REPORT OF THE 2019 ICCAT WHITE MARLIN DATA PREPARATORY MEETING

(Madrid, Spain 12-15 March 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 at the ICCAT Secretariat in Madrid, 12-15 March 2019. Mrs. Fambaye Ngom (Senegal), the Species Group ("the Group") rapporteur and meeting Chairman, opened the meeting and welcomed participants. Mr. Camille J.P. Manel (ICCAT Executive Secretary) welcomed the participants and thanked the scientists for their work. The Chair proceeded to review the Agenda, which was adopted with no modifications (**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 and presentations provided at the meeting are included in **Appendix 4**. The following served as rapporteurs:

Sections	*Rapporteur*
Items 1, 8 and 10	M. Ortiz
Item 2	D. Die
Item 3	C. Palma, M. Ortiz
Item 4	C. Brown, A. Kimoto
Item 5	M. Schirripa, B. Mourato
Item 6	M. Schirripa, B. Mourato
Item 7	F. Ngom, M. Neves dos Santos
Item 8	R. Coelho, F. Ngom
Item 9	F. Ngom, D. Die, R. Coelho

2. Biology

2.1 Changes in scientific names

The Group discussed the issue of changes to the scientific names of billfishes. The Group discussed again, the proposals for revision of scientific names for billfish presented in Colette *et al.* (2006) and confirmed by the White Marlin Biological Review Team (2007). It is worth noting that IATTC, WCPFC, Fishbase, American Fisheries Society, Word Register of Marine Species (WRMS), and Eschmeyer's Catalog of Fishes have adopted the new billfish taxonomy proposed by Colette *et al.* (2006), but neither FAO nor IOTC have done so yet. It is worth noting however, that the Caribbean Management and Conservation Plan for billfish (Bealey *et al*., 2019), produced on behalf of FAO-WECAFC does use the taxonomy of Colette *et al*. (2006). Note, however, that there is continued uncertainty in taxonomy of billfish as past and on-going taxonomic work suggests the possibility that the two pan-oceanic species, sailfish and blue marlin, may have separate species between the Atlantic and Indo-Pacific. Colette *et al*. (2006) does not recognize such splits.

The Group recommends that the list in the paper by Colette *et al*. (2006) be used as the basis of the names for ICCAT billfish species as the most current accepted taxonomy for this Group. **Table 1** contains the new proposed names and the previous names used by ICCAT.

If the SCRS accepts this list it should communicate to the Commission, the need to incorporate these changes to the annex of the list of species under ICCAT management that is part of the convention amendment documents.

2.2 Growth

A summary of the collection of data and samples on growth for all billfish species in Senegal, Côte d'Ivoire and São Tomé was presented (SCRS/P/2019/013). Length, weight, sex, location, the first three anal fin spines and genetic samples have been collected with funds from the ICCAT billfish research program. Sampling started late in the fishing season of 2018 so the number of samples is still limited. Samples collected for white marlin range from 150 to 190 cm. The numbers of rings identified in the white marlin fin sections were from 2 to 5. The number of these rings are an underestimate of fish age because rings deposited early are lost by the vascularization of the core of the spine. Ageing samples from São Tomé were collected but lost during shipping to Senegal.

It has been shown that swordfish otoliths can be collected and processed, although it is very challenging, it may be possible to do the same thing for marlin's otoliths. EU-Portugal is collecting such otoliths of swordfish on-board longliners and intend to collect some for billfish as well and is willing to liaise with those scientists that are interested in learning how to extract otoliths. This is especially important given the apparent differences in age estimates obtained from spines and otoliths in swordfish, and stresses the importance of validating age readings.

It would be interesting to share samples of spine sections of eastern fish with those samples collected in previous years by scientists in the west Atlantic. It is recommended that those that have images of fin sections of marlins collate those and send copies of them with the appropriate metadata to the ICCAT Secretariat. By doing so a consolidated database of biological samples images will be developed and maintained at ICCAT. It would be desirable also to try to expand these biological data collection activities to other fleets that catch billfish in the eastern Atlantic. ICCAT has held ageing workshops to standardize ageing procedures for other species and it may be useful to hold one for billfish.

2.3 Natural mortality

Billfishes grow in length very fast and are harvested at relatively large lengths in relation to their maximum length. Under the assumption that natural mortality (M) is mostly changing as a function of length it is not expected that M would change much during the exploited part of the life history of the species. Thus the Group agreed to continue with the practice of using a constant M across ages. Die and Drew (2008) reported that the oldest white marlin collected in the Atlantic was 13 years old and the average age of fish in their sample was 5-6 years. The ICCAT tagging database contains several fish that had been at large for over 10 years, and one fish that had been at large for 15 years and was 160 cm at release. A lifespan of 22 years is consistent with these observations and would correspond with a natural mortality of 0.2, according to Hoenig (1983) and Hewith and Hoenig (2009) estimators.

3. Review of available data for the assessment

The Group revised the most up-to-date information available in the ICCAT database system (ICCAT-DB) for white marlin (WHM) and other billfish species, namely the fishery statistics datasets (T1NC: Task I nominal catches; T2CE: Task II catch & effort; T2SZ: Task II size frequencies) and conventional tagging data.

3.1 Task I and II catch data

The Group revised entirely (1956-2017) the WHM catches, and to a minor extent, the catches of the rest of the billfish species. This work aimed to identify the WHM missing catches in the T1NC dataset, improve the gear discrimination by flag across the entire catch series, and, whenever possible discriminate billfish unclassified (BIL) catches by species in particular when BIL catches were identified as duplicates (already reported by species by a given CPC). The gap completion work, only covered WHM and were all estimated using the average catch of the three previous years (carry overs) within each series. The most important carry overs were made to the longline series of Barbados: 2004-2005, 2007-2009; Spain: 1986-1987, Korea: 1998-1999, Philippines: 2009, 2012-2014, Trinidad and Tobago: 1992; Uruguay: 1993-1999, 2000-2001, 2008, 2010), the gillnet series of Ghana: 2007, 2010, 2014-2016; Venezuela: 2015-2017 and, the rod and reel series of Bermuda: 1985.

All the estimations made using "carry overs" are always considered preliminary by the SCRS. As a common practice, the Secretariat will request to the above mentioned ICCAT CPCs the need to replace these "carry overs" by official catch estimates. In addition, gear corrections (in its majority from unclassified to longline, as observed in the corresponding flag catch series by gear of other species) were also made to Argentina (1985-1991), Barbados (1990-1996), Cuba (1991-2007), Dominica (1997-2007), Grenada (1977-1989), and UK-Sta Helena (1995-2003, baitboat). Several official corrections were also made to USA (2011), S. Tomé e Príncipe (2007 and 2008), and Côte d'Ivoire (2010 and 2012). All the revisions, stored in ICCAT-DB, were adopted by the Group as the best scientific T1NC estimation.

The revised total catches (T1NC, containing landings and dead discards) of the various billfish species by year, is presented in **Table 2 and Figure 1.** The WHM total catches by year and gear (**Table 3** and **Figure 2**) show a predominance of longline (~90%) across the entire series, where the dead discards reported account on average for about 3% (**Table 4**) of the total catches on the last three decades. In relation to the live discards of WHM and other billfish species (**Table 5**) the CPCs reporting level is low. The Group reiterates that, it is mandatory to report Task I discriminated by landings, dead and live discards for all ICCAT managed species.

After the continuous work of this Group in discriminating BIL unclassified into billfish species over the last decade, these BIL amounts are becoming residual (**Table 6**). Effort should be made in the future to completely eliminate the reporting of BIL unclassified catches in the future.

The SCRS catalogue for WHM (**Table 7**) on Task I and Task II data available was updated with all the Task I corrections. The revision work made by the Group, together with some T2SZ revisions provided by Mexico (1993-2014), increased the score from 4.8 (SCRS 2018 annual meeting) to 5.04, which reflects a reasonable improvement (availability and discrimination) in a relatively short period of time.

Document SCRS/2019/040 presented a description of the artisanal drift gillnet fishery from Côte d'Ivoire taking place in the EEZ. The study covers the period 2014 to 2017 and indicates that the nominal catches were almost exclusively dominated by tunas (73.92-83.17%) followed by Elasmobranchs (11.48-15.00 %), Billfish (2,54-9,72 %) and Xiphiidae (0,23-1,35 %). For Billfish, catches were dominated by sailfish (60.93-76.82%) whereas blue and white marlins represented respectively 15.42-20.49% and 0.96-2.03% of the landed species.

3.1.1 Roundscale spearfish

All ICCAT assessments to date are considered to represent the complex of white marlin and roundscale spearfish (*Tetrapterus georgii*). Such practice goes against the recommendations made by Beerkircher *et al.* (2009) that noted that misidentification of the two species may be masking significant differences in population trends for the two species. Catches of these two species have historically not been separated in catch reports or in most scientific studies. In fact there are only a few countries that have made efforts to separate the two species with their on-board scientific observer programs, because of the difficulty of identifying them. As of today there are few roundscale spearfish catches reported to ICCAT as Task 1, however, such reports are increasing in quantity of landing (**Figure 3**). The first year of catch reports of roundscale spearfish was 2008 when 3.5 t were reported by EU-Spain. In 2017 total catches of the fleets reporting spearfish (EU- Spain, USA and Venezuela) were 36.5 t, the highest value in the series. The only other fleet reporting roundscale spearfish was South Africa that reported 2.5 t in 2009. All reports correspond to longlines except those from the US that correspond to rod and reel.

As there are some recent reports of roundscale catches, the Group agree to combine these catches with those of white marlin for the assessment.

It is important to stress that the advice provided by the SCRS about the mixed stock of white marlin and roundscale spearfish may have generated some confusion: From the Annual SCRS Report of 2011: "*Noting the misidentification problems between white marlin and spearfishes, the Group recommended that management recommendations combine these species as a mixed stock until more accurate species identification and differentiation of species catches are available. 3. The Commission should encourage the reporting of catches of white marlin and roundscale spearfish separated.* "

However, in subsequent recommendations the Commission repeatedly refers to management measures, including quotas for "*white marlin/spearfish*". From [Rec. 12-04]: "*NOTING that, due to the misidentification problems between white marlin and spearfishes (genus Tetrapturus), the SCRS also recommended that management measures should be applied to these species together as a mixed stock complex until more accurate species identification and differentiation of species catches are available… An annual limit of 2,000 t* *for blue marlin and 400 t for white marlin/spearfish is established for these stocks, for 2013, 2014 and 2015.*" And from [Rec. 18-04]: "*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*."

It should be made clear to the Commission that the species identification difficulties are between white marlin and roundscale spearfish and therefore management measures aimed at rebuilding white marlin should refer to **white marlin/roundscale spearfish**. This is especially important because recent catches of the other spearfish species; longbill spearfish (*Tetrapterus pfluegeri*) (see Section 8) have, in 2013 and 2017 exceeded 300 tons (**Figure 4**), during a period when catches of WHM alone were exceeding the limit of 400 tons set in [Rec. 12-04].

