REPORT OF THE 2019 ICCAT WHITE MARLIN STOCK ASSESSMENT MEETING

(Miami, USA 10-14 June 2019)

"The results, conclusions and recommendations contained in this Report only reflect the view of the Billfish Species Group. Therefore, these should be considered preliminary until the SCRS adopts them at its annual Plenary meeting and the Commission revise them at its Annual meeting.

Accordingly, ICCAT reserves the right to comment, object and endorse this Report, until it is finally adopted by the Commission."

1. Opening, adoption of agenda and meeting arrangements

The meeting was held in Miami at the Rosenstiel School of Marine and Atmospheric Science, Cooperative Institute of Marine and Atmospheric Studies, at the University of Miami, from 10 to 14 June 2019. 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 white marlin is one of the two stocks being assessed in 2019 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 participants served as rapporteurs:

Sections	*Rapporteur*
Items 1	M. Ortiz
Item 2.1	A. Norelli, M. Ortiz
Item 2.2	F. Forrestal
Item 2.3	K. Ramirez, B. Gibbs
Item 2.4, 2.5	M. Ortiz
Item 3	M. Lauretta, B. Mourato, K. Ba
Item 4	A. Kimoto, D. Die, M. Schirripa, B. Mourato
Item 5	A. Kimoto, G. Diaz
Item 6	F. Sow, R. Coelho, C. Brown
Item 7	D. Die, M. Willis
Item 8	F. Ngom, M. Neves dos Santos
Item 9	M. Ortiz

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

2.1 Catches

The Secretariat provided the reported Task I NC (nominal catches) available as of 5 June 2019 (**Table 1**). It was noted that for 2018 there were very few reports submitted by CPCs and catches for that year are considered highly incomplete. The Group agreed to used 2017 as the last year for the assessment model inputs. As indicated at the data preparatory meeting, few CPCs had officially reported estimates of dead discards and live releases of white marlin.

Following the recommendations and workplan adopted by the Group during the data preparatory meeting (SCRS/2019/004), the Secretariat summarized the Task I and Task II updates for white marlin received from CPCs. The Group was reminded that the reported catches represent both white marlin (*Kajikia albida*) and roundscale spearfish (*Tetrapturus georgii*) due to the difficulty of distinguishing one species from the other. Although, previous genetic studies indicated a low proportion of roundscale spearfish compared to white marlin (Shivji, *et al*., 2006), it was noted that assessment results and recommendations will include the complex of the two species.

The low reporting of both dead discards and live discards by CPCs was discussed. Of 68 CPCs or fishing entities that have historically reported catches of white marlin only 7 CPCs had reported dead discards of white marlin since 1990, and 6 CPCs had reported live discards since 2000, even though data reporting obligations do require to provide these estimates for all billfishes. During the data preparatory meeting, the Group agreed and recommended national scientists to review the estimates of dead discards and live releases, and to report to the Group updates of these estimates based primarily on data from national observer programs, with a dateline of 31 March 2019 for submission. The Group was informed that only one CPC provided such information, thus preventing further analysis. Alternative estimates were developed and presented by the Secretariat, based on annual proportions of dead discards for the longline fishing gear with the assumption that other CPCs that have longline fisheries should have similar rates of white marlin dead discards. **Figure 1** shows the total catch of WHM from longline fleets that reported dead discards and the component of catches from non-reporting fleets. It was noted that although total catches have been decreasing since 1995, the catch proportion from the non-reporting dead discard fleets has increased since the 1990s accounting up to 80% in recent years. The Group suggested this could be due to an increase in dead white marlin being kept instead of discarded.

Table 2 shows the estimated annual discard rates by LL fleets and the corresponding running average of 3 years, with a range between 0% and 2.4% (**Figure 2**). This running average estimate was applied to the LL fleets that haven't reported dead discards. It was noted that the estimates of dead discards from the Observer Program of EU_Portugal were comparable to those estimated by the Secretariat (0.8% to 6.2%). It was noted that most of the EU_Portugal catches were shallow sets at night [swordfish target fishery]. The Secretariat also estimated the live discards by all fleets that haven't reported WHM live discards in the period 2000-2017. Based on scientific studies, an average of post-release mortality for billfish of 24% (Horodysky and Graves, 2005; Kerstetter and Graves, 2006; Musyl and Gilman, 2019) was applied to the live discards. However, the Group considered that the average of live releases from different fisheries/gears was not appropriate to apply to the rest of the fleets, as it does not take into account changes in local/national regulations, gear type and other factors that could affect survival of releases such as fishing area and seasonal effects. The Group concluded that the estimates of mortality from live discards should not be included in the matrix of total removals for the assessment inputs. The Group recommended that a study of time, area and gear configuration variation for discards using observer data should be conducted in the future to improve dead discard estimates and that tagging studies should also be conducted to improve our understanding of post-release mortality.

Table 3 presents the final estimates of the total removals adopted by the Group as input for the stock assessment models.

