case where selectivity is constant when the largest fish are consistently targeted. Changes in selectivity concerns could be addressed by further simulation. The time lag for changes in maximum size is greater than the mean length-based estimators, which are likely to be more sensitive to variability in recruitment. For selection of the threshold value, a target of the 90th percentile of the cumulative probability distribution may be a good rule of thumb.

This method (NZ50) was actually applied to the BUM data. The results of this work were shown in the BUM/SS presentation. The important point of the results was that the trend in F from the NZ50 analysis was in good agreement with the overall trends in F estimated by the SS model.

4. Stock status results

4.1 Surplus Production models

ASPIC

The estimates of current stock status and management benchmarks estimated in ASPIC are summarized in **Table 2**. The estimates from ASPIC were not considered reliable because the results were sensitive to model assumptions.

Model diagnostics of the ASPIC base run demonstrated poor model fit to the CPUE series (**Figure 5**). The lack of fit may be a result of contrasting indices that cannot be reconciled in the ASPIC model. To evaluate the influence of the divergent data on model estimates, two additional runs in ASPIC were conducted, a run with the 7 LL indices included exclusively, and a run with the 3 RR indices only. Both models demonstrated lack of convergence.

Relative status over time compared across the three runs demonstrated high uncertainty in the stock trajectory and current status (**Figure 6**), depending on model parameterization, and therefore, ASPIC was not selected for management advice in favor of the other model platforms.

JABBA

All scenarios for JABBA were able to converge adequately as judged by the Gelman and Rubin (1992) and Heidelberger and Welch (1983) diagnostic test and satisfying stationary behavior of the MCMC chains. Posterior medians for *K*, *MSY*, B_{MSY}, F_{MSY}, B/B_{MSY} and F/F_{MSY}, were generally consistent across scenarios (**Figure 7**), with only slightly differences in *K*, B_{MSY} and F_{MSY} for S3_LL. Retrospective analysis for nine years was also presented, which showed no evidence of strong retrospective patterns and was very consistent among scenarios (**Figure 8** to **10**). All runs indicated that results were robust in terms of similar stock status (F/F_{MSY}; B/B_{MSY}) and *MSY*.

The Group expressed concern regarding the prior developed for the carrying capacity *K*, noting that the prior could have been very informative and affected the medians of the posteriors for this parameter. To address this, an additional sensitivity analyses was presented based on the following variations of the input prior for *K*: 1) a base case with lognormal distribution with mean of 50,000 t and CV of 200%; 2) with range of the 15,000-150,000 t, which is converted into inputs for a lognormal distribution (see details in Winker *et al.* 2018) and; 3) with lognormal distribution with mean of 150,000 t and CV of 200%. Results were very similar and consistent between runs, indicating that input data were informative and override the prior information. The resulting *K* estimates were fairly insensitive to the input prior, and estimates of K ranged between 82,000-85,000 t for all runs (**Figure 11**).

The final base case model chosen was scenario 2 (i.e. h=0.5, excluding TAI-LL late and US-Rec). The justification for this choice was based on the influence of individual CPUE series and the concerns of the Group regarding these indices (see section 2.4 for details of CPUE indices). The RMSE, a good-of-fit indicator improved when excluding these two indices. Final base case model residuals indicated some discrepancies between CPUE series and model predictions (RMSE = 58.2%), especially for Venezuelan, Brazilian and Ghana fleets, which all might be characterized as CPUE series with high variation (**Figure 12**).

The predicted CPUE indices from model fit were compared to the observed CPUE (**Figure 13**). The model fits for blue marlin CPUEs indicated that there was a lack of fit from longline fisheries of Chinese Taipei, Brazil and Venezuela and from Brazilian and Venezuelan recreational fisheries and Ghana gillnet fishery (**Figure 13**). Plots of posterior densities together with prior densities for the final base case model are depicted in the **Figure 14** and summaries of posterior quantiles for parameters and management quantities of interest are presented in **Table 3**.

The trajectory of B/B_{MSY} showed a sharp decrease until the mid 1970s to an overfished status followed by a decreasing trend until 2000. Since the early 2000s the relative biomass has remained stable at levels below B_{MSY} until 2016 (**Figure 15**). The F/F_{MSY} trajectory showed an increasing trend since the beginning of time series, becoming greater than F_{MSY} in the mid 1980s, followed by a decreasing trend after 2000s, but remaining higher than F_{MSY} until the last year (**Figure 15**). The Kobe plot revealed a typical anti-clockwise pattern with the stock status moving from underexploited through a period of unsustainable fishing to the overexploited phase since the mid 1980s (**Figure 16**). The resulting stock status posteriors for 2016 showed that the Atlantic blue marlin stock has a 41.9% probability of being both subject to overfishing and overfished (**Figure 17**). The results of JABBA provide evidence that the Atlantic blue marlin biomass remained below B_{MSY} in 2016.

4.2 Length-based age-structured models: Stock Synthesis

All parameters, values and standard deviations for the final SS base model are given in **Table 4**. It was demonstrated that the values of M, steepness and R0 could all be successfully estimated within the model, without informative priors. The resulting posterior distributions of the parameters encompassed the predetermined values agreed upon for the sensitivity analysis. The estimated values of natural mortality (M = 0.148, SD = 0.018) and steepness (h = 0.497, SD = 0.124) were similar to the values that were suggested for exploration during the Data Preparatory meeting (M values of 0.10, 0.122 and 0.139; steepness values of 0.40, 0.50 and 0.60). Estimating these parameters as opposed to fixing them ensured that the uncertainty in their values was propagated through to the estimates of biomass, fishing mortality and associated benchmarks. As the estimated values of natural mortality and steepness were similar to the values already explored, many of the previous model diagnostics were assumed to adequately capture the characteristics of the final base case model.

The estimated maximum sustainable yield (MSY) was 2,701 t (2,072-3,329 t). This value is similar to the estimated value in 2011 (2,837 t). Historical trends in B/B_{MSY} and F/F_{MSY} were similar to those arrived at during the 2011 assessment (**Figure 18**). The trend B/B_{MSY} has shown a near continuous downward trend up until 2005. After 2005 the B/B_{MSY} leveled off and remained flat up until 2016. The estimated value of B/B_{MSY} in 2016 was 0.68 (0.43 – 0.93). This value is very similar to the value that was projected from the 2011 assessment for 2016 (B/B_{MSY} = 0.64) when the actual catch values for 2010-2016 were used. The trend in F/F_{MSY} followed the trends in landings very closely (as expected). The estimated value of F/F_{MSY} in 2016 was 1.16 (0.56-1.77). The estimated B/B_{MSY} and F/F_{MSY} were such that the current stock status is overfished and undergoing overfishing.

After the meeting, the Kobe plot was updated on the basis of 4910 MCMC runs (**Figure 19**), and the percent of the scatter in each of the quadrants was 65% in the red, 29% in the yellow, and 6% in the green.

4.3 Synthesis of assessment results

The Group agreed to use a combination of results from JABBA and SS3 to produce the advice on stock status and outlook. The resulting combination of results would reflect more of the uncertainty associated with the estimates of stocks status. One model is based on aggregated biomass (JABBA) and uses less data, and the other model uses more data and considers changes in the age distribution of the population (SS3). Using results from both models therefore provides a better representation of some of the process errors in the assessment. The Group also agreed that both models would be given equal weight in such combination. The parameters used in the fitting of the data to each “base case” model were made as much as possible so as to reflect equivalent productivity.

The Group agreed to calculate uncertainty by combining 5000 MCMCS runs from each model. MCMC runs for JABBA were completed during the meeting. SS3 MCMC runs were conducted after the meeting. The combined calculations were done on the basis of 4910 JABBA MCMC and 4910 SS3 MCMC runs, just below originally intended 5000 runs. At the meeting, preliminary uncertainty for SS3, was estimated by drawing random, bivariate correlated, pairs of SSB/SSB_{MSY} and F/F_{MSY} drawn from distributions defined by the parameters estimates.

Both models estimated similar annual trends of biomass and fishing mortality. Biomass declined rapidly in the 1970s, briefly stabilized and continued to decrease but much more slightly since the 1990s. When the results of both models were combined after the meeting, the median of the current (2016) biomass ratio is 0.69 with 10% and 90% confidence intervals of 0.52 and 0.91, respectively (**Figure 20**). Fishing mortality climbed rapidly and has exceeded F_{MSY} since 1990. The current fishing mortality ratio F_{2016}/F_{MSY} is 1.03 with 10% and 90% confidence limits of 0.74 and 1.50.

This implies that in 2016 the stock of Atlantic blue marlin was overfished and experiencing overfishing. The probability of being in the red quadrant of the Kobe plot was estimated to be 54% (**Figure 20**). The probability of being in the yellow quadrants of the Kobe plot was estimated to be 42% and that of being in the green quadrant only 4%. The estimated MSY was determined to be 3,056 t with 10% and 90% credible limits of 2,384 to 3,536. The value estimated for MSY in 2011 was 2,837 t.

ICCAT established a rebuilding plan for marlins [Rec. 00-13]. The plan first established annual landing limits for 2001 and 2002 of 50% of the 1999 landings for pelagic longline and purse seine vessels. Later, Rec. 12-04 established a 2,000 t landing limit (maintained in Rec. 15-05) for the period starting in 2013.

Following the 2011 assessment, the SCRS advised that the catch (including dead discards) must remain at 2,000 t or less to permit the stock to increase. Annual catches have generally exceeded 2,000 t since 2012, and as expected the stock has not increased. The stock biomass in 2016, estimated at 0.69 of B_{MSY}, is very similar to 0.67 of B_{MSY}, the level that the Group estimated for 2009, implying that the stock has not rebuilt much during the period 2009-2016. This matches the predictions presented in the Kobe matrix of 2011 which predicted that with catches of 2,500 t a year the biomass in 2016 would be at 0.69 of B_{MSY} (catches for the period 2010-2016 have averaged 2,468 t per year). In summary, the main effects of the rebuilding plan have been to reduce the fishing mortality to a level very close to F_{MSY} and to halt the decline in biomass.

5. Projections

Note that for both models biomass projections refer to the biomass at the beginning of the year, while fishing mortality refers to the entire year. Therefore biomass reported for 2019 is only affected by catches prior to 2019, while fishing mortality of 2019 is determined by catches in 2019.

5.1 Production models

The Group requested to run projections from the final base models of the Bayesian Surplus Production model JABBA and the Age structure Stock Synthesis model assuming constant catch scenarios. The specifications for the projections were: i) for 2017 and 2018 it was assumed a catch equal to the Task I nominal catch of 2016 (2,036 t); ii) different catch scenarios will start in 2019 and run for 10 years (2028); and iii) scenarios included catch from 0 up to 3,500 t, with increments of 250 t after 1,000 t.

Overall projections of stock recovering with the JABBA are more optimistic (**Figure 21**), in the sense that with equivalent catches, the stock will reach target objectives in a shorter time compared to those from the Stock Synthesis model (**Figure 22**). Although, the overall estimates of total stock (K) and the current biomass (B_{2016}/B_{MSY}) status are very similar between the two models the estimate of F_{2016}/F_{MSY} is greater for SS than for JABBA. After discussions, it was noted that the age-structure will play an important role in the recovery of the population, a feature that is not explicitly captured with Surplus Production models.

5.2 Length-based age-structured models: Stock Synthesis

Deterministic projections were carried out with the final base case model assuming values for landings in 2017 and 2018 equal to those in 2016 (2,036 t). Projections were made from 2019-2028 with landings of zero and from 1,500-3,500 in increments of 250 t. The time series of the projected relative biomass are shown in **Figure 22.** Catch levels between 2,250 t and 2,500 t are projected to maintain the relative biomass at current levels. Catches below 2,250 t are projected to result in an increasing trend in B/B_{MSY} in the future. Catches of 1,500 t are projected to achieve a B/B_{MSY} to reach 0.90 by the year 2028.

5.3 Synthesis of projections

As was the case for stock status results, the Group agreed to use a combination of projection results from JABBA and SS to produce the advice outlook, including the Kobe strategy matrices. The resulting combination of results would reflect more of the uncertainty associated with not only the estimates of current stock status, but also the different assumptions regarding population dynamics inherent in each model. The model based on aggregated biomass (JABBA) does not estimate age structure within the stock, whereas SS3 does. Therefore, the two models might be expected to predict different population responses to future catch levels. The Group considered that this might especially be the case, given the estimated biomass depletion level (around 0.68), and corresponding shift in age structure. As was the case for the stock status results, the Group agreed that both models would be given equal weight in such combination.

Projections were made by assuming the current reported catch for 2016 (2,036 t) will have also been taken in 2017 and 2018. Projections were made at constant catch levels, ranging from 1,000 t – 3,500 t at 250 t intervals (plus a projection at zero catch). For each model, 4910 projections were made at each constant catch level (**Figure 23** and **Table 5**). According to these projections the current TAC of 2000 t will only provide a 46% probability of being in the green quadrant by 2028. In contrast, TACs lower than 2000 t will allow the stock to rebuild with more than 50 % probability by the year 2028.

6. Recommendations

6.1 Research and statistics

In order to improve the monitoring and reporting of billfish statistics the:

- Group recognizes that the most significant source of uncertainty in the blue marlin assessment is in the landings data. Furthermore, the number of dead discards and fate of the live discards is also not well known and a large contributor to uncertainty. As has been recommended in the past, data on landings as well as dead and live discards need to be more complete and accounted for.

- Group recognizes the benefit of the effort that WECAFC is pursuing to develop software and monitoring structures through capacity building that could help Caribbean countries report ICCAT species fishery statistics to both the WECAFC and ICCAT databases. The Group recommends the Secretariat and CPCs support this effort by collaborating with WECAFC.

- SCRS should develop an inventory of sport fishing activities that may interact with billfish through a collaboration with organizations such as the IGFA and The Billfish Foundation. Such inventory should seek to establish a list of countries, and where possible, ports within the ICCAT Convention area, where sport fishing activities are known to be interacting with billfish. Activities should include, established charter companies and tournaments. This inventory will help the SCRS and CPCs in the design of data collections and sampling programs.

- Commission should continue to support the initiatives that seek to improve data collection for billfishes in the Caribbean and West African regions through activities that implement the most important recommendations provided by the initial fact finding projects conducted by ICCAT in recent years.

- SCRS should put in place tools and mechanisms that encourage scientists from all CPCs with fisheries that have significant interactions with billfishes to support the work of the Billfish Species Group by contributing papers, relative abundance indices and by being present during the data preparatory and assessment meetings of billfish stocks.

- Group recommends a study that will provide photographic and biological sampling evidence to confirm sex determination in samples from the western Gulf of Mexico longline fisheries.

6.2 Management

The 2018 stock assessment confirms the advice provided in 2011 that a 2000 t TAC would have allowed the stock to rebuild. Because the catches have generally exceeded the TAC, the stock has not rebuilt. The first recommendation from the SCRS is that the Commission should find ways to make sure that the catches are not allowed to exceed established TACs. As the stock has not rebuilt catches need to be lower than the current TAC.

The Group expressed concern that paragraph 2 of Rec. 15-05 limits the effectiveness of the recommendation to reduce fishing mortality of billfish. This paragraph states the following:

"To the extent possible, as the CPC approaches its landings limits, such CPC shall take appropriate measures to ensure that all blue marlin and white marlin/spearfish that are alive by the time of boarding are released in a manner that maximizes their survival."

This implies that: 1) CPCs do not need to release live marlin while their catch limit has not been reached; 2) it also implies that CPCs which reach the limit, will produce mortality in excess of the limit, because many fish caught after the limit will be dead upon haul back and some of the live-released fish will not survive; 3) Because the recommendation specifically refers to fish "...alive by the time of boarding..." it is not as effective as if it referred to fish alive at haul back. Fish alive at haul back could be dead by the time they are boarded, depending on the fishery operation.

- The Group therefore recommends that if the Commission wanted to further reduce fishing mortality, the Commission could consider doing so by modifying Rec. 15-05 so that fishermen should be required to release all marlins that are alive at haul back through methods that maximise their survival. This would eliminate the provision from Rec. 15-05 that requires this only when CPCs are about to reach the catch limits.