3.2 Task II effort and size data

Document SCRS/2019/036 presented a summary of the available size and catch-at-size information for Atlantic white marlin. Size sampling data is available since 1970. Preliminary analysis indicated that since 1970 there are adequate size frequency information for the main gears of longline, gillnets and rod and reel. Unfortunately for the 1960s when the largest catches of Atlantic white marlin were taken, there is not size information. Reported size sampling is mainly in 5 cm bin size intervals, thus the size frequencies should be aggregate to 5 cm LJFL.

The mean size of white marlin is similar for the main gears, longline, gillnet and rod and reel. Overall size distributions show a unimodal distribution with a median size of catch at about 160 cm and overlapping size ranges for all three main gears. The longline size catches show larger range of sizes [90-230 cm LJFL] compare to gillnets or rod and reel. Annual trends show rather a stable mean size of catches for all gears and none seasonal trends. Mexico provided an update and size sampling revisions for the 1993 - 2017 years, these were included in the database. It was also indicated that Venezuela provided preliminary size samples of white marlin for 2015 -2017, however they are missing gear and fleet data source, and they are pending to be integrated in the database until further details are provided. A revision of size sampling also indicated inconsistent sampling for the Brazil-Panama fleet in the first month of 2005. These samples were eliminated.

For the assessment models, size frequency samples were estimated by aggregating observations by year season and main fishing gear. A minimum of 25 size measures were considered by strata to be included, also samples with extreme kurtosis or skewness were excluded, using their 95% quartiles as cut off values for inclusion, respectively.

The Group requested exploring possible difference in size distribution by area. **Figure 5** shows the white marlin size distributions by ICCAT sampling areas and main gear. The plots show no discerning differences in size distribution or mean size for the longline, other gears main indicate some differences but the limited number of size sample by area preclude any conclusions.

3.3 Tagging data

The Secretariat informed the Group that the WHM conventional tagging information presented is basically the same one presented to the 2018 SCRS annual meeting.

4. Review of relative indices of abundance (CPUEs)

There were 5 documents and one presentation on relative indices of abundance examined during the meeting.

Document SCRS/2019/034 presented the standardized CPUE by Brazilian sport fishing tournaments 1996-2017 in the southwestern Atlantic. It was noted that the positive catch rates and the number of monitored tournament days increased since 2009, while relatively high numbers of white marlin were observed since 2013. The reason for the increase in the number of tournament days was unclear, but the increase in the numbers of fish in the more recent years was attributed in part to a large increase in the number of boats participating in the tournaments (number of boats per tournament day was the unit of effort for the CPUE calculation). It was clarified that the main fishing ground is Espirito Santo where more white marlins have been caught compared to other areas, and the standardization captured correctly this information.

A concern was raised regarding the huge increase in 2010 in the standardized CPUE that is biologically implausible. The cause for the low value in 2009 was not clear, but higher catch rates continued since 2010. The Group noted that the recent trend of this index is opposite to the other indices in the south Atlantic and discussed whether or not this index should be considered as covering only a "hotspot" area (off Espirito Santo). It was noted that generally indices in hotspots respond to stock reduction more slowly than other areas, as fish tend to continue to concentrate in these more favored areas. It was further indicated that, although the Espirito Santo was clearly a local hotspot within the limited range of the tournament survey area, it wasn't clear that it was an overall hotspot within the stock range.

The Group questioned if the ratio of discard/release changed overtime in the analyzed period. It was clarified that the fishermen constantly released fish through the entire period, although all release became mandatory in 2005. It was noted the importance of understanding the potential effect of this regulation on fishermen's behavior. It was also pointed out that similar to blue marlin catches, the oil platforms in the southeast Brazilian coast also affected the catch rates and, as a consequence, the behavior of the fishermen.

Document SCRS/2019/035 presented the standardization of Brazilian longline CPUE in 1978-2017 in the southwestern Atlantic. It was clarified that the logbook data used for the standardization do not contain discard information. Although the scientific observer data record discard/release information, the observer program was discontinued during the period 2011-2017. It restarted in 2018, and observer data may be incorporated in the analysis for the following stock assessment after 2019.

With respect to the effects of management regulations, it was pointed out that the trend was not affected by the 2005 regulation of live release. The author clarified that it seemed that fishermen continuously reported dead discards after 2005 until 2010, since that the proportion of positive catches was about 13%. However after 2010 fishermen began discarding all marlins at sea, and dead discards were not recorded effectively in the logbooks, with the proportion of positive catches dropping to 3%. Therefore the author recommended, and the Group agreed not to use the CPUE values from 2011 forward. The updated index was provided during the meeting including CPUE data until 2010 only.

Document SCRS/2019/037 presented the standardized CPUE of Japanese longline fishery in the Atlantic in 1976-2017 using various type of models. The authors suggested to use 3 split indices: 1976-1993, 1994-2000, 2001-2017, and not to use the historic CPUE started in 1959 used in the 2012 stock assessment. The Group suggested to the authors considering a zero-inflated negative binomial standardization model as it may handle overdispersion better, while also noting that some of the diagnostics of residual patterns may be indicative of under-dispersion. A comparison of the updated index after 2001 and the previous index used in the 2012 stock assessment was presented. The updated index showed a decreasing trend, while the previous one showed relatively flat trend. This is mainly because the updated index extracted signal for only adult fish using the core area, while the previous one used the whole tropical area.

A concern was raised regarding losing the historical longline index information in the assessment, noting that indices during the initial period of depletion are very useful, for instance in the estimation of B_0. For this reason, while acknowledging the limitation of the early data, the Group requested that the authors consider developing an index covering the period from 1959-1975. The Group agreed to the recommendation of the authors to use the indices provided for the years beginning in 1976 (taking into account any revisions resulting from the suggestions to the authors made during this meeting). If the authors are unable to prepare a new index covering the 1959-1975 period, the Group plans to use the prior Japanese longline index for the years 1959-1975 (as used in the 2012 stock assessment) as a sensitivity analysis.

Document SCRS/2019/038 presented the standardized CPUE of the Chinese Taipei longline fishery in the Atlantic in 1968-2017. The authors recommended splitting this index into three time periods: 1968-1989, 1990-1998, 1999-2017, due to the change of fishing patterns (a shift from targeting albacore to targeting bigeye tuna) around 1990 and the addition to data collection system of hooks per basket information (which is only available since 1999). It was noted that information on dead discards or live releases was not considered in this analysis, and more time is needed to incorporate them from the scientific observer data. The Group was concerned that a continuous index from 1999-2017 might be inconsistent for representing the abundance trend, as after 2001 it may underestimate abundance due to the introduction of Rec. [00-05], that required the release of all live billfish, and that the discard information is missing. The Group recommended that the authors reconstruct the most recent two indices to cover two different time periods: 1990-2000 (ignoring the hooks per basket information available for 1999 and 2000) and 2001-2017 (with hooks per basket information). The authors were able to respond to this recommendation and provided the revised indices during the meeting.

Document SCRS/2019/039 presented the updated standardized CPUE by U.S. recreational tournament fishery in 1974-2017. The Group requested that the paper be revised to include the deviance table. The Group asked if "rodeo style" tournament data were included in the analysis data set. The rodeo style tournaments normally are longer than the regular tournaments (3-5 days), and it is difficult to define the fishing effort because the registration and active vessels do not match. This data could give noise in the standardization; thus, it was suggested to check the data used, and remove the rodeo style tournaments from the analysis. U.S. scientists considered that the inclusion of rodeo tournament data was unlikely, given that the tournaments selected for inclusion were tournaments specifically directed at marlins. However, this will be investigated and, if necessary and appropriate, revised indices will be provided before the adopted deadline for data inputs.

It was noted that the observed mean CPUEs after 2010 became relatively large values, while the number of the tournaments in the data decreased at the same time. U.S. scientists explained that the requirements and procedures of tournament registration and monitoring changed around 2010, and that this may have contributed to reduce the sampling in the Bahamas region. However, it is also possible that the tournament effort has declined there.

Presentation SCRS/P/2019/011 shows the update of standardized index for white marlin and spearfish by the USA pelagic longline fishery in 1993-2017 using scientific observer data. It was noted that this analysis used the catch of white marlin and roundscale spearfish, and the author noted that often these species are misidentified and therefore it is difficult to separate the catch by species. The Group acknowledged that this situation exists to varying degrees for all of the Task I, Task II, and index data provided by the different CPCs.

The Group discussed the factors in the standardization, nothing that for several factors the number of categories within a given factor can be reduced (e.g. hooks per float, area, and hook type), as the observed mean CPUE showed similar values between categories. Comments were also raised about the use of environmental data as factors. The Group noted that both sea depth and seafloor gradient are likely correlated factors and commented that sea depth and seafloor gradient normally affect primarily the distribution of demersal species. The author clarified that these factors are not always correlated and may differ by area, and in the case of pelagic species may inform the catch and effort data on bathymetric features, such a shelf edges, slopes, and seamounts. The U.S. scientists expressed appreciation for the Group suggestions and indicated that these would be considered in future analyses as possible ways to improve estimates. However, the author stressed that the model converged with the current structure and that based on previous testing results with the longline simulator, the current configuration of the model performs well in the calculation of indices reflective of the underlying abundance trends.

A question was raised as to whether size distributions by area could provide insight on the areas where adult fish can be caught, and where the recruitment area is. The Secretariat provided size distributions histograms by ICCAT sampling areas for billfish (**Figure 5**), by main gear type. Overall no clear pattern for the longline was evident by sampling areas, suggesting rather a similar distribution of size catches of white marlin through the Atlantic. The limited number of samples for other gears by area prevent further conclusions.

In addition to the above presented standardized indices, the Group discussed the other standardized indices used in the 2012 stock assessment. These included a Spanish longline index, and Venezuelan gillnet and longline indices. It was recommended to consult with the authors if they can provide the updated indices up to 2017 before the dateline of March 30th, 2019. The Group then will consider whether or not to include these indices.

The Group discussed the CPUE evaluation tables completed for each series presented during the meeting. The agreed information for each series is provided in **Table 7**. In summary, the following indices are currently available for the 2019 stock assessment, shown in **Table 8** and **Figure 6**.

1. Brazil, longline, 1978-2010
2. Brazil, recreational, 1996-2017
3. Chinese Taipei, longline, 1968-1989, 1990-2000, 2001-2017
4. Japan, longline, 1976-1993, 1994-2000, 2001-2017
5. USA, longline, 1993-2017
6. USA, recreational, 1974-2017
7. Japan, longline (from 2012 assessment), 1959-1975
8. Spain, longline, 1988-2010
9. Venezuela, gillnet, 1991-2010
10. Venezuela, longline, 1991-2010

After discussions, the Group agreed/concluded for the 2019 stock assessment:

1. to use the indices presented in the current meeting (CPUEs 1-6 in the list) with the suggestions to the authors.

    a) use Brazilian longline index up to 2010
    b) use Brazilian recreational index
    c) use USA recreational index
    d) use Chinese Taipei longline index with 3 time series
    e) use Japanese longline index with 3 time series
    f) use a revised prior Japanese longline index for the period 1959-1975, if provided.

2. to use Spanish longline and Venezuelan longline and gillnet indices used in the 2012 stock assessment. The Group requests the authors to try to update those indices.

3. if a revised Japanese longline index for 1959-1975 is not provided, to use the prior Japanese longline index in 1959-1975 (from 2012 assessment) as sensitivity analysis.

4. to use 0.3 for CV if the actual observed values are smaller than 0.3.