2.2 Indices of abundance

The Group discussed the standardized CPUE index for EU_Spain longline landings of white marlin and roundscale spearfish presented in SCRS/2019/046. The authors recommended the last three years contained in the index be removed to account for regulations that might bias the index. Recent domestic regulations went into force beginning in 2015, potentially influencing the reported landings used in the index.

It was noted that an earlier version of the EU_Spain LL index was submitted within the timeframe for inclusion in the stock assessment. However the earlier version differed significantly from the index presented in this paper, and both differed from the previous version of the index presented in 2012 (**Figure 3**). The Group confirmed that this index is potentially useful because of the spatial and temporal extent of the data, and that the analysis and diagnostics were appropriate given the small proportion of positive trips in the data set. Furthermore, this index was used in the 2012 assessment (Anon. 2013). The Group was concerned, however, that SCRS/2019/047 reported much higher proportion of positive sets for those sets monitored by scientific observers than the percentage of positive sets for trips reported in SCRS/2019/046. Additionally, there was a concern that Task I reports from the EU_Spain longline for that same fishery in 2015-2017 had large catches in comparison to previous years, even though SCRS/2019/046 reports very low CPUE at landing for that same period.

Given this combination of facts: the changes in the index that were made available by the deadline for analysis, the discrepancies in proportion of positives sets and catch and CPUE for the recent period, and the authors acknowledgement that regulations may have impacted the quality of the data, the Group determined that the EU_Spain LL index should not be used in the stock assessment models used to develop management advice. However, the Group determined that the CPUE index contained within SCRS/2019/046 should be used in the sensitivity analysis for the production model with the three most recent years removed (2015-2017), as recommended by the authors. Including this index in the sensitivity analysis will aid the Group's understanding of the level of potential uncertainty in assessment results resulting from the inclusion or exclusion of the EU_Spain index. Furthermore, the Group agreed that in cases where CPUE data for certain years is determined to be inappropriate for CPUE standardization due to changes in monitoring or management measures, such data should not be included in the analysis. Therefore, the Group recommends that future standardization of EU_Spain longline CPUE should not contain the years 2015-2017. The Group acknowledged that given the length of the time series exclusion of the data for year 2015-2017 may not affect the result of the analysis very much, and that using the index estimates from SCRS/2019/046 for the period 1988-2014 was still useful for the purposes of sensitivity analysis.

The Group discussed the need for clarity with regards to indices containing dead discards and live discards. There were concerns that this information may not have been collected or recorded in the historical catches, potentially inflating or deflating the reported catches. It was noted that consistency in how this issue was treated across billfish assessments was needed as this discussion has arisen across recent assessments. The Group agreed that observer data was the data source most likely to contain such information.

The Group discussed the issues related to standardizing the US recreational index and other indices that rely on tournament data, specifically the Brazilian recreational index. Concerns were raised that the data provided to standardize these indices do not include enough information to account for gear changes that have the potential to increase catchability. However, the Group decided to include these two indices in the assessment models.

The Group decided to use the following indices for the assessment (**Table 4** and **Figure 4**):

1. Brazil, longline, 1978-2010
2. Brazil, recreational, 1996-2017
3. Chinese Taipei, longline, 1968-1989, 1990-2000, 2001-2017
4. Japan, longline, 1959-1975, 1976-1993, 1994-2000, 2001-2017
5. USA, longline, 1993-2017
6. USA, recreational, 1974-2017
7. Venezuela, gillnet, 1991-2010
8. Venezuela, longline, 1991-2010

2.3 Biology

Document SCRS/2019/047 updated the data from scientific observers in the EU_Spain surface longline fishery that targets primarily swordfish in the Atlantic.

The Group discussed the importance of information related to the fate of catches (landed, dead or alive discards). Of particular interest were the reports of the proportion of dead and live discards throughout the time series. This proportion changed from year to year and was greater than what has been reported for other fleets. Another issue raised by the Group was the inclusion of data from experimental longline trials in the analysis, including the proportion of such data and the potential effect on the results presented.

The SCRS/2019/106 document discussed status of fish at set retrieval (haul-back) and sex ratios of white marlin caught by the Chinese Taipei longline fishery in the Atlantic Ocean. The "survival ratio" calculated in this document was the number of alive individuals divided by all alive and dead individuals recorded at hauling.

The Group agreed that the term "survival ratio" is really an alive-at-haulback ratio and recommended using this term to avoid confusion with the normal use of survival rates (e.g. proportion of fish that survive a fishing interaction after release). The Group also suggested that the degree of injury and the condition at the time of release in conjunction with electronic tagging could be used to obtain better estimates of post-release-mortality rates.