- The Group also recommends that CPCs consider that their monitoring programs should be designed to be able to monitor the billfish effectively as required in Rec. 15-05. Given the intention of requiring live releases as a means to reduce fishing mortality it is essential that monitoring should include recording and reporting accurate estimates of live releases and dead discards. The Group recommends that such monitoring should be supported through observer programs at a greater level of coverage than those being currently implemented by most CPCs.

7. Responses to the Commission

7.1 Analysis of recommendations enmanating from the Second ICCAT Performance Review and possible actions

The Group reviewed the extract provided by the Secretariat regarding the recommendations made by the Ad Hoc Working Group to Follow-up on the Second ICCAT Performance Review (Anon. 2018). In its discussions it was agreed that several of those recommendations were pertinent to the Group and that some needed enhancements and clarifications to make them clearer with regard to their ultimate goal.

The table below addresses the items discussed and are numbered in the same order as they appear in the Recommendations of the Second ICCAT Performance Review.

Chapter	Recommendations	Bilfish Species Group comments
Data Collection and Sharing	6bis. The Panel concludes that ICCAT scores well in terms of agreed forms and protocols for data collection but, while progress has been made, more needs to be done particularly for bycatch species and discards.	- Currently billfish have catch limits and are often bycatch. These limits may have changed the discarding practices of fishing fleets. Unfortunately few CPCs report discards (dead or alive). - Accurate discard information for reporting Task I and II, requires observers at-sea. Billfish species are rare occurrences, therefore, need more observer coverage and complete reporting than presently provided. - Marlin species are under a rebuilding program that requires to live releases. Therefore, marlin species require information on live discards more than any other ICCAT species.

	7. The Panel considers that major progress in data availability is necessary and recommends that substantial improvements in data quality and data completeness can only be achieved by simplifying and automating the process of collecting data in a systematic and integrated way. This may not be possible for artisanal fleets but should be possible for most of the fleets in developed CPCs.	- It is possible to improve data for artisanal/small scale fleets. The recent ICCAT initiatives for improving the data collection for these fleets in West Africa and Caribbean have been effective but need to continue to be supported and expanded.
Trends in the Status of Non-Target Species	4. The Panel recommends that the precautionary approach be consistently applied for associated species considering that the assessments for these species are highly uncertainty and that their status is often poorly known.	- The catch advice provided for billfishes has, in general, been followed by the Commission. - However, billfishes assessments tend to be among the most uncertain of all assessments conducted at ICCAT. Therefore catch limits should be more precautionary than for other species. In general the Commission has not exerted more precaution for BILL than for other species. - In addition, recent blue marlin harvests have exceeded the levels of catch that in 2011 the SCRS had predicted would allow the stock to rebuild (2,000 t or less, including dead discards). The SCRS emphasizes to the Commission that persistent over-harvest will compromise stock rebuilding and will potentially lead to further stock declines. - The Commission should consider other management measures such as time/area closures or gear modifications (circle hooks) to reduce fishing mortality of blue marlin.
Blue and White Marlins	38. The Panel supports the SCRS advice that ICCAT actively encourage, or make obligatory, the use of non-offset circle hooks on longline fisheries to reduce the mortality of released marlin.	- The Billfish SG continues to support the use of non-offset circle hooks because it will reduce the mortality of live releases and increase the probability of fish to be alive upon haul back.
Best Scientific Advice	112. The Panel re-iterates the recommendation of the 2008 Panel that a better balance of scientists with knowledge of the fishery and modelling expertise be sent to the assessment meetings of the SCRS.	- The Billfish SG notes that there has been a lack of participation in recent times from countries that account for significant proportions of the catch of billfish species, and that have produced indices in abundances that now are not being updated. The

		Group wants to encourage participation in SCRS meetings of all CPCs that have fisheries interacting with billfish. The SCRS should consider mechanisms to encourage scientists from all CPCs to engage in the work which supports the Billfish SG.
	113. The Panel recommends that Management Strategy Evaluation should be used on a few stocks to estimate the costs and benefits of collecting more detailed information.	- The Billfish SG agreed that MSE for billfish species should consider the overall strategic plan for MSE before the SCRS could be asked to engage in such MSE process. Many of the experts engaged in billfishes assessments and that potentially could engage in billfishes MSE are already involved in the other MSE processes in ICCAT.
Adequacy SRCS and Secretariat	118. The Panel recommends that ICCAT evaluates the benefits of outsourcing its stock assessments to an external science provider while retaining the SCRS as a body to formulate the advice based on the stock assessments.	- The Billfish SG does not support the outsourcing of the whole assessment. The current system ensures broad input from scientists familiar with relevant knowledge on the fish and fisheries been assessed. - The Billfish SG supports the use of external experts with special knowledge when this is required and also support the current peer review process. - The presence of peer reviewers during the assessment is strongly preferred.

7.2 Anaysis of the ICCAT exception fact sheet for billfishes

The Group reviewed and provided a few comments to the sheet (see **Appendix 6**). In addition the Group discussed shortcomings in the monitoring of fishing mortality related to Rec. 15-05. Recommendations related to such monitoring are contained in section 6 of this report.

8. Other matters

No other matters were discussed.

9. Adoption of the report and closure

Due to the limited time, some Agenda items were only partially reviewed prior to the close of the meeting: 4.4) Synthesis of assessment results, 5.3) Synthesis of projections and 6.2) Management recommendations. Therefore, these sections of the report were adopted electronically after the meeting. The remainder of the report was adopted during the meeting. The meeting was adjourned.

References

Anonymous. (in press). 2018 Blue Marlin Data Preparatory Meeting, Madrid, Spain, 12-16 March 2018. Document SCRS/2018/001: 39 pp.

Anonymous. 2018. 4.3 Report for biennial period, 2016-17, Part II (2017) – Vol. 1. Report of the Meeting of the Ad Hoc Working Group on Follow Up of the Second ICCAT Performance Review, Madrid, Spain, 27-

28 June 2017).

Gelman, A., Rubin, D.B. 1992. Inference from iterative simulation using multiple sequences. Stat. Sci. 7: 457-511.

Goodman, C.P. 2015. NZ50 a new metric for maximum size in the catch: an example with blue marlin. Document SCRS/2016/028 (withdrawn).

Goodyear, C.P. 2015. Understanding maximum size in the catch: Atlantic blue marlin as an example. Transactions of the American Fisheries Society 144, 274-282.

Heidelberger, P., Welch, P.D. 1983. Simulation run length control in the presence of an initial transient. Oper. Res. 31: 1109-1144.

Hewitt, D.A., Hoenig, J.M. 2005. Comparison of two approaches for estimating natural mortality based on longevity. Fishery Bulletin 103, 433-437.

Hoenig, J.M. 1983. Empirical use of longevity data to estimate mortality rates. Fishery Bulletin 82, 898-902.

Shimose, T., Yokawa, K., Tachihara, K. 2015. Age determination and growth estimation from otolith micro-increments and fin spine sections of blue marlin (*Makaira nigricans*) in the western North Pacific. Marine and Freshwater Research 66, 1116-1127.

Winker, H.; Carvalho, F. and Kapur, M. 2018. JABBA: Just Another Bayesian Biomass Assessment. Fish. Res. 204: 275–288.

Table 1. Estimated catches (landings + dead discards, t) of Atlantic blue marlin (*Makaira nigricans*) by area, gear and flag.

				1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
BUM	TOTAL			4612	4220	3099	3175	4258	4228	5418	5735	5696	5390	5481	4471	3906	4418	3208	3577	3174	4296	3776	3345	3052	2901	2855	2161	2805	2188	2019
Landings	A+M		Longline	3618	3463	2319	2167	2966	2934	3786	4218	4151	3632	3658	2498	1743	2001	1666	1906	1677	2289	2100	1859	1773	1294	1198	1005	1287	1047	1121
			Other surf.	698	453	428	588	870	869	1118	950	1033	1237	1302	1400	1459	1650	884	1126	888	1327	787	775	739	855	903	744	870	518	499
			Sport (HL+RR)	136	161	205	293	311	272	318	428	460	437	462	548	655	747	623	520	571	637	851	650	521	696	680	354	590	511	340
Discards	A+M		Longline	159	142	146	127	111	153	197	139	51	83	60	22	37	19	34	24	38	42	37	40	19	56	70	55	54	106	52
			Other surf.	0	0	0	0	0	0	0	0	1	0	0	2	11	0	1	1	0	0	1	20	1	0	2	4	3	5	7
Landings	A+M	CP	Angola	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0
			Barbados	18	12	18	21	19	31	25	30	25	19	19	18	11	11	0	0	25	0	0	0	9	13	14	11	12	34	11
			Belize	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	3	3	7	47	19	8	5	13
			Brazil	52	61	125	147	81	180	331	193	486	509	467	780	387	577	195	612	298	262	182	150	130	63	48	114	105	89	79
			Canada	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			China PR	0	0	0	0	62	73	62	78	120	201	23	92	88	89	58	96	99	65	13	77	100	99	61	45	40	44	50
			Curaçao	50	40	40	40	40	40	40	40	40	40	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Côte d'Ivoire	67	76	56	104	151	134	113	157	66	189	288	208	111	171	115	21	8	132	66	72	54	17	48	48	87	15	72
			EU.España	6	14	47	44	55	40	158	122	195	125	140	94	28	12	51	24	91	38	55	160	257	131	190	147	209	287	225
			EU.France	85	98	115	179	191	197	252	299	333	370	397	428	443	443	450	470	470	461	585	498	344	461	395	212	393	406	165
			EU.Portugal	1	4	2	15	11	10	7	3	47	8	22	18	8	32	27	48	105	135	158	106	140	54	53	25	23	46	50
			FR.St Pierre et Miquelon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Gabon	0	0	0	1	2	0	304	5	0	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
			Ghana	324	126	123	236	441	471	422	491	447	624	639	795	999	415	470	759	405	683	191	140	116	332	234	163	236	88	44
			Japan	1217	900	1017	926	1523	1409	1679	1349	1185	790	883	335	267	442	540	442	490	920	1028	822	731	402	430	189	280	293	294
			Korea Rep.	324	537	24	13	56	56	144	56	2	3	1	1	0	0	1	6	33	64	91	36	85	57	34	24	10	3	26
			Liberia	0	0	0	0	0	87	148	148	701	420	712	235	158	115	188	304	162	274	76	56	46	133	94	178	293	35	127
			Maroc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	4	7
			Mexico	0	0	0	3	13	13	13	13	27	35	68	37	50	70	90	86	64	91	81	93	89	68	106	86	67	72	66
			Namibia	0	0	0	0	0	0	0	0	0	0	0	0	3	0	5	9	57	0	50	2	23	10	0	8	36	8	32
			Panama	0	0	0	0	0	0	0	0	0	0	41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Philippines	0	0	0	0	0	0	0	0	7	71	38	0	0	0	0	0	0	0	8	0	3	4	1	2	2	0	0
			Russian Federation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
			S. Tomé e Príncipe	17	18	21	25	28	33	36	35	33	30	32	32	32	32	9	21	26	0	68	70	72	74	76	78	81	11	10
			Senegal	1	4	8	0	9	0	2	5	0	0	0	11	24	32	11	1	5	91	114	61	41	64	164	45	72	10	82
			South Africa	0	0	0	0	0	0	0	0	0	0	0	1	4	0	0	0	0	2	0	0	1	0	0	0	1	1	0
			St. Vincent and Grenadines	0	0	1	2	2	2	0	1	0	0	0	0	20	0	0	0	0	1	3	2	1	0	0	2	0	0	0
			Trinidad and Tobago	11	6	1	2	16	28	14	49	15	20	51	17	16	9	11	7	14	16	34	26	22	25	46	48	48	35	19
			U.S.A.	29	33	51	80	88	43	43	46	50	37	24	16	17	19	26	16	17	9	13	6	4	6	14	9	1	9	19
			U.S.S.R.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			UK.Bermuda	17	18	19	11	15	15	15	3	5	1	2	2	2	2	2	2	2	2	2	0	1	2	2	3	3	3	2
			UK.British Virgin Islands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
			UK.Sta Helena	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	12	2	1	1	0
			UK.Turks and Caicos	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0
			Uruguay	0	1	0	0	3	1	1	26	23	0	0	0	1	5	3	2	8	5	0	6	1	0	0	0	0	0	0
			Vanuatu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	7	8	6	3	2	0	0
			Venezuela	75	56	67	86	122	117	148	142	226	240	125	84	88	120	101	160	172	222	130	120	151	116	143	111	139	150	185
		NCC	Chinese Taipei	1704	1672	824	685	663	467	660	1478	578	486	485	240	294	319	315	151	99	233	148	195	153	199	133	78	62	61	75
		NCO	Benin	6	6	6	6	5	5	5	5	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Cuba	202	189	204	69	39	85	43	53	12	38	55	56	34	3	4	7	7	0	0	0	0	0	0	0	0	0	0
			Dominica	0	0	0	0	0	0	0	0	0	0	0	64	69	75	36	44	55	58	106	76	76	60	0	0	85	62	49
			Dominican Republic	0	0	0	0	0	0	0	41	71	29	23	23	115	207	142	30	38	47	67	60	65	100	98	99	96	73	170
			Grenada	30	36	30	33	52	50	26	47	60	100	87	104	69	72	45	42	33	49	54	32	69	53	32	63	63	0	0
			Jamaica	0	0	0	0	0	0	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Mixed flags (FR+ES)	199	137	116	146	133	126	96	82	80	83	147	151	131	148	171	150	136	135	139	164	178	186	181	191	173	176	0
			NEI (BIL)	18	20	38	0	0	0	0	0	0	0	53	184	258	167	89	7	160	209	205	177	0	34	0	0	0	0	0
			NEI (ETRO)	0	0	0	174	326	362	435	548	803	761	492	274	17	14	0	0	0	0	0	0	0	0	0	0	0	0	0
			Saint Kitts and Nevis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
			Sta. Lucia	0	0	0	0	0	0	0	4	1	0	10	5	9	18	17	21	53	46	70	72	58	64	119	99	111	53	88
			Togo	0	0	0	0	0	0	0	23	0	73	53	141	103	775	0	0	0	0	0	0	0	0	0	0	0	0	0
			Ukraine	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Discards	A+M	CP	Brazil	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
			EU.España	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0	1	4	3	5	7
			EU.France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Korea Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	1	1	0
			Mexico	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			U.S.A.	159	142	146	127	111	153	197	139	52	83	60	25	49	19	35	25	36	42	38	42	19	50	39	55	53	81	25
		NCC	Chinese Taipei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32	0	0	24	27

Table 2. Results from ASPIC demonstrating the variability depending upon model assumptions. Results were not considered for management advice.

Parameter	2018 Continuity	2018 estimate K	2018 Base
F2016	0.132	0.043	0.021
F_{MSY}	0.38	0.017	0.025
F2016:F_{MSY}	0.34	2.5	0.37
B2016	14130	47130	99530
B_{MSY}	11960	90580	99,180
B:B_{MSY}	1.2	0.52	1.00

Table 3. Summary of posterior quantiles denoting the 95% credibility intervals of parameters for the Bayesian state-space surplus production model JABBA for Atlantic blue marlin.

Estimates	Median	2.50%	97.50%
K	89156	67864	121324
r	0.098	0.072	0.131
$\psi(psi)$	0.922	0.712	1.112
σ_{proc}	0.071	0.071	0.071
F_{MSY}	0.102	0.076	0.137
B_{MSY}	32097	24432	43679
MSY	3302	2806	3864
B_{1959}/K	0.922	0.714	1.042
B_{2016}/K	0.233	0.155	0.348
B_{2016}/B_{MSY}	0.646	0.43	0.967
F_{2016}/F_{MSY}	0.957	0.626	1.474

Table 4. Parameters, values and standard deviations for the Atlantic blue marlin SS base case model.