5. Discussion on models to be used during the assessment and their assumptions

The Group discussed which population dynamic models would be most appropriate to use for the assessment of the white marlin stock. The previous white marlin assessment (completed in 2012) used a combination of the non-equilibrium production model ASPIC (version 5.3.4) and the fully integrated model Stock Synthesis (SS, version 3.23b) to provide the final management advice. A Bayesian Surplus Production Model (BSPM) was presented to the 2012 Group as a third model option. However, that Group was unable to fully evaluate the methods, diagnostics, and results of this model during the meeting. Although the cursory evaluation that was done indicated that the results were generally consistent with the other two models, the results were not formally considered for management advice due to a lack of detailed Group evaluation.

The Group decided that for the 2019 assessment the Bayesian Surplus Production model, Just Another Bayesian Biomass Assessment (JABBA); Winker *et al*., 2018) will be used for the first time. This model was one of the models used to provide management advice for the 2018 blue marlin assessment and was deemed appropriate for white marlin as well. Considering the limited biological information of white marlin, one of the most important issues for SPM models is the prior parameters to the intrinsic growth rate *r*. The presentation SCRS/P/2019/009 provided the first initial *r* priors through a Monte-Carlo simulation which objectively integrates limited stock specific life history information and inference from life history meta-analysis. In summary, this approach uses of an age-structured equilibrium model to convert conventional life history parameters into the *r* prior and the associated shape parameter *m* of the Pella-Tomlison SPM. The R package FishLife (Thorson *et al*., 2017) was used to generate multivariate life history parameter distributions, which were then subsampled based on a range of plausible stock-specific estimates of the asymptotic length (L infinity) that were derived by fitting the Length-based Bayesian estimator (LBB, Froese *et al*., 2018) to available size data of Atlantic white marlin. The resulting FishLife predictions of parameter means and their covariance were then used to propagate parameter uncertainty and correlation structure into the formulation of the *r* prior and the associated shape parameter *m*. Initial candidate priors were presented for a range of alternative assumptions on the steepness *h* parameter of the stock-recruitment relationship.

A presentation was given on the methods used to establish initial surplus production model priors for white marlin for use in the JABBA model (SCRS/P/2019/009). The presentation was based on preliminary analysis only and will be updated before the assessment. The Group noted some important differences in some of the biological parameter values estimated by this process and the ones used in the SS model for the assessment. Most notably the average value of M across all ages was centred on 0.50 and seemed very high for a species such as white marlin. A simulation testing approach is ongoing, and will consider extra uncertainty in M. It is proposed to evaluate the performance of the preliminary presented SPM priors against conventional prior formulations using life history tables. Results from this simulation testing should be presented at the 2019 white marlin stock assessment meeting. Also, the Group decided that a sensitivity analysis should be also tested for SPM models, including non-informative priors for *r*.

Additionally, SCRS/P/2019/012 provides an initial result for white marlin stock assessment using the catch-resilience method CMSY (Froese *et al*., 2017). This method is considered a data limited method for use when only catch is known. This is a new method presented for evaluation and it was suggested by the author and the Group that this offers an alternative tool to evaluate catch data. The presentation showed that the model results were driven a great deal by the assumptions of final year depletion input. As such, a great deal of care needs to be used when employing the model. It was noted that the Indian Ocean Tuna Commission has examined the CMSY model and it has been used for comparison with other models. The comment was made that catch only methods such as CMSY rely mainly on catch data which is often highly uncertain. However, these methods can help to isolate and explore issues of uncertainty in the catch data.

The basic configuration and parameters of the SS model were discussed. It was noted that the configuration of the SS model will remain essentially unchanged from the 2012 assessment model. The parameterization of the model is defined in detail in Schirripa, 2013. The configuration is a two-sex model, with different estimated growth rates. Estimated parameters included virgin recruitment (R0), steepness, recruitment deviations, and selectivity parameters. Four fleets are used in this model: longline, purse seine, gillnet and recreational. Troll catches are assumed to be similar to recreational rod and reel gear. The longline, purse seine and recreational fleets were assumed to have asymptotic selectivity while the gillnet gear was allowed to have a dome-shaped selectivity. Sensitivities like those performed in the 2012 assessment (e.g. M, steepness, etc.) will also be explored in the 2019 assessment.

In 2012 assessment management advice was based on the results from a combination of the ASPIC and SS models. The Group discussed whether to include the ASPIC model in 2019 assessment. It was decided that it was not necessary to do both ASPIC and JABBA surplus production models.

6. Other data relevant for stock assessment and remaining issues in preparation for the June stock assessment meeting

The Group spent a considerable amount of time discussing the Commission's request to update the rebuilding plan for billfish. In this regard, it was noted that both blue marlin and white marlin assessments do not fully account for non-reported dead and live discards and that this could be having a significant influence on the assessments and thus the rebuilding plan. In the case for blue marlin, arriving at estimates of the absolute number (or weight) of live and dead discards was a formidable task. The Group also noted the possibility that some CPC's may not be discarding a large amount of white marlin, despite the CPC specific quotas. The Group proposed that perhaps national observer data is one way to help estimate discards. However, since that National Observer data reported to ICCAT is currently reported in an aggregated manner, thus limiting the usefulness of this database and so little to no help in this regard. A cursory look at some observer data suggested that perhaps not many white marlins are being discarded. However, a comparison of CPUE's from one CPC logbooks versus that CPCs observer program suggested that, at least for that fishery, logbooks may not be capturing all discards.

In an effort to more clearly depict whether discards may be a significant source of mortality the Group was presented with the percentages of reported catches of white marlin by major CPCs that are part of the rebuilding plan. Based on this information the Group decided to attempt to reconstruct the discards from observer data for the various CPCs with a significant portion of the white marlin catches. The Group requested that each CPC that is part of the rebuilding plan, and is able to do so, will provide a count of the number of fish landed, the number released dead, and the number released alive from their National Observer data. This type of information could be evaluated as a means to arrive at the percentage of white marlin discarded and released, which can be used within the SS modelling framework. The Group felt that even if the information relevant to live/dead discards could not be used in the assessment model; the information would be very useful in evaluating the effects of the current stock rebuilding plan. The task of reporting the discard data from the individual observer programs was included in the work plan for the assessment meeting with a requested delivery date of 30 March 2019.

7. Enhanced Program for Billfish Research (EPBR)

Presentation SCRS/P/2019/013 provided a detailed description of the work that has been conducted within a contract signed between ICCAT and a Consortium led by IFAN on the collection of samples of three billfishes (blue marlin, white marlin and sailfish) in the eastern Atlantic. A total of 108 samples have been collected so far (BUM 44, WHM 22 and SAI 42). Fins rays have been collected, processed and age readings provided.

The Group highlighted the importance of the ongoing study and the work carried out over the past 8 months, and reiterated the need for such activities to be maintained. The Group also requested the Consortium to explore the possibility to engage further teams to enlarge the geographic area and reduce the time needed to collect the necessary samples to complete the study. On this regards EU-Portugal committed to also participate in future phases of this project, namely through the collection of samples (spines, otoliths and tissue for genetics).

The Group suggested the authors revise the age reading bearing in mind that over time there is the absorption of the inner bands in the rays, which if not taken into account would result in underestimation of the age of the fish. In that regard, the Group suggested the collection of otoliths as these can be used for ageing calibration studies.

The Secretariat provided detailed explanation on the Enhanced Program for Billfish Research (EPBR) budget for 2019, which are in line with the request by the SCRS for the development of the 2019 work plan. A total amount of €70,000 is available, as shown below:

Activity	**Requested (€)**
Sampling and shipping*	30,000
Age and growth	20,000
Reproductive biology	15,000
Genetics study (stock differentiation)	5,000

* Including €9,000 for surveying of fishing activities in Côte d'Ivoire, Senegal and São Tomé e Príncipe (equally shared by the three CPs).

The Group stressed the importance of continuing support sampling fishing activities to improve the quality of data on billfish collected from artisanal fisheries and the difficulty to achieve such goals without a multi-annual program, as these activities have to be carried out over a period exceeding the bi-annual timeframe of the ICCAT science budget. Accordingly, surveys of fishing activities (catch, effort and size data) in the eastern Atlantic shall be included as an additional task to the contract to be awarded regarding the collection of biological samples.

The Group also suggested EPBR to consider a workshop on age reading of billfish to enhance current expertise in the eastern Atlantic and to standardize processing and reading protocols between laboratories. If budget is available such a workshop should be conducted in 2019, otherwise no later than 2020.

Finally, following the request for research and biological sampling of blue marlin from the Gulf of Mexico Mexican longline fisheries, the Group recommended this activity to be conducted by Mexico within a two-year study. Moreover, the collection of biological and photographic samples should include the following:

1. Identify the gender and maturity status of blue marlin caught as by-catch, as preliminary analyses indicated that larger fish from this fishery are primarily males (Ramírez-López, 2018), contrary to the current biological assumptions of the SCRS regarding blue marlin.

2. Collection of gonads, hard parts and genetic samples to confirm the preliminary results, as well as recording digital images of these samples to create an image bank for reference and post-evaluation if required.

3. Sampling a wide size range through the year [if possible, from 90 to 350 cm LJFL] and collect 250 to 300 gonad individual fish samples (uniformly distributed as much as possible within the size range).

4. To be able to compare results with previous studies, sampling and analysis should allow:

   (i) estimating maturity and reproductive status at size and age for males and females, and

   (ii) identify sex ratios and spatio-temporal distributions by sex.

5. The study should provide macroscopic and histological analysis of gonads and maturity status for both ovary and testis.

The Group agreed that the specific activities to be developed during 2019 will be reviewed later by the Species Group rapporteur and provided to the Secretariat no later 30 April 2019.

8. Other matters

Blue marlin and white marlin rebuilding plan

In 2018 the ICCAT Commission requested that the SCRS evaluate the progress toward the goals of the rebuilding programs for blue and white marlin/spearfish. This plan started in 1997 in response to the determination by the SCRS of the overfished status of marlin stocks. The plan had a goal to reduce fishing mortality. Various ICCAT recommendations (**Table 9**) established catch limits/TACs for purse seine and longline of 1,194[1] t for 1999-2000, 544[1] t for 2001, 568[1] t for 2002-2012 and 400 t for 2013-2019. The release of fish caught alive on purse seine and longline was voluntary from 1998-2000 and compulsory from 2001 until now. The US agree to limits its take of marlins from recreational fleets in 2000 and at the same time ICCAT recommended minimum size limits for such fleets. A sale prohibition and landing limits were imposed in 2012 for all recreational fleets.

The Group agreed to use analyses conducted during the 2019 white marlin assessment as the basis for the evaluation of the progress on white marlin rebuilding achieved by the ICCAT marlin rebuilding plan.

9. Recommendations

Recommendations with financial implications

- Continuing support to the Enhanced Billfish Research Programme (EBRP): The Group noted the success of this project, with ongoing sampling and data analysis and survey of fishery activities for several fisheries and a new sampling initiative in the Gulf of Mexico. The Group recommended that the SCRS continues to support this project and that the Commission continues to provide the needed funds to maintain the activities in the future.