2.4 Length compositions

The Secretariat provided updated Task II size information. Following the data preparatory meeting, updates of size samples for white marlin were provided by Mexico (1993-2017) and Venezuela (2015 -2017) for white marlin. The new information was incorporated in the size frequency data analysis and inputs for the stock synthesis model. With the inclusion of the new size data, size frequency samples were consistent with the data presented in SCRS/2019/036. It was noted there were few size samples for white marlin from sport fisheries in recent years. This was mostly due to the changes in the recreational fisheries where catch-and-release is mandatory for most recreational fishing tournaments. Therefore, the measurements are not representative of the total catch including releases fish.

2.5 Other relevant data

No other relevant data for the white assessment was discussed or presented during the meeting.

3. Methods relevant to the assessment

3.1 Production models

The most recent version Bayesian surplus production model, JABBA (v1.5Beta) available online (www.github.com/henning-winker/JABBAbeta), was applied to the time series of white marlin landings and fishery dependent indices to assess the stock status. The development of prior distributions on population growth rate (r) for the model was based on an algorithm developed by Winker *et al*. 2019 (SCRS/2019/103). The approach applied an age-structured equilibrium model to approximate a functional distribution of r approximated from the set of life history parameters selected for Stock Synthesis (size-at-age, natural mortality, maturity, stock recruitment steepness). The effects of key input parameters, including steepness parameter h of the spawning recruitment relationship on the production model parameters *r* and *m* were demonstrated. Simulation test results indicated that biomass estimates, and benchmarks should be calculated as total exploitable biomass, as a large proportion of the landings are immature fish (SCRS/2019/103). Based on the three steepness scenarios modeled (h = 0.5, h = 0.6 and h = 0.7), alternative priors for *r* were approximated based on lognormal distribution as input on JABBA (**Figure 5**).

The Group reviewed the provisional parameterization and results from JABBA, as well as the results of simulation testing of the statistical model (SCRS/2019/104). Initial set of parameters and data input were reviewed in the meeting and some of them modified, so the final list was as follows:

- Natural mortality = 0.2 (CV=30%)
- Length-at-50% maturity = 160.4 cm LJFL (Arocha and Barrios, 2009; SCRS/2019/103)
- Growth parameters (Linf=172.0 cm and 160.6 cm, k = 0.32 and 0.54 for females and males respectively and t0=-1) were inferred from (Arocha and Barrios, 2009).
- Size-at-age parameters were adapted from (SCRS/2019/103), these parameters were used to estimate the appropriate priors for JABBA.
- Steepness was assumed equal to 0.6 to be consistent with estimates from SS, which corresponds *r* prior as (log(*r*) ~ N(log(0.181), 0.180) and a fixed input value of B_{MSY}/K=0.39, *m* =1.12).
- Removals should include reported landings and dead discards estimated by the Group (see Section 2.1).
- The EU_Spain longline CPUE was excluded from model input (see Section 2.2).

3.2 Length-based age-structured models: Stock Synthesis

Document SCRS/2019/110 provided a description of the provisional Stock Synthesis (SS) parameterization and results. The range of observational data used in the base model is shown in **Figure 6**. The Group reviewed the SS set-up, diagnostics, and sensitivities and recommended a reference case model to include:

- Removals should include reported landings and dead discards estimated by the Group (see section 2.1).
- Exclusion of the EU_Spain longline CPUE from model input (see section 2.2)
- Natural mortality = 0.2 (fixed)
- Length-at-50% maturity = 160.4 cm LJFL (Arocha and Barrios, 2009)
- Growth parameters (Linf=172.0 cm and 160.6 cm, k = 0.32 and 0.54 for females and males respectively and t0=-1) were inferred from (Arocha and Barrios, 2009).
- Three fleets: (1) gillnet, (2) longline, and (3) recreational rod & reel.
- For models that estimated a catch multiplier, the parameter was estimated for the time block 1998-2017, since the implementation over management regulations by the Commission in 1998-1999.

Diagnostics

The Group outlined a set of standardized model diagnostics to be presented and reviewed for reference models, which included:

- Model fits to indices of abundance and size compositions
- Retrospective analysis of biomass and fishing mortality estimates, and calculation of Mohn's rho for each model run
- Indices jackknife to evaluate the influence of each CPUE on model results
- Likelihood profiles of steepness, R0, and catch multipliers
- Run tests for randomness of CPUE residuals (Carvalho *et al.* 2017).

3.3 Other methods

No other methods were applied.

4. Stock status results

4.1 Production models

The Group reviewed the results obtained with JABBA a surplus production model. JABBA model runs included one base case scenario and two sensitivity scenarios as follows: (S1) sensitivity run 1; included 13 CPUEs (excluding only EU_Spain longline index), (S2) sensitivity run 2; included all 14 CPUEs, and (S3) base case; same setting as S1 but removed data for 1959-1961 in early Japanese longline index. JABBA models converged adequately, and diagnostics indicated no model misspecifications. Outputs showed very similar trends and results across scenarios. The Group concluded that scenario S3 is the best representation of the Atlantic white marlin stock dynamics and it was selected as base model.