Num	Label	Value	Active_Cnt	Phase	Min	Max	Init	Status	Parm_StDev	PR_type	Prior	Pr_SD
1	NatM_p_1_Fem_GP_1	0.148083	1	3	0.1	0.3	0.148392	OK	0.0182821	No_prior		
2	L_at_Amin_Fem_GP_1	179.859	2	2	160	210	185.85	OK	4.31388	Normal	185.85	5.58
3	L_at_Amax_Fem_GP_1	286.603	3	2	270	310	288.8	OK	2.80451	Normal	288.8	5
4	VonBert_K_Fem_GP_1	0.212745	4	3	0.1	0.3	0.226	OK	0.0199259	Normal	0.226	0.05
8	CV_young_Fem_GP_1	0.12	_	-6	0.1	0.5	0.12	NA	_	Normal	0.12	0.2
9	CV_old_Fem_GP_1	0.12	_	-6	0.1	0.5	0.12	NA	_	Normal	0.12	0.2
10	NatM_p_1_Mal_GP_1	0.148392	_	-3	0.1	0.3	0.148392	NA	_	No_prior		
11	L_at_Amin_Mal_GP_1	172.1	_	-1	160	210	172.1	NA	_	Normal	172.1	5.58
12	L_at_Amax_Mal_GP_1	208.577	5	2	200	220	209.95	OK	1.99697	Normal	209.95	4
13	VonBert_K_Mal_GP_1	0.299658	6	3	0.2	0.8	0.504	OK	0.0568123	Normal	0.504	0.1
17	CV_young_Mal_GP_1	0.12	_	-6	0.1	0.5	0.12	NA	_	Normal	0.12	0.2
18	CV_old_Mal_GP_1	0.12	_	-6	0.1	0.5	0.12	NA	_	Normal	0.12	0.2
19	Wtlen_1_Fem	1.90E-06	_	-2	0	1	1.90E-06	NA	_	Normal	1.90E-06	0.8
20	Wtlen_2_Fem	3.2842	_	-2	0	4	3.2842	NA	_	Normal	3.2842	0.8
21	Mat50%_Fem	206	_	-3	0	300	206	NA	_	No_prior		
22	Mat_slope_Fem	-0.125	_	-3	-3	3	-0.125	NA	_	No_prior		
23	Eggs/kg_inter_Fem	1	_	-3	-3	3	1	NA	_	No_prior		
24	Eggs/kg_slope_wt_Fem	0	_	-3	-3	3	0	NA	_	No_prior		
25	Wtlen_1_Mal	2.47E-06	_	-2	0	1	2.47E-06	NA	_	Normal	2.47E-06	0.8
26	Wtlen_2_Mal	3.2243	_	-2	0	4	3.2243	NA	_	Normal	3.2243	0.8
31	SR_LN(R0)	4.97412	7	1	4.8	5.2	5.03	OK	0.282998	No_prior		
32	SR_BH_steep	0.469786	8	2	0.3	0.99	0.5	OK	0.123689	No_prior		
33	SR_sigmaR	0.6	_	-4	0	2	0.6	NA	_	No_prior		
77	Q_envlink_17_Japan_00_17	1.23204	44	4	0	3	0	OK	0.209541	No_prior		
90	LnQ_base_17_Japan_00_17	-6.86163	45	1	-7.1	-6.6	-6.88	OK	0.280349	No_prior		
91	SizeSel_1P_1_Art_Gillnet_1	220.874	46	2	200	240	232	OK	9.2998	No_prior		
92	SizeSel_1P_2_Art_Gillnet_1	-11.7198	47	3	-15	-8	-11.72	OK	2.19912	Normal	-11.72	2.2
93	SizeSel_1P_3_Art_Gillnet_1	7.79647	48	4	1	10	8.2696	OK	0.331247	No_prior		
94	SizeSel_1P_4_Art_Gillnet_1	-9	49	3	-12	-6	-9	OK	1.79935	Normal	-9	1.8
95	SizeSel_1P_5_Art_Gillnet_1	-15	_	-2	-16	5	-15	NA	_	No_prior		
96	SizeSel_1P_6_Art_Gillnet_1	1.80977	50	2	0.2	5	1	OK	0.987377	No_prior		
97	SizeSel_2P_1_LongLine_2	91.1199	51	2	90	120	91.226	OK	34.3366	No_prior		
99	SizeSel_2P_3_LongLine_2	10.5808	52	3	3	12	10.5456	OK	30.065	No_prior		
103	SizeSel_3P_1_Purse_Seine_3	1	_	-1	1	1	1	NA	_	Normal	1	99
104	SizeSel_3P_2_Purse_Seine_3	89	_	-6	89	89	89	NA	_	Normal	89	99
105	SizeSel_4P_1_RR_4	259.646	53	2	160	270	255	OK	13.1553	Normal	220	44
106	SizeSel_4P_2_RR_4	-0.00098	54	3	-1	1	0.199	OK	22.6111	No_prior		
107	SizeSel_4P_3_RR_4	9.38342	55	4	5	12	9.3806	OK	0.329243	No_prior		
108	SizeSel_4P_4_RR_4	2	56	5	-2	6	2	OK	3.99601	Normal	2	4
109	SizeSel_4P_5_RR_4	-15	_	-2	-15	5	-15	NA	_	No_prior		
110	SizeSel_4P_6_RR_4	15	_	-5	-5	15	15	NA	_	No_prior		
111	Retain_4P_1_RR_4	161	_	-2	15	370	161	NA	_	No_prior		
112	Retain_4P_2_RR_4	1	_	-4	-1	40	1	NA	_	No_prior		
113	Retain_4P_3_RR_4	1	_	-2	0	1	1	NA	_	No_prior		
114	Retain_4P_4_RR_4	0	_	-4	-1	2	0	NA	_	No_prior		
115	DiscMort_4P_1_RR_4	10	_	-2	-1	30	10	NA	_	No_prior		
116	DiscMort_4P_2_RR_4	1	_	-4	-1	2	1	NA	_	No_prior		
117	DiscMort_4P_3_RR_4	0.05	_	-2	-1	2	0.05	NA	_	No_prior		
118	DiscMort_4P_4_RR_4	0	_	-4	-1	2	0	NA	_	No_prior		
149	Retain_4P_1_RR_4_BLK1repl_1987	222	_	-6	220	250	222	NA	_	Sym_Beta	222	99
150	Retain_4P_1_RR_4_BLK1repl_1994	225	_	-6	220	250	225	NA	_	Sym_Beta	225	99
151	Retain_4P_1_RR_4_BLK1repl_1999	251	_	-6	200	260	251	NA	_	Sym_Beta	251	99
152	Retain_4P_2_RR_4_BLK1repl_1987	23.9226	57	4	-1	30	26	OK	4.40348	No_prior		
153	Retain_4P_2_RR_4_BLK1repl_1994	3.66216	58	4	-1	10	4	OK	0.924429	No_prior		
154	Retain_4P_2_RR_4_BLK1repl_1999	6.43381	59	4	-1	10	6	OK	1.78841	No_prior		
155	Retain_4P_3_RR_4_BLK2repl_1956	1	_	-6	0	1	1	NA	_	No_prior		
156	Retain_4P_3_RR_4_BLK2repl_1987	0.795396	60	6	0	1	0.519	OK	0.16538	No_prior		
157	Retain_4P_3_RR_4_BLK2repl_1989	0.594878	61	6	0	1	0.57	OK	0.125629	No_prior		
158	Retain_4P_3_RR_4_BLK2repl_1994	0.531376	62	6	0	1	0.52	OK	0.175249	No_prior		
159	Retain_4P_3_RR_4_BLK2repl_1998	0.333397	63	6	0	1	0.324	OK	0.378168	No_prior		
160	Retain_4P_3_RR_4_BLK2repl_1999	0.305204	64	6	0	1	0.466	OK	0.267064	No_prior		
161	Retain_4P_3_RR_4_BLK2repl_2005	0.236239	65	6	0	1	0.328	OK	0.186788	No_prior		

Table 5. Kobe II matrices for Atlantic blue marlin giving the probability that $F<F_{MSY}$, $B>B_{MSY}$ and the joint probability of $F<F_{MSY}$ and $B>B_{MSY}$, between 2019 and 2028, with various constant catch levels based on JABBA and SS3 base case model results.

a) Probability that $F<F_{MSY}$

TAC | Year	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
0	100	100	100	100	100	100	100	100	100	100
1000	97	98	98	98	98	98	98	98	98	98
1250	92	93	93	93	93	94	94	94	94	94
1500	84	85	85	86	86	87	87	88	88	89
1750	73	74	76	77	78	79	80	80	80	81
2000	60	62	64	65	67	69	70	71	72	73
2250	45	48	51	53	55	57	58	59	60	62
2500	33	36	38	40	42	44	46	47	49	51
2750	23	25	27	29	31	32	34	35	37	39
3000	15	17	18	20	21	23	24	26	27	30
3250	9	9	10	11	12	13	15	17	19	22
3500	6	6	7	7	9	10	12	14	17	19

b) Probability that $B>B_{MSY}$

TAC | Year	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
0	10	21	34	47	59	68	75	80	84	86
1000	10	18	26	35	43	51	57	63	68	71
1250	10	16	24	31	39	46	51	57	61	66
1500	10	16	22	28	34	40	46	51	56	60
1750	10	15	20	25	31	36	41	46	49	53
2000	10	14	19	24	28	32	36	40	43	46
2250	10	14	17	21	24	27	31	34	37	39
2500	10	13	16	18	21	24	27	28	31	33
2750	10	12	14	16	18	20	21	23	24	26
3000	10	12	13	14	16	17	18	19	19	20
3250	10	11	12	12	13	14	14	14	15	15
3500	10	11	11	11	11	11	11	11	11	11

c) Probability that $F<F_{MSY}$ and $B>B_{MSY}$

TAC | Year	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
0	10	21	34	47	59	68	75	80	84	86
1000	10	18	26	35	43	51	57	63	68	71
1250	10	16	24	31	39	46	51	57	61	66
1500	10	16	22	28	34	40	46	51	56	60
1750	10	15	20	25	31	36	41	46	49	53
2000	10	14	19	24	28	32	36	40	43	46
2250	10	14	17	20	24	27	31	34	36	39
2500	10	13	15	18	20	23	26	28	30	32
2750	10	11	13	15	17	19	20	22	23	25
3000	10	10	12	12	14	15	16	17	17	18
3250	9	8	8	9	10	10	11	11	12	12
3500	6	6	6	6	7	7	7	7	8	8

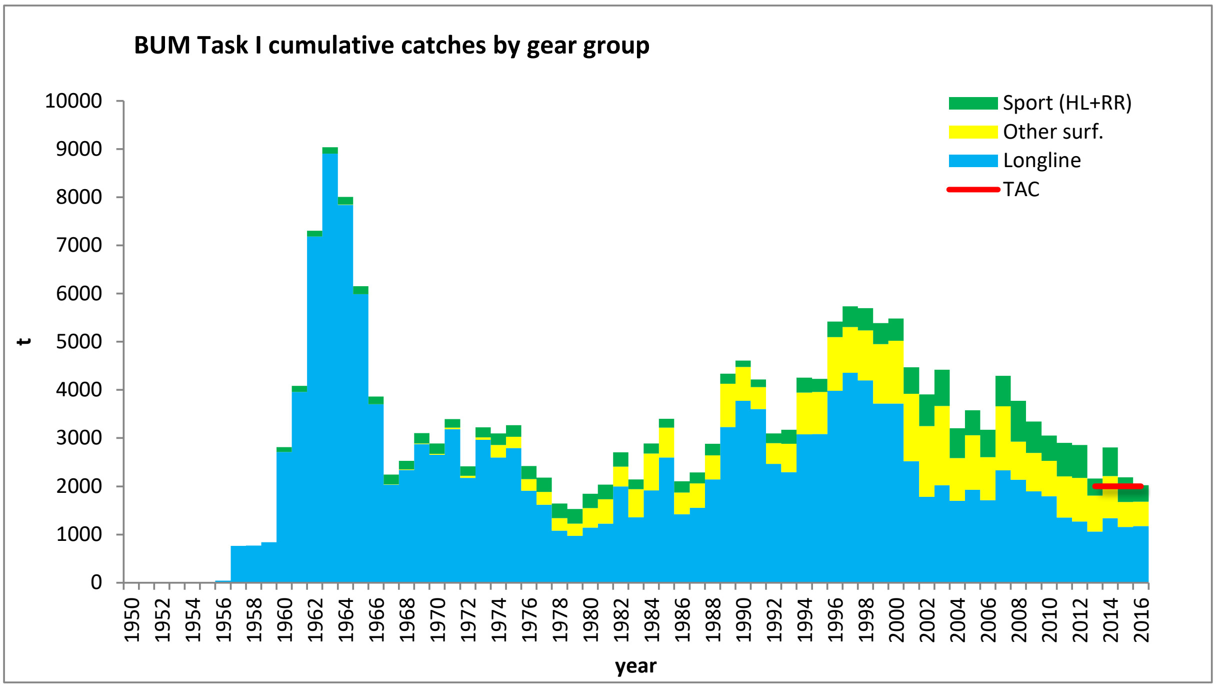

Figure 1. Atlantic blue marlin (*Makaira nigricans*) Task I cumulative catches (landings + dead discards) (t) by gear type between 1950 and 2016.

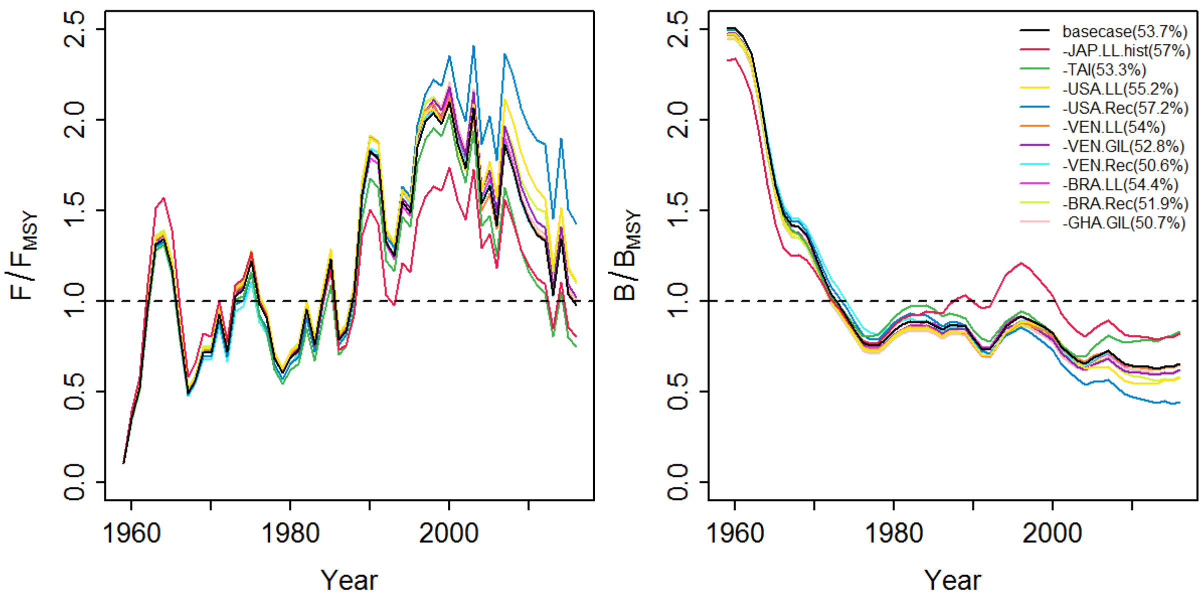

Figure 2. Sensitivity analysis showing the influence of removing one CPUE series at a time on the stock status trajectories F/F_{MSY} and B/B_{MSY} for the model JABBA for Atlantic blue marlin. Values in parenthesis depict the RMSE (%) used to judge the goodness-of-fit to the retained CPUE series.