- Ageing workshop: Following the request for the continued support to the EBRP, the Group recommended that specifically for 2019 or 2020 ageing workshop is planned, so that the various laboratories can coordinate their spine collection and processing methods, and the age reading estimates. An age calibration set for spines should be established for the workshop, involving the various laboratories that are reading the structures and making the age estimations. Additionally, consideration should also be given to otoliths for comparison of age estimates from spines, and eventual correction of the initial bands in the spine vascularization zone.

Recommendations related with statistics

- Improvements in ICCAT data: CPCs that have historic reports of unclassified billfish and unclassified gear should continue to review such reports with the purpose of improving the precision of the ICCAT database.

- Revisions in billfish taxonomy: The Group recommended updating the scientific names for billfishes to reflect the more recently adopted taxonomy, described in Collette *et al.* (2006). This revised taxonomy is referred in Table 1 (see Section 2).

Other Recommendations

- Need for more participation and contribution of data, especially from the major fleets capturing billfishes: Participation has been lacking from scientists from some of the CPCs that contribute to large portion of the billfishes catches. This may reflect the low priority that billfish have for some CPCs, that are mostly captured as by-catch. However, it is important to consider that management of billfish by-catch may ultimately influence management of target species, for example if spatial/seasonal restrictions are put in placed in some regions. As such, the Group recommends that especially for CPCs that have the larger portion of the catches scientific representation and provision of data are ensured and provided to the Group, including standardized CPUEs for assessment purposes.

[1] The ICCAT Recommendations did not specify a TAC but rather percent reductions in catch intended to be accomplished by each industrial purse seine and longline fleet. Values were calculated from the 1996-1999 task 1 reported catches of all purse seine and longliners as available during the current meeting.

- Collaboration with Western Central Atlantic Fishery Commission (WECAFC): The 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 for reporting on 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.

- Evaluation of the rebuilding plan: The Group recommends to use the analyses conducted during the assessment of white marlin in 2019 to evaluate the success of this plan. SCRS scientists should examine the request of data on monitoring and controls to support the plan contained in [Rec. 18-05] to understand how, in the future, such data can be used in support of the SCRS work. This is especially important for the estimation of discards.

- Review of the recommendations of the reports on monitoring of billfish artisanal catches in the West and East Atlantic by the billfish Working Group. And, develop a workplan to respond to those recommendations.

Recommendations related with inter-sessional work for the June WHM assessment meeting

Appendix 5 presents the tentative agenda for the upcoming white marlin stock assessment meeting, to accomplish the objectives of the meeting the Group recommends.

- Estimation of discard ratios from observer data for assessment purposes: The Group expressed concerns about the extremely poor discard data currently available in ICCAT, noting that at least dead discards must be taken into account in the total fishery removals. As such, the Group recommends that more work is devoted on this issue, and that specifically for the upcoming white marlin assessment, observer data (as specified in item 6 be explored and used to estimate ratios of fish kept vs. live discards vs. dead discards. This should be done by year and gear, to also take into account possible changes in discard practices throughout time. This data should be collated inter-sessionally (deadline specified in item 6 by each CPC and provided to the Secretariat to have initial estimation on those percentages for use as a sensitivity scenario in the June white marlin assessment (work coordinators: Craig Brown and Secretariat).

- Estimations of post-release mortality for assessment purposes: The Group recommends work to collate estimates of survival from live releases from different gear types. This should be done inter-sessionally and prioritizing the upcoming 2019 white marlin assessment (work coordinator: David Die).

10. Adoption of the report and closure

The report was adopted by the Group and the meeting was adjourned.

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Table 1. Proposed changes to the list of scientific names for billfish reported to ICCAT. Species for which changes are proposed are in bold.

ICCAT code	***Common name (English)***	***Scientific name***	***Synonym (previously used by ICCAT)***	***Main area of distribution***
SAI	**Sailfish**	***Istiophorus platypterus***	*Istiophorus albicans*	Pan-Oceanic
BLM	**Black marlin**	***Istiompax indica***	*Makaira indica*	Indo-Pacific*
BUM	Blue marlin	*Makaira nigricans*	-	Pan-Oceanic
WHM	**White marlin**	***Kajikia albida***	*Tetrapterus albicans*	Atlantic
MLS	**Striped marlin**	***Kajikia audax***	*Tetrapterus audax*	Indo-Pacific*
SSP	Shortbill spearfish	*Tetrapterus angustirostris*	-	Indo-Pacific*
MSP	Mediterranean spearfish	*Tetrapterus belone*	-	Mediterranean
RSP	Roundscale spearfish	*Tetrapterus georgii*	-	Atlantic
SPF	Longbill spearfish	*Tetrapterus pfluegeri*	-	Atlantic

*Also present occasionally in the southern Atlantic.

Table 2. Total catches (T1NC t) including landings and dead discards of the various billfish species by year.

	Major Billfish						Other Billfish					
	BUM	SAI		SPF		WHM	BIL	BLM	MSP	RSP	SSP	MLS
	Makaira nigricans	*Istiophorus albicans*		*Tetrapturus pfluegeri*		*Tetrapturus albidus*	*Istiophoridae*	*Makaira indica*	*Tetrapturus belone*	*Tetrapturus georgii*	*Tetrapturus angustirostris*	*Tetrapturus audax*
Year	A+M	ATE	ATW	ATE	ATW	A+M	A+M	A+M	A+M	A+M	A+M	A+M
1956	39		1		0	19						
1957	764	71	24	19	4	160						
1958	772	32	66	7	13	161						
1959	841	4	5	8	11	112						
1960	2815	50	176	41	59	313						
1961	4083	173	350	131	36	830						
1962	7308	218	364	241	80	2064						
1963	9038	230	354	282	135	2614						
1964	8011	264	533	281	412	3735						
1965	6156	797	979	592	557	4906						
1966	3863	540	649	828	422	3513						
1967	2246	848	693	348	308	1427						
1968	2527	920	871	437	409	2049						
1969	3106	962	752	308	342	2272						
1970	2886	628	1258	338	572	2147						
1971	3398	916	1243	354	360	2266						
1972	2414	870	804	737	241	2289						
1973	3226	670	649	430	130	1868						
1974	3095	3573	753	246	120	1775						
1975	3271	5278	732	219	60	1761						
1976	2419	5398	852	453	147	1839						
1977	2181	1457	900	337	32	1150						
1978	1642	2529	779	272	16	975						
1979	1527	3230	867	261	36	1039						
1980	1848	2069	841	300	66	976						
1981	2032	2082	968	365	88	1241	116					
1982	2708	2796	1042	406	76	1100						
1983	2142	3706	1186	351	46	1780		1				
1984	2888	2445	1151	269	70	1213		6				
1985	3403	2269	1004	287	89	1730		2				
1986	2104	2065	1252	293	123	1689		16				
1987	2290	2553	1193	284	100	1612	5	0				
1988	2881	2109	1143	295	236	1472	1		0			
1989	4339	1710	1052	310	108	1923	1	26	0			
1990	4612	2315	1235	417	64	1739	1	2	0			
1991	4220	1476	1225	131	83	1743		5	1			
1992	3104	1780	1459	255	19	1557			0			
1993	3175	1815	1413	419	120	1680	27	4	0			
1994	4258	1172	1120	198	122	2201		34	0			
1995	4230	1234	1211	207	33	1879		117	1			
1996	5421	1881	1142	128	37	1679		70	1			
1997	5737	1347	1257	194	7	1513		151	2			
1998	5713	1362	1615	192	74	1945		177	3			
1999	5408	1342	1580	257	50	1786		147	3		0	
2000	5485	1980	1996	181	97	1535	37	49	5			
2001	4474	2806	1797	81	107	1078	25	53	3			
2002	3910	2351	2060	84	95	1012	2	17	54			
2003	4419	2639	1498	54	79	844	9	54	105		2	
2004	3209	2612	1727	51	137	841	32	12	88			
2005	3579	2220	1839	68	101	767	104	16	50			9
2006	3176	1916	1939	84	256	611		28	2			20
2007	4364	2577	1561	66	102	738	9	24	5			22
2008	3780	2229	1733	60	106	700	13	21	269	4		1
2009	3345	2129	1624	78	62	742	27	440	391	2	7	59
2010	3052	1853	1229	128	117	502	29	14	150	2		
2011	2901	1553	1335	73	80	528	122	46	92			7
2012	2856	1591	1275	170	58	462	107	29	37	1	3	75
2013	2162	1339	985	95	352	639	6	11	45	8	5	8
2014	2689	1163	859	16	36	436	1	14	118	16	1	14
2015	1925	1246	898	18	62	479	3	3	20	12	45	26
2016	2022	1422	1214	15	62	438	53	2	11	22	43	14
2017	2132	1650	1080	29	321	417	108	4	10	36	53	19

Table 3. WHM catches (T1NC, t) by gear group and year, with the LL percent of total (%) by year.

Catch t	WHM														
YearC	LL	RR	GN	TR	PS	UN	HL	BB	HP	TW	TN	TL	TP	TOTAL	LL %
1956	19													19	100%
1957	160													160	100%
1958	161													161	100%
1959	112													112	100%
1960	253	60												313	81%
1961	763	67												830	92%
1962	1985	79												2064	96%
1963	2548	66												2614	97%
1964	3661	74												3735	98%
1965	4827	79												4906	98%
1966	3425	87			1									3513	97%
1967	1335	91			1									1427	94%
1968	1949	98			2									2049	95%
1969	2171	98			3									2272	96%
1970	2027	116			4									2147	94%
1971	2153	107			6									2266	95%
1972	2171	109			9									2289	95%
1973	1750	109			9									1868	94%
1974	1645	115			15									1775	93%
1975	1634	111			16									1761	93%
1976	1680	114			20	25								1839	91%
1977	1011	111			25	3								1150	88%
1978	837	111			25	2								975	86%
1979	900	111			23	5								1039	87%
1980	822	112	6		27	9								976	84%
1981	1011	72	45		31	82								1241	81%
1982	990	45	21		32	12								1100	90%
1983	1512	79	142		31	16								1780	85%
1984	1054	66	55		22	17								1213	87%
1985	1619	44	16		23	29								1730	94%
1986	1548	32	22		25	61								1689	92%
1987	1486	38	6		25	57								1612	92%
1988	1165	29	112	14	25	127								1472	79%
1989	1784	17	69	16	27	11								1923	93%
1990	1626	25	31	19	37	1								1739	94%
1991	1665	19	22	26	11									1743	96%
1992	1477	22	17	24	10	8								1557	95%
1993	1594	30	26	17	12	1								1680	95%
1994	2107	30	13	21	11	19								2201	96%
1995	1820	22	7	21	9									1879	97%
1996	1599	24	6	30	7	13								1679	95%
1997	1437	14	9	45	7				0					1513	95%
1998	1749	6	25	40	9	116								1945	90%
1999	1695	6	38	36	8	3								1786	95%
2000	1444	2	26	37	12	14								1535	94%
2001	987	4	35	37	14	1						0		1078	92%
2002	863	6	25	37	12	4		65				0		1012	85%
2003	773	1	19	37	13	1	0		0					844	92%
2004	784	1	21	21	13	1			0					841	93%
2005	706	1	15	33	11	1			0				0	767	92%
2006	543	2	22	29	10	4			0					611	89%
2007	655	1	29	35	9	8			0					738	89%
2008	613	2	23	36	10	15								700	88%
2009	643	2	25	37	12	23					0			742	87%
2010	428	3	11	38	12	7	3	0	0		0		0	502	85%
2011	439	3	8	39	37	0	1	0			0		0	528	83%
2012	393	1	16	42	0	5	5		0	0	0			462	85%
2013	467	4	14	42	0		112		0					639	73%
2014	369	2	17	43	0	0	5		0					436	85%
2015	442	3	16	18	0		0	0	0					479	92%
2016	401	2	16	15	0		3	0	0	1				438	92%
2017	370	2	16	20	4	1	3		0	0				417	89%

Table 4. WHM catches (T1NC, t) by gear group and year, with the LL ratio (%) by year.