JABBA-residual plots showed that the exclusion of EU_Spain longline index improved model fit by reducing RMSE from 58% to around 53% (S1). The exclusion of the first three years of early Japanese longline index showed a slight decrease in RMSE (**Figure 7**), and it estimated the initial biomass ratio (1956) to a more reasonable estimate (0.86) compared to initial runs. The longline fleets from Chinese Taipei and Brazil seem to be the most influential and exhibited the highest discrepancies between CPUE series and model predictions. The predicted CPUE indices fits were compared to the observed CPUE for each scenario (**Figure 8, 9** and **10**). The model fits for white marlin CPUEs indicated that there was a lack of fit from longline fisheries of Chinese Taipei and Brazil, in the third time block period (2001-2017) of Japanese fleet, and US recreational fishery. Plots of process error deviates are shown in **Figure 11,** values of process error have declined more or less continuously since 1995. It is important to note that process error represents annual changes in the indices of abundance that are not explained by the dynamics of the stock production model and the observed catches.

Plots of posterior densities together with prior densities for the three models are depicted in the **Figures 12** to **14** and summaries of posterior quantiles for parameters and management benchmarks are presented in **Table 5**. The trajectory of B/B_{MSY} showed a sharp decrease in the mid-1970s to an overfished status followed by a continuing decreasing trend until 2000. Since the early 2000s the relative biomass showed a slight recovery but remained at levels below B_{MSY} to the end of the time series (base case B_{2017}/B_{MSY} = 0.463). The F/F_{MSY} trajectory showed an overall increasing trend from the beginning of the time series until mid-1990s, followed by a decreasing trend after 2000s with no overfishing (base case F_{2017}/F_{MSY} = 0.606) in recent years (**Figure 15**). The slow rebuilding in the biomass estimated in recent years is explained by the fact that fishing mortality remained above F_{MSY} until 2011 and partially because of the persistent decline in the process error since 1995. A retrospective analysis for eight years was also presented, which showed no evidence of strong retrospective patterns and was very consistent among scenarios (**Figure 16, 17, 18**). All runs indicated that results were robust in terms of similar stock status (F/F_{MSY}; B/B_{MSY}) and MSY (**Table 5**).

The Kobe plot overlaid with the production model revealed a typical anti-clockwise pattern with the stock status moving from underexploited level through a period of unsustainable fishing to the overexploited phase since mid-1970s for all scenarios (**Figure 19** and **20**). The stock status results for 2017 showed that Atlantic white marlin stock has a 99 % probability of being overfished but not suffering overfishing (**Figure 19**).

4.2 Length-based age-structured models: Stock Synthesis

After the Group reviewed Document SCRS/2019/110, the following 4 additional runs (model 4 to 7) were provided to discuss final base case model for Stock Synthesis.

- Model 4: Use all index except EU_Spain longline, without a catch multiplier, without variance reweighting,
- Model 5: Use all index except EU_Spain longline, estimate a catch multiplier, without variance reweighting,
- Model 6: Use all index except EU_Spain longline, without a catch multiplier, with variance reweighting,
- Model 7: Use all index except EU_Spain longline, estimate a catch multiplier, with variance reweighting.

The Group agreed to use models 6 and 7 as final SS3 base case models. The Group carried out variance reweighting which estimates an additional parameter for each CPUE index. These parameters are an additive constant which are added to the input standard deviation of each index. Reweighting was suggested by SCRS/2019/110, and it has the end result of reducing the influence of CPUE series which are not in agreement with predicted trends in stock size. The Group acknowledged that reweigthing improved the model diagnostics, thus it was agreed to use variance reweighting for the final model setting (retrospective analysis: **Figure 21** for models 4 and 5, and **Figure 22** for models 6 and 7). The estimated additive constants from reweighting are shown in **Figure 23**.

The Group continued to have concerns on the accuracy of the white marlin reported catch and the estimates of dead discards as a consequence of the implementation of management measures since1998-1999. The total catch removals matrix used in the assessment models for both JABBA and SS3 analysis (see Section 2.1) may not fully account for all removals from the stock. In the 2012 assessment, the Group decided to use alternative vectors of removals as an approach to evaluate this uncertainty. At this assessment, the Group evaluated the use of a catch multiplier parameter in the SS3 model for the period 1998-2017. This assumed that catch removals are not perfectly known since 1998 but that they were known without error prior to that. Furthermore, this assumes that the under-reported removals for 1998-2017 are a constant proportion of the reported catch. It was noted that estimating a catch multiplier within the SS3 model is a different technique that can be used to account for unaccounted IUU catches, while alternative catch series, as those developed in the 2013 assessment are tipically estimated outside the model.