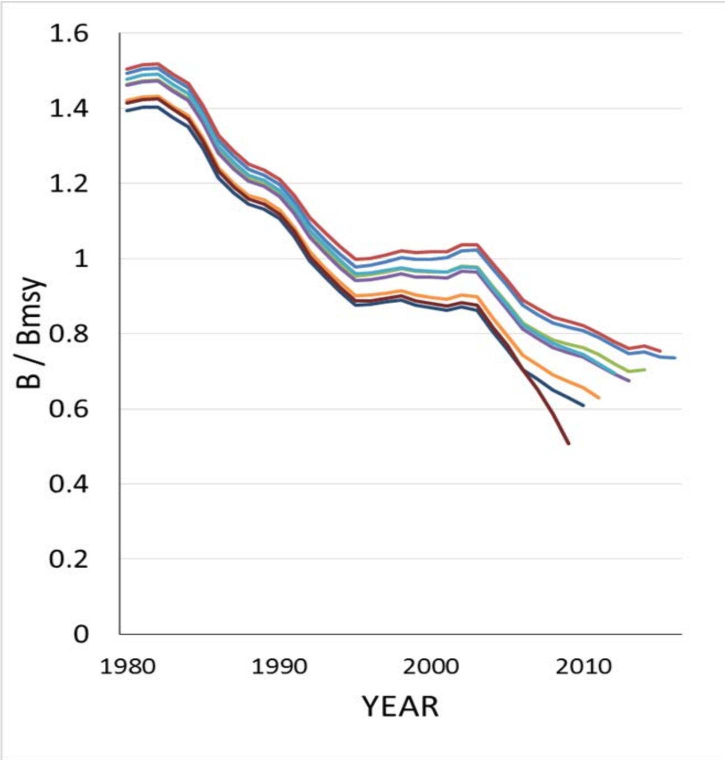

Figure 3. Stock biomass retrospective pattern observed in the provisional configuration of the SS assessment of Atlantic blue marlin.

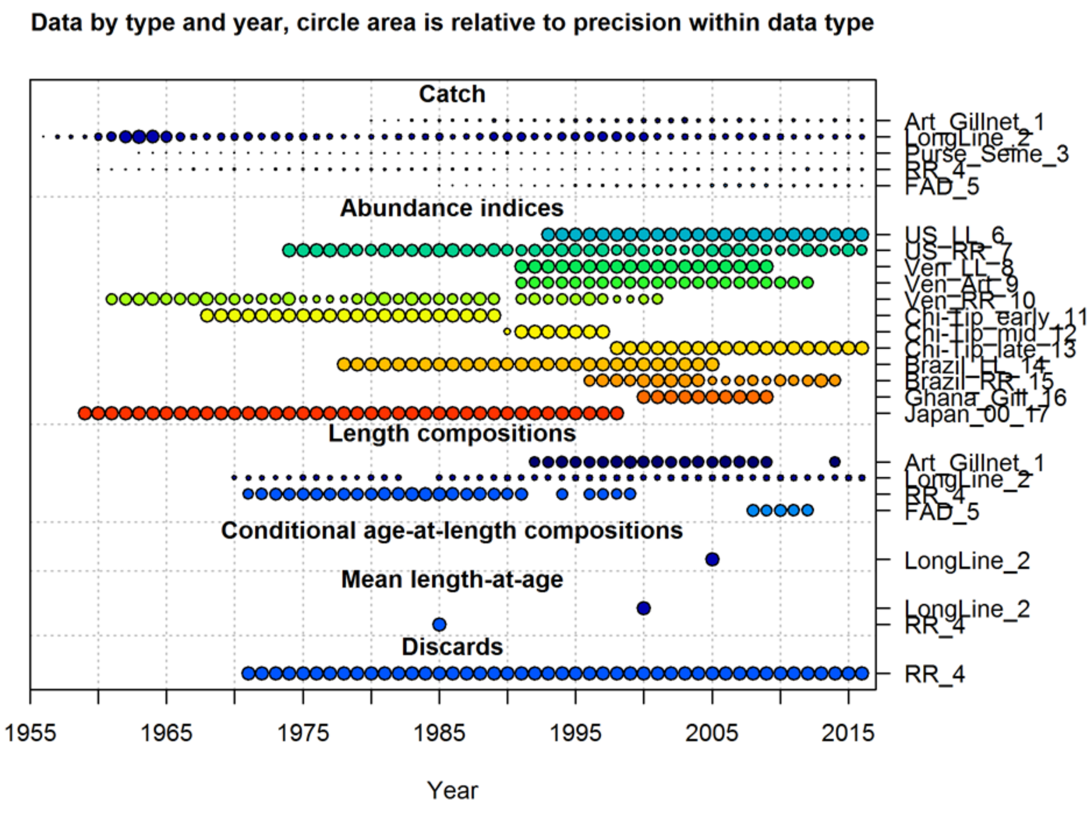

Figure 4. Data presence by year for each fleet, where circle area is relative within a data type, and proportional to precision for indices and compositions, and absolute catch for catches. Note that the circles are scaled relative to maximum for each data series.

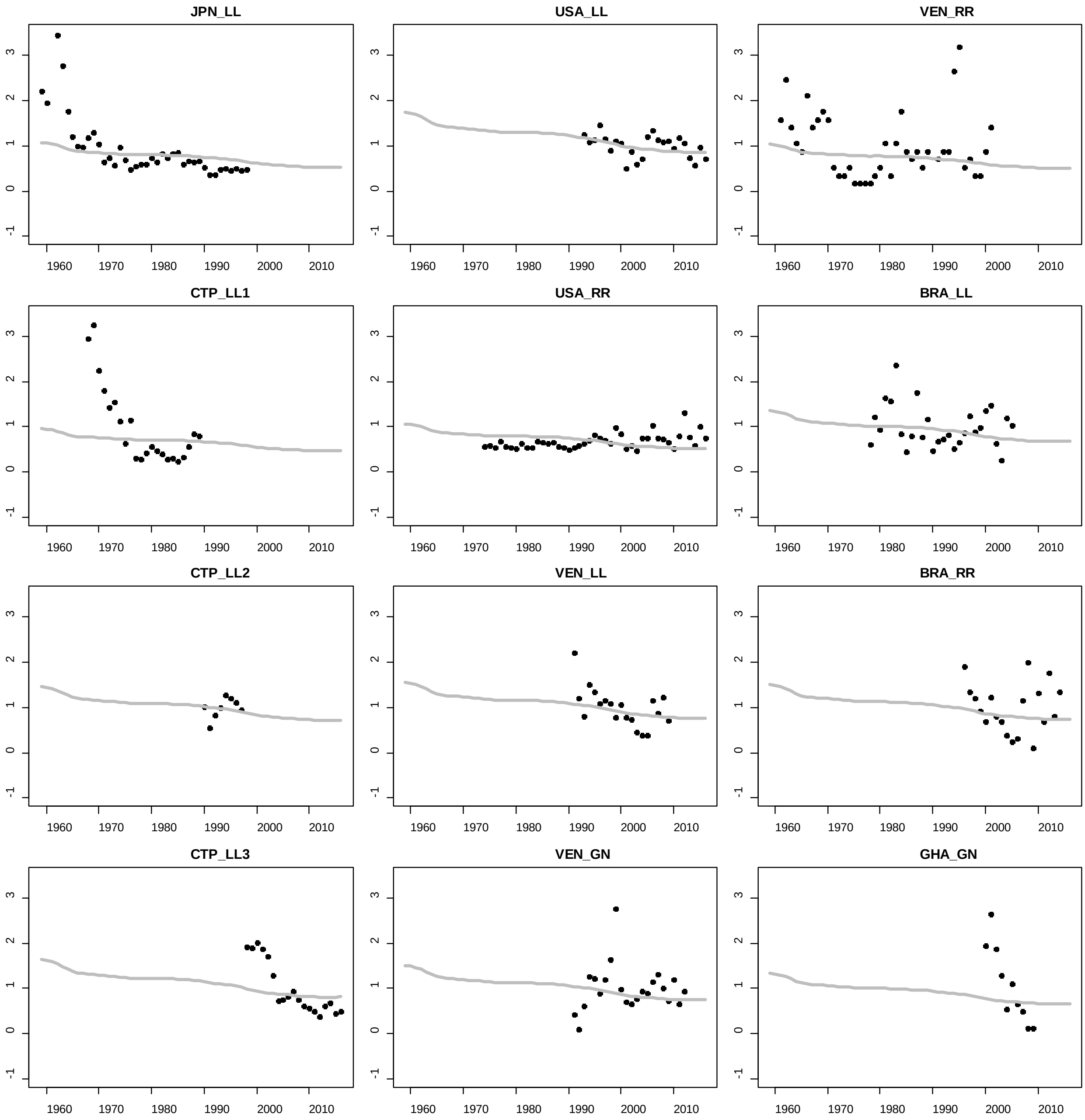

Figure 5. ASPIC base model fits to blue marlin indices of abundance. Black points represent the observed CPUEs and the gray lines represent the ASPIC base model fit.

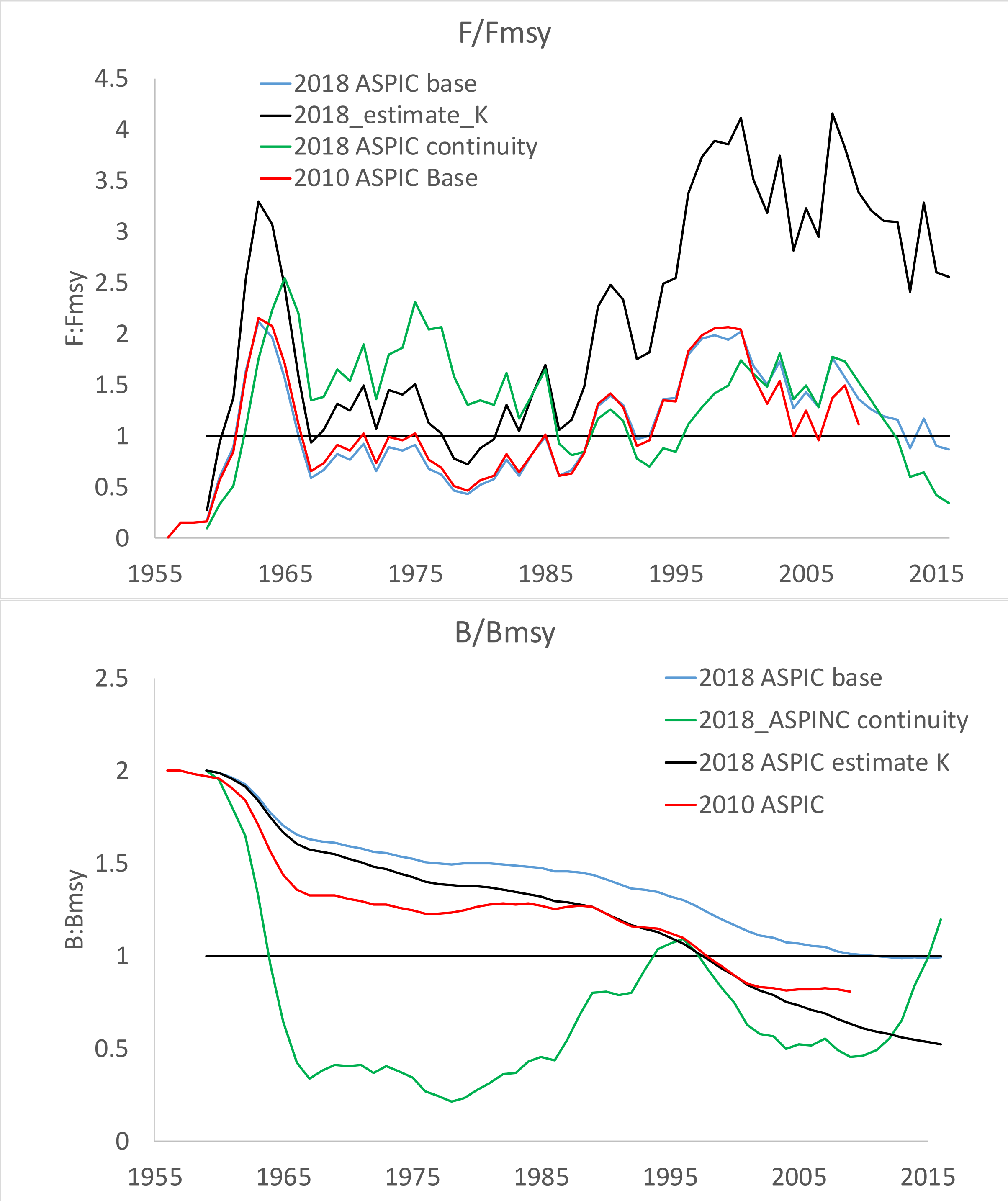

Figure 6. Comparison of stock status estimates from ASPIC runs.

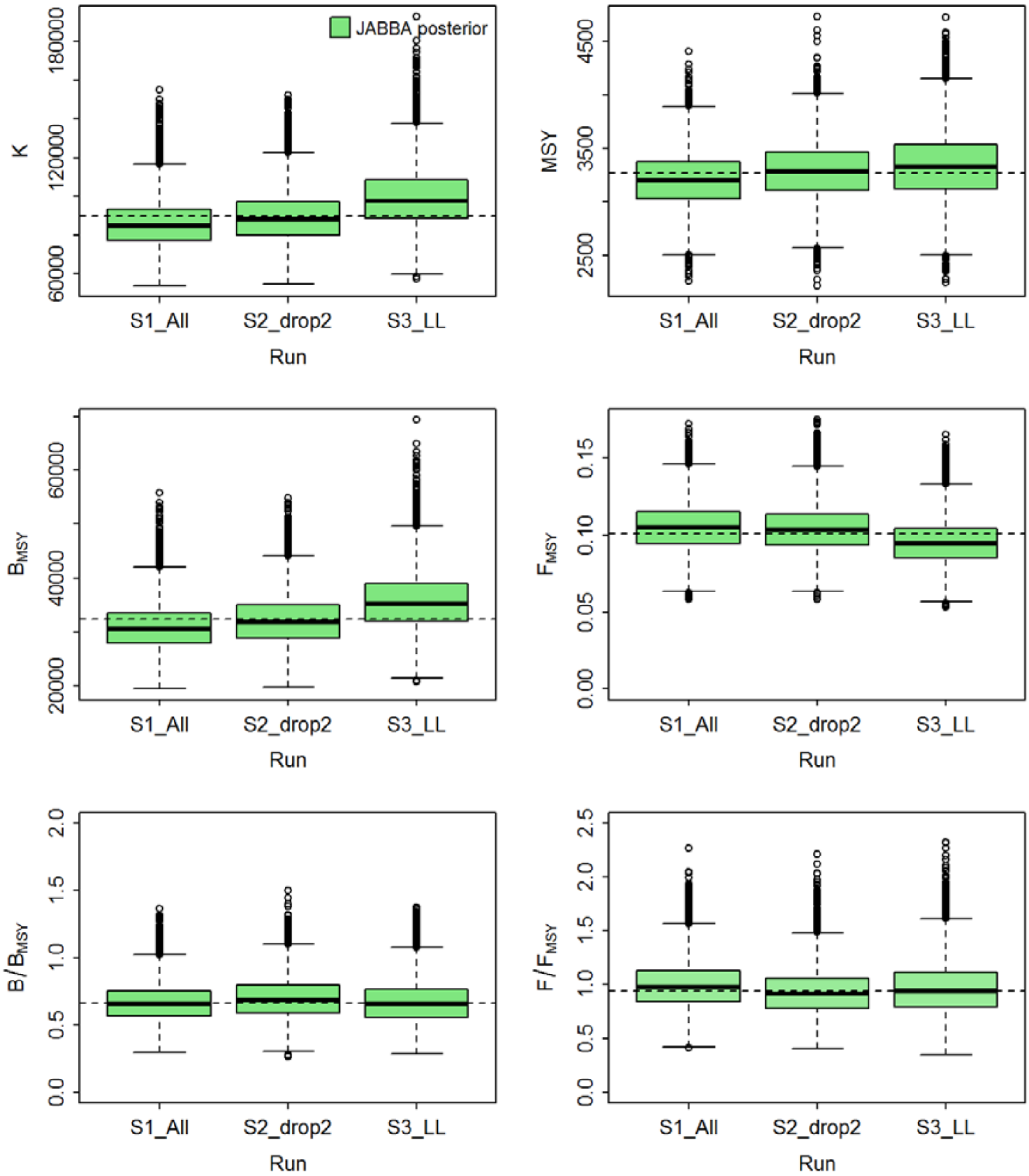

Figure 7. Comparison between posterior medians for the 3 scenarios from the Bayesian state-space surplus production model JABBA for Atlantic blue marlin. **S1_All** - a base case model (*h* = 0.5 with *r* prior fitted by a lognormal distribution with mean 0.098 and standard deviation of 0.18), including all CPUE series; **S2_drop2** - same *r* prior (*h* = 0.5), excluding TAI-LL late and US-Rec and; **S3_LL** - same *r* prior (*h*= 0.5), excluding all TAI-LL CPUE series.