	WHM (A+M) catches (t) in Task I (T1NC)				
Year	**Catches (C)**	**Landings (L)**	**Dead Discard (DD)**	TOTAL	**DD (%)**
1956	19			19	0.0
1957	160			160	0.0
1958	161			161	0.0
1959	112			112	0.0
1960	313			313	0.0
1961	830			830	0.0
1962	2064			2064	0.0
1963	2614			2614	0.0
1964	3735			3735	0.0
1965	4906			4906	0.0
1966	3513			3513	0.0
1967	1427			1427	0.0
1968	2049			2049	0.0
1969	2272			2272	0.0
1970	2147			2147	0.0
1971	2266			2266	0.0
1972	2289			2289	0.0
1973	1868			1868	0.0
1974	1775			1775	0.0
1975	1761			1761	0.0
1976	1839			1839	0.0
1977	1150	0		1150	0.0
1978	975	0		975	0.0
1979	1039			1039	0.0
1980	976			976	0.0
1981	1241	0		1241	0.0
1982	1100	0		1100	0.0
1983	1780			1780	0.0
1984	1213			1213	0.0
1985	1730	0		1730	0.0
1986	1646	42		1689	0.0
1987	1461	89	62	1612	3.8
1988	1327	85	60	1472	4.1
1989	1721	94	107	1923	5.6
1990	1573	85	81	1739	4.7
1991	1537	116	90	1743	5.2
1992	1380	90	88	1557	5.7
1993	1478	136	66	1680	3.9
1994	2062	97	42	2201	1.9
1995	1649	130	100	1879	5.3
1996	1502	113	65	1679	3.9
1997	1314	129	70	1513	4.7
1998	1644	268	33	1945	1.7
1999	1530	199	58	1786	3.2
2000	1296	198	41	1535	2.7
2001	826	234	18	1078	1.7
2002	728	251	33	1012	3.2
2003	512	316	17	844	2.0
2004	583	230	27	841	3.3
2005	325	424	17	767	2.3
2006	312	287	11	611	1.8
2007	520	192	27	738	3.6
2008	517	173	10	700	1.5
2009	443	284	15	742	2.0
2010	208	284	10	502	2.0
2011	87	416	25	528	4.8
2012		439	23	462	5.1
2013		629	10	639	1.6
2014		425	11	436	2.6
2015		470	10	479	2.0
2016		433	5	438	1.2
2017		410	7	417	1.6

Table 5. Live discards (DL, t) available in Task I (T1NC) by year, flag and gear of each billfish species.

			Live discards (DL)																	
Species	**Flag**	**GearGrp**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
BIL	El Salvador	PS																		0.3
BLM	EU.France	PS																0.1		
	South Africa	LL														0.0				
BUM	Brazil	LL							46.5	57.9	19.5									
		RR							0.4											
	Canada	LL																		0.2
	Curaçao	PS																		0.3
	EU.España	PS										1.0		1.8		0.8		0.7	0.1	0.4
	EU.France	PS																0.5		0.5
	Guatemala	PS																		0.2
	Mexico	LL							0.4	0.7	0.9	1.1	0.7	0.9	0.9	0.5	0.4	0.6	1.0	1.0
	Panama	PS																		0.2
	South Africa	LL															0.0			
	U.S.A.	LL										58.3	30.1	108.5	110.4	137.9	93.2	142.2	71.7	91.9
		UN											0.2		4.5					
	UK.Bermuda	RR																		26.6
	UK.Turks and Caicos	RR					2.3													
MSP	EU.España	LL																	0.0	
SAI	Brazil	LL							10.6	5.1	2.3									
		RR							2.1											
	EU.France	PS																0.1		
	Mexico	LL							0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.2	0.0	0.0	0.0	0.0
	U.S.A.	LL															10.8		11.6	16.0
SPF	Mexico	LL																0.0	0.0	0.0
WHM	Brazil	LL							14.8	24.4	5.8									
		RR							0.1											
	Canada	LL																	0.1	0.3
		TW																	0.0	
	Korea Rep.	LL											0.2							
	Mexico	LL	0.3	0.1	0.7	0.2	0.3	0.1	0.0	0.4	0.3	0.3	0.2	0.2	0.0	0.0	0.1	0.1	0.4	0.2
	U.S.A.	LL											14.8	35.7	14.5	3.4	5.6	1.1	3.1	
		UN										5.8	0.1		3.6					
	UK.Bermuda	LL															0.0			
		RR																		1.2

Table 6. BIL unclassified catches (t) remaining in Task I (T1NC).

		BIL (Istiophoridae) unclassified (t)																						
Status	**Flag**	**1981**	**1987**	**1988**	**1989**	**1990**	**1993**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
CP	Brazil							18		1	4	28					11	114	79					
	Canada																					0	0	0
	Curaçao																							0
	El Salvador																							37
	EU.España									1	1			3	6	17	5	2	3	3	1	1		1
	EU.France															1		0	1	1			1	0
	EU.Netherlands														0			0						
	EU.Portugal		5	1	1	1			25				97				5	0	22	3				
	Gabon	116																						
	Guatemala																							0
	Guinea Ecuatorial																			0				
	Korea Rep.															1						2	3	1
	Liberia						27																	
	Mauritania																						0	
	Panama																							0
	Sierra Leone																	1						
	Trinidad and Tobago										5	3	7	7	6	8	8	5	2	0	0		0	0
NCC	Guyana																						48	67
NCO	Seychelles							16		0														
	Sta. Lucia							4																
TOTAL		**116**	**5**	**1**	**1**	**1**	**27**	**37**	**25**	**2**	**9**	**32**	**104**	**9**	**13**	**27**	**29**	**122**	**107**	**6**	**1**	**3**	**53**	**108**

Table 7. CPUE evaluation table for CPUE series presented during the meeting.

SCRS Doc No.	**SCRS/2019/034**	**SCRS/2019/035**	**SCRS/2019/037**	**SCRS/2019/038**	**SCRS/2019/039**	**SCRS/P/2019/011**
Index Name:	Brazil-recreational	Brazil longline	Japan longline	Chinese-Taipei longline	USA-recreational	USA-longline
Data Source (state if based on logbooks, observer data etc)	sport fisheries	logbooks	logbooks	logbooks	tournament reports	scientific observers
Do the authors indicate the percentage of total effort of the fleet the CPUE data represents?	NA	No	No	Yes	No	Yes
If the answer to 1 is yes, what is the percentage?				91-100%		0-10%
Are sufficient diagnostics provided to assess model performance??	Sufficient	Sufficient	Sufficient	Sufficient	Sufficient	Sufficient
How does the model perform relative to the diagnostics ?	Well	Well	Well	Well	Mixed	Well
Documented data exclusions and classifications?	Yes	Yes	Yes	Yes	Yes	Yes
Data exclusions appropriate?	Yes	Yes	Yes	NA	Yes	Yes
Data classifications appropriate?	Yes	Yes	Yes	Yes	Yes	Yes
Geographical Area	Atl SW	Atl S	Atl S	Atlantic	Atl NW	Atl NW
Data resolution level	trip	Set	Set	Set	trip	Set
Ranking of Catch of fleet in TINC database (use data catalogue)	11 or more	1-5	1-5	1-5	11 or more	6-10
Length of Time Series	longer than 20 years	longer than 20 years	longer than 20 years	longer than 20 years	longer than 20 years	longer than 20 years
Are other indices available for the same time period?	Few	Few	Few	Few	Few	Few
Are other indices available for the same geographic range?	None	Few	Few	Few	Few	None
Does the index standardization account for Known factors that influence catchability/selectivity? (eg. Type of hook, bait type, depth etc.)	Yes	Yes	Yes	Yes	No	Yes
Estimated annual CV of the CPUE series	Variable	Variable	Low	Low	High	Low
Annual variation in the estimated CPUE exceeds biological plausibility	Possible	Possible	Unlikely	Unlikely	Possible	Possible
Is data adequate for standardization purposes	Yes	Yes	Yes	Yes	Yes	Yes
Is this standardised CPUE time series continuous?	Yes	Yes	No	Yes	Yes	Yes
For fisheries independent surveys: what is the survey type?						
For 19: Is the survey design clearly described?					No	Yes
Other Comments		Useful to stock assessment until 2010	3 split series	3 split series	Not used for BUM	mixture of white marlin and roundscale spearfish

Table 8. Available standardized CPUE for the 2019 White Marlin stock assessment. Spanish and Venezuelan CPUEs used in the 2012 stock assessment were not updated during the 2019 White Marlin data preparatory meeting.