The Group agreed that a reliable estimate of removals is essentially to ensure the quality of the assessment results, and that there are some under reported removals of white marlin. There were a number of concerns discussed by the Group concerning the catch multiplier approach. Among these concerns were 1) the assumption of a constant under-reporting for the period considered, 2) the assumption that prior to 1999 there was no under-reporting, and 3) that the estimates of underreporting (~27%) were much greater than the values reported by current observer programs. Estimating a catch multiplier did reduce the estimates of recruitment deviations (**Figure 24**), however, it did not eliminate or reduce significantly other data conflicts. As a result, the Group recommended that in order to reduce the uncertainty in removal estimates further improvements of CPUEs and catch data collection are required, especially with respect to monitoring of discards (see Section 6). The Group agreed to use both models 6 and 7 as the final SS3 base case models. The Group agreed that the use of the catch multiplier was a promising approach, and that work should continue to explore its further use.

All parameter values and standard deviations for the final SS3 base models (models 6 and 7) are given in **Table 6**. The model estimated R0 using a noninformative prior, for steepness (*h*) a normal distribution prior with mean of 0.5 and standard deviation of 0.05 was used. The resulting posterior distributions of the parameters encompassed the predetermined values agreed upon for the sensitivity analyses. The estimated values of steepness were 0.557 (SD = 0.018) and 0.617 (SD = 0.018) in the models 6 and 7, respectively. These values were slightly smaller than the one estimated in the 2012 assessment which was 0.654 (SD = 0.032). The estimated catch multiplier in the model 7 was 0.734 (SD =0.080).

The estimated maximum sustainable yield (MSY) in the models 6 and 7 were 1,371 t (1,288-1,453 t), and 1,467 t (1,372-1,562 t), respectively. These values were smaller than the one in the 2012 stock assessment (Anon. 2013) 1,604 t (SD = 28 t). The estimated B/B_{MSY} and F/F_{MSY} showed very similar trend in the both models 6 and 7 (**Figure 26**). The trend B/B_{MSY} has shown a significant decreasing trend in the 1960s, and a continuous downward trend until the late 1980s. After 1990s, the B/B_{MSY} remained below 1.0. The estimated values of B/B_{MSY} in 2017 were 0.60 (0.40-0.80) and 0.66 (0.44-0.88) in the models 6 and 7, respectively. These values are larger compared to the estimated biomass level B_{2010}/B_{MSY}=0.322 (SD = 0.046) in the 2012 stock assessment. The trend in F/F_{MSY} showed immediate increase in early 1960s, and gradually increased around 1.5 in the late 1960s to 2.5 in the early 2010s except some years. After 2010 the F/F_{MSY} showed a continuous decreasing trend up to 2017, and the estimated values of F/F_{MSY} in 2017 were 0.60 (0.42-0.78) and 0.68 (049-0.87) in the models 6 and 7, respectively. The estimated B/B_{MSY} and F/F_{MSY} were such that the current stock status is overfished but is not undergoing overfishing (**Figures 27** and **28**). A Kobe plot was calculated by combining the results from 5000 MVN (multivariate normal approach) runs of models 6 and 7 (**Figure 19**). In 2017, the probability of overfishing and overfished was 0.5%, the probability of overfished but not overfishing 99% and the probability of being neither overfished nor overfishing 0.3%.

4.3 Other methods

No other methods were applied.

4.4 Synthesis of assessment results

During this meeting, JABBA (version 1.5 beta) and Stock Synthesis (version 3.30) were applied. The Group agreed to use a combination of results from JABBA (model S3) and SS3 (models 6 and 7) to develop the advice on stock status and outlook. The 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 error in the assessment. The Group also agreed that all three models would be given equal weight in such combination.

The trajectories of B/B_{MSY} and F/F_{MSY} from three models (JABBA S3 in **Figure 15**, and SS3 models 6 and 7 in **Figure 26**) were overlaid in **Figures 29** and **30**, respectively. It was noted that B/B_{MSY} was calculated using spawning stock biomass for SS3, and biomass for JABBA. Generally, all models estimated similar annual trends and values of both B/B_{MSY} and F/F_{MSY}. The estimated B/B_{MSY} declined rapidly from the mid-1950s to the mid-1970s, and continued to decrease slightly until 2010 (**Figure 29**). In the recent years, an increasing trend in B/B_{MSY} was observed by SS3, while JABBA showed a flat trend. These differences are associated to the different treatment of CPUEs in each model: SS3 used variance reweighting (see Section 4.2) while JABBA did not incorporate it. It should be noted that the results of SS3 without variance reweighting (models 4 and 5) showed the same flat trend as JABBA.

The estimated F/ F_{MSY} values rapidly increased in the 1960s, and fluctuated between 1.0 and 2.0 in the 1970s and 1980s (**Figure 30**). The values were further increased in 1990s and fluctuated between 2.0 and 3.0 where JABBA estimated higher fishing mortality (3.0) than SS3 (2.0-2.5). Since the late 1990s, it showed a continuous decreasing trend increased until the last year considered in the assessment, 2017.