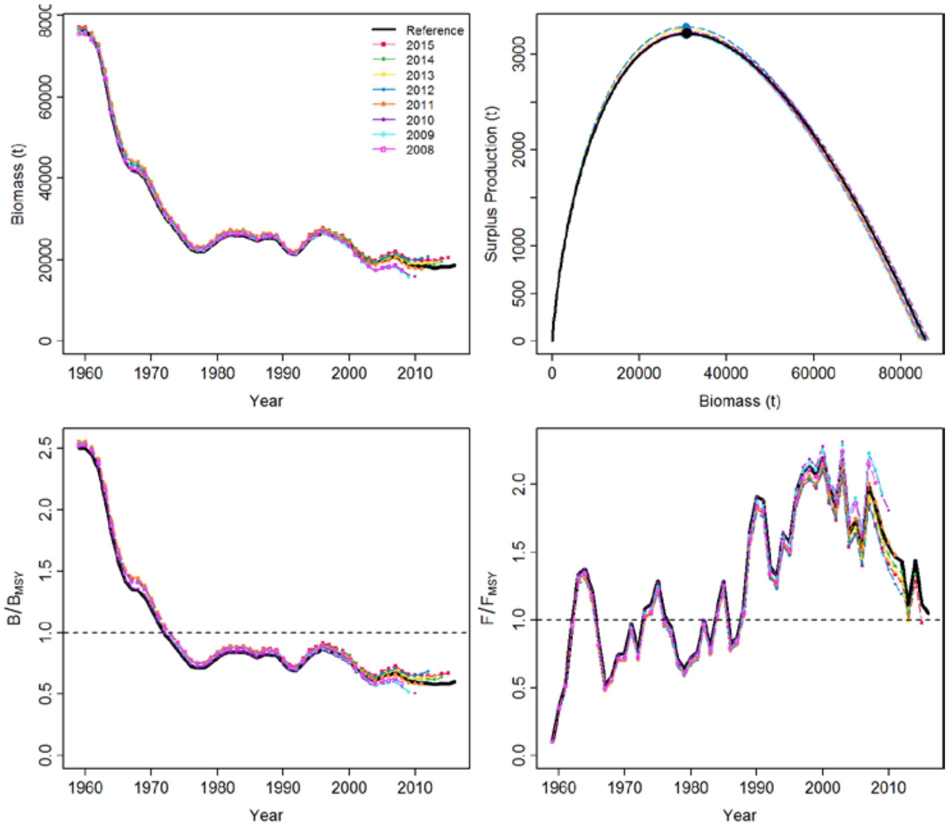

Figure 8. Retrospective plot for the Bayesian state-space surplus production model JABBA for Atlantic blue marlin (Scenario S1_All).

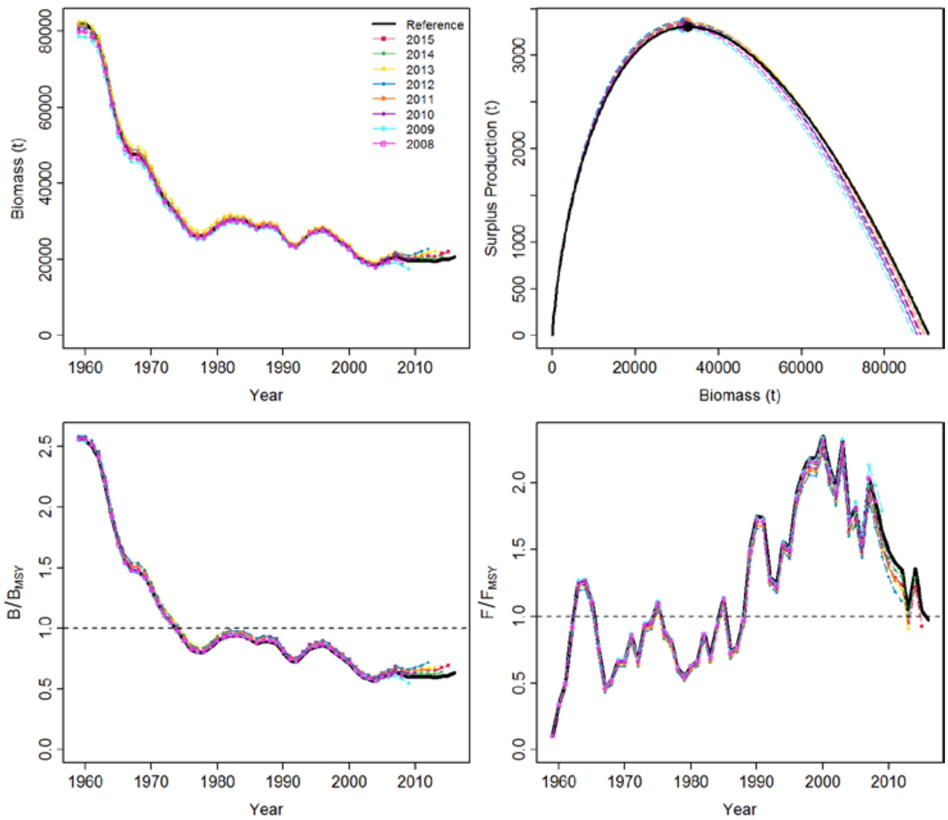

Figure 9. Retrospective plot for the Bayesian state-space surplus production model JABBA for Atlantic blue marlin (Scenario S2_drop2).

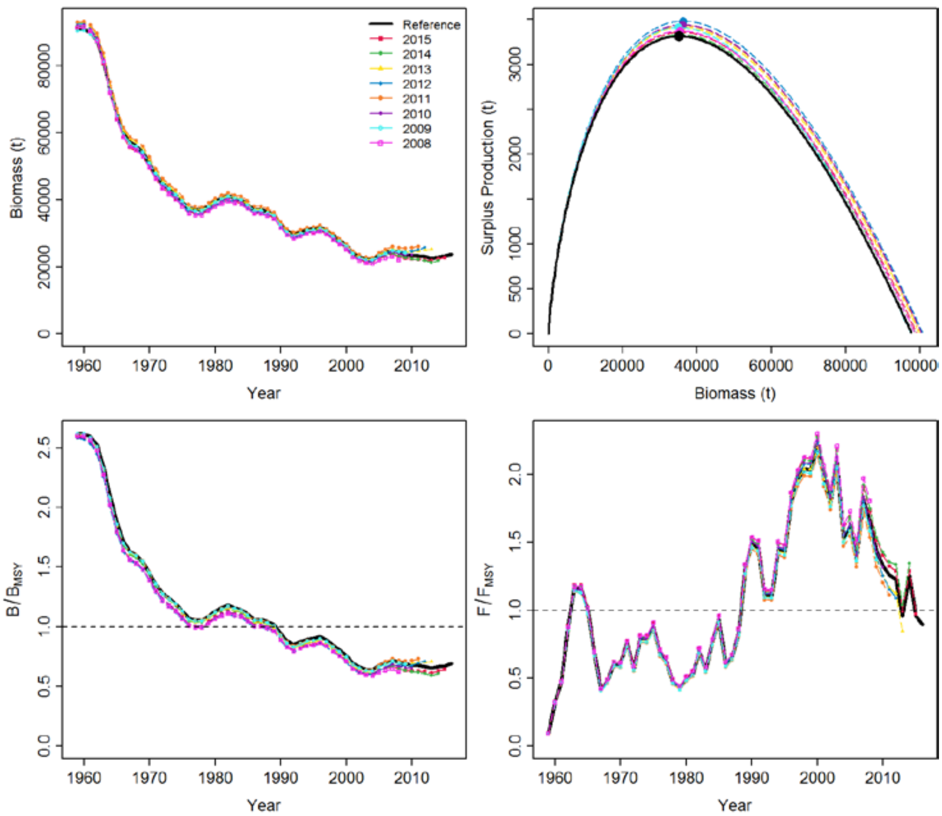

Figure 10. Retrospective plot for the Bayesian state-space surplus production model JABBA for Atlantic blue marlin (Scenario S3_all).

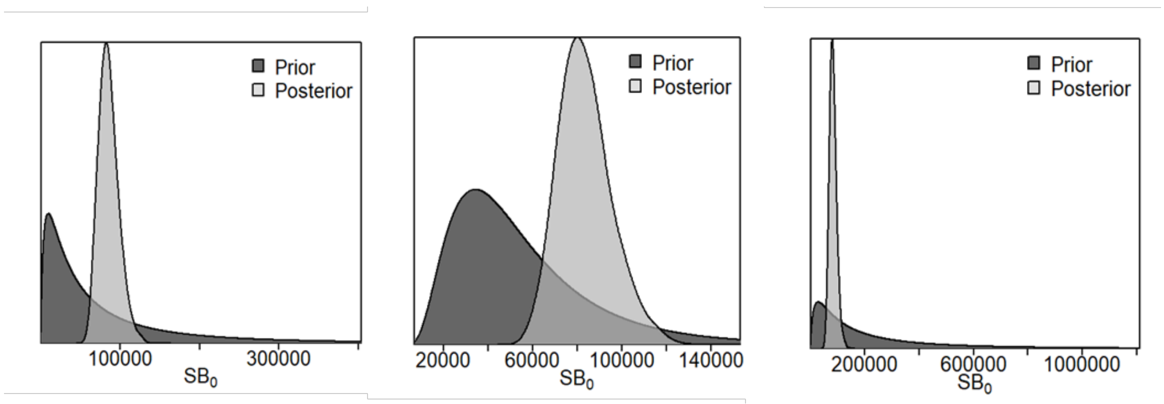

Figure 11. Sensitivity analysis regarding the prior developed for the carrying capacity *K* for the Bayesian state-space surplus production model JABBA for Atlantic blue marlin

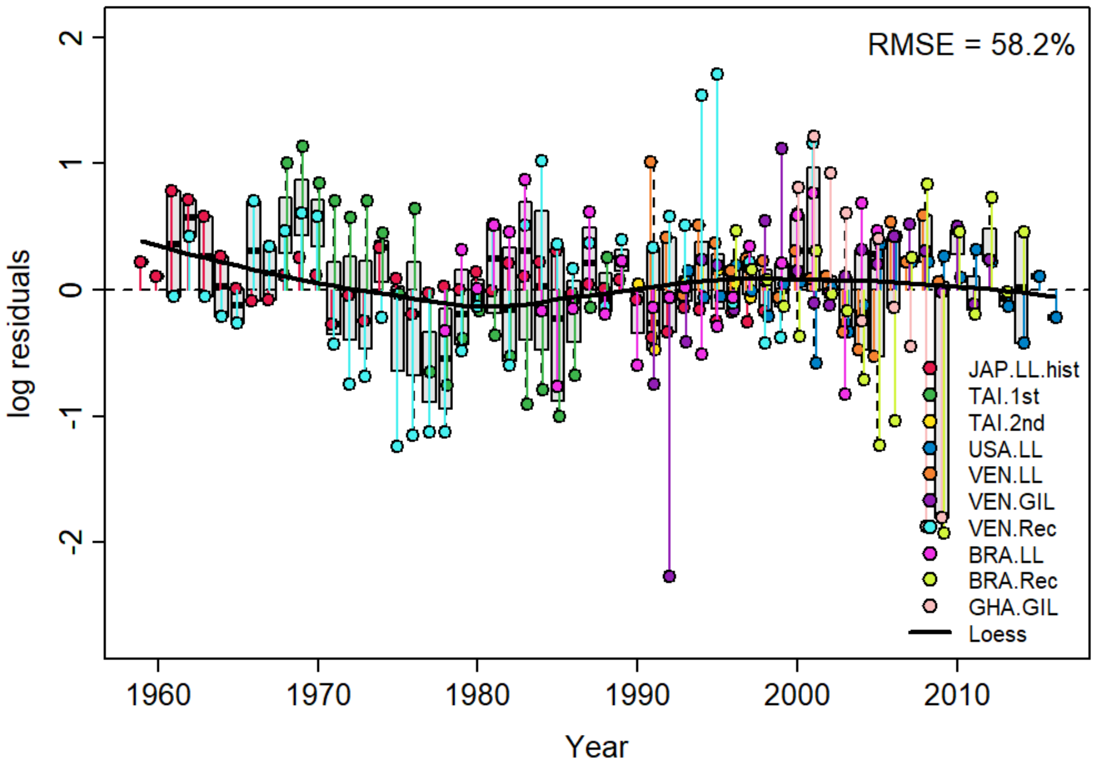

Figure 12. Residual diagnostics plots for final base model (S2_drop2) from the Bayesian state-surplus production model JABBA for the Atlantic blue marlin.

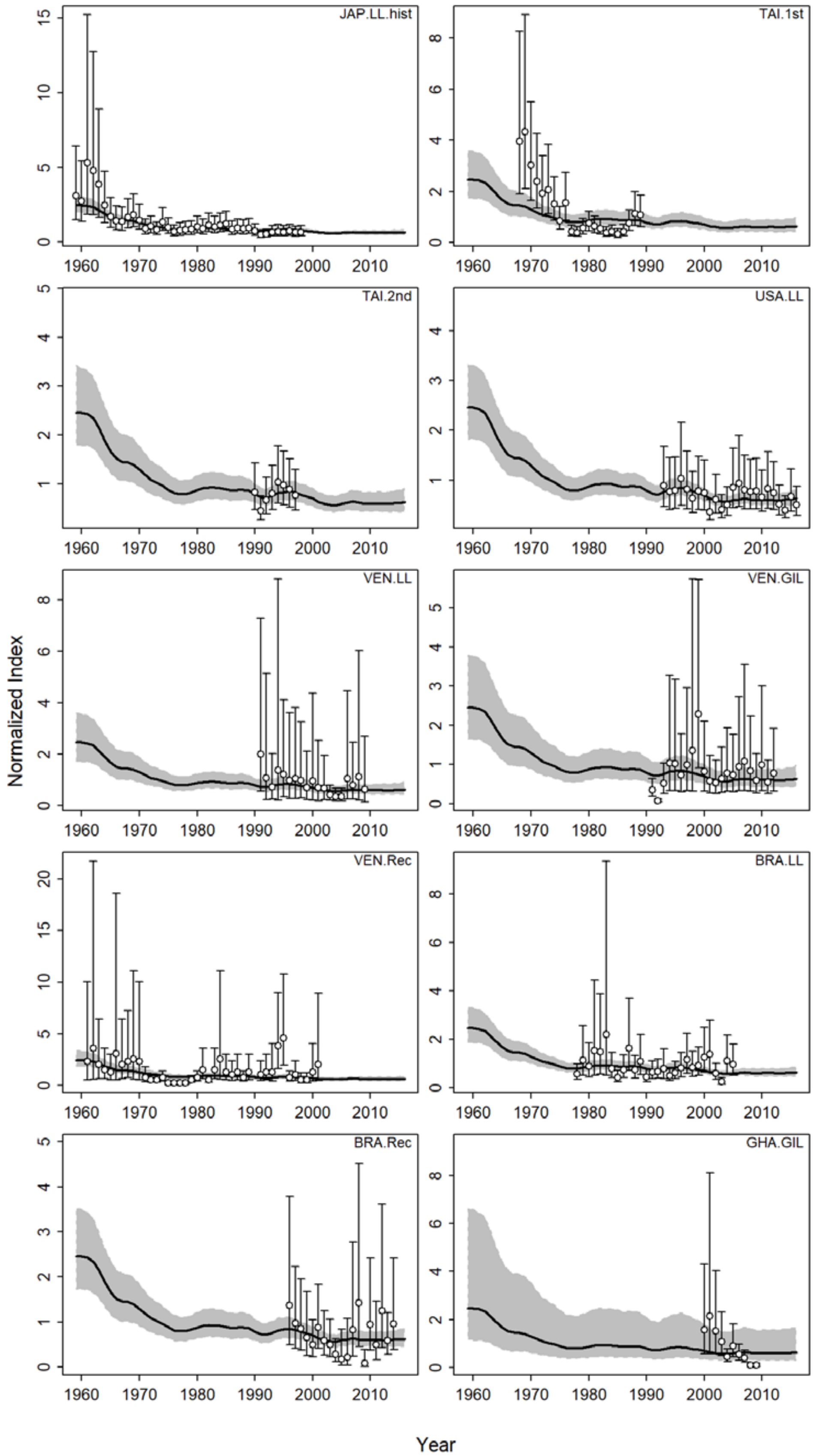

Figure 13. Time-series of observed (circle and SE error bars) and predicted (solid line) CPUE of blue marlin in the Atlantic Ocean for the final base model (S2_drop2) from the Bayesian state-space surplus production model JABBA. Shaded grey area indicates 95% C.I.