Document	SCRS_2019_034	SCRS_2019_035	SCRS/2019/037			SCRS/2000/081	SCRS/2019/038			SCRS/2019/039	SCRS/P/2019/011	SCRS/2012/054	SCRS/2011/034	SCRS/2011/033
Name	BRARR	BRALL	CTPLL1	CTPLL2	CTPLL3	JPNLLprior	JPNLL1	JPNLL2	JPNLL3	USARR	USALL	SPNLL	VENGL	VENLL
Num / Wgt	N fish	N fish	N fish	N fish	N fish	N fish	N fish	N fish	N fish	N fish	N fish	N fish	N fish	N fish
Year	CPUE CV	CPUE CV	CPUE CV	CPUE CV	CPUE CV	CPUE CV	CPUE CV	CPUE CV	CPUE CV	CPUE CV	CPUE CV	CPUE SE	CPUE SE	CPUE SE
1959						0.39								
1960						0.66								
1961						1.54								
1962						3.28								
1963						3.12								
1964						2.46								
1965						2.21								
1966						2.63								
1967						2.26								
1968			0.20 0.13			1.86								
1969			0.17 0.11			1.90								
1970			0.11 0.10			1.52								
1971			0.14 0.10			1.06								
1972			0.09 0.12			1.35								
1973			0.15 0.14			0.78								
1974			0.11 0.10			1.01				0.72 0.33				
1975			0.08 0.12			0.67				0.80 0.42				
1976			0.02 0.17				0.34 0.16			0.78 0.38				
1977			0.01 0.16				0.19 0.20			0.64 0.40				
1978		0.18 0.28	0.02 0.14				0.38 0.11			0.63 0.39				
1979		0.30 0.34	0.03 0.15				0.30 0.15			0.76 0.38				
1980		0.25 0.35	0.04 0.11				0.32 0.09			1.19 0.37				
1981		0.40 0.38	0.04 0.11				0.38 0.09			0.87 0.35				
1982		0.06 0.40	0.02 0.10				0.26 0.09			1.12 0.36				
1983		0.09 0.39	0.03 0.12				0.20 0.10			1.06 0.35				
1984		0.06 0.28	0.02 0.12				0.27 0.09			0.95 0.35				
1985		0.02 0.38	0.02 0.11				0.28 0.09			0.63 0.35				
1986		0.25 0.28	0.05 0.10				0.24 0.09			0.63 0.37				
1987		0.16 0.27	0.08 0.11				0.33 0.09			0.54 0.41				
1988		0.09 0.30	0.08 0.17				0.20 0.09			0.45 0.43		0.12 0.04		
1989		0.06 0.31	0.09 0.17				0.17 0.08			0.29 0.54		0.12 0.04		
1990		0.19 0.40		0.04 0.16			0.15 0.09			0.35 0.45		0.05 0.02		
1991		0.15 0.27		0.04 0.20			0.14 0.08			0.31 0.54		0.04 0.01	2.54 0.74	0.69 0.52
1992		0.10 0.28		0.06 0.18			0.15 0.09			0.31 0.55		0.01 0.01	1.46 0.47	0.45 0.28
1993		0.13 0.39		0.15 0.12			0.14 0.09			0.26 0.67	1.38 0.1	0.02 0.01	1.94 0.59	0.64 0.36
1994		0.08 0.27		0.16 0.11				0.12 0.18		0.41 0.56	0.68 0.2	0.02 0.01	7.17 1.90	0.59 0.36
1995		0.07 0.26		0.10 0.11				0.11 0.18		0.50 0.47	1.35 0.1	0.04 0.01	3.63 1.01	0.96 0.41
1996	2.56 0.27	0.33 0.26		0.10 0.11				0.09 0.18		0.50 0.48	0.91 0.2	0.11 0.03	1.30 0.45	0.35 0.20
1997	3.66 0.19	0.11 0.26		0.08 0.10				0.08 0.18		0.37 0.53	1.06 0.2	0.15 0.34	1.22 0.41	0.50 0.26
1998	2.97 0.24	0.13 0.25		0.05 0.13				0.12 0.18		0.91 0.45	0.89 0.2	0.20 0.04	3.10 0.88	0.57 0.29
1999	1.10 0.67	0.19 0.25		0.03 0.10				0.08 0.19		0.42 0.56	1.60 0.2	0.03 0.01	5.39 1.46	0.45 0.29
2000	3.33 0.20	0.14 0.26		0.03 0.10				0.07 0.19		0.36 0.74	1.22 0.2	0.03 0.01	3.70 1.03	0.20 0.14
2001	1.15 0.59	0.17 0.25			0.05 0.12				0.05 0.39	0.46 0.57	0.49 0.2	0.05 0.02	2.30 0.68	0.14 0.11
2002	3.35 0.20	0.04 0.26			0.04 0.12				0.04 0.40	0.66 0.48	1.00 0.2	0.00 0.00	3.22 0.91	0.20 0.13
2003	2.61 0.26	0.06 0.29			0.03 0.13				0.03 0.41	0.15 1.09	0.55 0.2	0.05 0.02	3.51 0.99	0.46 0.22
2004	1.65 0.41	0.11 0.27			0.02 0.12				0.04 0.39	0.58 0.49	0.97 0.1	0.03 0.01	5.28 1.43	0.42 0.23
2005	2.17 0.33	0.07 0.32			0.03 0.12				0.04 0.39	0.65 0.49	1.24 0.1	0.04 0.01	5.34 1.44	0.34 0.20
2006	1.99 0.37	0.05 0.32			0.03 0.13				0.07 0.39	0.78 0.46	0.80 0.2	0.03 0.01	5.12 1.39	0.28 0.16
2007	2.22 0.31	0.05 0.32			0.02 0.15				0.05 0.40	0.34 0.72	0.61 0.1	0.05 0.01	5.86 1.57	0.60 0.35
2008	1.85 0.43	0.04 0.33			0.01 0.21				0.03 0.41	0.57 0.57	0.59 0.1	0.03 0.14	4.21 1.16	0.65 0.43
2009	0.77 0.91	0.03 0.33			0.03 0.11				0.03 0.39	0.48 0.62	1.02 0.1	0.00 0.00	3.58 1.00	0.20 0.20
2010	2.89 0.24	0.11 0.34			0.02 0.11				0.02 0.40	0.66 0.54	0.66 0.1	0.01 0.00	2.29 0.68	0.61 0.35
2011	2.67 0.26				0.03 0.11				0.03 0.40	1.33 0.44	1.64 0.1			
2012	2.97 0.25				0.02 0.11				0.02 0.41	1.06 0.49	1.52 0.1			
2013	3.62 0.19				0.01 0.23				0.04 0.42	0.69 0.50	0.92 0.1			
2014	2.95 0.23				0.01 0.21				0.03 0.42	0.60 0.57	0.98 0.1			
2015	3.30 0.21				0.01 0.19				0.02 0.43	0.88 0.49	1.03 0.1			
2016	3.01 0.22				0.01 0.20				0.02 0.41	0.74 0.54	0.99 0.1			
2017	3.55 0.19				0.01 0.21				0.01 0.43	0.45 0.80	0.90 0.1			

Table 9. Summary of provisions of marlin rebuilding plan of the ICCAT Commission.

	Industrial purse seine and longline		**Recreational fleets**	
Rec.	**Catch limits/TAC**	**Release of fish caught alive**	**Minimum size limits (MSL)**	**Catch limits**
97-09 98-10	Reduce catches of white marlin and blue marlin by 25% of the levels of 1996, and to achieve such reductions by 1999	Voluntary	No regulation	No regulation
00-13	Catches to be reduced to 33% of the 1999 levels	Required	MSL for each CPC	US shall limit take to 250 individual marlins (BUM, WHM, RSP).
01-13, 02-13, 04-09, 06-09 10-05	Catches to be reduced to 33% of the greatest of 1996-1999	Required		
12-04 15-05	TAC of 400 t for white marlin and spearfish*	As CPCs approach landing limit, require release of live fish	MSL of 166 cm LJFL	2 t limit per CPC, except US, where the limit is 250 individual marlins (BUM, WHM, RSP). Sale prohibition
18-04, 18-05				

* In response to the SCRS advice that catches of white marlin include also catches of roundscale spearfish.

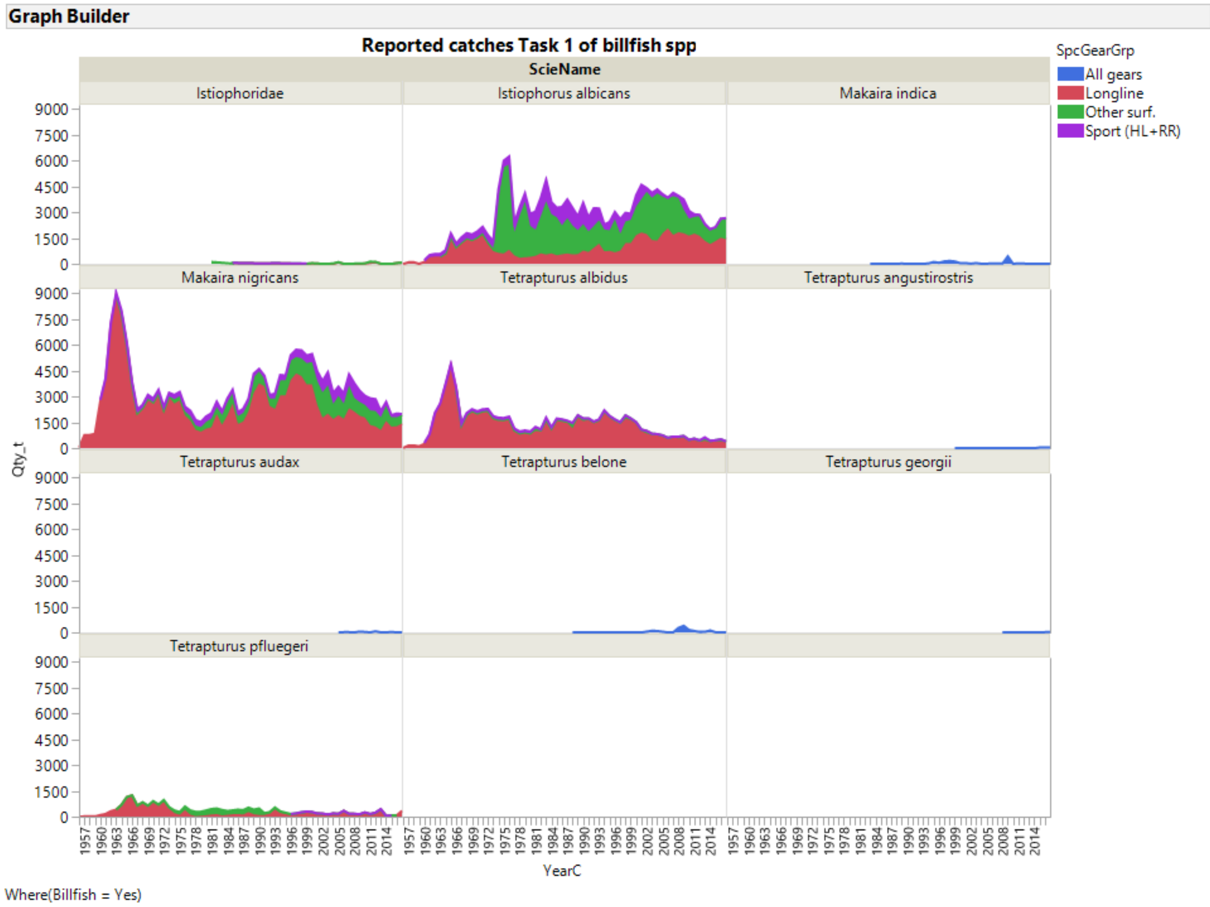

Figure 1. total catches (T1NC, containing landings and dead discards) of the various billfish species by year.

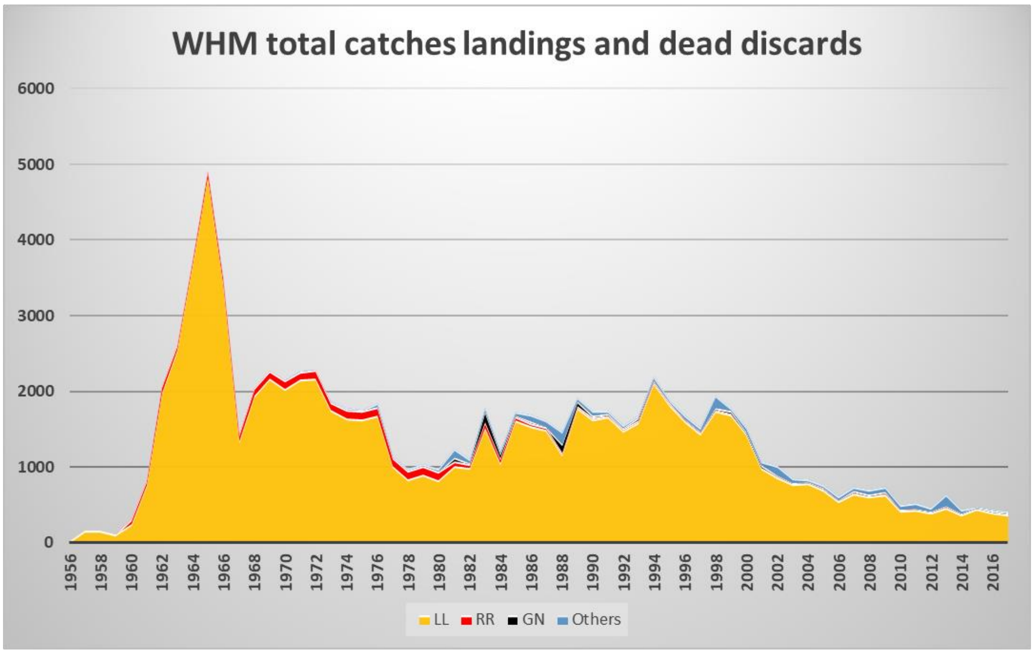

Figure 2. The WHM total catches by year and gear.