The Group agreed to calculate uncertainty in Kobe plot by combining 5000 MCMCs iterations from JABBA (model S3), and iterations from SS3 using MVN (multivariate normal) approach. 5000 iterations were also used for each of the SS3 models 6 and 7. Those iterations were randomly extracted from 10000 initial iterations from JABBA and 6000 initial iterations from SS3. The median of the current (2017) biomass ratio and fishing mortality ratio with 95% confidence intervals are 0.58 (0.27-0.87) and 0.65 (0.45-0.93), respectively (**Figure 31**). This implies that in 2017 the stock of Atlantic white marlin was being overfished but not undergoing overfishing. The probability of being in the red quadrant of the Kobe plot was estimated to be 1%. The probability of being in the yellow quadrants of the Kobe plot was estimated to be 99% and that of being in the green quadrant less than 1%. The estimated MSY was determined to be 1,495 t with 95% confidence intervals (1,316 t – 1,745t).

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 2020 is only affected by catches prior to 2020, while fishing mortality of 2020 is determined by catches in 2020. The Group agreed that projections be conducted for constant catch scenarios starting at 0 t and up to 1600 t at 200 t intervals and for a period of 10 years (2020 to 2029). The catch for years 2018 and 2019 was set to 458 t which corresponds to the carryover of the catch in 2017 (reported landings + dead discards estimated by the Group). To calculate uncertainty, 5000 MCMCs iterations from JABBA, and iterations from SS3 using MVN (multivariate normal) approach were used for the projections.

5.1 Production models

Projections of future stock status with JABBA were conducted for the base model (S3) and they were similar to and less optimistic (**Figure 32**) than those conducted with stock synthesis model (**Figure 33**). However, at high catch levels (TAC > 1,000 t), some iteractions predicted exteremly small biomass ratios and exteremly high F ratios indicating basically a stock collapse. To summarize this trend, the probability of the biomass being less than 10% of B_{MSY} was calculated for each projection year and catch scenario. This probability (**Table 7**) increased with high TAC levels and year, reaching a 24% probability of biomass falling below 10% of B_{MSY} in 2029 with a constant catch of 1,600 t. For the projection figures, the extreme F/F_{MSY} values, that were reached over 400, were replaced to 9.

The projections with JABBA (**Figure 32**) showed that with catches as high as 800 t the stock can recover to B_{MSY} by 2025 and that with catches as high as 1,000 t the stock will not experience overfishing. The Group discussed that these results are inconsistent with the history of the dynamics of the stock. In other words, the stock has shown slow increases in biomass with catches in the order of 400-500 t and, therefore, the Group considered that it is unlikely that catches as high as 1,000 t can rapidly rebuild the stock as suggested by the projections. The Group noted that the JABBA assessment runs showed that in the last several years of the assessment period, there was a period of negative values (2005-2017) in the process error. However, since process error can not be included in the JABBA projections, the predicted increases in stock biomass may be overly optimistic. As such, these projections should be interpreted with caution.

5.2 Length-based age-structured models

Stock synthesis projections were conducted with model 6 and by assuming the average recruitment level from the Beverton–Holt stock recruitment model. Like the JABBA projections, they also showed that the stock can quickly recover even with catches that are substantially higher than currently reported levels (**Figure 33**), and the projections of future stock status with Stock synthesis were slightly more optimistic than those with JABBA. For example, 1,000 t can recover the stock to the spawning stock biomass level that can support MSY by 2025. The Group discussed that the projections assumed that recruitment will be as expected given the stock recruitment parameters, but in fact recruitment estimates were below the expected values for the period 2002- 2015. If low recruitment continues in the future, the forecasted result might be overestimated by this deterministic recruitment approach.In summary, these optimistic projections should also be interpreted with extreme caution.

5.3 Synthesis of projections

For the results of projections, the Group agreed to use a combination of projection results from JABBA (S3) and SS (model 6) to produce the advice outlook, including the Kobe strategy matrices. As was the case for the stock status results, the Group agreed that both models would be given equal weight in such combination. The projection for both models showed very similar results in the median, but JABBA provides wider range of values compared to SS3 (**Figure 34**). The projections with SS3 using MVN approach and assuming the average recruitment level from the Beverton–Holt stock recruitment model may not capture all uncertainties in the projections.

According to these projections (**Figure 35** and **Table 8**: Kobe II matrix), the current 400 t TAC will provide 93% probability of being in green quadrant by 2029. The results show that with a constant 1,000 t catch will achieve the stock status of being in the green quadrant in 2029 with 68% probability, however the Group considered that these estimates predicted increases in stock biomass may be overly optimistic in both JABBA and SS3. It was strengthened that these projections should be interpreted with caution.

6. Recommendations

6.1 Research and statistics

Need for CPCs to report discards: The Group noted that to date only 7 CPCs (out of 68 CPCs or fishing entities) have ever reported billfish discards and using such limited information the estimates of dead discards are around 2-3%. On the other hand, by using statistical analysis within the stock assessment models it was noted that unaccounted IUU catches, including dead discards may reach values of around 27% of the reported catches. Having the total catches, including dead and live discards, and estimates of post-release mortality is important for stock assessment purposes. As such, the Group emphasized the need for all CPCs to comply with the mandatory requirements to report discards (both dead and alive) for billfishes.