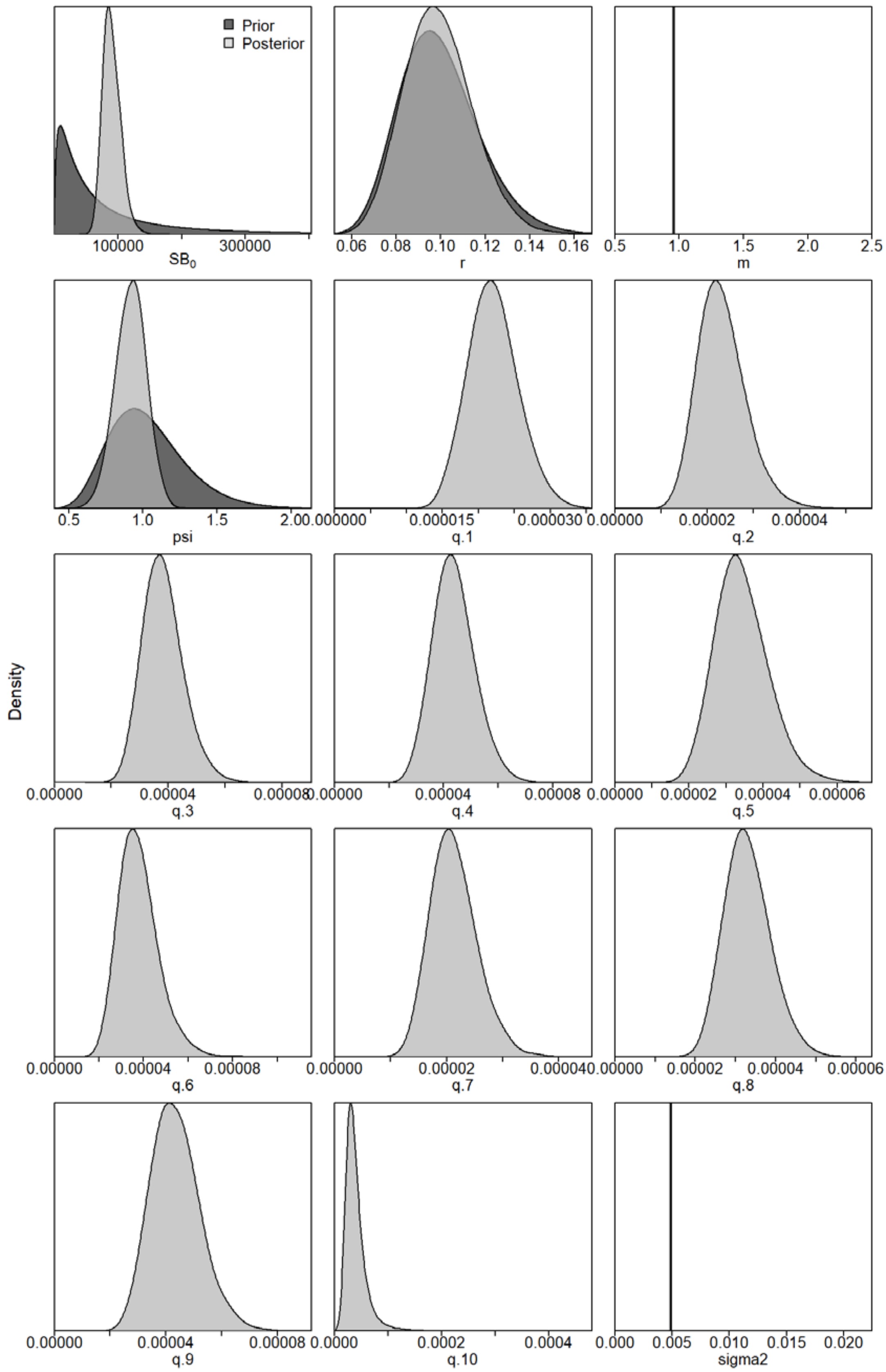

Figure 14. Prior and posterior distribution of various model and management parameters for the Bayesian state-space surplus production model (final base model S2_drop2) for blue marlin in the Atlantic Ocean.

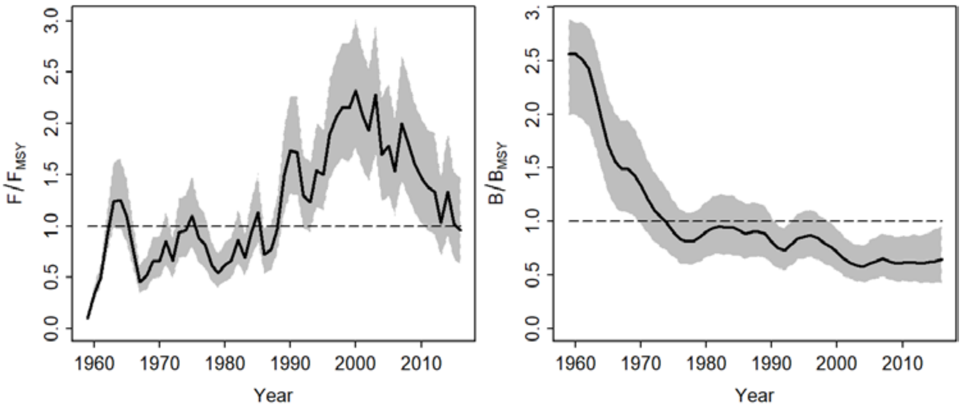

Figure 15. Trends in harvest rate relative to F_{MSY} and biomass relative to B_{MSY} for the final base model (S2_drop2) from the Bayesian state-space surplus production model JABBA fits to Atlantic blue marlin. Shaded grey area indicates 95% C.I.

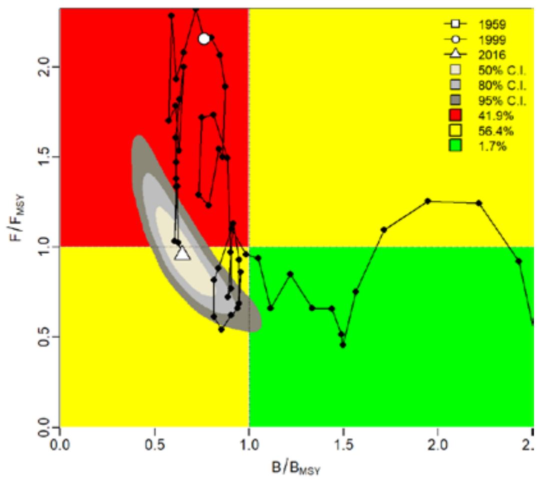

Figure 16. Kobe diagram showing the estimated trajectories (1959-2016) of B/B_{MSY} and F/F_{MSY} for the Bayesian state-space surplus production model JABBA (final base model S2_drop2) for the Atlantic blue marlin.

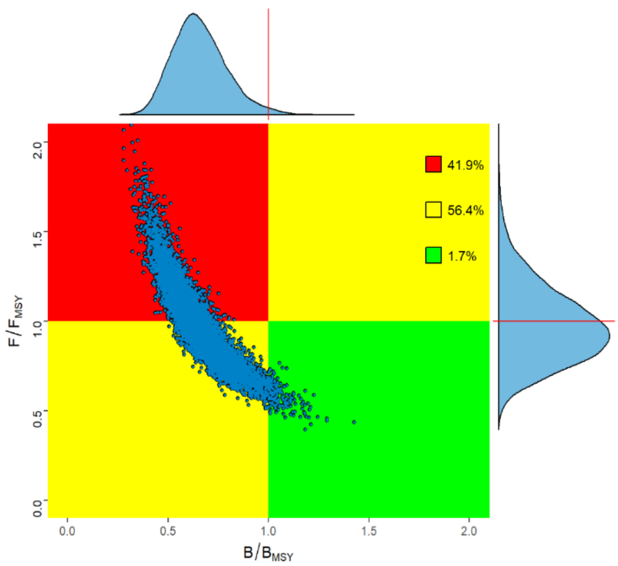

Figure 17. Kobe phase plot for the final base model (S2_drop2) for the Bayesian state-space surplus production model JABBA for the Atlantic blue marlin.

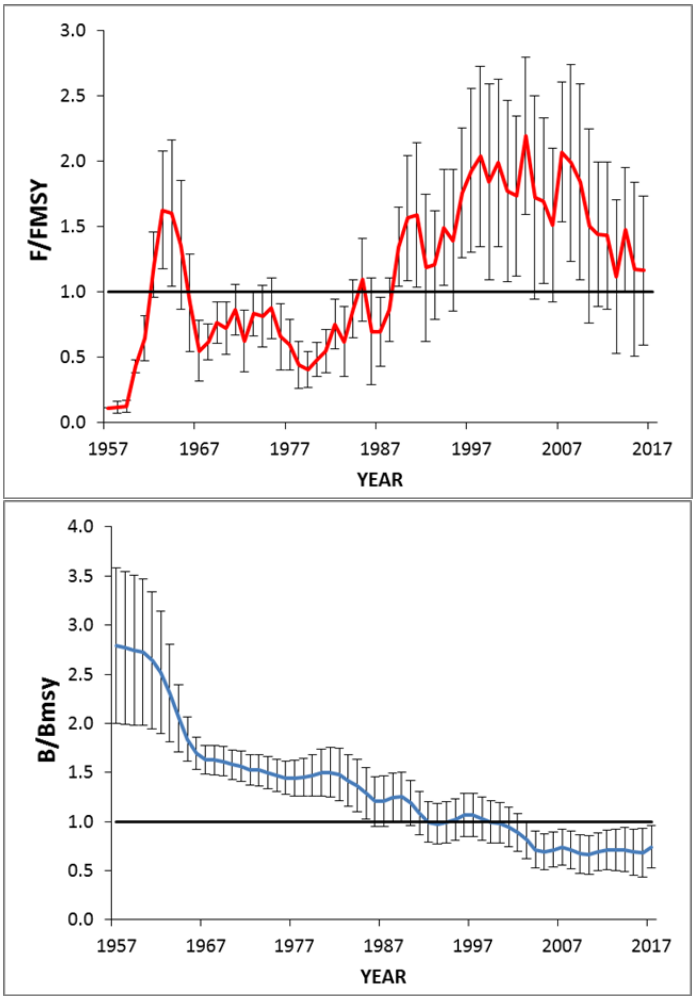

Figure 18. Trend in B/B_{MSY} (top) and F/F_{MSY} (bottom) for the SS base case model, including approximate 95% confidence intervals.

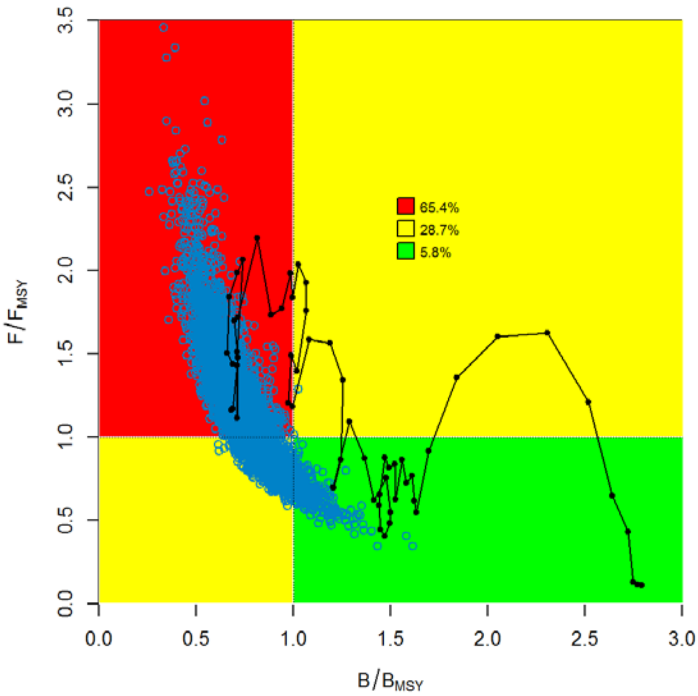

Figure 19. Kobe plot and tracks for the Atlantic blue marlin from the SS base case model on the basis of MCMC runs.

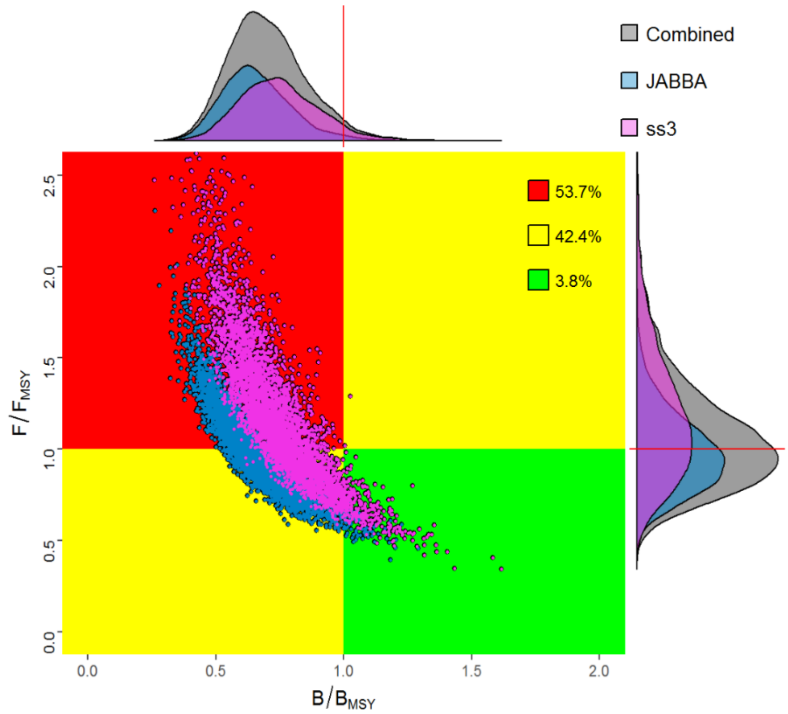

Figure 20. Combined Kobe plots for the final base cases of JABBA (blue) and SS (pink) models for the Atlantic blue marlin.