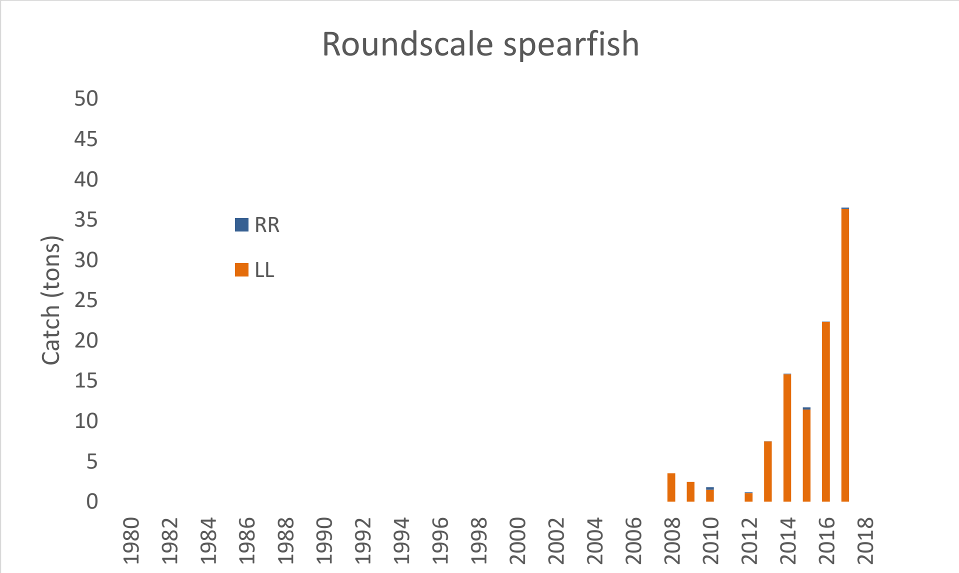

Figure 3. Task I catches of round-scale spearfish by gear type.

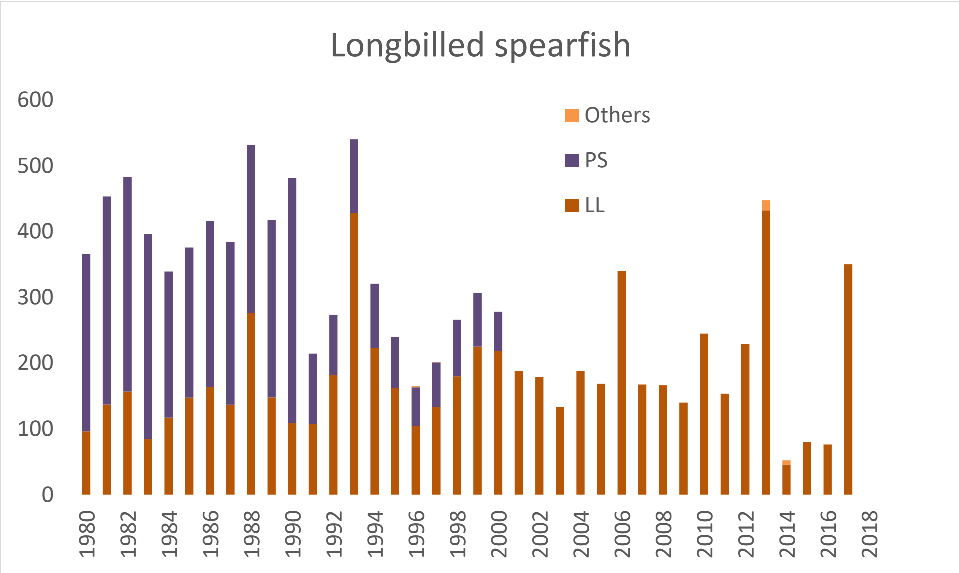

Figure 4. Task I catches of longbill spearfish by gear type.

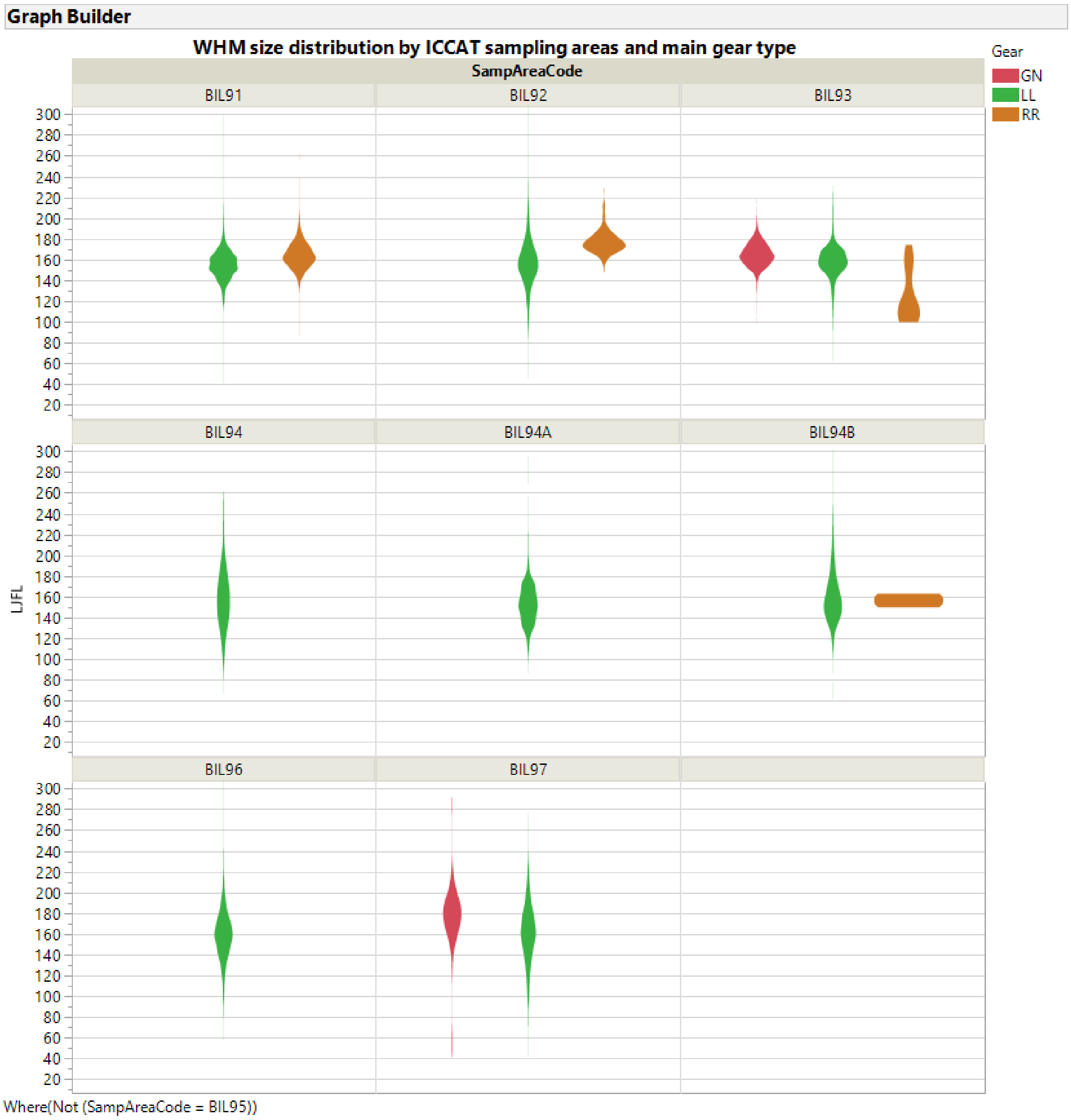

Figure 5. White marlin size distribution by main sampling areas (ICCAT Billfish sampling areas) and fishing gear.

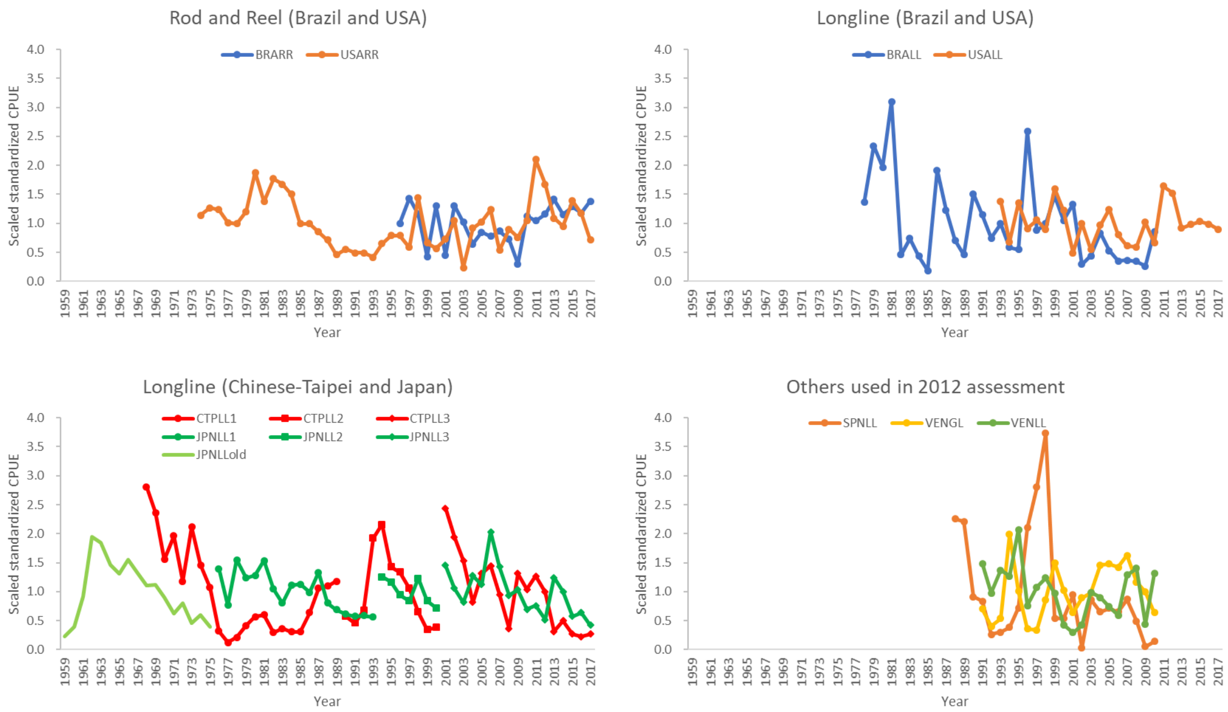

Figure 6. Available standardized CPUE for the 2019 White Marlin stock assessment. Spanish and Venezuelan CPUEs used in the 2012 stock assessment were not updated during the 2019 White Marlin data preparatory meeting.