Sports fisheries CPUEs: There may still be issues related with increasing catchability in sports fisheries over time that are not fully taken into account in the CPUE standardization. As such, the Group recommends that work be conducted to collect and incorporate any data which informs on the historical evolution of fishing practices which could affect catchability.

Joint CPUE: The Group recommended that joint CPUE indices for longline fleets be developed for future billfish stock assessments using fine scale operational level data. Due to the fact that marlins are, in general, by-catch species, they are often not accurately reported in logbooks. Observer data should therefore be used to assure that all catches, including live and dead discards, are included.

Compare observer and logbook data CPUEs indices: National scientists should develop both observed data and logbook CPUEs indices within their fleets.

Size data analysis: CPUEs indices developed from catches with high proportion of juveniles specimens are often more variable than those developed from catches with higher proportion of adults. As such, the Group recommended that CPUE standardization documents include information on the size distribution of the catches used to develop the indices.

Stock assessment diagnostics: The Group recommended that the Working Group on Stock Assessment Methods develop a standardized set of stock assessment model diagnostics which should include standardized figures, tables and statistics.

Develop estimates of billfish discard mortality: The Group recommended that national scientists collaborate in a study of the effect of time, area and gear configuration variations for discards using observer data to improve discard estimates.

6.2 Recommendations with financial implications

Enhanced Program for Billfish Research (EPBR): The Group recommends continuing funding for the EPBR research activities for future years, to further improve the biological information for the species and areas prioritized. The details for the EPBR workplan are provided in section 8.

Given the misidentification of roundscale spearfishes as white marlin in the data, the Group reiterates its concern regarding uncertainty in stock assessment results and enforcement related problems and maintains its recommendation that research to address this problem should continue to be supported by the Commission.

6.3 Management

In 2012, the Commission adopted Rec. 12-04, intended to reduce the total harvest to 400 t in 2013-2015 to allow the rebuilding of the white marlin stock from the overfished condition. Subsequently, the Commission extended the 400 t annual catch limit to 2016-2018 (Rec. 15-05), and 2019 (Rec. 18-04). Although there is some evidence of slow rebuilding in recent years, the Group noted that catches have exceeded the 400 t TAC in every year since its initial implementation and warns that if catches continue to exceed the TAC, the rebuilding of the stock will proceed more slowly, or be put at risk of further declines. Further reductions in fishing mortality are likely to speed up the rebuilding of the stock. Unfortunately, the inability to accurately estimate fishing mortality will continue to compromise the Group's ability to predict and monitor the stock's recovery period. This is due to the inadequate reporting of discards, as well as the lack of reports from some artisanal and recreational fisheries that take marlin species.

- Measures should be taken to ensure that monitoring and reporting of all landings and discards, including live releases, are appropriate, accurate, and complete. This will likely require improvements to the observer programs of many CPCs, as well as the implantation of discard estimation methods using those data.

- Efforts should be made, building on previous work, to fully account for the catches of artisanal and all recreational fisheries.

Given the overfished status of the stock and the uncertainties in the data, including for both total removals and indices of abundance:

- The Commission, at the minimum, should ensure that catches do not exceed current TAC until the stock has fully recovered.

To reduce the chance of exceeding any established TAC, the Commission should require:

- The release of all marlins that are alive at haul back in ways that maximize their survival.

- The use of circle hooks as terminal gear. Experimental research has demonstrated that in longline fisheries the use of circle hooks resulted in a reduction of marlin catch rates and haulback mortality. Currently, four ICCAT Contracting Parties (Brazil, Canada, Mexico, and the United States) already mandate the use of circle hooks on their pelagic longline fleets.

7. Responses to the Commission

The only active requests from the Commission to the SCRS appear in Rec. 2018-04 which states:

"10.… The SCRS shall review the data and determine the feasibility of estimating fishing mortalities by commercial fisheries (including longline and purse seine), recreational fisheries and artisanal fisheries. The SCRS shall also develop a new data collection initiative as part of the ICCAT Enhanced Program for Billfish Research to overcome the data gap issues of those fisheries, in particular artisanal fisheries of developing CPCs, and shall recommend the initiative to the Commission for its approval in 2019."

The original plan (1986) for EPBR included the following objectives: (1) to provide more detailed catch and effort statistics, particularly for size frequency data; (2) to initiate the ICCAT tagging programme for billfish; and (3) to assist in collecting data for age and growth studies. See section 8 of this report for the status of initiatives within the EPBR. In terms of ongoing effort to close the data gap in artisanal fisheries, there will be intersessional work to finalise a draft EPBR work plan for discussion at the Group meeting in September. The draft work plan will be led by the Rapporteur of the Group and will include the EPBR coordinators, David Die and a representative of the secretariat. The authors of the review reports of the artisanal fisheries of West Africa and Caribbean will be invited to contribute to the draft. All members of the Group are welcome to provide input to the draft work plan as it is being developed intersessionally.