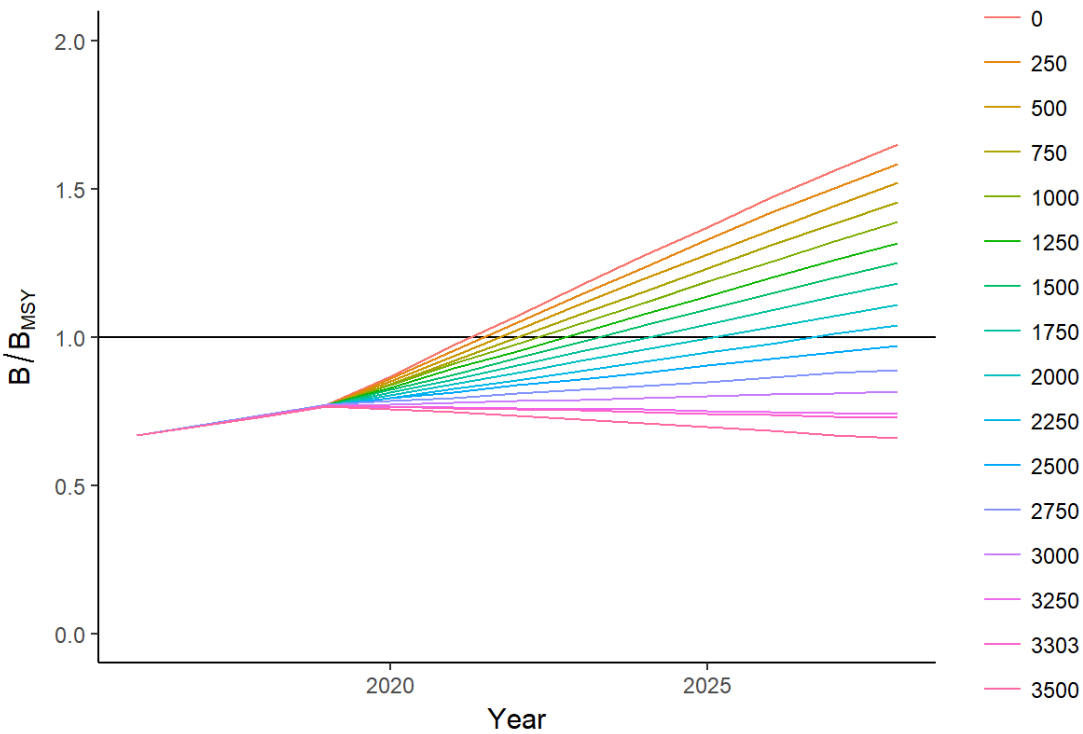

Figure 21. Trends of relative biomass (B/B_{MSY}) of projections of blue marlin current status under different TAC scenarios from the SPM JABBA final base model.

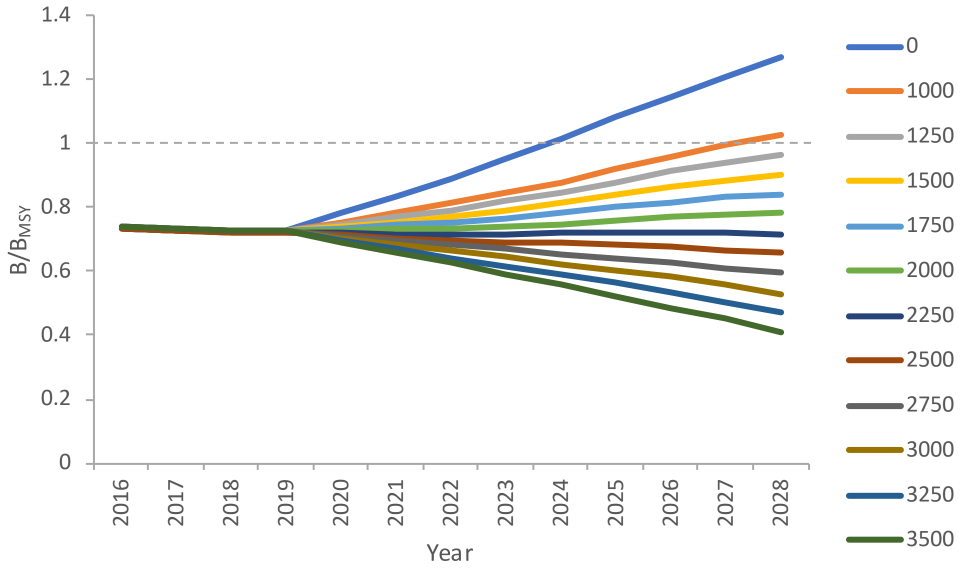

Figure 22. Projections of B/B_{MSY} for Atlantic blue marlin from the SS base case model for the range of future catches.

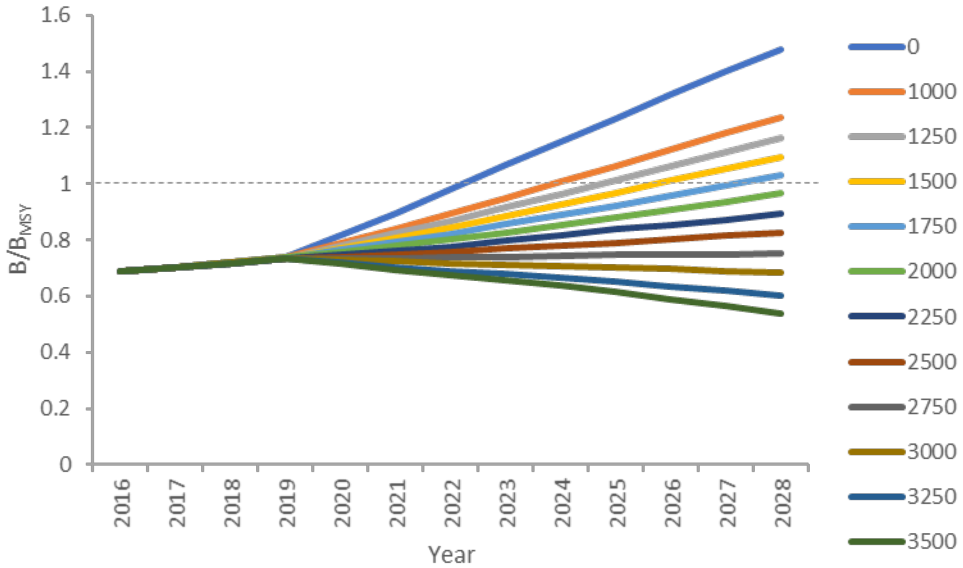

Figure 23. Combined results of projections of B/B_{MSY} for Atlantic blue marlin for both the SS3 and JABBA base case models under different TAC scenarios.

Appendix 1

Agenda

1. Opening, adoption of Agenda and meeting arrangements
2. Summary of updated data submitted after the Data Preparatory meeting, before the assessment data deadline (30 March 2018)
    - 2.1 Catches
    - 2.2 Indices of abundance
    - 2.3 Biology
    - 2.4 Length compositions
    - 2.5 Other relevant data
3. Methods relevant to the assessment
    - 3.1 Production models
    - 3.2 Length-based age-structured models: Stock Synthesis
    - 3.3 Other methods
4. Stock status results
    - 4.1 Production models
    - 4.2 Length-based age-structured models: Stock Synthesis
    - 4.3 Synthesis of assessment results
5. Projections
    - 5.1 Production models
    - 5.2 Length-based age-structured models: Stock Synthesis
    - 5.3 Synthesis of projections
6. Recommendations
    - 6.1 Research and statistics
    - 6.2 Management
7. Responses to the Commission
    - 7.1 Analysis of recommendations emanating from the Second ICCAT Performance Review and possible actions
    - 7.2 Analysis of the ICCAT exception fact sheet for billfishes
8. Other matters
    - 8.1 Start discussion on Exec Summary billfish
9. Adoption of the report and closure

Appendix 2

List of participants

CONTRACTING PARTIES

BRAZIL
Leite Mourato, Bruno
Profesor Adjunto, Departamento de Ciências do Mar, Universidade Federal de São PauloRua Carvalho de Mendoça, 144, Encruzilhada, 11070-100 Santos, SP
Tel: +55 61 2023 3540, Fax: +55 61 2023 3909, E-Mail: bruno.pesca@gmail.com; mourato.br@gmail.com

EUROPEAN UNION
Reynal, Lionel
IFREMER, 79, Pointe Fort, 97231 Le Robert, Martinique
Tel: +33 596 696 94 46 33, Fax: +33 05 9665 1941, E-Mail: lionel.reynal@ifremer.fr

MEXICO
Ramírez López, Karina
Instituto Nacional de Pesca y Acuacultura - Veracruz, Av. Ejército Mexicano No.106 - Colonia Exhacienda, Ylang Ylang, C.P. 94298 Boca de Río Veracruz
Tel: +52 22 9130 4520, E-Mail: kramirez_inp@yahoo.com; kramirez.inp@gmail.com

S. TOMÉ E PRÍNCIPE
Da Conceiçao, Ilair
Chef du Département de Recherche, Statistiques et de l'aquaculture, Direcçao das Pescas, Responsavel pelo serviço de Estatística PesqueiraBairro 3 de Fevereiro - PB 59
Tel: +239 990 9315, Fax: +239 12 22 414, E-Mail: ilair1984@gmail.com

SENEGAL
Sow, Fambaye Ngom
Chercheur Biologiste des Pêches, Centre de Recherches Océanographiques de Dakar Thiaroye, CRODT/ISRALNERV - Route du Front de Terre - BP 2241, Dakar
Tel: +221 3 0108 1104; +221 77 502 67 79, Fax: +221 33 832 8262, E-Mail: famngom@yahoo.com

UNITED STATES
Brown, Craig A.
Chief, Highly Migratory Species Branch, Sustainable Fisheries Division, NOAA Fisheries Southeast Fisheries Science Center, 75 Virginia Beach Drive, Miami Florida 33149
Tel: +1 305 586 6589, Fax: +1 305 361 4562, E-Mail: craig.brown@noaa.gov

Díaz, Guillermo
NOAA-Fisheries, Southeast Fisheries Science Center, 75 Virginia Beach Drive, Miami Florida 33149
Tel: +1 305 898 4035, E-Mail: guillermo.diaz@noaa.gov

Gibbs, Briana
University of Miami, Office 205 CIMAS, Rosenstiel School for Marine and Atmospheric Sciences, 4600 Rickenbacker Causeway, Miami FL 33149
Tel: +1 949 274 0600, E-Mail: briana.gibbs@rsmas.miami.edu; b.gibbs@miami.edu

Goodyear, Philip
1214 North Lakeshore Drive, Niceville Florida 32578
Tel: +1 850 897 2666, Fax: +1 850 897 2666, E-Mail: phil_goodyear@msn.com

Hoolihan, John
NOAA Fisheries, Southeast Fisheries Science Center, 75 Virginia Beach Drive, Miami Florida 33149
Tel: +1 305 282 8376, Fax: +1 305 361 4562, E-Mail: john.hoolihan@noaa.gov

Lauretta, Matthew
NOAA Fisheries Southeast Fisheries Center, 75 Virginia Beach Drive, Miami Florida 33149
Tel: +1 305 361 4481, E-Mail: matthew.lauretta@noaa.gov

Luo, Jiangang
University of Miami, RSMAS, 4600 Rickenbacker Causeway, Miami FL 33149
Tel: +1 305 421 4847, E-Mail: jluo@rsmas.miami.edu

Norelli, Alexandra
University of Miami, CIMAS Office 303, RSMAS4600 Rickenbacker Causeway, Miami FL 33149-1098
Tel: +1 203 918 0949, E-Mail: alexandra.norelli@rsmas.miami.edu; apn26@miami.edu

Schirripa, Michael
NOAA Fisheries, Southeast Fisheries Science Center, 75 Virginia Beach Drive, Miami Florida 33149
Tel: +1 305 361 4568, Fax: +1 305 361 4562, E-Mail: michael.schirripa@noaa.gov

Snodgrass, Derke
Sustainable Fisheries Division, NOAA Fisheries, 75 Virginia Beach Drive, Miami FL 33149
Tel: +1 305 361-4590, E-Mail: derke.snodgrass@noaa.gov

OBSERVERS FROM COOPERATING NON-CONTRACTING PARTIES, ENTITIES, FISHING ENTITIES

CHINESE TAIPEI
Lu, Yi-Sin
Department of Environmental Biology and Fisheries Science, No. 2 Pei-Ning Rd. Keelung
Tel: +886 2 2462 2192 # 5046, E-Mail: z5834211@gmail.com

Su, Nan-Jay
Assistant Professor, Department of Environmental Biology and Fisheries Science, No. 2 Pei-Ning Rd. Keelung, 202
Tel: +886 2 2462-2192 #5046, E-Mail: nanjay@ntou.edu.tw

OBSERVERS FROM INTERGOVERNMENTAL ORGANIZATIONS

WESTERN CENTRAL ATLANTIC FISHERY COMMISSION - WECAFC
Bealey, Roy
Food and Agriculture Organization of the United Nations, Caribbean Billfish Project, Subregional Office for the Caribbean (FAO-SLC), 2nd floor, United Nations House, Marine Gardens, Hastings, Christ Church, BB11000 Barbados
Tel: +1 246 426 7110/11 Ext. 244, Fax: +1 246 427 6075, E-Mail: roy.bealey@fao.org

SCRS CHAIRMAN
Die, David
SCRS Chairman, Cooperative Institute of Marine and Atmospheric Studies, University of Miami, 4600 Rickenbacker Causeway, Miami Florida 33149, United States
Tel: +34 673 985 817, Fax: +1 305 421 4607, E-Mail: ddie@rsmas.miami.edu

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ICCAT Secretariat
C/ Corazón de María 8 – 6th floor, 28002 Madrid – Spain
Tel: +34 91 416 56 00; Fax: +34 91 415 26 12; E-mail: info@iccat.int

Neves dos Santos, Miguel
Ortiz, Mauricio

EXPERT GUEST
Arocha, Freddy, Instituto Oceanográfico de Venezuela, Universidad de Oriente, A.P. 204, 6101 Cumaná Estado Sucre, Venezuela
Tel: +58-293-400-2111 - móvil: 58 416 693 0389, E-Mail: farocha@udo.edu.ve; farochap@gmail.com

Appendix 3

List of Papers and Presentations

Reference	Title	Authors
SCRS/2018/089	Análisis de la captura, distribución de longitud, relación longitud-peso y proporción de sexo del marlín azul (*Makaira nigricans*) capturado incidentalmente por la flota palangrera mexicana en el golfo de México	Ramírez- López K. and Gutiérrez-Benítez O.
SCRS/2018/090	Catch estimates and size compositions of blue marlin for the Taiwanese tuna longline fishery in the Atlantic Ocean	Su N.-J. and Lu Y.-S.
SCRS/2018/091	Stock assessment of Atlantic blue marlin (*Makaira nigricans*) using a Bayesian state-space surplus production model JABBA	Mourato B.L., Winker H., Carvalho F. and Ortiz M.
SCRS/2018/092	Unifying parameterizations between age-structured and surplus production models: an application to Atlantic blue marlin (*Makaira nigricans*)	Winker H., Carvalho F., Sow F.N. and Ortiz M.
SCRS/2018/097	Current status of the blue marlin (*Makaira nigricans*) stock in the Atlantic Ocean 2018: Pre-decisional stock assessment model	Schirripa M.

SCRS/P/2018/037	Short-term contract Comprehensive study of strategic investments related to artisanal fisheries data collection in iccat fisheries of the Caribbean/Central American region - Mid-term report	Arocha F.
SCRS/P/2018/038	Perspectives on estimates of blue marlin growth	Goodyear P.
SCRS/P/2018/039	The Caribbean Billfish Project Summary of achievements and developing plans	Bealey R.
SCRS/P/2018/040	Current status of the blue marlin (*Makaira nigricans*) stock in the Atlantic Ocean 2018: Pre-decisional stock assessment model	Schirripa M.
SCRS/P/2018/041	Stock production models using ASPIC for blue marlin in the Atlantic Ocean from 1959-2016	Forrestal F.C. and Schirripa M.J.
SCRS/P/2018/042	JABBA Atlantic Blue Marlin Assessment: Robustness runs and retrospectives analysis	Winker H., Mourato B., Carvalho F. and Ortiz M.

Appendix 4

SCRS Document and Presentations Abstracts as provided by the authors

SCRS/2018/089 - Se analiza la captura y algunos aspectos biológicos del marlín azul (*Makaira nigricans*). Los análisis para la captura se hicieron mediante el método Singulas Spectrum Analysis (SSA), para las distribuciones de la Longitud Mandíbula Inferior a la Furca (LMIF) se utilizaron los estimadores de densidad por Kernel, asimismo se exploró la relación longitud-peso y la proporción de sexos. Se identificó la tendencia y un componente armónico, los cuales explican el 93.724% de la variabilidad de la captura. Se identificaron de 4-5 modas para machos y 3-4 modas para hembras. La proporción de sexo mostró predominancia de machos.