Appendix 1

Agenda

1. Opening, adoption of the Agenda and meeting arrangements
2. Biology
3. Review of available data for the assessment
   3.1 Task I and II catch data
   3.2 Task II effort and size data
   3.3 Tagging data
4. Review of relative indices of abundance (CPUEs)
5. Discussion on models to be used during the assessment and their assumptions
6. Other data relevant for stock assessment and remaining issues in preparation for the June stock assessment meeting
7. Enhanced Program for Billfish Research (EPBR)
8. Other matters
9. Recommendations
10. Adoption of the report and closure

Appendix 2

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Appendix 3

List of Papers and Presentations

SCRS/2019/034	Bayesian generalized linear models for standardization of white marlin (*Kajikia albida*) catch rates based on Brazilian sport fishing tournaments (1996-2017) in the southwestern Atlantic	Mourato B.L. Malavasi-Bruno E.; Dantas M. Hazin F., Pimenta E. and Amorim A. F.
SCRS/2019/035	Standardization of longline Catch-Per-Unit-Effort for white marlin (*Kajikia albida*) from Brazilian fleet (1978-2017)	Mourato B.L., Hazin F. and Amorim A.F.
SCRS/2019/036	Review and preliminary analyses of size samples of Atlantic white marlin (*Tetrapturus albidus*).	Ortiz M., and Palma C.
SCRS/2019/037	Japanese longline CPUE standardization (1976-2017) for Atlantic white marlin (*Kajikia albidus*) using zero-inflated generalized linear mixed model (GLMM).	Ijima H., and Honda H.
SCRS/2019/038	CPUE standardization for white marlin (*Kajikia albida*) caught in the Taiwanese distant-water longline fishery in the Atlantic	Su N.J., and Lu J.L.
SCRS/2019/039	White marlin (*Kajikia albida*) standardized indices of abundance from the U.S. recreational tournament fishery	Lauretta M.
SCRS/2019/040	Preliminary study and description of the Artisanal fishery of drifted gillnets of Cote d'Ivoire	Justin Konan K., Kouame Y.N., Diaha N.C. and Amande M.J.

SCRS/P/2019/009	Initial Surplus Production Model priors for Atlantic white marlin (*Kajikia albida*) with limited biological information	Winker H., Mourato B., Sow F.N., and Ortiz M.
SCRS/P/2019/010	Modelling abundance indices of white marlin species and stock assessment	Ba K., and Ngom F.
SCRS/P/2019/011	White marlin (*Kajikia albida*) + spearfish (*Tetrapturus spp.*) standardized index of annual relative abundance U.S.A. pelagic longline observer program 1993 - 2017.	Lauretta M.
SCRS/P/2019/012	Initial results for white marlin (*Kajikia albida*) stock assessment using the Catch-Resilience method CMSY	Mourato B., Winker H., Fambaye N.S, and Ortiz M.
SCRS/P/2019/013	Collection of biological samples for the study of growth of billfish in the Eastern Atlantic	Diouf K., Diop K., Ba A., Ndiour Y., Sow F., Konan J.K. and Conceicao I.D.

Appendix 4

SCRS Document Abstracts

Document SCRS/2019/034 - In the present work, daily radio logbook records from recreational tournaments of Yacht Clubs from São Paulo, Rio de Janeiro, Espírito Santo and Bahia, including 386 tournament days, from 1996 to 2017, were used to generate a standardized CPUE series, by a Bayesian generalized linear model, using Integrated Nested Laplace Approximation (INLA) approach with different probability distribution. The factors included were: “year” (1996 to 2017), “local” (off São Paulo, Rio de Janeiro, Espírito Santo and Bahia), quarter (1th and 4th quarters) and “target”. The target species was estimated by a cluster analysis, based on the proportion of each species or group of species in relation to the total catch, using the “K Means” method. The standardized catch rate series shows a gradual decreasing trend until 2009 followed by an increasing trend between 2010 to 2017, particularly after the year 2012. The apparent rise in catch rates in recent years might be an indication of the recovery of the stock of white marlin, at least considering the local relative abundance estimated for this species.

Document SCRS/2019/035 - In the present paper, catch and effort data from 99,790 sets done by the Brazilian tuna longline fleet, including both national and chartered vessels, in the equatorial and southwestern Atlantic Ocean, from 1978 to 2017, were analyzed. The CPUE of the white marlin was standardized by a Generalized Linear Mixed Model (GLMM) using a Delta Lognormal approach. The factors used in the model were: year, quarter and area. The standardized CPUE series shows a gradual decreasing trend, particularly after the year 2000, reaching a low level from 2002-2009, and decreasing to an even lower level from 2011 to 2017.These drops in CPUE, however, were much more a consequence of a new regulation, in 2005, prohibiting the taking of marlins if they were alive by the time of gear retrieval, as well as their commercialization, if they were dead, than to an actual change in abundance. This means the signal of white marlin abundance from this fishery is lost and the CPUE series after 2005 is not suitable for stock assessment purposes.

Document SCRS/2019/036 - Size sampling data of Atlantic white marlin was reviewed, and preliminary analyses performed for its use within the stock evaluation models. Size data is normally submitted to the Secretariat by CPCs under the Task II requirements; optionally CPCs can submit Catch at Size, size samples or both for the major fisheries. The size samples data was revised, standardized and aggregated to size frequencies samples by main gear type, year and quarter. Preliminary analyses indicated a minimum number of 25 fish measured per size frequency sample, with size information since 1970 for the longline, gillnet and rod & reel fishing gears. For Atlantic white marlin, the size sampling proportion among the major fishing gears is consistent with the proportion of the catch since 1970; in general longline fisheries have been well sampled.

Document SCRS/2019/037 - To grasp the historical trajectory of Atlantic white marlin stock abundance, we addressed standardizing the CPUE of Atlantic white marlin caught by Japanese longliners using their logbook data for the period (1976-2017). In this analysis, we revised the previous analysis methodology specifically for that: i) we changed the period separations for the standardization, ii) reconsidered evaluation area, iii) examined zero-inflated Poisson distribution (ZIP) to cope with zero-inflated catch data, iv) constructed the generalized linear mixed model (GLMM) using the random effect variable and, v) selected goodness fit model using Bayesian Information Criterion (BIC). We also constructed a simple Poisson generalized linear model (GLM) and Poisson GLMM, but BIC of complex ZIP GLMM was the smallest in all time-series. The standardized CPUE showed a decreasing trend throughout all periods. The ZIP GLMM has improved the fitness to Japanese longline logbook data, but the explanatory of deviance is still low (0.21-0.30). Although we made the crossed GLMM that seems to reflect the actual fishery, this complicated model did not converge. It is necessary to consider spatiotemporal correlation into the future model because the ZIP GLMM could not incorporate operational patterns of Japanese longliners in relation to time and area that may be fluctuating every year. However, our result improved from the previous analysis and the standardized CPUE is the best available index at the moment. In the next stock assessment for Atlantic white marlin, we proposed not to use the old CPUE time series (1959-1999) that was submitted by Yokawa et al. (2001) because this index may not sufficiently standardized.

Document SCRS/2019/038 - Catch and effort data of white marlin (*Kajikia albida*) were standardized for the Chinese Taipei distant-water tuna longline fishery in the Atlantic Ocean by period and a whole period (1968-2017) using a generalized linear model (GLM). Four periods of 1968-1989, 1990-2017, 1968-2017 and 1998-2017 (with the information on operation type, i.e., the number of hooks per basket, HPB) were considered in the CPUE (catch per unit effort) standardization of white marlin to address the issue of historical targeting change in this fishery. Abundance indices of white marlin were developed for various periods, which showed almost identical trends to those derived from the model of entire period (1968-2017), except for the model in recent period (1998-2017). However, results were insensitive to the inclusion of gear configuration (HPB) in the model as an explanatory variable. Standardized CPUE trend of Atlantic white marlin started to decrease in the 1970s, with a following increase to a higher level during the 1980s and early 1990s, but dropped gradually from the late 1990s to recent years.

Document SCRS/2019/039 - An index of relative abundance for white marlin in the Atlantic Ocean is presented for the U.S. recreational billfish tournament fishery. The index standardization included year, area, and quarter, with a random tournament effect. The imprecise location of fishing during tournaments was a limitation in standardization, where only the fishing port was known. The random effect model for individual tournaments likely captured much of the variation that might be attributed to differences in habitat or other covariates.

Document SCRS/2019/040 - The present study aims to describe the artisanal driftnet fishery that land tuna and associated species (sharks, billfishes and swordfish) in Côte d'Ivoire. At each landing site, a survey was conducted among the owners and / or managers of this fishing gear, fishermen belonging to these fishing units and fishmongers. A total of 15 units, 10 fishing gear owners, 50 fishermen and 10 wholesalers were surveyed. The number of outgoing and unloaded canoes as well as those actually surveyed were also noted. Each fishing team consists of 6 to 7 people. The number of gillnets depends on the size of the pirogue. The big pirogues have 25 to 30 nets while the smaller ones have 15 to 20 nets on board. Artisanal fishermen operate at night with 40 hp motorized canoes, ranging in length from 12 to 18 m and multi-filament nets. The nets generally have a total length of between 1500 and 2500 m, a mesh of 25 mm, 30 mm, 35 mm, 40 mm and 45 mm and a drop that varies from 15 to 30 meters. Fishing takes place from the edge of the continental shelf between 5 à 10 miles. Fishing activity is practiced only by men. Women are responsible for the processing and marketing of fish products. Fishermen and owners are almost exclusively Ghanaians belonging to the Fantis ethnic group. Nominal catches from 2014 to 2017 were almost exclusively dominated by Tunas (73.92-83.17%) followed by Elasmobranchs (11.48-15.00). %), Billfish (2,54-9,72 %) and Xiphiidae (0,23-1,35 %). For Billfish, catches were dominated by sailfish (60.93-76.82%) whereas blue and white marlins represented respectively 15.42-20.49% and 0.96-2.03% of landed species.

Presentation SCRS/P/2019/011 - The document presented an updated white marlin/spearfish relative abundance index based on observations from the U.S. pelagic longline fishery observer program. Standardized annual mean catches of white marlin/spearfish per 1000 hooks were estimated using a generalized linear model with the following covariates: sea surface temperature, fishing area, year, season, number of hooks between floats, day vs night set, hook type, and ocean depth.

Appendix 5

Tentative Agenda for the White marlin Stock Assessment session

1. Opening, adoption of Agenda and meeting arrangements

2. Summary of updated data submitted after the Data Preparatory meeting and before the assessment data deadline (30 March 2019)
   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. Other methods
   4.4. Synthesis of assessment results

5. Projections

6. Recommendations
   6.1. Research and statistics
   6.2. Management

7. Responses to the Commission

8. Other matters

9. Adoption of the report and closure