"13. At its next assessments of blue marlin and white marlin/spearfish stocks, the SCRS shall evaluate progress toward the goals of the rebuilding programs for blue marlin and white marlin/spearfish."

Section 6.2 provides management recommendations which includes the evaluation of previous measures.

8. Other matters

8.1 Enhanced Program for Billfish Research (EPBR)

The Secretariat provided a brief explanation on the procedures to fund the activities to be conducted within the EPBR in 2019, since a contract recently ended on 31 May 2019. In addition, the Secretariat noted the difficulties faced by some of the members of the working teams responsible for collecting billfish hard structures in the eastern Atlantic and emphasized the need to overcome the administrative issues and enhance coordination.

Two possible approaches were suggested to move forward the aging study for the three billfish species (blue and white marlin, and sailfish) in the eastern Atlantic: 1) launch a new Call for tenders; or 2) sign a new contract with the consortium led by IFAN and give the opportunity for other teams to join as a partner or sub-contractor/collaborator.

The Group highlighted the importance of the ongoing study and the work carried out over the past 12 months and reiterated the need for such activities to be maintained. The Group also recognized the difficulties faced over the past 12 months and the need to further enhance coordination and the engagement of new teams that could help on the collection of hard structures to conclude the age and growth study more rapidly. The Group noted the availability of Gabon and the European Union (Portugal and Spain) to join this collaborative study by providing samples and helping on the processing and analysis of these. Finally, the Group suggested that the best and fastest approach would be for the Secretariat to sign a new contract with the Consortium, once new partners/sub-contractors could agree to join this cooperative study.

A suggestion was made to include in EPBR the collection of otoliths and tissue samples for genetics. Regarding genetics, the Group noted that a study on the differentiation of white marlin and roundscale spearfish has been ongoing for a number of years, though no results have been made available to the Group yet. In this regards the previous coordinator of EPBR for the western Atlantic was contacted and the Group was informed that a relatively low number of samples have been sent back in recent years and that a minimum number 50 should be collected before being analyzed. The Group urged that a database with the available samples and distributed kits be developed in order to plan future sample collection.

The Group was informed that Dr. John Hoolihan (USA) will no longer act as coordinator of the EPBR for the western Atlantic. The Group expressed its gratitude to Dr. Hoolihan for his role and work over the past years as EPBR coordinator. The Group also agreed that he will be replaced by Karina Ramírez-López (Mexico). Dr. Fambaye N'gom will remain as overall and eastern Atlantic EPBR coordinator.

The Secretariat also informed that the Terms of Reference for the *Atlantic blue marlin Gulf of Mexico reproductive biology study*, were received from the rapporteur (**Appendix 5**), as agreed during the White Marlin Data Preparatory meeting (Anon. in press). Furthermore, the Secretariat informed the Group that a budget quotation request has been sent to experts in the field working in the area, aiming a 12 months contract. The work is expected to start in July 2019 as the necessary funds have already been made available.

The Secretariat also reiterated to the Group that funds had been secured to allow continuing support of sampling fishing activities to improve the quality of data on billfish collected from artisanal fisheries in the Eastern Atlantic. Funding is available for Senegal, Côte d'Ivoire and São Tomé e Príncipe. In order to proceed these CPCs were urged to formally request to the Secretariat the reimbursement related to these activities.

The Group also agreed to work intersessionaly on an EPBR workplan proposal for 2020 that will be discussed at the Group meeting in September 2019.

8.2 Western Central Atlantic Fishery Commission (WECAFC)

The Secretariat provided a brief overview on recent exchanges of correspondence between ICCAT and WECAFC, and on the developments regarding the transformation of WECAFC into a Regional Fisheries Management Organization. A key issue being discussed is "*whether to include a general provision relating to "all fishery resources in the Area of Competence of the Commission" or specific stocks, such as straddling fish stocks, deep sea, and highly migratory species not covered under ICCAT's mandate as well as some transboundary stocks such as sharks…*".

The Group was informed that ICCAT was represented at an WECAFC Working Group on FADs meeting held in April 2019. The meeting provided progress on the science in support of management of moored FADs in the WECAFC area. It discussed some information relevant to billfish and particularly to blue marlin, which dominates billfish catches made on FADs. Given that most species caught around FADs are managed by ICCAT, efforts on data collection and analysis related to FADs made by this WECAFC Working Group are of clear benefit to ICCAT. The Group highlighted the importance to continue to strengthen the coordination and collaboration of activities between ICCAT and WECAFC.

9. Adoption of the report and closure

Due to the limited time, the text report regarding agenda items 4.4 (Synthesis of assessment results) and 5.3 (Synthesis of projections) could not be reviewed prior to the closure of the meeting and therefore were adopted by correspondence. The remainder of the report was adopted during the meeting by the Group. The meeting was adjourned.

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