SCRS/2018/090 – Blue marlin (*Makaira nigricans*) are highly migratory pelagic species in the three oceans. Catches from the Taiwanese tuna longline fishery in the Atlantic Ocean vary dramatically in the early period (late 1960s and early 1970s) and the 1990s. Annual catches for certain year increased to more than 1,000 t but dropped substantially after the peak occurred. Size data (eye fork length, EFL) of blue marlin were collected and analyzed by year based on information from logbooks, with the sample sizes ranging from 276 to 674. The mean lengths for each year remain stable from 200.1 to 213.9 cm EFL during the period between 2012 and 2016.

SCRS/2018/091 – Bayesian State-Space Surplus Production Models were fitted to Atlantic blue marlin (*Makaira nigricans*) catch and CPUE data using the open-source stock assessment tool JABBA. The first three scenarios (S1-S3) were based on alternative hypotheses about the stock's productivity and fitted to 12 individual CPUE series, while the fourth scenario (S4) was fitted using an averaged CPUE index based on the same specifications as for S1. The results for the four alternative scenarios estimated MSY between 3158 tons and 3265 tons. Stock status trajectories showed a typical anti-clockwise pattern, moving from initially underexploited through a period of unsustainable fishing, leading to a > 95% probability of stock biomass in 2016 being below levels that can produce MSY when inferred from combined posteriors for S1-S3 . The 2016 harvest rate estimates were close to or exceeding the sustainable exploitation levels that would be required to achieve rebuilding to biomass levels at MSY in the short- to medium term, albeit associated with high uncertainty. Despite a number of CPUE indices indicating relatively poor fits, considering all CPUEs in the assessment appears to be an objective option that would enables to produce reasonable model diagnostics and plausible stock status estimates. Options for possible alternative scenarios are discussed.

SCRS/2018/092 – Age-structured models (ASMs; e.g. ss3) and surplus production models (SPMS; e.g. ASPIC, JABBA) are increasingly run in parallel during stock assessments conducted by tuna Regional Management Organizations (tRFOMs). Yet, the choice of parameterization for the two different model types may not always be compatible, which can violate the validity model comparison and consequently inferences about the stock status. Here, we propose an approach for unifying the model parameterization between ASMs and SPMs. Central to this approach is the application of an age-structured equilibrium model (ASEM) to translate a set of typical ASM input parameters into the intrinsic rate of population increase r and the shape parameter m of the Pella-Tomlison SPM. We apply this approach using the age- and sex-specific stock parameters for Atlantic blue marlin (*Makaira nigricans*) and specifically explore the effects of the key input parameters natural mortality M and the steepness h of the spawning recruitment relationship on the SPM parameters r and m. We demonstrate that the functional form of a 16-parameter yield curve for an age- and sex-structured stock (i.e. ss3-type) can be closely approximated by the 2-parameter Pella surplus production curve. Based on the three steepness h scenarios (h = 0.4, h = 0.5 and h = 0.6) put forward for the 2018 ICCAT blue marlin assessment and admitting reasonable uncertainty about M, we propose three sets steepness-specific priors for r and m input values for consideration in SPM assessments scenarios for Atlantic blue marlin.

SCRS/2018/097 – this document describes the pre-decisional base case model configured to estimate the status of the blue marlin (*Makaira nigricans*) stock for the June 2018 stock assessment meeting. The model configuration is based on the 2011 model used to provide management advice. Uncertainties specifically accounted for were growth, length at 50% maturity, stock-recruitment steepness, natural mortality and conflicting CPUE trends. Uncertainties not accounted for where, inter alia, seasonal and/or aerial differences in life history traits and illegal, unreported and unregulated (IUU) landings. Several assumptions were investigated via different model configurations, namely three steepness values (0.40, 0.50 and 0.60) and three natural mortality values (0.10, 0.122 and 0.139). Uncertainty distributions around all nine combinations the terminal year estimates of B/B_{MSY} and F/F_{MSY} were constructed using the means and standard deviations and assuming bivariate normal distributions. When considering all combinations simultaneously, 81 percent of the points were in the red zone of the KOBE matrix (both overfished and overfishing) 18 percent in the yellow, and 1 percent in the green (neither overfishing nor overfished).

SCRS/P/2018/037 – No summary provided by author.

SCRS/P/2018/038 – No summary provided by author.

SCRS/P/2018/039 – provided a project update on behalf of the project executing Western Central Atlantic Fisheries Commission (WECAFC). This project is achieving its objective of developing business plans for one or more long-term pilot projects aimed at sustainable management and conservation of billfish within the Western Central Atlantic Ocean. Completed studies have provided holistic assessments of various billfish sustainability issues in the region, while various project actions have improved the regional capacity to more sustainably manage harvests from the stocks of blue marlin and other regionally shared stocks. Project completion is expected by the end of 2018 and further cooperation between ICCAT and the WECAFC, to collectively address relevant fishery issues, was actively encouraged.

SCRS/P/2018/040 – No summary provided by author.

SCRS/P/2018/041 – Indices of abundance presented at the 2018 blue marlin data preparatory meeting were to update stock production models (ASPIC) developed for the 2011 blue marlin assessment. A continuity run was conducted using updated CPUE indices that were available in 2011 and 2018 under the "low production" assumptions of a set K of 100,000. Additional model runs were conducted with all the available CPUEs and all the model parameters estimated.

SCRS/P/2018/042 – No summary provided by authors.

Appendix 5

Bayesian Surplus production model (BSPM): Just Another Bayesian Biomass Assessment (JABBA) - model formulation

Blue marlin BSPM assessment was implemented using the Bayesian state-space surplus production model framework JABBA, version v1.1 (Winker *et al*. 2018). The JABBA software includes options for: (1) automatic fitting of multiple CPUE time series and associated standard errors; (2) estimating or fixing the process variance, (3) optional estimation of additional observation variance for individual or grouped CPUE time series, and (4) specifying a Fox, Schaefer or Pella-Tomlinson production function by setting the inflection point B_{MSY}/K and converting this ratio into shape a parameter m. A full JABBA model description, including formulation and state-space implementation, prior specification options and diagnostic tools is available in Winker *et al*. 2018.

For K, it was assumed a vaguely informative lognormal prior with a mean 50,000 metric tons and CV of 200%. Initial depletion lognormal prior ($\varphi = B_{1959}/K$) was set with mean = 1 and CV of 25%. All catchability parameters were formulated as uniform priors, while the observation variance was implemented by assuming inverse-gamma prior. Initial trials indicated that estimating the process error (sigma) resulted in large variance estimates that would result implausible large variations in annual stock biomass. Instead, the process error was therefore fixed at 0.07 (see Ono et al., 2012 for details). JABBA is implemented in R (R Development Core Team, https://www.r-project.org/) with JAGS interface (Plummer, 2003) to estimate the Bayesian posterior distributions of all quantities of interest by means of a Markov Chains Monte Carlo (MCMC) simulation. In the preliminary run, two MCMC chains were used. The model was run for 30,000 iterations, sampled with a burn-in period of 5,000 for each chain. Basic diagnostics of model convergence included visualization of the MCMC chains throughout trace-plots.

To evaluate CPUE fits, the model predicted CPUE indices were compared to the observed CPUE. JABBA residual plots were also examined, and the randomness of model residuals was evaluated by means of the Root-Mean-Squared-Error (RMSE). To provide additional model performance diagnostics, we focused on the relative influence of individual CPUE series on the stock status estimates for scenario S1 by removing one CPUE series at a time and predicting the stock status in the form of B/B_{MSY} and F/F_{MSY} trajectories.

References

Ono, K., Punt, A.E., and Rivot, E. 2012. Model performance analysis for Bayesian biomass dynamics models using bias, precision and reliability metrics. Fish. Res. 125: 173–183.

Plummer, M., 2003. JAGS: a program for analysis of Bayesian graphical models using Gibbs sampling. In: 3rd International Workshop on Distributed Statistical Computing (DSC 2003). Vienna, Austria.

Winker, H.; Carvalho, F. and Kapur, M. 2018. JABBA: Just Another Bayesian Biomass Assessment. Fish. Res. 204: 275–288.

Appendix 6

Billfish Check Sheet

(Name of CPC)____________________________________

Note: Each ICCAT requirement must be implemented in a legally binding manner. Just requesting fishermen to implement measures should not be regarded as implementation.

Rec. #	*Para #*	*Requirement*	*Status of implementation*	*Relevant domestic laws, regulations or industry/public initiatives in support of recommendation (e.g. best practice codes, monitoring programs) (as applicable). Include text, references, or links to where this information is codified.*	*Notes/explanations*
15-05	1	Landings limits – *Blue marlin landings limits.* Para. 1 establishes CPC-specific landing limits for certain CPCs and a generally applicable landing limit for all other CPCs. Were your CPC's total landings (from all fisheries, including commercial, recreational, sport, artisanal, subsistence) for blue marlin within the applicable limit in paragraph 1 or (or in the case of CPCs with a specific landings limit, within that CPC's adjusted landings limit on the relevant marlin compliance table)?	Yes or No		If No, please indicate total landings and explain steps being taken to ensure landings do not exceed the ICCAT limit or adjusted limit applicable to the CPC. (N/A is not a permissible response.)

15-05	1	*White marlin/spearfish combined landings limits.* Para. 1 establishes CPC-specific landings limits for certain CPCs and a generally applicable landing limit for all other CPCs. Were your CPC's total landings (from all fisheries, including commercial, recreational, sport, artisanal, subsistence) for white marlin/spearfish (combined) within the applicable limit in paragraph 1 or (or in the case of CPCs with a specific landings limit, within that CPC's adjusted landings limit on the relevant marlin compliance table)?	Yes or No		If No, please indicate total landings and explain steps being taken to ensure landings do not exceed the ICCAT limit or adjusted limit applicable to the CPC. (N/A is not a permissible response.)
15-05	2	"To the extent possible, as the CPC approaches its landings limits, such CPC shall take appropriate measures to ensure that all blue marlin and white marlin/spearfish that are alive by the time of boarding are released in a manner that maximizes their survival."	Yes or No or N/A (Not applicable)		If "No" or "N/A", explain the reason. If "No", please explain any steps your CPC plans to implement this requirement. (N/A is only a permissible response if your CPC did not approach its landings limit, which includes CPCs without a specific landings limit and therefore subject to the generally applicable limit in para. 1.)
15-05	2	15-05 provides: "For CPCs that prohibit dead discards, the landings of blue marlin and white marlin/spearfish that are dead when brought alongside the vessel and that are not sold or entered into commerce shall not count against the limits established in paragraph 1, on the condition that such prohibition be clearly explained."	Yes or No		If "Yes", please also explain your dead discard prohibition and rules concerning sale/entry into commerce here. (N/A is not a permissible response.)

		Does your CPC prohibit dead discard of blue marlin and white marlin/spearfish?			
15-05	4	"CPCs shall work to minimize the post-release mortality of marlins/spearfish"	Yes or No		If "No", please explain the reason. If Yes, please explain how. Include any information on best practices for handling bycatch of marlins if those have been adopted. (N/A is not a permissible response.)
15-05	5-7	Does the CPC have recreational fisheries that interact with blue marlin or white marlin/spearfish?	Yes or No		(N/A is not a permissible response.)
15-05	5	"CPCs with recreational fisheries shall maintain 5% scientific observer coverage of blue marlin and white marlin/spearfish tournament landings" Does your CPC meet the 5% requirement?	Yes or No or N/A (Not applicable)		If "No" or "N/A", explain the reason. If "No", please also explain any steps your CPC plans to implement this requirement. ("N/A" only a permissible response if your CPC has confirmed in this check sheet that it does not have any recreational fisheries that interact with blue marlin or white marlin/spearfish.)
15-05	6	"CPCs with recreational fisheries shall adopt domestic regulations that establish minimum sizes in their recreational fisheries that meet or exceed the following lengths: 251 cm LJFL for blue marlin and 168 cm LJFL for white marlin/spearfish, or comparable limits by weight. Has your CPC adopted minimum size requirements consistent with these?	Yes or No or N/A (Not applicable)		If "Yes", please indicate what minimum size your CPC has set for each species, including if your CPC implements through a comparable weight limit. If "No" or "N/A", explain the reason.

					If "No", please also explain any steps your CPC plans to implement this requirement. ("N/A" is only a permissible response if your CPC has confirmed in this check sheet that it does not have any recreational fisheries that interact with blue marlin or white marlin/spearfish.)
15-05	7	"CPCs shall prohibit the sale, or offering for sale, of any part or whole carcass of blue marlin or white marlin/spearfish caught in recreational fisheries." Has your CPC implemented this no sale provision?	Yes or No or N/A (Not applicable)		If "No" or "N/A", please explain the reason. If "No", please also explain any steps your CPC plans to implement this requirement. ("N/A" may only be used if the CPC has confirmed in this check sheet that it does not have any recreational fisheries that interact with blue marlin or white marlin/spearfish.)
15-05	8	"CPCs shall inform the Commission of steps taken to implement the provisions of this Recommendation through domestic law or regulations, including monitoring, control and surveillance measures." Does your CPC provide this information to ICCAT?	Yes or No		If "Yes", please provide here information on implementation (including monitoring, control, and surveillance measures) not otherwise covered elsewhere on this check sheet. If "No", please explain the reason, and any steps your CPC plans to implement this requirement.

15-05	9	Does your CPC have non-industrial fisheries that interact with blue marlin or white marlin/sailfish?	Yes or No		“N/A” is not a permissible response.
15-05	9	“CPCs with non-industrial fisheries shall provide information about their data collection programs.”	Yes or No or N/A (Not applicable)		If “Yes”, ~~provide information here~~ please briefly describe the data collection program. If "No" or "N/A", explain the reason. If “No”, please also explain any steps your CPC plans to implement this requirement. (“N/A” may only be used if the CPC has confirmed in this check sheet that it does not have any non-industrial fisheries that interact with blue marlin or white marlin/spearfish.”)
	10	“CPCs shall provide their estimates of live and dead discards, and all available data including observer data on landings and discards for blue marlin, white marlin/spearfish, annually by July 31 as part of their Task I and II data submission to support the stock assessment process.” Has your CPC provided this data by the deadline?	Yes or No		If "No", please explain the reason and any steps your CPC plans to implement this requirement.

16-11	1	“Contracting Parties and Cooperating non-Contracting Parties, Entities or Fishing Entities (CPCs) whose vessels catch Atlantic sailfish (*Istiophorus albicans*) in the Convention Area shall ensure that management measures are in place to support the conservation of this species in line with ICCAT's Convention objective by undertaking the following: …. (b) To prevent catches from exceeding this level for either stock of sailfish, CPCs shall take or maintain appropriate measures to limit sailfish mortality. Such measures could include, for example: releasing live sailfish, encouraging or requiring the use of circle hooks or other effective gear modifications, implementing a minimum size, and/or limiting days at sea.”	Yes or No		If Yes, please explain management measures taken or maintained to implement this requirement. If "No", explain the reason, and any steps your CPC plans to implement this requirement. (“N/A” is not a permissible response.)
16-11	2	“CPCs shall enhance their efforts to collect data on catches of sailfish, including live and dead discards, and report these data annually as part of their Task I and II data submission to support the stock assessment process.” Has your CPC enhanced its data collection efforts as required?	Yes or No		If yes, please explain actions taken. If "No", please explain the reason [and any implementation steps your CPC plans to take]. (“N/A” is not a permissible response.)
16-11	3	CPCs shall describe their data collection programmes and steps taken to implement this Recommendation Has your CPC described its data collection programmes?	Yes or No		If “Yes”, please provide the information here, or if the information has been reported to ICCAT through means other than this check sheet, please indicate where.

					If "No the reason, and any implementation steps the CPC plans to take. ("N/A" is not a permissible response.)

Notes: